John Wesley Powell Blvd.
West Extension Design - City of Flagstaff

Prepared For: Jeff Bauman

PE, PTOE, Traffic Engineer, City of Flagstaff

By: Cristine Aguila, Elijah Begay, Logan McFarland, and Steven McKimmey

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Final Report

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AADT	Average Annual Daily Traffic
AASHTO	American Association of Highway and Transportation Officials
ADA	American Disabilities Act
ADOT	Arizona Department of Transportation
CCEDCM	Coconino County Engineering Design and Construction Manual
CoF	City of Flagstaff
DDM	Drainage Design Manual for Yavapai County
DEM	Digital Elevation Map
FHWA BSP	Federal Highway Administration Bases and Subbases for Pavements Manual
FUTS	Flagstaff Urban Trail System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
JAMAR	Traffic Data Analysis & Reporting Software
JWP	John Wesley Powell
LOS	Level of Service
MAG SPDPWC	Maricopa Association of Governments Specifications and Details for Public Works Constructions
MUTCD	Manual on Uniform Traffic Control Devices
NOAA	National Oceanic and Atmospheric Administration
SWMDM	Storm Water Management Design Manual
TAC	TexAmericas Center
USACE	U.S. Army Corps of Engineers
USGS	United States Geographical Survey
VHF-DME	Very High-Frequency Omni-Directional Range with Distance Measuring Equipment
WSS	Web Soil Survey

Acknowledgements

This project would not have been possible without Jeff Bauman, the project client. The team would like to thank him for providing field data for this project to allow us to stay on schedule.

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1.0 Project Introduction

The John Wesley Powell Blvd West Extension Design project aims to extend John Wesley Powell Boulevard (JWP) from South Pulliam Drive to Lake Mary Road, with the primary purpose of enhancing the accessibility to underserved areas. This project centers on a 1.5-mile section between South Pulliam Dr. and Lake Mary Rd.

1.1 Project location

The project is in the Northern Arizona region. The site lies due East of I-17, see Figure 1-1 below. The City of Flagstaff, various neighborhoods, local facilities, and key landmarks can also be seen surrounding the project location in the figure below.

Figure 1-1: Location map of project within Flagstaff, Arizona [1]

The JWP Extension Project aids in improving connectivity and accessibility within this portion of Flagstaff, while offering benefits to both its residents and visitors. Figure 1-2 provides a satellite image of this location; this map is an overview of the project area, hatched in white.

Figure 1-2: Existing project site

1.2 Existing Conditions

Figure 1-2, the vicinity map of the project area, provides a detailed overview of the immediate surroundings as it serves as a reference point for understanding the specific challenges imposed by the existing conditions. Other factors that were considered are: an ongoing housing development to the north, a significant wash located at the intersection of Lake Mary Rd. and JWP Blvd., an existing dirt road that traverses through forested areas, natural terrain, ridges, hills, and minor washes. Additionally, there is a permanent Very High-Frequency Omni-Directional Range (VHF-DME) with Distance Measuring Equipment situated in a cleared field nearby.

1.3 Constraints

The JWP West Road extension faces several constraints. The roadway's path is restricted due to minimal space availability and the need to avoid interfering with airport’s daily operations, VHF Omni-Directional Range device, and airport runway thus limiting options to one viable route.

Due to the close proximity of the road to neighboring communities and businesses, the installation of pedestrian facilities such as sidewalks and the American Disabilities Act (ADA) accessible ramps are necessary. However, this requires additional space for sidewalks, bike lanes, crossings, and other facilities and utilities, thus limiting culvert and gutter design options.

Additionally, Flagstaff's freeze and thaw cycles pose as a constraint for road durability and maintenance, as it limits material selection and installation, construction, and maintenance techniques.

1.4 Major Objectives

The major objective of the JWP West Blvd. extension is to connect South Pulliam Dr. with Lake Mary Rd. This will provide greater access to nearby communities and provide a quicker route for getting across town, reducing traffic congestion in crucial areas.

1.5 Exclusions

The following items will not be included nor collected for the project: geotechnical lab sampling/testing, utility design (sanitary sewer, water, storm, gas, electrical, etc.), a full hydraulic design of ditches along the new roadway. Additionally, the Flagstaff Urban Trail System (FUTS) will not be included into the design process; however, it will be considered for later development.

2.0 Research and Data Collection

The research and data collection section covers the methods employed to understand the current conditions of the project site. This includes examination of roadway design standards and regulations, as well as utilization of online tools for site properties identification.

2.1 Review Codes and Standards

In order to ensure adherence to established roadway design standards, an extensive examination of regulatory specifications and standards at the local, state, and federal levels were conducted. The team collectively decided to focus on the manuals and codes from reputable sources, including the City of Flagstaff (CoF) Website, as well as higher-level governmental agencies such as the Storm Water Management Design Manual (SWMDM), Manual on Uniform Traffic Control Devices (MUTCD), and Arizona Department of Transportation (ADOT). With these sources, accurate design practices were able to be followed throughout the entirety of the project.

2.2 Identify Design Vehicle

The primary design vehicle was determined by identifying the type of existing roadways within the project vicinity, the surrounding terrain, and the standard types and volume of vehicles currently using the intersections. This information was needed so that the road can properly accommodate the anticipated flow of traffic both safely and effectively.

Using the Arizona Department of Transportation (ADOT) Roadway Design Guidelines, the roadway was classified as a minor arterial, and therefore the design vehicle was determined to be a WB-67 [2].

As shown in Figure 2-1, the WB-67 refers to a specific type of truck widely used in transportation. These trucks are characterized by their significant size and weight capacity, making them suitable for long-haul transport and heavy-duty applications. With an overall length of up to 76-feet and a maximum gross vehicle weight rating (GVWR) of 67,000 pounds, WB-67 vehicles play a crucial role in the movement of goods and materials across highways and roadways. Their dimensions and weight capacities are important considerations in transportation planning to ensure the safe and efficient operation of these vehicles on public roads.

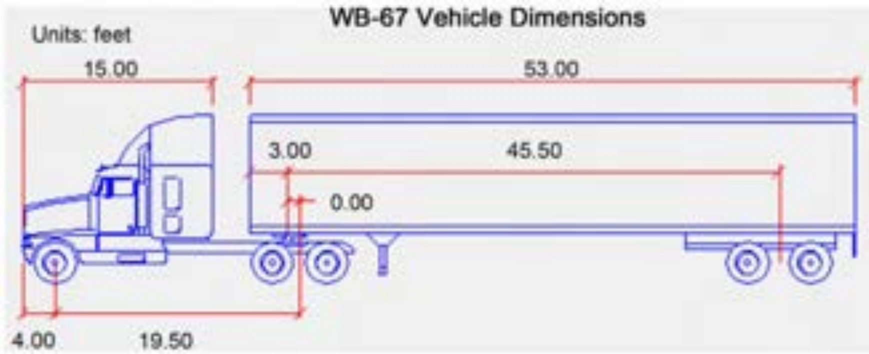

Figure 2-1: Typical WB-67 vehicle dimensions [2]

2.3 Collect Existing Geotechnical Data

Soil data was collected via the Web Soil Survey (WSS) provided by the United States Geological Survey (USGS) [3]. This information was necessary for the design of the roadway and its construction. The west portion of the road was found to be predominantly a telephone-daze complex.

Telephone Daze Complex series soil is characterized by its unique composition, typically consisting of a mixture of sandy loam or loamy sand with varying degrees of gravel content. These soils often exhibit good drainage properties and are suitable for various agricultural and horticultural activities, depending on local conditions and management practices.

The eastern portion of the road was found to be a mix of a fine sandy loam and a gravelly sandy loam. Figure 2-2, below, shows the mapped area of the project where the soil was analyzed. See Appendix A for the full soil report related to the project site.

Figure 2-2: Geotechnical drainage area map

According to the USGS web soil report, the project site consists of 3 primary soils. By using Table 2-1, the information will be used to assess the runoff curve number for the determination of peak discharge through using the assigned hydrologic soil group. This information will also help determine what type of sub grade will be used for the road and if the soil is feasible for the road. This is necessary for the roadway design and any cut/fill construction costs.

Table 2-1: Map unit legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
8	Paymaster family fine sandy loam, 0 to 3 percent slopes	8.2	7.1%
19	Telephone gravelly sandy loam, 0 to 15 percent slopes	32.8	28.60%
19A	Telephone-Daze complex, 0 to 8 percent slopes	73.8	64.30%
Totals for Area of Interest		**114.8**	**100.0%**

3.0 Site Investigation

Site investigation includes the collection of data and existing conditions of the project. These observations aid in understanding existing site geometry, surrounding intersections, and infrastructures.

3.1 Site Visit Planning

A safety plan was composed by the team to ensure a safe and productive trip to the site. This plan included the objectives of the visit, planned activities, equipment required, and the risks associated. The full version of this safety plan can be found in Appendix B.

3.2 Land Survey

Surveying was performed at the site to analyze the existing channel on the east section of the project site. This was necessary to determine the capacity of the existing channel, quantifying the peak flow, and if modifications need to be made. It was found that the channel exists to the north of the JWP west road extension but not to the south side. A photo of the team performing surveying work can be found in figure 3-1 below. See field notes in Appendix C.

Figure 3-1: Surveying existing channel

3.3 Traffic Counts

Traffic counts were performed at the intersections of JWP & Lake Mary Rd. and JWP & South Pulliam Dr, both ends of the project. The purpose of the counts was to determine the current volume of traffic at these intersections so that the traffic volume in 2045 can be estimated with the implementation of the new road. This information is needed so that the new road will continue to serve Flagstaff and its residents for years to come. The traffic counts were performed using a TDC Ultra traffic data recorder from JAMAR Technologies at each intersection on February 1st, 2023, as shown in Figure 3-2. PetroPro software, version 1.7.43, from JAMAR Technologies was used to evaluate and interpret this information. Fully detailed tables showing turn movements at these intersections can be found in Appendix D.

Figure 3-2: Team member utilizing JAMAR board to manually count traffic

Figure 3-3 and Figure 3-4 are an image representation of the intersection with its traffic volumes and turn movements; for both A.M. (8 am to 9 am) and P.M. (4 pm to 5 pm) peak hours. Figure 3-3 represents the counts that were completed on the west intersection of the project: South Pulliam Dr. & JWP Blvd. It is important to note that within this intersection, it branches into potential users entering/exiting from the Flagstaff Pulliam Airport and FedEx workers utilizing the intersection. Since there is no existing road from the east, it was expected to have a lower number of users. Other contributing users were due to nearby residential areas and the usage of the interstate for both A.M. and P.M. peak hours.

Figure 3-4 represents the counts that were collected on the east intersection of the project: Lake Mary Rd. & JWP Blvd. The volume contributors would seem to be diverse due to Lake Mary Rd. operating as a main highway that enters Flagstaff and JWP Blvd. servicing local residents, that potentially departs into other locations (i.e., schools, rehabilitation facilities).

S. Pulliam Dr. & JWP Blvd. (*AM/PM Hours)*

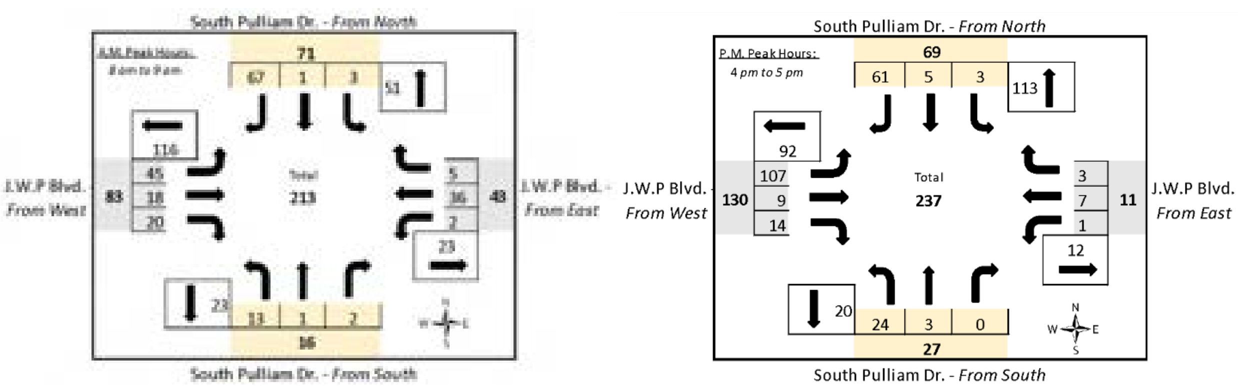

Figure 3-3: Turning movements for West intersection

Lake Mary Rd. & JWP Blvd. (*AM/PM Hours*)

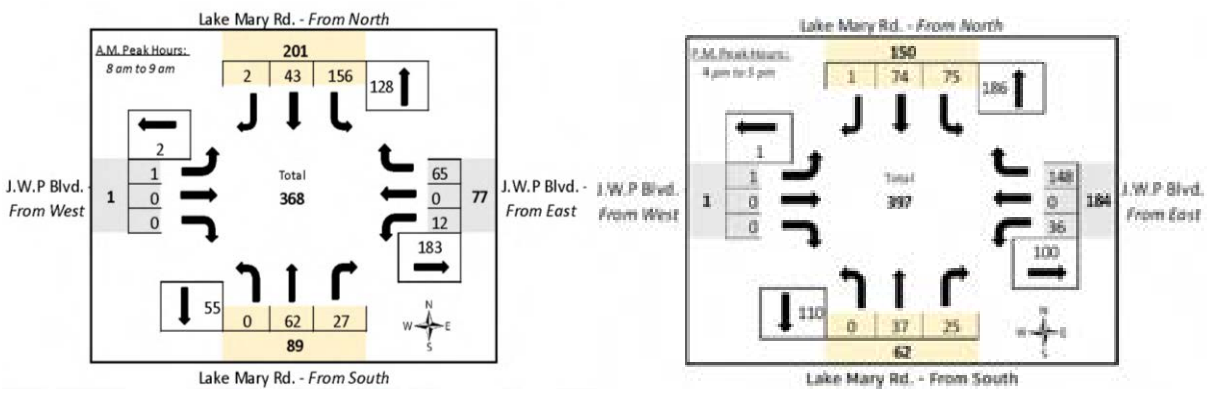

Figure 3-4: Turning movements for East intersection

Furthermore, the data provided from the city are future projections of traffic volumes within the vicinity of the project. Such forecast is used to evaluate the level of service of these intersections depending on the volume. They are also used to determine what necessary designs (i.e. signalized intersection, roundabout, etc.) that should be incorporated into the project.

This data will be used in conjuncture with the CoF's projected traffic volume for 2045 (Table 3-1). This will be done by assuming a 10% peak hour traffic for the average annual daily traffic (AADT). An engineer's estimate will be performed by analyzing the turning movements at each intersection to predict the future traffic movements with the addition of the proposed road.

Table 3-1: Projected data for year 2045

2045 Projected Traffic Volume		
Intersection: Lake Mary Road and JWP	AADT	Peak Hour
Lake Mary (Southbound)	6578	658
Lake Mary (Northbound)	2093	209
JWP (Eastbound)	4133	413
JWP (Westbound)	7973	797
Intersection: S Pulliam Drive and JWP	AADT	Peak Hour
S Pulliam (Southbound)	1793	179
S Pulliam (Northbound)	2490	249
JWP (Eastbound)	7963	796
JWP (Westbound)	5429	543

3.4 Photographs of Site Features

Photographs of the site were taken to ensure a complete understanding of the project site and its physical features. These photos were used for clarification and reference to avoid extra visits to the site causing additional travel costs. The picture below shows a few key features that are necessary for better understanding the existing conditions. Figure 3-5 is an image of the channel, looking downstream (northeast towards Lake Mary Rd). The channel is lightly vegetated with semi-tall shrubs and newly planted pine trees. The bottom of the channel is composed of muddy and coarse soil along with some rocky linen at the beginning of the channel, seen in Figure 3-5. Additional photos taken at the site can be found in Appendix E.

Figure 3-5: Looking downstream of existing channel

3.5 Collect Existing Hydraulic Structure Data

Within the boundaries of the project, one operable channel can be observed trailing North, near the east intersection. This channel is segmented along the north side of the Flagstaff Pulliam Airport runway, far upstream from this focused area. Figure 3-6 is an ariel image of the channel that intersects with the proposed graded JWP alignment. This channel can be characterized with upstream and downstream regions, based on the direction flow to the north. As the channel progresses downstream, the channel becomes well defined at the red indicator; while in the upstream region, the channel is flat. The blue hatch in Figure 3-6 shows the existing channel bed.

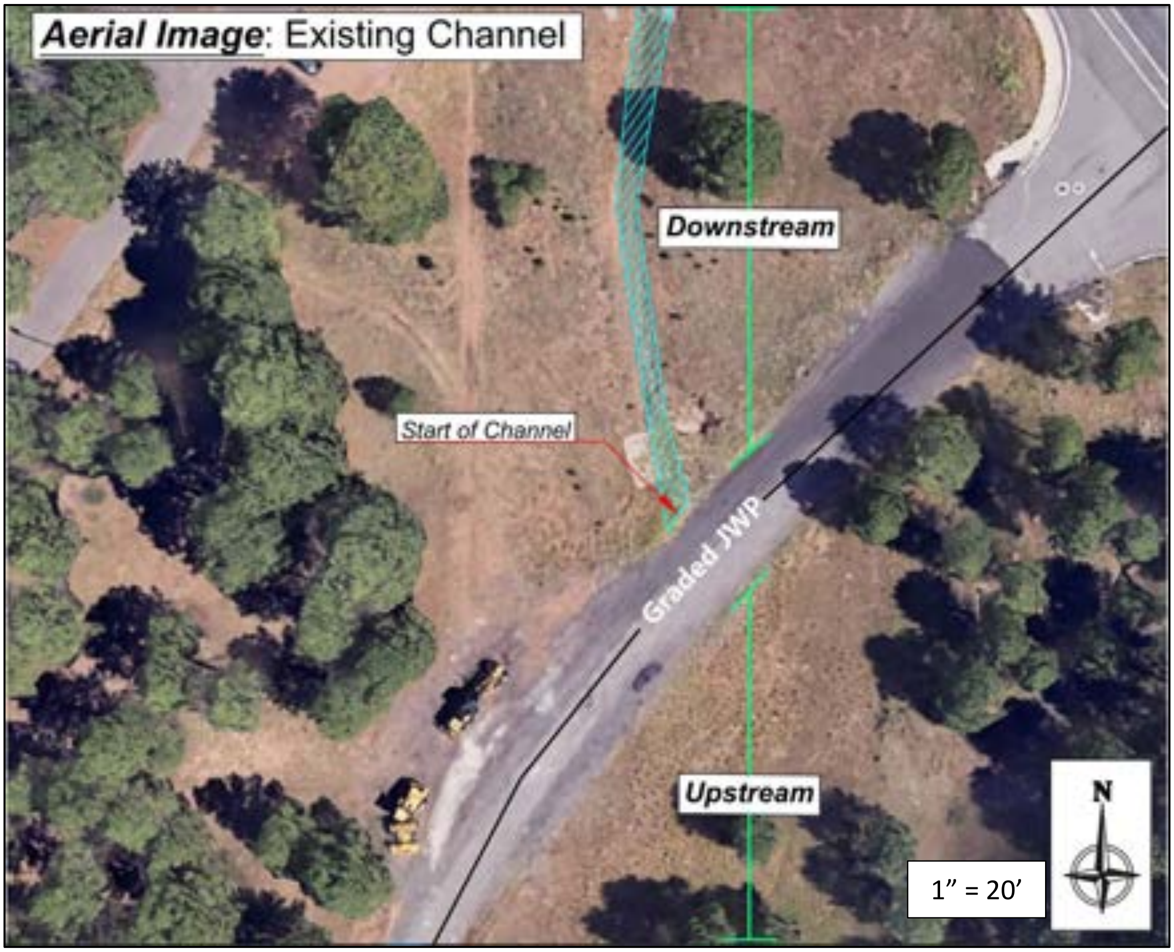

Figure 3-6: Ariel image of existing channel

To examine the channel's changes in slope, 6-points upstream and 10-points downstream were collected at the thalweg to create a profile of the existing channel. With the channel's cross sections being uniform, 3 cross-sections at 30-foot intervals were documented downstream and will be used to evaluate the existing flow of the stream. For these stations and cross sections, see Figure 3-7, which correspond with Figure 3-8. Note that no cross sections were documented upstream due to it being evenly flat. To enhance the quality of the necessary data of the cross sections, 7-points were surveyed to characterize the change of the cross section: these points are the left floodplain, left of top bank, left of bottom bank, the thalweg, right of bottom bank, right of top bank, and right floodplain. These point elevations were determined using surveying equipment and using one known elevation point of a manhole that was located near the east intersection. Cross sections of the downstream channel can be found in Appendix F. This channel can be identified as an existing hydraulic structure due to conveyance expectancy, while the culvert that underlays Lake Mary Rd. was not evaluated.

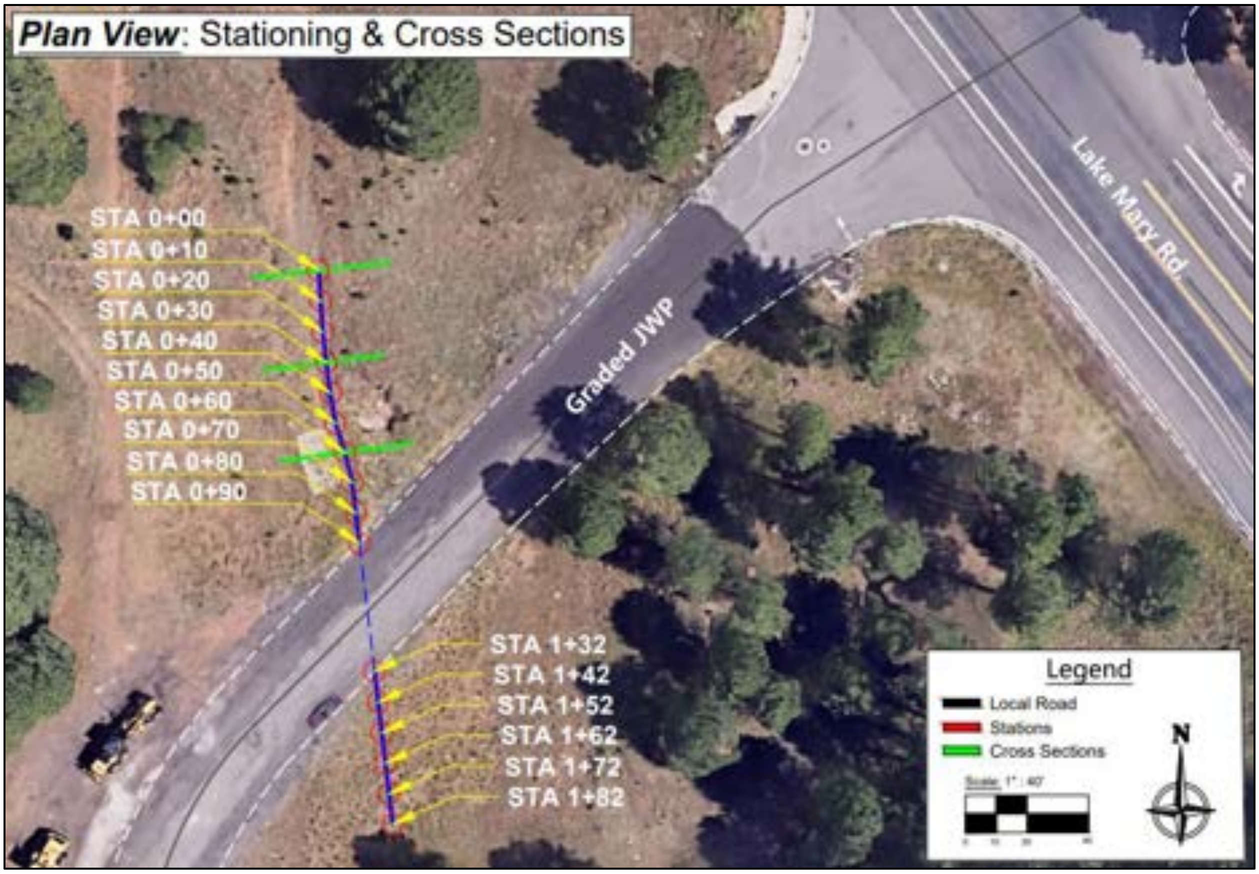

Figure 3-7: Plan view of stations and cross-sections

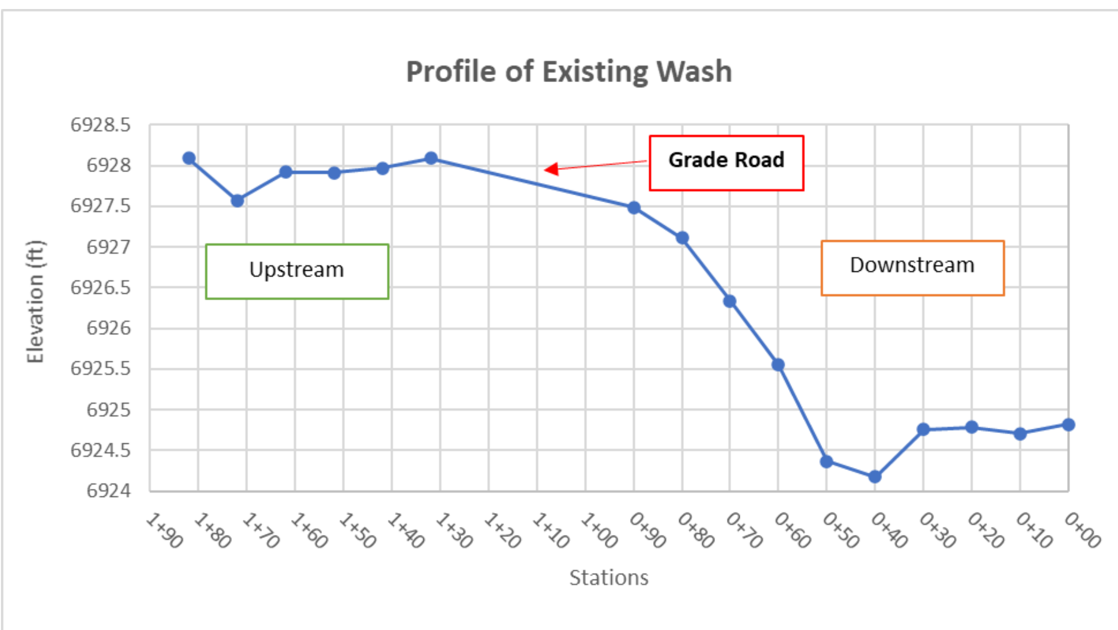

Figure 3-8: Channel profile

3.6 Topographic Map

A topographic map was acquired through the City of Flagstaff with 2-foot contour lines. This map was analyzed and turned into a surface using Autodesk Civil 3D 2024, in order to delineate the watershed and better understand both the flow of water and the current topography of the roadway. Figure 3-9 is the topographic map of the project. The road (seen in yellow) will be set in between the airport's boundary, and the VHF-DME. Other existing features are the surrounding residential areas and roads. To properly design the channel/culvert and the geometry of the roadway, it is important to note that water flows to the east due to the difference in the intersection's elevations. More information about existing culverts and stormwater drainages throughout the project can be found in Appendix G.

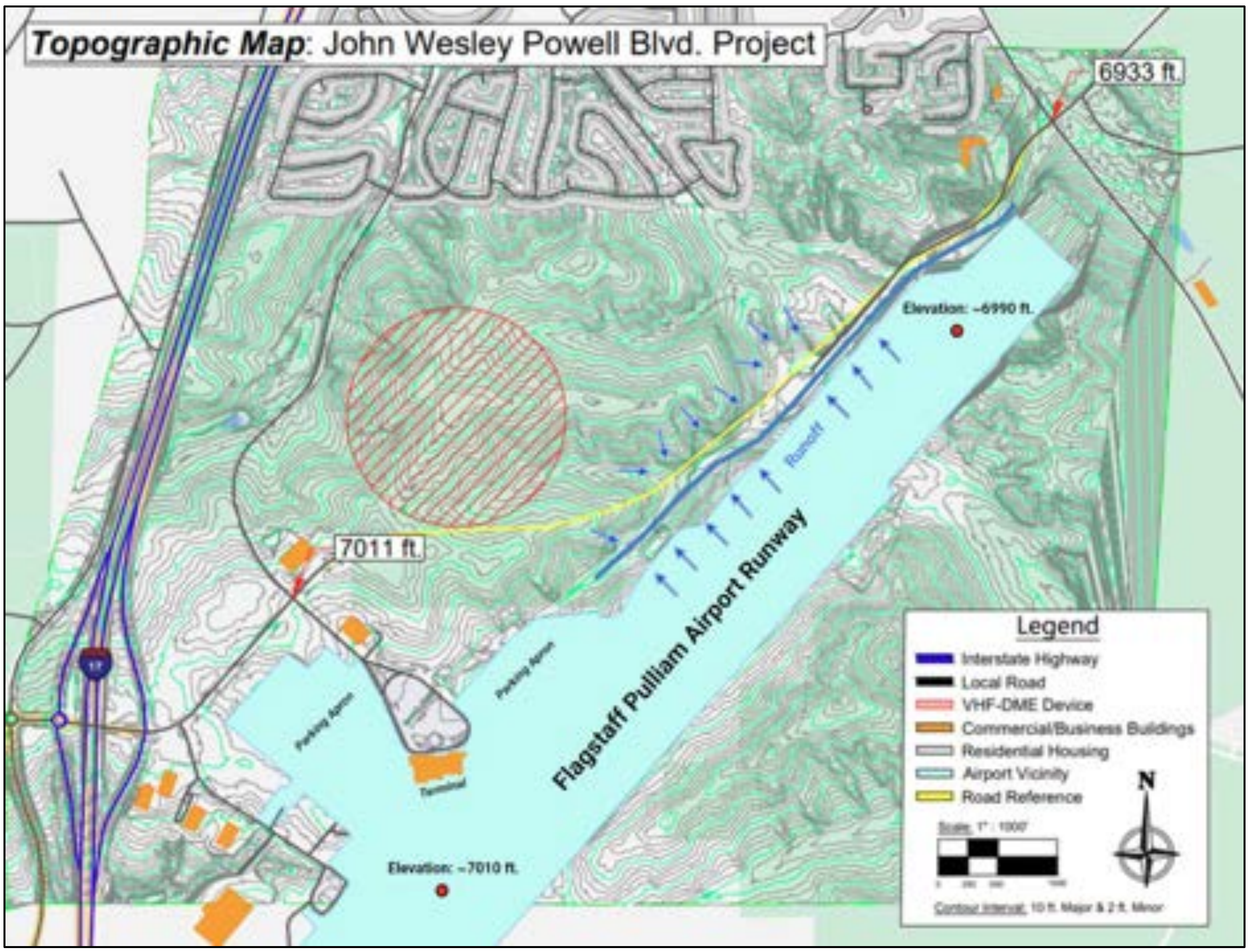

Figure 3-9: Topographic map

4.0 Hydrologic Analysis

A hydrological analysis included delineating the sub basin, determining the longest concentration path within the sub basin, and calculating the peak discharge for the project location. Using the watershed and knowing the soil conditions for each affected area allowed the use of the USDA TR-55 method to determine the peak storm water flow. The method is only applicable to drainage areas less than 2,000-acres with a time of concentration less than or equal to two hours; this project site has a drainage area of 155 acres (about twice the area of a large shopping mall). Using the graphical peak method is limited to a single watershed area, which the current project's watershed meets. Ultimately, the peak discharge was used as a parameter for designing a culvert on the upstream side of the existing channel under the proposed road.

4.1 Watershed Delineation

The watershed in the project site was delineated using USGS StreamStats (version 4) where it uses a Digital Elevation Map (DEM) to determine its drainage-basin boundaries. Choosing a junction on the site's east side served as the outlet for the watershed to be delineated (Figure 4-1). Using the Civil 3D software with the constructed surface map also gave more information pertaining to slope and elevations between different points along the channel. Refer to Appendix H for the full StreamStats report showing the boundaries and expected flow paths within the project site.

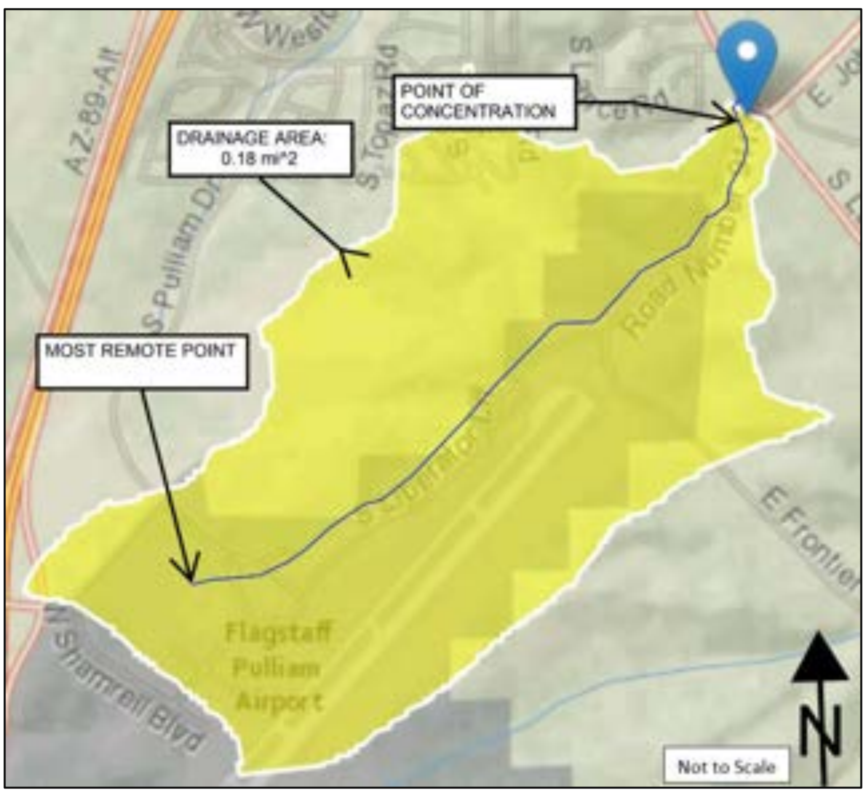

Figure 4-1: Drainage basin perimeters

4.2 Runoff Estimation

The soil was categorized into two different groups, B and D. A "Soil B" classification represents silt loam or loam. "Soil D" is classified as clay loam, silty clay loam, sandy clay, silty clay, or clay [4]. A runoff curve number was then selected from Table 2-2a of the USDA TR-55 manual [5]. This value was then used to find the potential maximum retention after runoff begins within the bounded area, see Equation 4-1. The precipitation data for the site was found using National Oceanic and Atmospheric Administration (NOAA) Atlas 14 for a 24-hour 50-year storm [6]; the 50-year storm is used because the road is classified as a collector/arterial street per Storm Water Management Design Manual (SWMDM). The runoff in units of length can now be calculated in Equation 4-2.

Equation 4-1: Potential maximum retention [5]

$$S = \frac{1000}{CN} - 10$$

Where,
S: Potential maximum retention after runoff begins (in)
CN: Curve number

Equation 4-2: Runoff in units of length [5]

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

Where,
Q: Runoff (in)
P: Rainfall (in)
S: Potential maximum retention after runoff begins (in)

4.3 Time of Concentration

The USDA TR-55 assumes open and unconfined flow over land and in channels. This method covers sheet flow, shallow concentrated flow, and channel flow to ultimately calculate the time of concentration, which represents the time it takes for runoff to travel from the farthest point in a watershed to a specific location of interest. Equation 4-3 calculated the travel time of sheet flow over a relatively flat surface (upstream from the existing channel). Equation 4-4 calculated shallow concentrated flow over small channels of water just downstream from overland flow (along the North side of Pulliam airport's runway). Equation 4-5,4-6,4-7 calculated channel flow where the collected hydraulic data was used to find the velocity and area of the channel's cross section (downstream near the Eastern intersection). The total time of concentration can now be calculated in Equation 4-8. The time of concentration was found to be 1.96-hours.

Equation 4-3: Sheet flow [5]

$$T_t = \frac{0.007(nL)^{0.8}}{{P_2}^{0.5} s^{0.4}}$$

Where,
T_t: Travel time (hr)
n: Manning's roughness coefficient
L: Flow length (ft)
P_2: Two-year frequency, 24-hour rainfall (in)
s: Slope of hydraulic grade line (ft/ft)

Equation 4-4: Shallow concentrated flow [5]

$$T_t = \frac{L}{3600\, V}$$

Where,
T_t: Travel time (hr)
L: Flow length (ft)
V: Average velocity (ft/s) from Figure 3-1 [5]

Equation 4-5: Hydraulic radius [5]

$$r = \frac{a}{P_w}$$

Where,
r: Hydraulic radius (ft)
a: Cross sectional flow area (ft^2)
P_w: Wetted perimeter (ft)

Equation 4-6: Manning's equation [5]

$$V = \frac{1.49 r^{2/3} s^{1/2}}{n}$$

Where,
r: Hydraulic radius (ft)
s: Slope of hydraulic grade line (ft/ft)
n: Manning's roughness coefficient from Table 3-1 [5]

Equation 4-7: Channel flow [5]

$$T_t = \frac{L}{3600\, V}$$

Where,
T_t: Travel time (hr)
L: Flow length (ft)
V: Average velocity (ft/s)

Equation 4-8: Time of concentration [5]

$$T_c = T_t + T_t + T_t$$

Where,
T_c: Time of concentration (hr)
T_t: Sheet flow travel time (hr)
T_t: Shallow concentrated flow travel time (hr)
T_t: Channel flow travel time (hr)

4.4 Storm Intensity

The USDA TR-55 method uses a 24-hour storm duration to determine the rainfall depth along with the time of concentration calculated above to estimate the peak discharge rate. NOAA Atlas 14 was used to find the 24-hour rainfall for the 50-year storm event. This value was found to be 4.12 inches of rainfall in a 24-hour period for a 50-year storm (Figure 4-2).

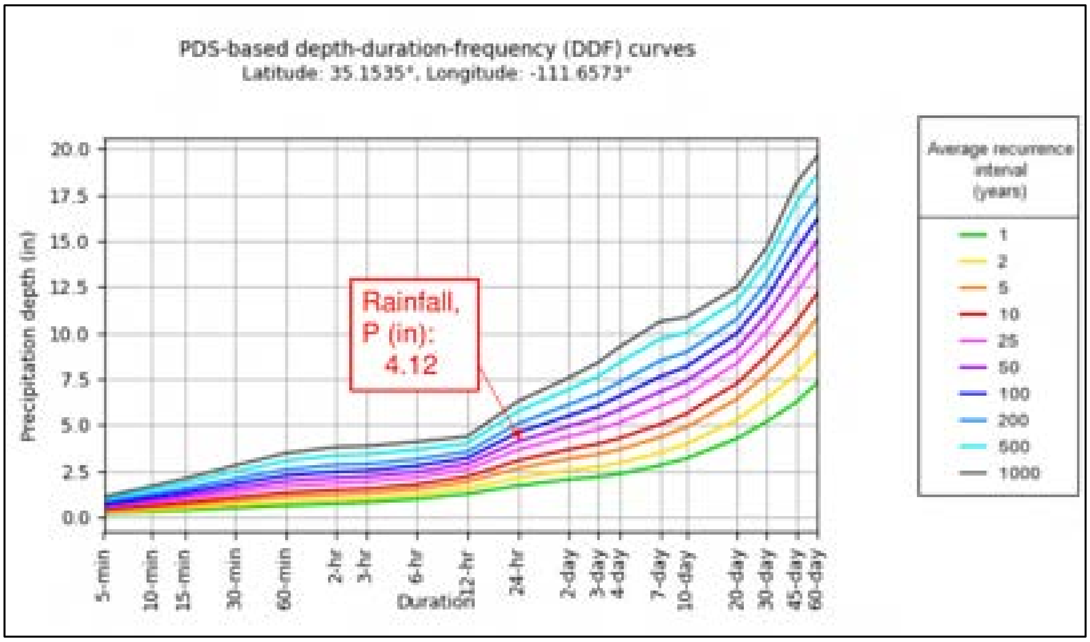

Figure 4-2: Rainfall intensity diagram [6]

4.5 Peak Flow

To calculate the peak discharge of the site (Equation 4-9), drainage area, runoff curve number, time of concentration, rainfall distribution, and unit peak discharge were used. Refer to Appendix I for the complete breakdown of the TR-55 procedure that was used to calculate a peak flow of 103 ft^3/s for the 50-year storm event. The peak flow is used to design a culvert under the new roadway.

Equation 4-9: Peak discharge [5]

$$q_p = q_u A_m Q F_p$$

Where,
q_p: Peak discharge (ft^3/s)
q_u: Unit peak discharge (csm/in) from Exhibit 4-11 [5]
A_m: Drainage area (mi^2)
Q: Runoff (in)
F_p: Pond and swamp adjustment factor

5.0 Hydraulic Analysis

A hydraulic analysis included evaluating existing channel conditions and proposed improvements to optimize hydraulic performance near the east intersection of the project. Looking at flow rates, velocities, water surface elevations, and compliance with the chosen design criteria, allowed the design of a culvert and channel that meets the project's objectives while ensuring hydraulic stability and functionality from a 50-year storm event. See Tables 5-1 & 5-2 for the following CoF SWMDM policies which guided the existing conditions and proposed improvements to the design [7].

Table 5-1: CoF SWMDM channel design guidelines

Channel Requirements		**Section of SWMDM**
Flow Rate	Shall be designed for the 25-year design storm at a minimum	4.3
Water Surface Elevation	Shall be consistent with maintaining a minimum freeboard of 1-foot throughout the channel	4.3.4
Velocity	Maximum velocity of 18 ft/s	4.3.3
Freeboard	Minimum freeboard of 1-foot	4.3.4
Flow Regime	Earth lined channels should *not* be operating at supercritical flow	4.3.3

Table 5-2: CoF SWMDM culvert design guidelines

Culvert Requirements		**Section of SWMDM**
Flow Rate	Culverts near a collector/arterial street should convey a 50-year storm event without overtopping (103 cfs)	5.2.1
Water Surface Elevation	Minimum freeboard of 2-feet at inlet with respect to the low chord	5.4.2.2
Velocity	Minimum velocity of 3 ft/s	5.2
Headwater	HW/D ratio must be ≤ 1.2 for cross sectional area greater than 30 sq. ft.	5.2.3.1
Freeboard	Minimum freeboard of 1-foot	4.3.4
Flow Regime	Avoid Froude number in the range of 0.86-1.13	4.3.3

5.1 Existing Channel Analysis

The U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center – River Analysis System (HEC–RAS) Version 6.3.1 was used as an iterative software that analyzed the existing channel reach. To accurately utilize HEC-RAS, channel and culvert characteristics were required. All existing data was input from the field survey to create a base 1-D model within the software (Figure 5-1). Note that the stations and cross sections that were used in HEC-RAS are different from the stations that were used previously in this report due to the software's specifics. See Appendix J for software outputs regarding the existing conditions of the channel (i.e. profile, cross-sections, and the standard table).

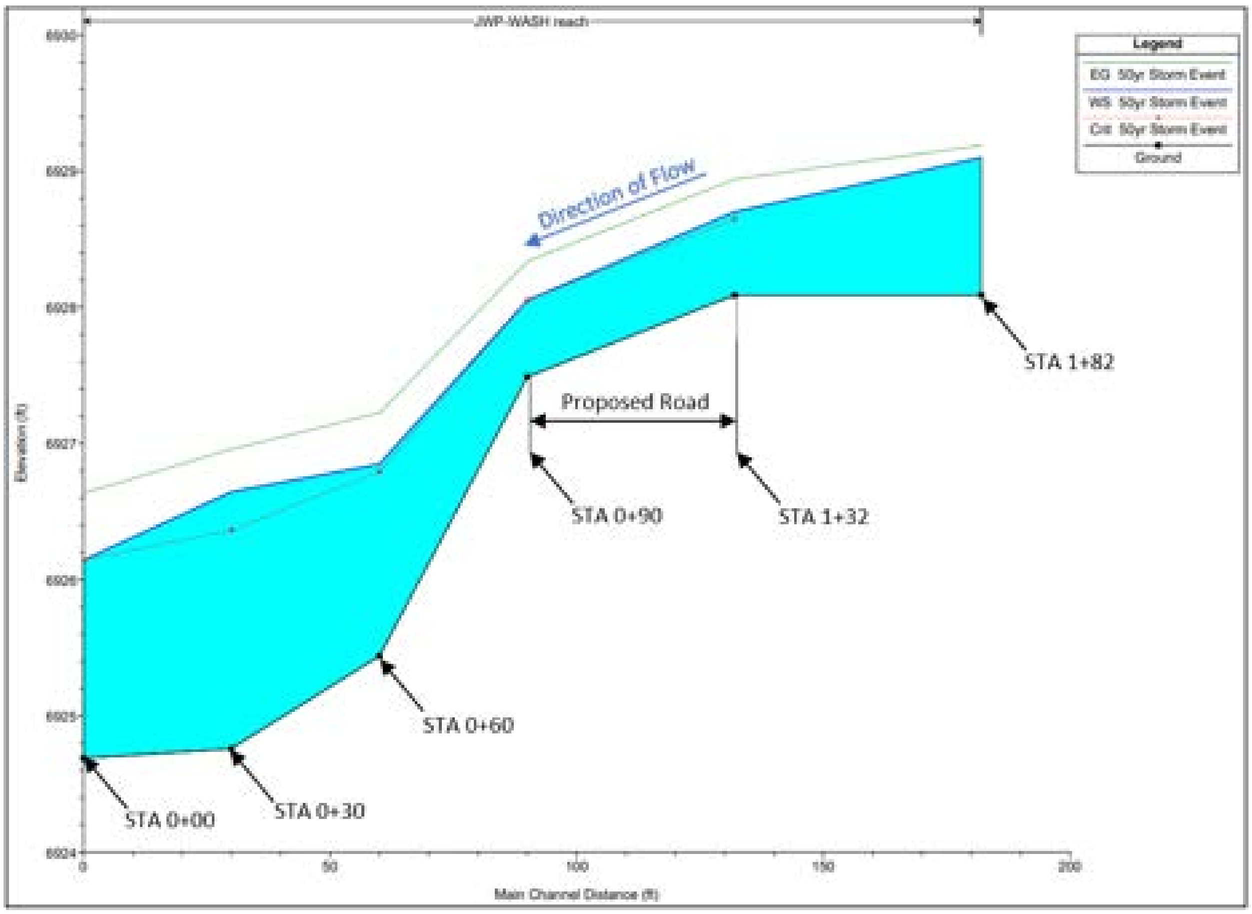

Figure 5-1: Profile view of 1-D HEC-RAS model of existing channel's condition

The assessment of the existing channel conditions included an examination of cross-sectional data, flow characteristics, and in compliance with the CoF SWMDM. Understanding the current state of the channel allowed the identification of areas that needed improvement such as providing a culvert to convey the water under the road instead of overflowing onto the roadway, this is seen depicted between STA 0+90 and STA 1+32 in Figure 5-1. Table 5-3 shows the existing conditions of the channel; these summaries are compared to CoF stormwater design compliance requirements and are listed as "Yes" or "No" [7].

Table 5-3: Evaluation of existing cross-sections using HEC-RAS

Existing Conditions of Cross-Sections HEC-RAS		
Variables	**Existing Conditions**	**Compliance**
STA 1+82	**50 years**	**50 years**
Flow rate (cfs)	103	Yes
Velocity (ft/s)	2.5	Yes
Water surface elevation (ft)	6929.1	N/A
Freeboard (ft)	0.0	No
Flow Regime	Subcritical	Yes
STA 1+32	**50 years**	**50 years**
Flow rate (cfs)	103	Yes
Velocity (ft/s)	4.0	Yes
Water surface elevation (ft)	6928.7	N/A
Freeboard (ft)	0.0	No
Flow Regime	Subcritical	Yes
STA 0+90	**50 years**	**50 years**
Flow rate (cfs)	103	Yes
Velocity (ft/s)	4.3	Yes
Water surface elevation (ft)	6927.5	N/A
Freeboard (ft)	0.0	No
Flow Regime	Supercritical	No
STA 0+60	**50 years**	**50 years**
Flow rate (cfs)	103	Yes
Velocity (ft/s)	4.9	Yes
Water surface elevation (ft)	6926.8	N/A
Freeboard (ft)	0.0	No
Flow Regime	Subcritical	Yes
STA 0+30	**50 years**	**50 years**
Flow rate (cfs)	103	Yes
Velocity (ft/s)	4.5	Yes
Water surface elevation (ft)	6926.6	N/A
Freeboard (ft)	0.0	No
Flow Regime	Subcritical	Yes
STA 0+00	**50 years**	**50 years**
Flow rate (cfs)	103	Yes
Velocity (ft/s)	5.6	Yes
Water surface elevation (ft)	6926.1	N/A
Freeboard (ft)	0.2	No
Flow Regime	Supercritical	No

5.2 Post-Improvement Hydraulic Analysis

In order to prevent water on the south side of the new road from flowing across the roadway, a new culvert is needed under the new road. After the completion of the HEC-RAS base model, a general culvert was incorporated under the proposed road where the upstream side was excavated to maintain a slope of 0.005 ft/ft to match the already existing channel on the downstream side. The downstream channel was only maintained through cleaning the channel's bottom and freshly excavating the entirety to make it earthy soil. Figure 5-2 shows the profile of the proposed channel and culvert. See Appendix K for software outputs regarding the proposed improvements of the channel (profile, cross-sections, and the standard tables for the channel &

culvert). An excavated ditch on the North and South sides of the proposed road will allow flow to be emptied into the existing channel on both the upstream and downstream sides. Figure 5-3 depicts a plan view of the road, including the proposed culvert underneath it, with stationing's along the channel that were inputted in HEC-RAS.

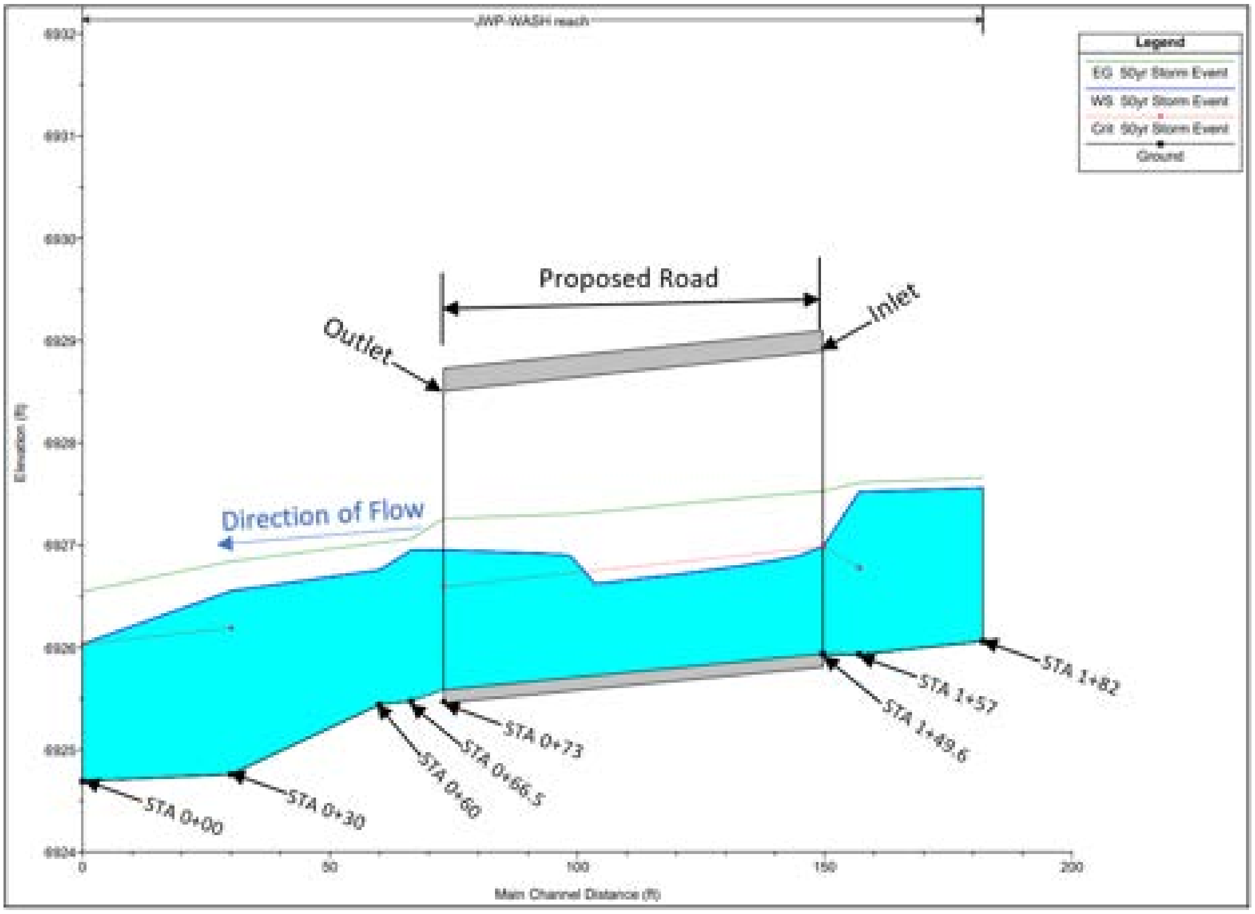

Figure 5-2: Profile view of 1-D HEC-RAS model of proposed hydraulic structure

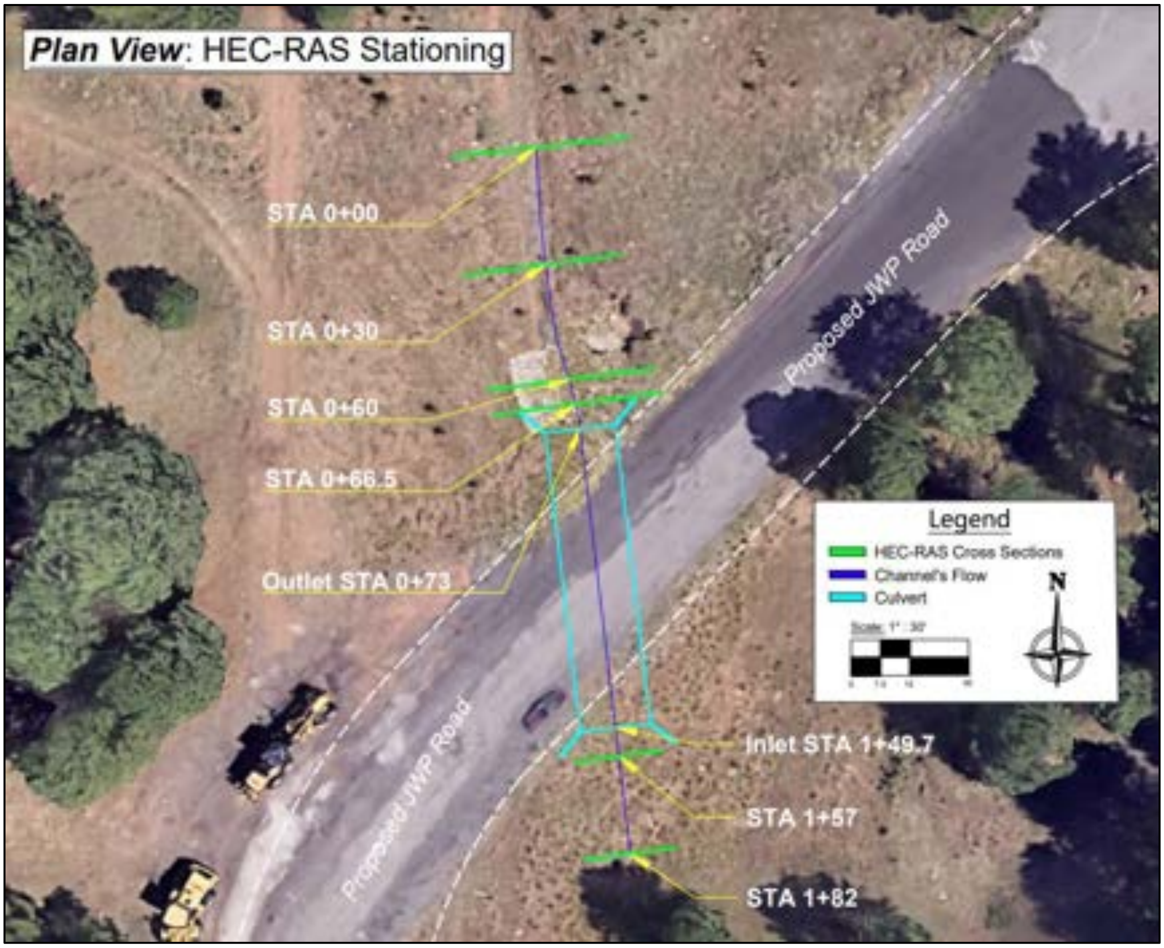

Figure 5-3: Plan view of HEC-RAS stationing

The assessment of the proposed channel conditions included an examination of cross-sectional data, flow characteristics, and compliance with the SWMDM. Table 5-4 shows the proposed improvements of the channel; these summaries are compared to CoF stormwater design compliance requirements and are listed as “Yes” or “No” [7]. The yellow cells in the table shows improvements when having a culvert in the channel’s system. Although freeboard didn’t meet the requirements, there’s still improvements within that area. If the existing channel’s thalweg elevation were to be lower and if the top of the banks were higher, a better improvement would be shown.

Table 5-4: Evaluation of improved cross-sections using HEC-RAS

Existing Conditions vs. Proposed Improvements of Cross-Sections HEC-RAS				
Variables	**Existing Conditions**	**Compliance**	**Proposed Improvements**	**Compliance**
STA	**1+82**		**1+82**	
Flow rate (cfs)	103	Yes	103	Yes
Velocity (ft/s)	2.5	Yes	2.5	Yes
Water surface elevation (ft)	6929.1	N/A	6927.6	N/A
Freeboard (ft)	0.0	No	0.3	No
Flow Regime	Subcritical	Yes	Subcritical	Yes
STA	***1+32***		**1+57**	
Flow rate (cfs)	103	Yes	103	Yes
Velocity (ft/s)	4.0	Yes	2.4	Yes
Water surface elevation (ft)	6928.7	N/A	6927.5	N/A
Freeboard (ft)	0.0	No	0.4	No
Flow Regime	Subcritical	Yes	Subcritical	Yes
STA	**0+90**		**0+66.5**	
Flow rate (cfs)	103	Yes	103	Yes
Velocity (ft/s)	4.3	Yes	2.67	Yes
Water surface elevation (ft)	6927.5	N/A	6927.0	N/A
Freeboard (ft)	0.0	No	0.7	No
Flow Regime	Supercritical	No	Subcritical	Yes
STA	**0+60**		**0+60**	
Flow rate (cfs)	103	Yes	103	Yes
Velocity (ft/s)	4.9	Yes	4.13	Yes
Water surface elevation (ft)	6926.8	N/A	6926.8	N/A
Freeboard (ft)	0.0	No	0.0	No
Flow Regime	Subcritical	Yes	Subcritical	Yes
STA	**0+30**		**0+30**	
Flow rate (cfs)	103	Yes	103	Yes
Velocity (ft/s)	4.5	Yes	4.3	Yes
Water surface elevation (ft)	6926.6	N/A	6926.6	N/A
Freeboard (ft)	0.0	No	0.0	No
Flow Regime	Subcritical	Yes	Subcritical	Yes
STA	**0+00**		**0+00**	
Flow rate (cfs)	103	Yes	103	Yes
Velocity (ft/s)	5.6	Yes	5.8	Yes
Water surface elevation (ft)	6926.1	N/A	6926.0	N/A
Freeboard (ft)	0.2	No	0.3	No
Flow Regime	Supercritical	No	Critical	Yes

The hydraulic structure was designed as a concrete twin-cell box culvert with dimensions of each cell being 8-feet wide by 3-feet high (refer to section 5.3.3 for culvert section) with an invert elevation of 6925.9-feet. The assessment of the proposed culvert design is shown in Table 5-5 with the included and relevant CoF stormwater design compliance requirements for culverts. As seen, all requirements are met with the proposed culvert; the outlet has the water surface elevation and headwater ratio set as “N/A” because there is no specific guidance.

Table 5-5: Evaluation of proposed culvert in HEC-RAS

	Culvert Conditions HEC-RAS				
	Culvert 8x3 (2)	Inlet	Compliance	Outlet	Compliance
	Variables	**50 years**		**50 years**	
Results & Compliance	Flow rate (cfs)	103	Yes	103	Yes
	Velocity (ft/s)	5.9	Yes	4.5	Yes
	Water surface elevation (ft)	6927.5	Yes	6927.0	N/A
	HW/D ≤ 1.2	0.47	Yes	N/A	N/A
	Freeboard (ft)	1.4	Yes	1.6	Yes
	Flow Regime	Supercritical	Yes	Supercritical	Yes

5.3 Proposed Culvert and Channel Design

The proposed culvert and channel design aimed to optimize hydraulic performance, ensure structural integrity, and meet regulatory requirements.

5.3.1 Determine Criteria

An established criteria that guided the selection and evaluation of design alternatives were considered:

- Cost: The design must be cost-effective, considering both initial costs and long-term maintenance expenses. Cost-effective solutions will be prioritized for the project's budget utilization.
- Efficiency: The design should maximize hydraulic efficiency through taking the average amount of freeboard on the immediate upstream and downstream cross-section. This helps ensure optimal flow rates and velocities to minimize energy losses and maximize conveyance capacity.
- Constructability: The design must be practical and easy to construct within the project constraints, considering factors such as available resources, equipment, and construction techniques. This is essential to ensure timely and cost-effective project implementation.
- Aesthetics: The design should enhance the visual appeal of the project area, integrating with the surrounding environment and meeting aesthetic preferences of stakeholders. This will contribute to the overall quality and perception of the project with a lower priority.

The assigned weights for each criterion were considered to align with project priorities. Cost, accounting for 35%, reflects the need for a budget-friendly solution that balances initial expenses and long-term maintenance costs. Efficiency, weighted at 35%, emphasizes hydraulic performance by optimizing freeboard and flowrates. Constructability, with a 20% weight, ensures practicality and timely execution within project constraints. Lastly, Aesthetics, at 10%, acknowledges the importance of visual integration while maintaining a lower priority in the overall evaluation.

5.3.2 Develop Alternatives

Design alternatives were developed based on different culvert configurations, materials, and dimensions. These alternatives were evaluated against the established criteria to determine their suitability and effectiveness. The following alternatives were considered: concrete box culvert, corrugated metal pipe, concrete arch-entrance, and concrete ellipse culvert.

The following options were analyzed: Concrete Box, noted for its hydraulic efficiency, ease of installation, and clean aesthetic look, yet it's challenged by initial cost; Corrugated Metal Pipe, praised for its cost-effectiveness and moderate flow suitability but faced concerns regarding durability and visual appeal; Concrete Arch, admired for its visually appealing arch design and hydraulic efficiency but hindered by higher construction costs and complexity of installation; and Concrete Ellipse, recognized for its hydraulic efficiency and harmonizing elongated shape with the natural surroundings, yet constrained by higher costs and installation complications. Each design presents distinct advantages and limitations, which required consideration in the culvert design and selection process.

5.3.3 Analyze Alternatives and Select Best

Each design alternative was analyzed against the established criteria to identify the most suitable option. This analysis involved hydraulic modeling, cost estimation, constructability assessment, and consideration of aesthetic preferences. See Table 5-6 for the decision matrix which was each scored on a scale of 1-3; "1" is worst, "2" is neutral, and "3" is good; for more information on the scale, see Table 5-7 for the descriptions of each criterion.

Table 5-6: Decision matrix for culvert shape

Decision Matrix										
Culvert Entrance Design:		Concrete Box		Corrugated Metal Pipe		Concete Arch		Ellipse	
		 ~ $6,600 per section - x10 (Total: $66,370)		 ~ $860 per 2' dia. pipe-x16 (Total: $13,800)		 ~ $370 per foot 3' dia. (Total: $79,000)		 ~ $1,010 per foot -3' dia. (Total: $76,800)	
Criteria	Weight (%)	Avg Score (1-3)	Weighted Score	Avg Score (1-3)	Weighted Score	Avg Score (1-3)	Weighted Score	Avg Score (1-3)	Weighted Score
Cost	35	2	0.70	3	0.89	1	0.35	1	0.35
Efficiency	35	3	0.95	1	0.35	2	0.79	1	0.47
Constructability	20	2	0.40	3	0.60	1	0.27	1	0.21
Aesthetics	10	2	0.24	1	0.10	3	0.30	2	0.20
Weighted Score	100		2.29		1.94		1.71		1.23

Table 5-7: Culvert scoring description

Scoring Description for Culvert			
Criteria	1 (Worst)	2 (Neutral)	3 (Good)
Cost	Structure is very costly & not economical (>$70,000)	Is costly nor economical	Structure is economical, very sufficient (<$30,000)
Efficiency	Does not meet conveyance & allowable freeboard	Able to either convey or have resonable freeboard	Able to channel design flow & has adequate amount of freeboard
Constructability	Challenging installation, requires additional labor & equipment	Structure requires adequate construction	Less labor & equipment
Aesthetics	Not eye-appealing; does not fit into surrounding background	Has normal appeal	Structure appears to fit into terrain

As seen in the decision matrix above, the concrete box culvert was chosen as the preferred option due to its favorable performance in terms of hydraulic efficiency, cost-effectiveness, ease of construction, and aesthetic appeal.

The typical characteristics of the culvert are shown in Table 5-8, where the material, length, span & height, inlet invert elevation, outlet invert elevation, slope, wingwalls, and the headwalls are described.

Table 5-8: Proposed culvert characteristics & dimensions

Culvert Characteristics	
Material	Concrete (ASTM C850)
Run Length (ft)	76.67 (10 sections at 7'8")
Span & Height (ft)	8x3 (2 entrances)
Inlet Invert Elevation (ft)	6925.9
Outlet Invert Elevation (ft)	6925.5
Slope (ft/ft)	0.005
Wingwalls	Flared 30-75 degrees
Headwalls	Square edge at crown
Soil Cover Inlet (ft)	1.16
Soil Cover Outlet (ft)	1.44

As stated, the primary focus of designing a culvert with its surrounding channel is to improve conveyance, providing a path for existing sheet flow to be channelized below a roadway to prevent infrastructure damage. Doing so will require a reduction in the water surface elevation at the existing cross-sections (downstream), as well as excavating a new channel on the upstream side. The ditch following the north side of the proposed road will feed into the channel's reach. Maintaining the channel's bottom and side banks will improve the flow path and promote positive freeboard through the channel's reach. Although the freeboard did not meet the minimum of 1-foot, improvements were made in all other areas. To increase freeboard, a larger cross-sectional area through the reach and a reduction in the channel's roughness such as having a complete concrete lining would improve efficiency. Note that only a few cross-sections were designed on the upstream side, so a complete channel design is outside the scope of work.

The side slopes of the earthy soil walls met the minimum requirement of 3V:1H per SWMDM 4.3.2 [7]. These slopes were completed by conducting a cut & fill analysis at each cross-section. The channel is reshaped to accommodate the culvert resulting in excess soil to be removed, see Appendix L for the cut & fill analysis. At the outlet of the culvert, there is a placement of 9-inch stones as riprap to combat the fast-moving outlet velocity. The riprap extends downstream for a length of 9-feet while the width of the riprap follows the contours of the defined trapezoidal channel (Appendix M). The riprap serves as a protective measure, preventing erosion and maintaining stability in the vicinity of the culvert outlet per the Drainage Design Manual for Yavapai County (DDM) [8].

See Figures 5-4 & 5-5 for a visual representation of the culvert's inlet, outlet, and wingwall configurations. Additionally, Figure 5-6 provides a plan view of the culvert integrated into the system, with the proposed road overlaid on top. This view will help illustrate the spatial relationship between the culvert and the roadway alignment. See Appendix N sheets 10, 11, & 12 for detailed construction plans regarding the hydraulic design.

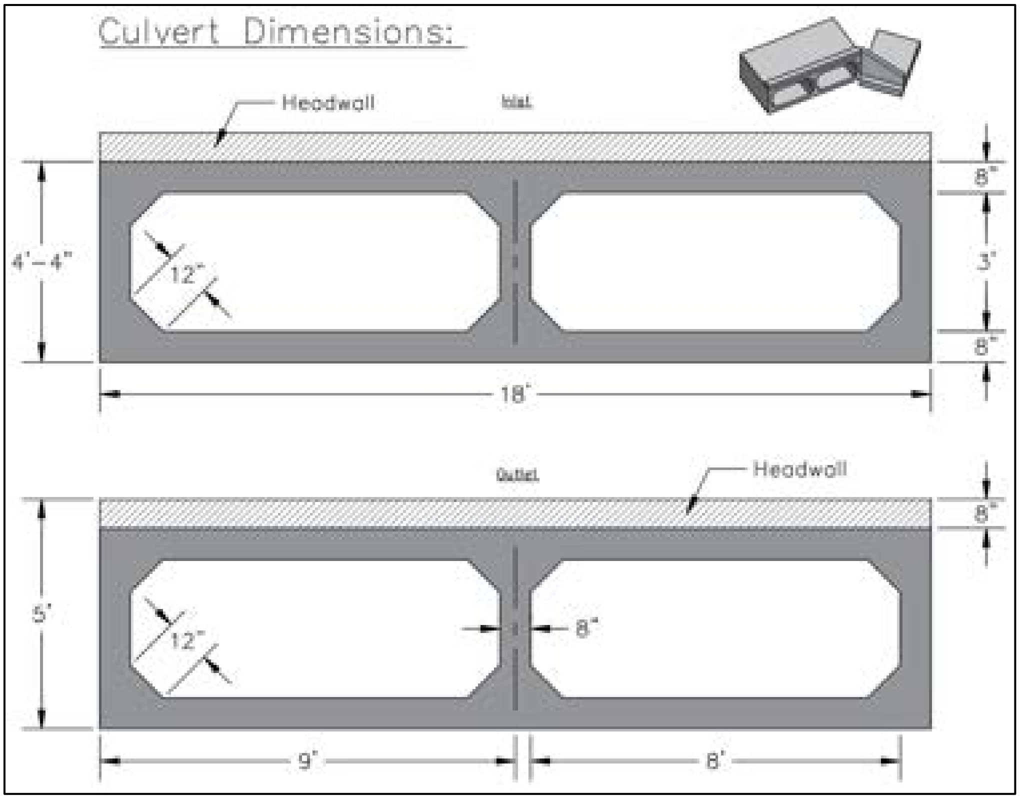

Figure 5-4: Proposed cross-section of the precast twin-cell culvert

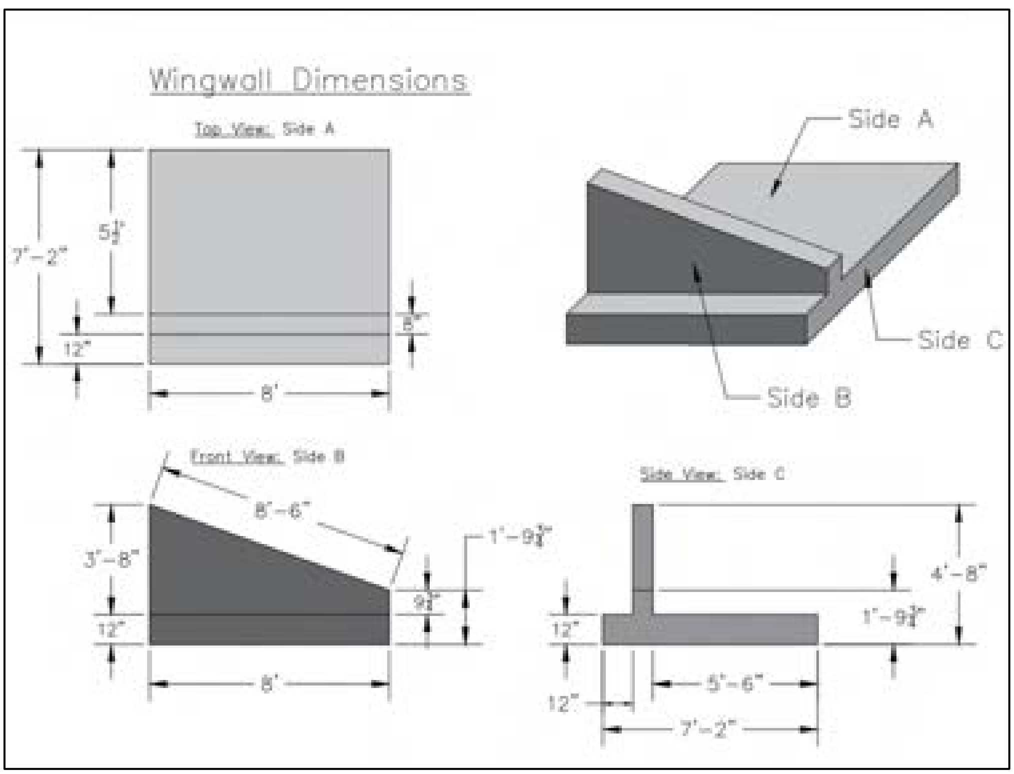

Figure 5-5: Flared wingwall configuration

Figure 5-6: Plan view of final hydraulic structure design

6.0 Roadway Design

The roadway design includes an extensive analysis and design process encompassing all aspects of the roadway. Roadway geometry was analyzed to determine the number of lanes, width, radius for curves, horizontal and vertical alignments, etc. Two intersections were also analyzed and designed to best serve the users in the most efficient and inexpensive way. Pavement design is necessary so the road can be properly maintained and serve the users for a long time. An effective sidewalk design was implemented so pedestrians feel safe and comfortable when traversing alongside the road. Finally, roadway signage and striping are required to help guide the users and maximize their safety.

6.1 Roadway Geometry

The roadway geometry consists of multiple different aspects, each contributing to the roadway design. Due to the surrounding terrain, there was only one feasible path for the designated roadway, which runs adjacent to Flagstaff Pulliam Airport. This path can be seen in Figure 6-1. The design speed stays consistent with the adjoining roads at 40-miles per hour.

Figure 6-1: Map of proposed alignment

The number of lanes was determined by calculating the level of service (LOS) of the roadway. Using the projected 2045 traffic volume provided by the city of flagstaff, the level of service for a two-lane road will operate at a LOS B. According to the ADOT Roadway Design Guidelines, this road should be operating at or above a LOS B, therefore the design requirement is met [2].

The lane and shoulder width were determined based on the design vehicle and the ADOT Roadway Design Guidelines. The width of each lane was determined to be 12-feet in both directions. The cross slope on each side of the roadway is 2%, meeting at the middle so the water can run off to the shoulder. The shoulder on each side is designed as 5.5-feet wide with the north side having a curb and gutter of 1.5-feet wide. The shoulder will have a slope of 4% to increase runoff and prevent water from backing up onto the road. Each shoulder will also serve as a bike lane. Drawing sheets showing the typical road section can be found in Appendix N sheet 3.

A 6-foot sidewalk was designed on the northern side of the road to help serve pedestrians. Only the northern side was designed with a sidewalk due to the nearby neighborhood. There are no attractions on the southern side that are accessible to the public, therefore pedestrian travel is not expected. Additionally, by leaving the southern side with just a shoulder, future development, such as adding lanes, can be more easily achieved.

Additionally, there will be trench drains along the sidewalk to allow for water to pass under the sidewalk and into a channelized ditch on the other side. The water flow on the southern side will run off the shoulder and into the existing ditch that is parallel to Flagstaff Pulliam Airport. Figure 6-2 shows a typical roadway plan view that will reflect what the roadway geometry looks like.

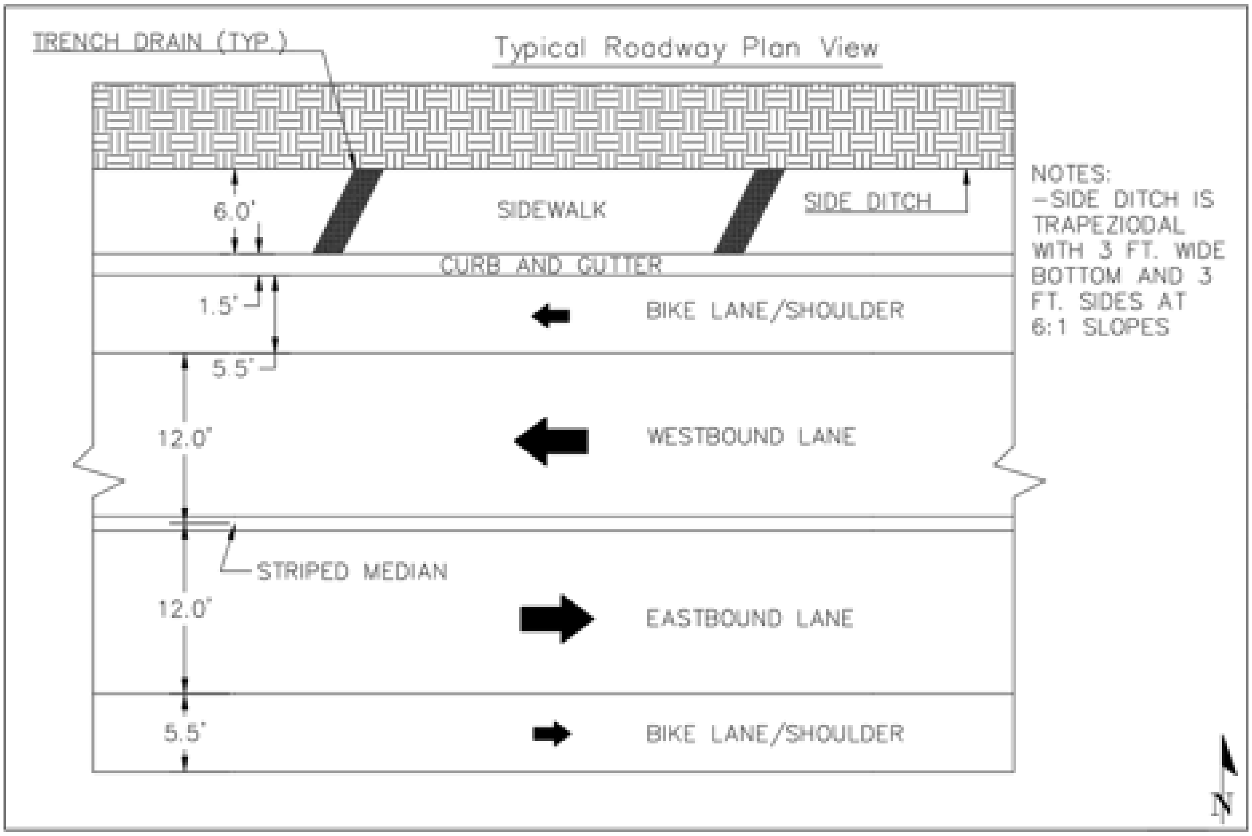

Figure 6-2: Typical roadway plan view

The horizontal alignment was designed according to the American Association of Highway and Transportation Officials (AASHTO) guidelines [9]. Equation 6-1 shows the formula for calculating the minimum radius for a horizontal curve.

Equation 6-1: Minimum radius for horizontal curve [9]

$$R = \frac{V^2}{15(f_s + \frac{e}{100})}$$

Where,
V: Design Speed (mph)
f_s: Side Friction Design Coefficient
e: Maximum Rate of Superelevation

The minimum radius for horizontal curves on the designated roadway was calculated to be 410-feet. Superelevation requirements are also required to counteract the centripetal forces on the vehicle. For a minor arterial, the maximum rate of superelevation shall be 0.04. All of these requirements were met in the roadway design. Each horizontal alignment was designed with a 410-foot radius of curvature. One of the horizontal alignments on the roadway can be seen in Figure 6-3 below.

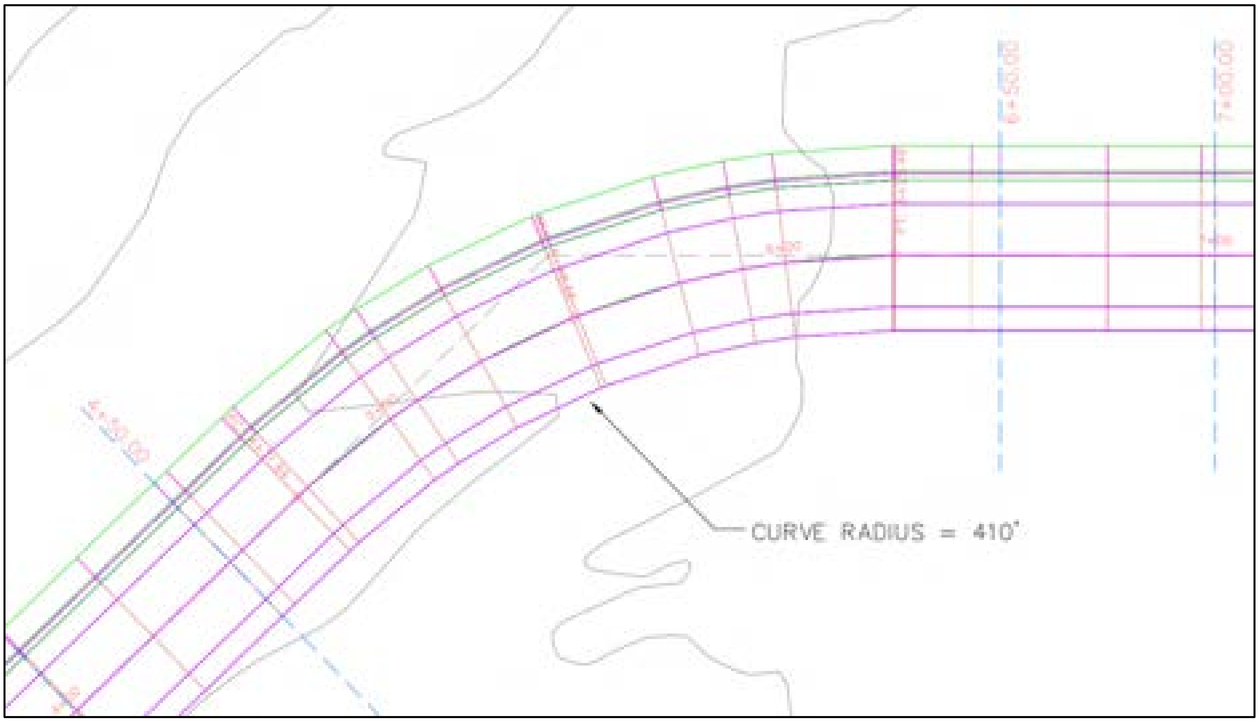

Figure 6-3: Horizontal Alignment

The vertical alignment of the roadway was designed according to the Coconino County Design Guidelines. Considering the design vehicle and the road classification, a maximum grade of 6% is to be used in the vertical direction. A minimum grade of 0.5% is also necessary to help contribute to rainfall runoff. In the design, the vertical grades range from 0.66-1.17%, meeting the design requirements. The vertical profile showing alignment information can be seen in Figure 6-4.

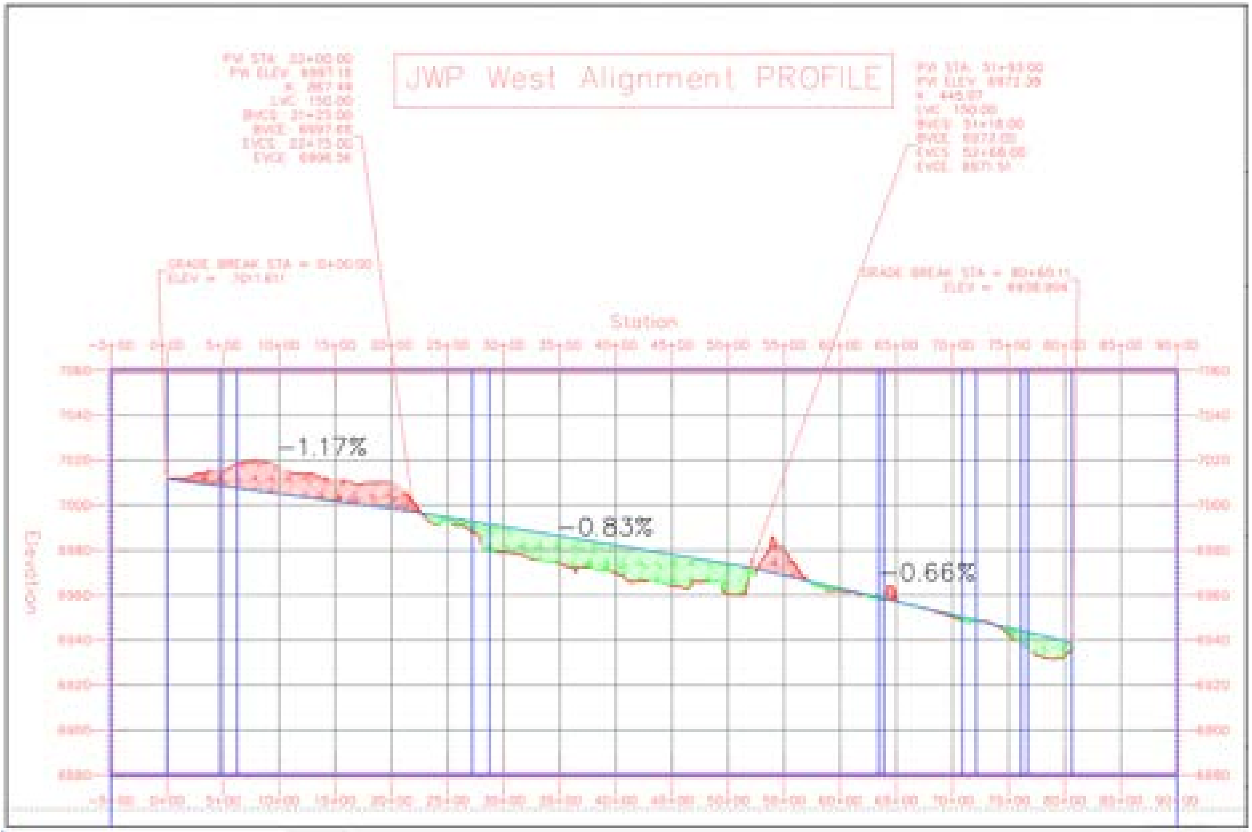

Figure 6-4: Vertical alignment and profile

6.2 Intersection Design

Two intersections were designed for the designated roadway, Lake Mary Rd. and John Wesley Powell Blvd. and Pulliam Dr. and John Wesley Powell Blvd. Each intersection was designed using the projected 2045 traffic data and the teams traffic counts. Using the traffic counts in section 3.3, an engineer's estimate was performed to project the turning and thru volumes for each leg.

6.2.1 Determine Criteria

According to the CoF and ADOT Design Guidelines, intersection design must consider efficiency, safety, capacity, cost of operation, and operating speed [2]. The intersections shall be accommodating to all users, including vehicles, bicycles, and pedestrians. The decision matric in Figure 6-1 is based off cost, efficiency, constructability, and service to pedestrians. Cost was weighted at 25% due to the financial practicality of each alternative. Efficiency was weighted at 40% as this determines how successful the intersection is. Constructability was weighted at 15% to compare the ease of construction/timeline. Service to pedestrians was weighted at 20% in order to accommodate pedestrians successfully and safely.

6.2.2 Develop Alternatives

Four alternatives were considered for each intersection, a two-way stop, four-way stop, roundabout, and signalized intersection. Each alternative was picked due to its popularity and potential service to the users.

A two-way stop would be inexpensive and easy to construct, but lack in the efficiency of the minor street to both vehicles and pedestrians. A four-way stop would also be inexpensive and easy to construct but would lack efficiency in all directions. A roundabout would be very expensive to construct, poor service to pedestrians, and excellent efficiency to vehicles. A signalized intersection would be costly to construct, provide excellent efficiency to pedestrians, and decent efficiency vehicles in all directions.

6.2.3 Analyze Alternatives and Select Best

All of the alternatives were evaluated using Vistro to determine the level of service, delay, signal phasing, etc. A decision matrix for the intersection of Pulliam Dr. and JWP can be found in Table 6-1 below. The scale for rating is from 1-3, "1" being bad, "2" being neutral, and "3" being good; for more information on the scale, see Table 6-2 for the descriptions of each criterion.

Table 6-1: Decision matrix for Lake Mary Rd. & JWP intersection design

Decision Matrix									
Lake Mary Road and JWP Intersection:		Signalized		2-Way Stop		4-Way Stop		Roundabout	
Criteria	Weight (%)	Avg Score (1 -3)	Weighted Score	Avg Score (1 -3)	Weighted Score	Avg Score (1 -3)	Weighted Score	Avg Score (1 -3)	Weighted Score
Cost	20	2	0.40	3	0.60	3	0.60	1	0.20
Efficiency	45	2	0.90	1	0.45	1	0.45	2	0.90
Constructability	15	2	0.30	3	0.45	3	0.45	1	0.15
Pedestrians	20	3	0.60	1	0.20	2	0.40	1	0.20
Weighted Score	100		2.20		1.70		1.90		1.45

Table 6-2: Intersection(s) scoring descriptions

Scoring Description for Intersection			
Criteria	1 (Worst)	2 (Neutral)	3 (Good)
Cost	Design is very costly	Design applies to categories 1 and 3	Design is not very costly
Efficiency	LOS E-F	LOS C-D	LOS A-B
Constructability	Challenging installation, requires additional labor & equipment	Requires adequate construction	Less labor & equipment
Pedestrians	LOS E-F	LOS C-D	LOS A-B

From the decision matrix above, a signalized intersection was determined to be the best alternative. This intersection was further evaluated in Vistro and determined to operate at a level of service C. Along with the addition of the designated road, a right turn lane was added on the eastern leg of the intersection. The full report for the designed intersection can be found in Appendix O. Figure 6-5 below shows an example of what the intersection would look like, along with its turning volumes (based on traffic projections for the year 2045), signal phases, and level of service for each leg. A fully detailed drawing sheet for this intersection can be found in Appendix N sheet 8.

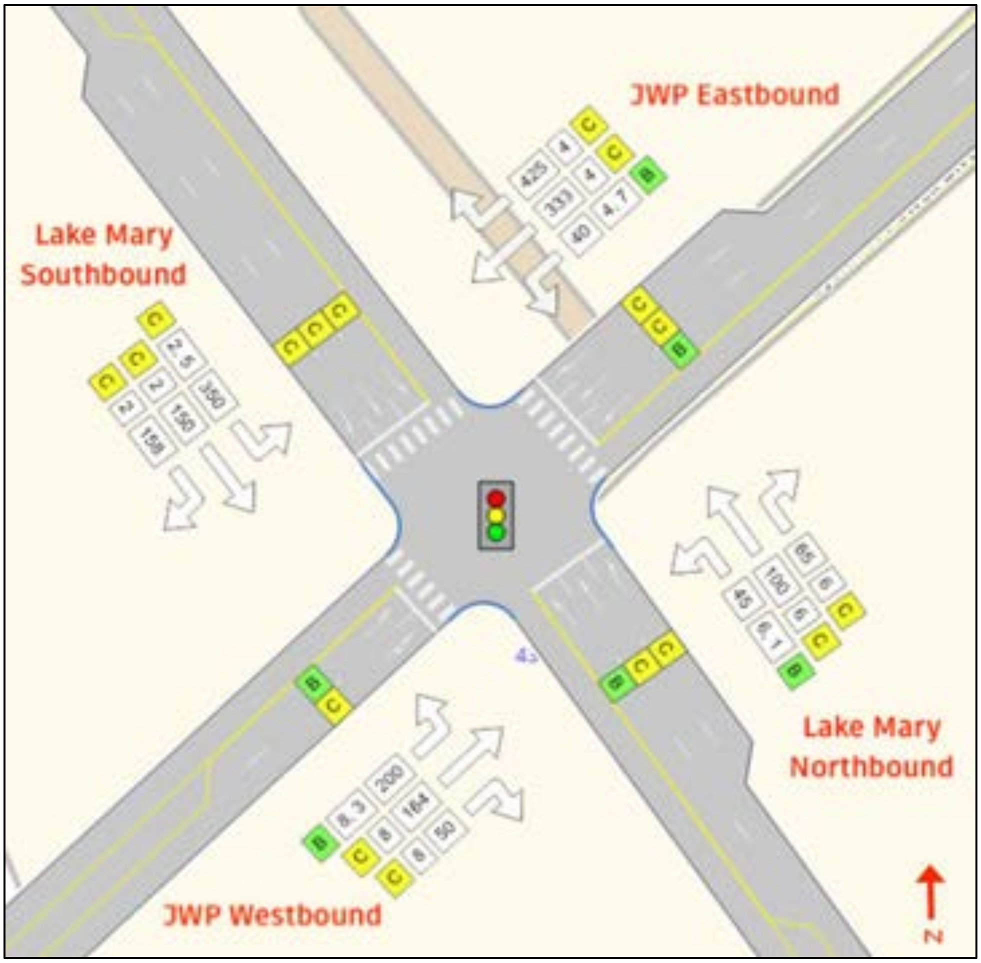

Figure 6-5: Proposed conditions of Lake Mary Rd. & JWP intersection

The intersection of Pulliam Dr. and John Wesley Powell Blvd. was also determined by the use of a decision matrix and can be found in Table 6-3 below.

Table 6-3: Decision matrix for S. Pulliam Dr. & JWP intersection design

Decision Matrix									
S Pulliam and JWP		Signalized		2-Way Stop		4-Way Stop		Roundabout	
Criteria	Weight (%)	Avg Score (1 -3)	Weighted Score	Avg Score (1 -3)	Weighted Score	Avg Score (1 -3)	Weighted Score	Avg Score (1 -3)	Weighted Score
Cost	20	2	0.40	3	0.60	3	0.60	1	0.20
Efficiency	45	3	1.35	2	0.90	1	0.45	3	1.35
Constructability	15	2	0.30	3	0.45	3	0.45	2	0.30
Pedestrians	20	3	0.60	2	0.40	2	0.40	1	0.20
Weighted Score	100		2.65		2.35		1.90		2.05

This intersection was also analyzed to ensure that a signal is warranted at this location. Using the peak hour volume of 1300 vehicles per hour on the main road and 250 vehicles per hour on the minor road for the year 2045, the MUTCD Warrant 3 was analyzed. This warrant compares the two roads peak hour volume, and if the value exceeds the line for 1 lane and 1 lane, the signal is warranted. Figure 6-6 shows warrant 3 with the traffic values in red.

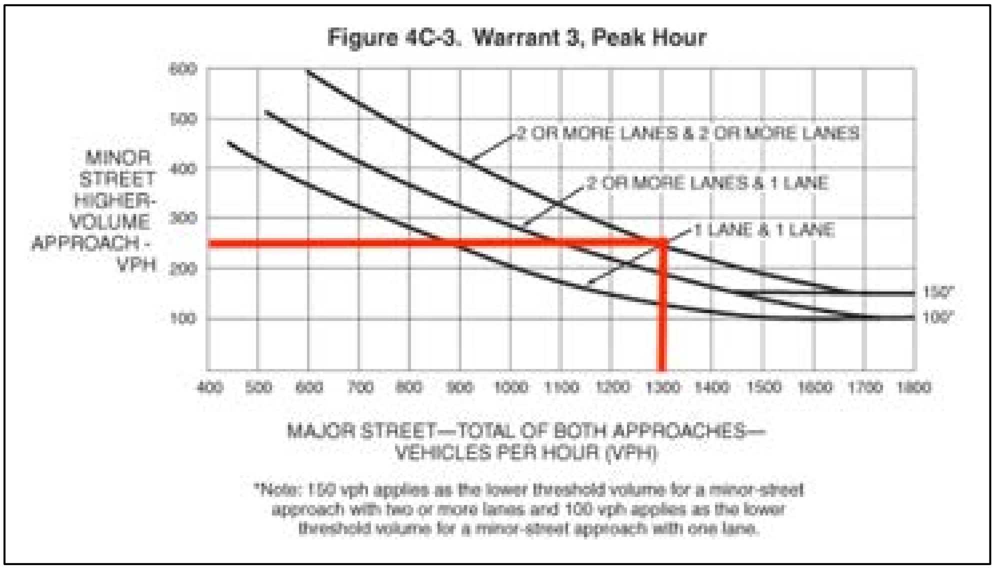

Figure 6-6: MUTCD Warrant 3

From the decision matrix and the signal warrant, a signalized intersection was determined to be the best alternative. This intersection was further evaluated in Vistro and determined to operate at a level of service B. The full report for the designed intersection can be found in Appendix O. Figure 6-7 below shows an example of what the intersection would look like, along with its turning volumes, signal phases, and level of service for each leg. A fully detailed drawing sheet for this intersection can be found in Appendix N sheet 9.

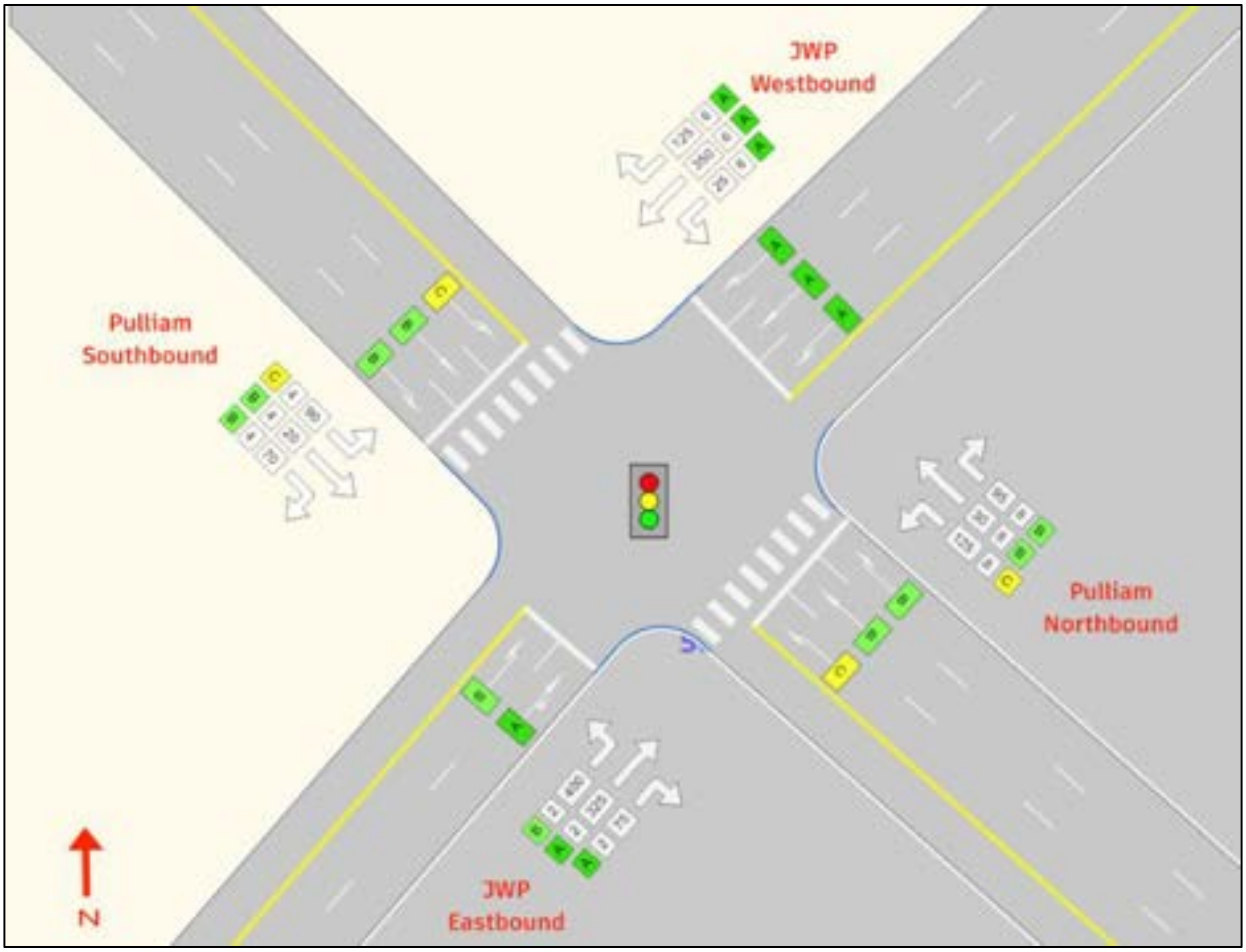

Figure 6-7: S. Pulliam Dr. & JWP Intersection

6.3 Pavement Design

Pavement Design for this project includes the analysis of the structural and functional aspects essential for constructing a durable, safe, and cost-effective road surface. The final pavement design was analyzed based on durability, effectiveness, and cost. Additional information including width, depth, and material selection specifications and requirements were based off of the Coconino County Engineering Design and Construction Manual (CCEDCM) [10], Maricopa Association of Governments Specifications and Details for Public Works Constructions (MAG SPDPWC) [11] and the Federal Highway Administration Bases and Subbases for Pavements Manual (FHWA BSP) [12].

6.3.1 Determine Criteria

Several criteria, namely durability, effectiveness, and cost, were carefully assessed for pavement design selection. Durability refers to the ability of the pavement to withstand wear and tear over time. Effectiveness pertains to how well the pavement meets the intended purpose of facilitating safe and efficient transportation, as well as assessing its drainage capabilities and its ability to perform under the road's expected volumes. Cost considers the financial implications of construction, maintenance, and rehabilitation throughout the pavement's lifespan.

See Table 6-5 for the decision matrix which was each scored on a scale of 1-3; "1" is worst, "2" is neutral, and "3" is good; for more information on the scale, see Table 6-4 for the descriptions of each criterion. Each criterion was assigned weights based on its importance and performance metrics to quantify the suitability of different design alternatives. Cost is allocated the highest weight at 35% because it directly impacts the project's budget and financial feasibility. This percentage indicates that minimizing costs and optimizing cost-efficiency throughout the pavement's lifecycle are crucial objectives for the project. Durability is also assigned a weight of 35% due to its critical role in determining the pavement's longevity and performance. A weight of 35% underscores the project's emphasis on selecting materials and designs that can withstand wear and tear over time, reducing maintenance costs and disruptions due to premature pavement failures. Effectiveness received a weight of 30%, highlighting its role in evaluating how well the pavement meets functional and performance requirements. This includes aspects such as safety, efficiency in transportation, drainage capabilities, and overall performance under expected traffic conditions. A weight of 30% indicates that while effectiveness is vital, it is slightly less weighted compared to cost and durability in this decision matrix.

This structured approach ensured that the chosen pavement design not only met technical requirements but also aligned with budgetary constraints and long-term sustainability goals.

Table 6-4: Scoring description for pavement design

Scoring Description for Pavement Design			
Criteria	1 (Worst)	2 (Neutral)	3 (Good)
Cost	highest upfront cost	moderate upfront cost	lowest upfront cost
Durability	shorterst lifespan, continuous maintenance necessary	moderate lifespan, moderate maintenance necessary	longest lifespan, minimal maintenance necessary
Effectiveness	not permeable, cannot withstand heavy traffic load	moderately permeable, lower ability to withstand heavy traffic load	permeable, can withstand heavy traffic load

6.3.2 Develop Alternatives

Two alternate materials considered for the pavement were asphaltic concrete and concrete. Asphaltic concrete, also known as asphalt pavement, consists of a mixture of asphalt binder and aggregates. It is commonly used for flexible pavement due to its ability to withstand heavy loads and adapt to minor ground movements. Asphaltic concrete offers benefits such as faster construction time, smoother ride quality, and ease of maintenance through surface treatments like overlays. Conversely, concrete pavement comprises a mixture of cement, water, and aggregates, providing rigid support for heavy traffic loads. Concrete pavements are known for their durability, long service life, and resistance to deformation under high temperatures. However, they often require longer construction periods and can be more expensive to install and repair compared to asphaltic concrete.

6.3.3 Analyze Alternatives and Select Best

In terms of cost based on cubic and square yards for the unit price, construction, and maintenance, asphaltic concrete is the most economical. The cost per cubic yard for asphaltic concrete typically ranges from $80 to $100, while concrete can range from $100 to $175 per cubic yard. Moreover, maintenance costs for asphaltic concrete are generally lower due to easier repairability.

In terms of durability, asphaltic concrete has a lifespan of approximately 15 to 20 years, depending on factors such as traffic volume and climate conditions, while concrete has an average lifespan of 20 to 30 years. However, it's important to note that proper maintenance practices can significantly extend the lifespan of both materials.

In terms of effectiveness, asphaltic concrete outperforms traditional concrete in terms of permeability, allowing for more efficient water drainage from roadways. This permeability not only reduces the risk of hydroplaning but also enhances drainage during heavy rainfall, thereby improving overall road safety and minimizing long-term maintenance costs. Moreover, the porous nature of asphaltic concrete helps mitigates traffic-generated noise, resulting in a quieter driving experience compared to concrete surfaces. However, the increased porosity of asphalt also contributes to its susceptibility to cracking and potholes in regions with freeze and thaw cycles, like Flagstaff. Consequently, regular crack sealing and seal coating of asphaltic pavement are required more frequently than with concrete pavement, to maintain its durability and performance.

By systematically scoring each material against the defined metrics, the decision matrix provided a comprehensive assessment of the advantages and disadvantages of each option, aiding in the selection of the most suitable pavement material for the project (Table 6-5).

Table 6-5: Decision matrix of pavement design

Decision Matrix					
Material Options:		Asphaltic Concrete		Concrete	
Criteria	Weight (%)	Avg Score (1-3)	Weighted Score	Avg Score (1-3)	Weighted Score
Cost	35	3	1.05	1	0.35
Durability	35	2	0.7	2	0.7
Effectiveness	30	2	0.6	2	0.6
Weighted Score	100		2.35		1.65

Based on the decision matrix, asphaltic concrete scored the highest and was selected for the roadway design. With the surface material selected, the full pavement was designed. As shown in Figure 6-8 several layers were needed to ensure compliance with the pavement design requirement. Per the CCEDCM, the topmost asphaltic concrete layer must have a minimum thickness of 6 inches and a base thickness of a minimum of 6 inches [10]. Per the FHWA BSP the sub-base layer must have a minimum thickness of 4 inches [12]. Lastly, per the MAG SPDPWC, any layer under asphaltic concrete must be compacted to 100% [11].

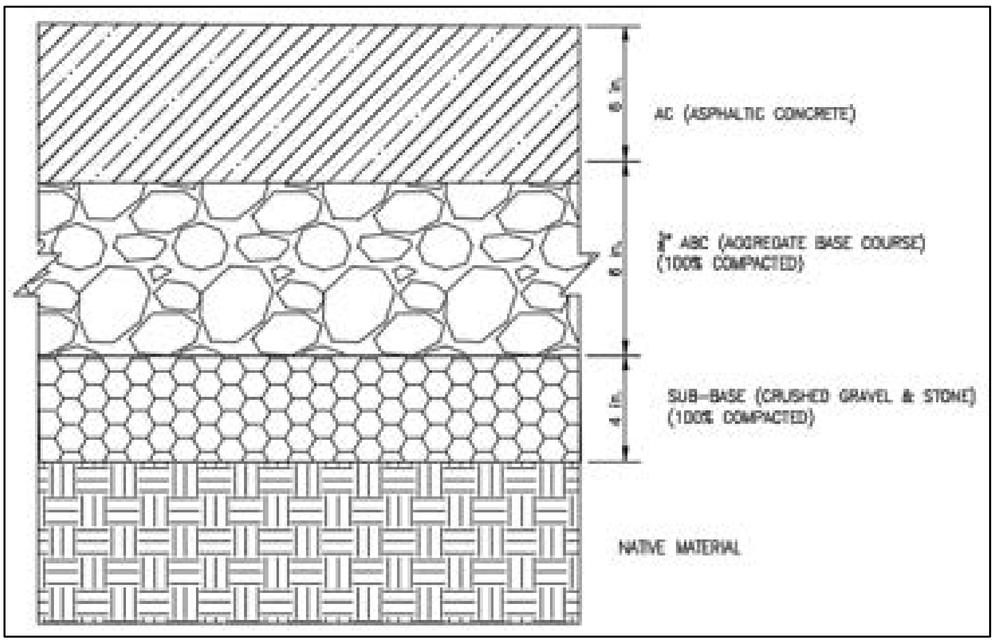

Figure 6-8: Typical layer cross-section for pavement design

Shown in Figure 6-9 and in the Appendix N sheet 2, is the final roadway cross section and pavement design. Key features of the roadway include 12-foot lanes with a 2% slope, a 5.5- foot shoulder with a 4% slope, a 1.5-foot curb and gutter with a 4% slope, and a 6-foot sidewalk along the north side of the roadway.

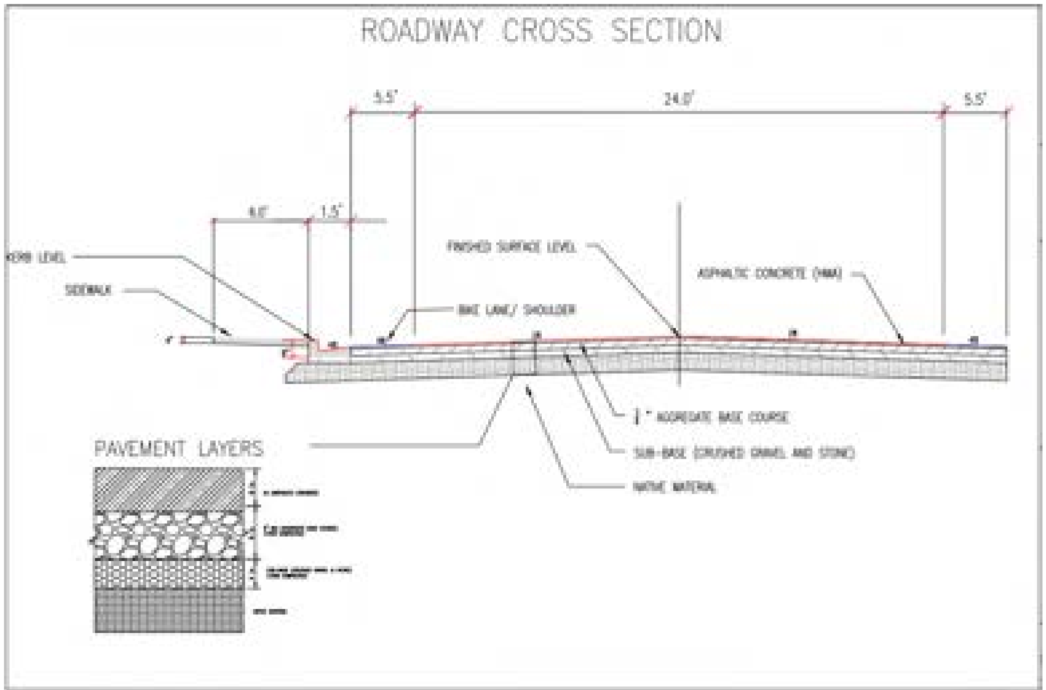

Figure 6-9: Typical roadway cross-section for pavement design

6.4 Sidewalk Design

Using the CCEDCM, it was determined that the sidewalk width be no less than 6-feet wide for arterial roads. Additionally, based on the Arizona Department of Transportation Concrete Driveway and Sidewalks Standard Drawings [13], it was determined that the sidewalk be 4-inches thick. Standard concrete will be used to make the sidewalk.

6.5 Signage and Striping

Signage and stripping are a fundamental aspect of a roadway as they guide users and promote safety. Signage sizing and shapes were followed according to the Manual on Uniform Traffic Control Devices (MUTCD).

White markings are used for the right-hand edge of the roadway, including the shoulder and bike lane. Yellow markings are used to delineate the separation of traffic traveling in opposing directions. These markings will be on the left-hand side of the road. Bike lanes will be marked with a figure and arrow to indicate the direction of travel. This figure will be 10-16 in the MUTCD. Each intersection will have a white stop line at its designed area to indicate stopping before the line. Where necessary, a continental crosswalk will be present in front of the stop line to indicate where pedestrians will be crossing the street. Turn lane markings at each intersection will be according to 10-10 in the MUTCD. These markings will indicate the turning movement of each lane and will promote safety at each intersection.

Due to the roadway having turns and not being very long, there will be no passing zones along its length and will consist of a solid yellow line in its entirety. To enforce this policy, "Do Not Pass" signs will be present throughout the roadway, configuring to R4-1 in the MUTCD. Speed limit signs will be placed on each side of the roadway and will configure to R2-1 in the MUTCD. All MUTCD signage and striping designs can be found in Appendix P.

Streetlights are to be spaced at intervals of 300-feet along the minor arterial. This consistent spacing ensures adequate coverage without creating unnecessary glare. Streetlights are positioned at the property lines. However, this placement should not conflict with other utility service locations. In areas where there is curbing but no sidewalk (south side), streetlights should be installed 2-feet from the back of the curb. When the sidewalk aligns with the back of the curb (north side), streetlights should be placed 1-foot from the back of the sidewalk [14].

7.0 Economic Cost

The project consists of two major components that work together to develop a safe and efficient design for JWP West. Therefore, two cost analyses were performed. Each analysis was completed by referencing local projects of similar scopes. Cost estimates for the roadway portion were obtained through CoF (Appendix Q) and cost estimates for the hydraulic portion were obtained from Wieser Concrete, a precast product company (Appendix R).

7.1 Construction Cost

The major contributors to the cost of this design are the asphaltic concrete pavement, concrete sidewalk, and the precast box culvert. The general estimate of the project came out to $4,466,022, excluding utilities and labor of work from the construction cost (Table 7-1).

Table 7-1: Construction cost analysis for roadway and hydraulic structure

Roadway and Hydraulic Structure				
ITEM	Quantity	Unit	Unit Price	Cost
Roadway:				
6" Asphatic Concrete over 10" MSL ABC Layer	30800	SY	$65	$2,002,000
Traffic Signal Installation	2	EA	$442,345	$884,690
Concrete Sidewalk	47520	SF	$16	$760,320
Streetlight	52	EA	$6,850	$356,200
Vertical Curb and Gutter	7920	LF	$25	$198,000
Remove Existing Tree	120	EA	$610	$73,200
White Bike Lane Striping	15840	LF	$2	$31,680
6" Double Yellow Stripe Marking	7920	LF	$4	$31,680
Roadway Earthwork (Cut & Fill)	1212	CY	$21	$25,452
40 MPH Speed Limit Sign	2	EA	$750	$1,500
Do Not Pass Sign	2	EA	$550	$1,100
Pavement Arrow Marking	4	EA	$125	$500
Crosswalk Marking	6	LF	$2	$12
Hydraulic Structure:				
Precast Concrete Box Culvert	1	EA	$66,375	$66,375
Flared Wingwalls	4	EA	$3,750	$15,000
Outlet Protection (RipRap)	121.5	CY	$75	$9,113
Inlet/Outlet Headwall	2	EA	$2,500	$5,000
Hydraulic Earthwork (Cut & Fill)	200	CY	$21	$4,200
TOTAL				**$4,466,022**

8.0 Impacts Analysis

The proposed extension of JWP Boulevard will bring about significant changes to the social, economic, and environmental landscape of the City of Flagstaff. It's crucial to acknowledge that while there are many positive outcomes, there are also accompanying negative effects that will demand attention and mitigation strategies. The following section provides a comprehensive analysis of the complexities surrounding the extension of JWP Boulevard.

8.1 Social Impacts

The extension of JWP Boulevard West will bring about significant societal effects, both positive and negative. One of the key positive impacts lies in enhanced accessibility. The roadway extension will improve access to local employment centers and essential services, thereby benefiting residents by increasing convenience and reducing future commute times. However, there are also potential negative aspects to consider. Increased traffic flow resulting from the initial construction period could lead to congestion and longer commute times for some residents, offsetting the accessibility benefits for those living in the immediate vicinity. Additionally, increased traffic within the area may result in a substantial increase in noise pollution and overall reduction in aesthetic appeal for surrounding residences. While the design and implementation of the roadway extension aims to enhance safety, there may be initial disruptions and hazards during construction, potentially impacting road safety for pedestrians, cyclists, and motorists alike. However, it's important to note that measures are being taken to mitigate these risks. For instance, the installation of a sidewalk alongside the extended roadway will provide greater pedestrian access, which will be beneficial in the future. This improvement in pedestrian infrastructure can enhance safety by separating pedestrians from vehicular traffic, ultimately reducing the risk of accidents, and promoting walkability in the community.

8.2 Economic Impacts

The extension of JWP Boulevard West is anticipated to have significant economic effects, encompassing both positive and negative outcomes. One positive impact is the potential increase in property values in adjacent areas. Improved accessibility and shorter commute times resulting from the extension may lead to higher property values, benefiting homeowners and potentially attracting new residents. However, there is also the possibility of negative consequences, such as heightened noise pollution and decreased aesthetic appeal due to changes in traffic patterns, which could result in decreased property values for some residents. In terms of economic development, the extension is expected to stimulate growth by facilitating the movement of goods and people. This enhanced access can lead to increased business activity and investment in the region, thereby bolstering the local economy. Nonetheless, there may be challenges associated with managing increased traffic flow and ensuring infrastructure keeps pace with development to support sustainable economic growth.

8.3 Environmental Impacts

The extension of JWP Boulevard West will have environmental effects, presenting both positive and negative implications. One significant concern is the potential for water pollution. Runoff from the road surface, as well as from construction activities, may carry pollutants such as oils, heavy metals, and sediment into nearby waterways, thereby impacting water quality and posing risks to aquatic ecosystems. This presents a clear negative consequence that must be addressed through proper mitigation measures. Additionally, habitat disruption is another notable environmental consideration. The road construction process will involve clearing land, which will disrupt the local environment by removing vegetation and altering natural drainage patterns. This disruption can negatively affect wildlife habitats and biodiversity in the area. However, there may also be positive environmental outcomes to consider. For instance, the implementation of stormwater management systems and erosion control measures during construction can help minimize water pollution and mitigate habitat disruption to some extent. Moreover, if properly planned and executed, the extension could potentially contribute to improved transportation efficiency, reducing overall carbon emissions and mitigating environmental impacts associated with vehicle congestion.

9.0 Summary of Engineering Work

The original proposed design schedule can be found in Appendix S. All the work done for the project followed closely to the teams original set schedule with no major deviations. Field work, including surveying and taking traffic counts were conducted in month of January. By February, analysis of the field work, and the background research for the project were concluded. Following this, the team primarily focused on the hydraulics, hydrology, and geotechnical portions of the project during the month of February and March. By the end of March and the entirety of April, the team worked on the final design, construction plans, and the cost analysis, and were on track to conclude the project earlier than planned, see Appendix T for updated schedule. The main difference between the two schedules is that the actual had less hours and more defined deadlines regarding the submittals; the team continued to work on the weekends and throughout Spring break to meet the current schedule's needs. The remainder of the project duration will be utilized to work on the project website.

10.0 Summary of Engineering Costs

Table 10-1 below outlines the project original proposed staffing hours delegated by task. By estimation, the team determined that the project will take a total of 736 hours, with the Senior Engineer having the second lowest hours logged at 129 hours, the Project Engineer with the highest number of hours logged at 346 hours, the Lab Technician logging the lowest number of hours at 120 hours and the Intern logging a total of 141 hours. A full detailed breakdown of the hourly delegations per task and role can be found in Appendix U.

Table 10-1: Proposed staffing summary by task

Task	SENG	ENG	TECH	INT	Total Hours
1.0 Research and Data Collection	0	4	3	2	9
2.0 Site Investigation	1	13	30	24	68
3.0 Hydrologic Analysis	0	12	3	3	18
4.0 Hydraulic Analysis	15	34	32	10	91
5.0 Roadway Design	30	124	26	31	211
6.0 Construction Plans	8	23	0	18	49
7.0 Economic Analysis	6	18	0	7	31
8.0 Impact Analysis	1	6	0	5	12
9.0 Deliverables	8	65	14	24	111
10.0 Project Management	60	47	12	17	136
Total	129	346	120	141	736

Based on the hourly rates and staffing hours estimated above, a proposed cost of engineering services was created. As shown in Table 10-2, the total proposed cost of engineering services was originally estimated to be $82,395.

Table 10-2: Proposed staffing cost

Proposed Cost of Engineering Services				
1.0 Personnel	**Classification**	**Hours**	**Rate, $/hour**	**Cost**
	SENG	129	$ 200	$ 25,800
	ENG	346	$ 120	$ 41,520
	LAB	120	$ 75	$ 9,000
	INT	141	$ 25	$ 3,525
	Total	736		$ 79,845
2.0 Travel	**Classification**	**Miles/Trip**	**Rate, $/Mile**	**Cost**
	5 1-Day Trips	7	$ 0.40	$ 14
3.0 Supplies	**Classification**	**Days**	**Rate, $/Day**	**Cost**
	Surveying	3	$ 100	$ 300
	JAMAR Board	2	$ 75	$ 150
	Camera	2	$ 50	$ 100
	Computer Lab	20	$ 100	$ 2,000
Total				$ 82,395

By the conclusion of the project, it was determined that the hours logged for the project were significantly less than the original proposed staffing hours, with a difference of 87 hours. As shown in Table 10-3 the actual hours logged for the entire project totaled 649 hours with the Senior Engineer having the lowest hours logged at 61 hours, the Project Engineer with the highest number of hours logged at 277 hours, the Lab Technician logging the second lowest number of hours at 136 hours and the Intern logging a total of 175 hours.

Table 10-3: Staffing summary by task

Task	SENG	ENG	TECH	INT	Total Hours
1.0 Research and Data Collection	1	16	1	8	25
2.0 Site Investigation	0	21	11	15	47
3.0 Hydrologic Analysis	0	6	3	3	12
4.0 Hydraulic Analysis	5	28	29	28	89
5.0 Roadway Design	15	82	2	26	124
6.0 Construction Plans	4	20	29	24	77
7.0 Economic Analysis	1	5	5	5	16
8.0 Impact Analysis	0	3	2	3	8
9.0 Deliverables	28	71	42	51	191
10.0 Project Management	8	25	13	14	60
Total	61	277	136	175	649

The difference in the proposed hours and actual hours logged is reflected in the actual cost of engineering services. As shown in Table 10-4, the actual staffing hours logged were significantly less than the proposed staffing hours. It can be seen that actual and proposed cost of the project, has a difference of $19,830 with the total cost of engineering services coming out to $62,565. Three major project tasks experienced delays beyond the initial estimates. Firstly, the research and data collection task required an additional 16 hours to complete due to the extensive time needed to review multiple manuals. These manuals required frequent revisits throughout the project duration to ensure compliance with all project requirements. Secondly, the construction plans task took 28 hours longer than planned as new sheets had to be generated with each deliverable submission, necessitating ongoing revisions to individual sheets. Lastly, the deliverable creation task surpassed the original estimate by 80 hours due to the need to develop new sections for the report and revise existing work with each deliverable submission. Conversely, tasks such as site investigation, hydrologic analysis, hydraulic analysis, roadway design, economic analysis, impact analysis, and project management were completed more efficiently than anticipated. This successful management of certain tasks offset the extended timelines experienced in other project areas, enabling the project to maintain overall schedule adherence.

Table 10-4: Staffing cost summary

Actual Cost of Engineering Services				
1.0 Personnel	**Classification**	**Hours**	**Rate, $/hour**	**Cost**
	SENG	61	$ 200	$ 12,200
	ENG	277	$ 120	$ 33,240
	LAB	136	$ 75	$ 10,200
	INT	175	$ 25	$ 4,375
	Total	649		$ 60,015
2.0 Travel	**Classification**	**Miles/Trip**	**Rate, $/Mile**	**Cost**
	5 1-Day Trips	7	$ 0.40	$ 14
3.0 Supplies	**Classification**	**Days**	**Rate, $/Day**	**Cost**
	Surveying	3	$ 100	$ 300
	JAMAR Board	2	$ 75	$ 150
	Camera	2	$ 50	$ 100
	Computer Lab	20	$ 100	$ 2,000
Total				$ 62,565

11.0 Conclusion

The final design the team selected was a 35-foot road with a 1.5-foot curb/gutter and a 6-foot sidewalk on the northern end. This road traverses to the north of Flagstaff Pulliam Airport and will increase serviceability to surrounding areas. The design abides by all city, county, and state regulations. It is designed according to the projected 2045 traffic volume and will continue to serve its users for years to come.

The road travels above a 76’-8” box culvert which was designed to accommodate a 50-year storm. This culvert design successfully conveys water beneath the roadway in a safe and efficient manner.

The total construction cost for the project is estimated to be $4,466,022 and the cost of engineering services was calculated to be $62,565.

The final design will positively impact Flagstaff and its residents by adding an efficient route to get around the city. The addition of this roadway will greatly decrease the amount of travel time users experience as there is currently no direct route between these locations. The design considers all impacts, including social, economic, and environmental. The proposed design enhances Flagstaff’s accessibility for all users, encompassing vehicles, bicyclists, and pedestrians.

In summary, while significant progress has been made in the project, several tasks remain to be addressed. Our exclusions, which include utility design, a comprehensive hydraulic design of ditches along the new roadway, FUTS, a full channel design for the upstream section of the existing channel, and the intersection leading up to the residential area, still require attention.

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Appendix

Appendix A: Soil Report

See the following pages for the soil report related to the project site.

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Oak Creek-San Francisco Peaks Area, Arizona, Part of Coconino County

JWP West

February 4, 2024

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

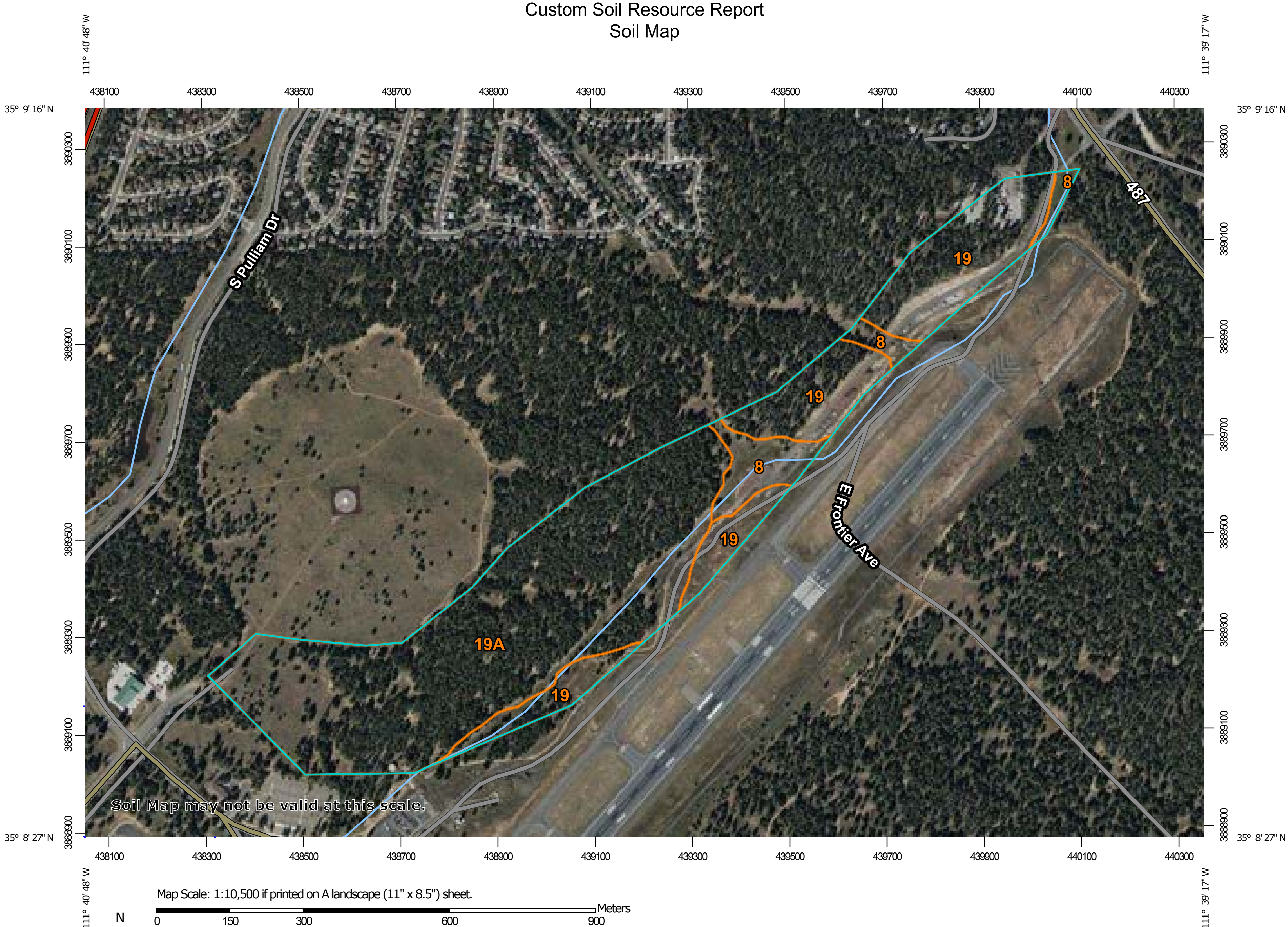
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



Map Scale: 1:10,500 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 150, 300, 600, 900

Feet: 0, 500, 1000, 2000, 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Oak Creek-San Francisco Peaks Area, Arizona, Part of Coconino County
Survey Area Data: Version 13, Sep 11, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 19, 2022—Oct 31, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
8	Paymaster family fine sandy loam, 0 to 3 percent slopes	8.2	7.1%
19	Telephone gravelly sandy loam, 0 to 15 percent slopes	32.8	28.6%
19A	Telephone-Daze complex, 0 to 8 percent slopes	73.8	64.3%
Totals for Area of Interest		**114.8**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Oak Creek-San Francisco Peaks Area, Arizona, Part of Coconino County

8—Paymaster family fine sandy loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 1vhk1
Elevation: 6,650 to 7,040 feet
Mean annual precipitation: 18 to 24 inches
Mean annual air temperature: 43 to 49 degrees F
Frost-free period: 90 to 115 days
Farmland classification: Not prime farmland

Map Unit Composition

Paymaster and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paymaster

Setting

Landform: Alluvial fans, flood plains
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium

Typical profile

H1 - 0 to 14 inches: fine sandy loam
H2 - 14 to 60 inches: loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 8.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: B
Ecological site: R039XA108AZ - Meadow 17-22" p.z.
Hydric soil rating: No

19—Telephone gravelly sandy loam, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 1vhkj
Elevation: 6,880 to 7,090 feet
Mean annual precipitation: 18 to 24 inches
Mean annual air temperature: 43 to 49 degrees F
Frost-free period: 90 to 115 days
Farmland classification: Not prime farmland

Map Unit Composition

Telephone and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Telephone

Setting

Landform: Hills
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Colluvium and/or residuum weathered from sandstone

Typical profile

H1 - 0 to 3 inches: gravelly sandy loam
H2 - 3 to 11 inches: gravelly loamy sand
R - 11 to 21 inches: bedrock

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: 8 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 0.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: D
Ecological site: F039XA139AZ - Limestone/Sandstone Upland 17-22"
Hydric soil rating: No

19A—Telephone-Daze complex, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: 1vhkk
Elevation: 6,620 to 7,130 feet
Mean annual precipitation: 18 to 24 inches
Mean annual air temperature: 43 to 49 degrees F
Frost-free period: 90 to 115 days
Farmland classification: Not prime farmland

Map Unit Composition

Telephone and similar soils: 55 percent
Daze and similar soils: 45 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Telephone

Setting

Landform: Hills
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Colluvium and/or residuum weathered from sandstone

Typical profile

H1 - 0 to 3 inches: gravelly sandy loam
H2 - 3 to 11 inches: gravelly loamy sand
R - 11 to 21 inches: bedrock

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 8 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 0.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: D
Ecological site: F039XA139AZ - Limestone/Sandstone Upland 17-22"
Hydric soil rating: No

Description of Daze

Setting

Landform: Plains, hills
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from limestone and sandstone

Typical profile

H1 - 0 to 3 inches: fine sandy loam
H2 - 3 to 7 inches: clay loam
H3 - 7 to 18 inches: clay
R - 18 to 28 inches: bedrock

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 2.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: D
Ecological site: F039XA139AZ - Limestone/Sandstone Upland 17-22"
Hydric soil rating: No

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Appendix B: Safety Plan

See the following pages for the safety plan related to the site visit.

Onsite Visit:

Safety Protocols

CELS ENGINEERING

PREPARED FOR: Jeffery Heiderscheidt

REVISED: 1/25/2023

EDITED BY:

Logan McFarland - Site Coordinator
Steven McKimmey - Safety Lead
Cristine Aguila - Technical Coordinator
Elijah Begay - Technical Coordinator

1. Project Background

Location of the project will take place at the intersection of Lake Mary Rd. and John Wesley Powell Blvd. (Figure 1) at 4:00 PM - 5:00 PM, Thursday, February 1st, 2024. A Morning site visit from 8:00 AM - 9:00 AM will also be conducted on Friday, February 2nd, 2024.

Figure 1: Intersection of interest (East side)

Location of the project will take place at the intersection of South Pulliam Dr. and John Wesley Powell Blvd. (Figure 2) at 4:00 PM - 5:00 PM, Thursday, February 1st, 2024. A Morning site visit from 8:00 AM - 9:00 AM will also be conducted on Friday, February 2nd, 2024.

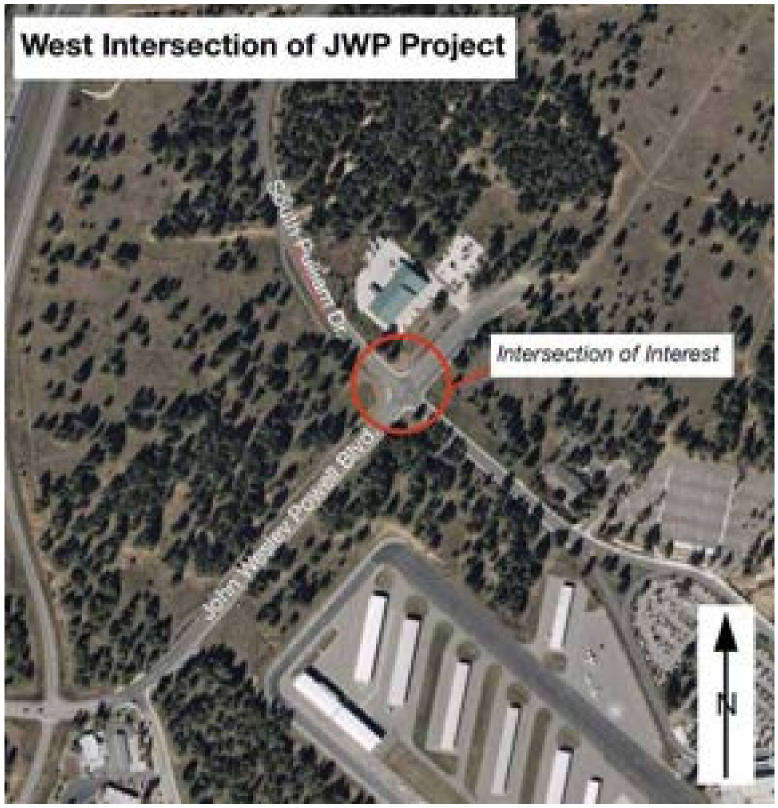


Figure 2: Intersection of interest (West side)

2. Project Objective

The team will meet at the intersections in order to make consecutive counts of traffic that is transposed on the JAMAR board. The count will be a 15-minute interval for 1-hour. Once the count is over, the data from the JAMAR board will then be transferred to the software 'Petro' for further analysis.

3. Planned Activities

The team will meet at both intersections of the East and West side to conduct a traffic count for a duration of 1-hour on both selected days (Thursday & Friday) while utilizing JAMAR boards. The team will also take photos of existing conditions along the proposed alignment.

4. Equipment Required

It is required that the team, on site, wear safety vests at all times due to being easily identifiable to users at the intersection. Prior knowledge of certain procedures, concerning the risks at any involvement of traffic, will also be required and talked over before collecting data. While maintaining safety, two JAMAR boards will be used for traffic counts.

5. Hazard/Risk Associated

While a serious injury or event can occur at the time of collecting data, it is always appropriate to take the necessary precautions and procedures when being near to ongoing traffic. Thus, the purpose of this protocol must be recognized and discussed, in case any event happens at the time.

6. Safety Protocols

The team has decided upon the following to ensure the safety of the public and team, this will have to be maintained and constantly checked:

- *Individual responsibility* is needed. Must always stand in a safe place, out of any traffic. Must only cross streets in a legal manner, at the crosswalk when a legal signal is displayed or “Stop” sign is present. Must never be in the street for any reason.

- *Teamwork* is required for safety procedures. Two members of the team: one will be logging the data, while the other is assigned coordination duties with the team on the opposite corner, keeping track of when to switch people. Another person needs to be watching the other two team members to help ensure that they do not do something that is considered to be endangering.

Given a possible list of potential actions:

1. Team member unconsciously steps out into the road
    a. A loud and stern shout to alert the endangered member
    b. A teammate in the proximity will quickly grab the endangered member out of harm
2. Team member standing too close to the curb
    a. Alert endangered member to stand back
    b. Command everyone to not make the mistake again

- *Protective clothing* is required to be seen by drivers. An orange safety vest will be provided by management. Everyone MUST wear their safety vest when on site.

- *Location* of the team members are listed:

1. Cristine Aguila: First user of the JAMAR board (West)
2. Logan McFarland: Standing near JAMAR board user
3. Elijah Begay: First user of the JAMAR board (East)
4. Steven McKimmey: Standing near JAMAR board user

   * Roles will be rotating and, thus, all team members must be precautious.

- *How and where the streets will be crossed* depends on the crosswalk usage and if a signalized crossing is available.

- *Vehicles* will be legally parked in the Swift Travel Center parking lot.

Additional details:

1. Before Count
    a. Make sure all team members are up to date with the JAMAR board, how it's used.
    b. Make sure all team members have orange safety vests on.
    c. Make sure all team members know the area.
    d. Be sure to be efficient enough with board so eyes are not taken off of the intersections
2. After count
    a. Be sure to have all members accounted for before leaving the site.
    b. All brought equipment is accounted for.
    c. The procedure was clear for all team members.

7. Emergency Response Plan

Logan McFarland: The caller for an emergency (911)

Elijah Begay: Emotional support for the injured individual

Cristine Aguila: Waver/Flagger against oncoming users

Steven McKimmey: Physical support for the injured member to transport him out of the danger zone

Once the injured person has been relieved to emergency care, members of the group will inform the course instructor, Jeffrey Heiderscheidt and the Dean of Students. More steps will be taken as needed.

The following is to ensure that each group member is well aware of the risks of traffic and their potential hazards, however, each member will be as precautious and concise to maintain each other's safety. While abiding by the laws that are carried out within traffic, each group member will fulfill their duties.

__________________ __________________ __________________

Cristine Aguila Elijah Begay Logan McFarland

____

Steven McKimmey

Appendix C: Field Notes

See the following pages for the handwritten field notes.

Downstream ~~Upstream~~ Profile HI 4.9'

Point	B.S.	H.I.	S.S (ft)	Elevation (ft)
BM#1	1.19'			6944 ft
STA 0+00		5.70	~~6.08~~	
STA 0+10		6.08	~~6.85~~	
STA 0+20		6.85	~~7.64~~	
STA 0+30		7.64	8.22	
STA 0+40		8.22	~~9.02~~	
STA 0+50		9.01	~~9.02~~	
STA 0+60			8.43	
STA 0+70			8.40	
STA 0+80			8.48	
STA 0+90			8.37	10.61

Upstream ~~Downstream~~ Profile

BM#1	1.53			6944 ft
STA 0+00			5.44	
STA 0+10			5.56	
STA 0+20			5.62	
STA 0+30			5.61	
STA 0+40			5.96	
STA 0+50			5.44	
STA 0+60				

EAST Intersection of JWP.

Date: 1/25/24

Time: 1:30pm – 4:37pm

Weather: Partially Cloudy, some snow ~40°F

Crew:

Downstream ~~Upstream~~ Cross Section L → R STA 0+30

Point	B.S.	H.I.	S.S (ft)	Elevation (ft)
BM#1	1.19			6944
STA 0+00			4.90	
STA 0+08.15			5.54	
STA 0+16.97			7.~~72~~34	
STA 0+21.1			7.~~6~~875	
STA 0+29.7			7.34	
STA 0+35.0			6.49	
STA 0+42.9			6.05	

✓ Down Stream L → R

~~Upstream~~ Cross Section STA 0+60

Point	B.S.	H.I.	S.S (ft)	Elevation (ft)
BM#1	1.38			6944
STA 0+00			4.52	
STA 0+14.3			7.01	
STA 0+15.8			8.56	
STA 0+21			8.62	
STA 0+~~32~~ 23.9			8.17	
STA 0+32.3			6.91	
STA 0+40			6.57	

Downstream Cross Section STA0+30

Bins	B.S.	H.I.	S.S. (ft)	Elevation (ft)
BM #1	1.51			6944
STA 0+00			4.26	
STA 0+13.7			6.40	
STA 0+17.25			8.71	
STA 0+21.5			8.82	
STA 0+26.0			8.59	
STA 0+35.2			7.20	
STA 0+45.0			6.91	

Appendix D: Traffic Counts

See the following pages for the full traffic counts showing all movements at different times.

West side	From North				From East				From South				From West				
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	
8:00:00 AM	18	1	0	0	2	14	1	0	1	1	4	0	6	11	14	0	
8:15:00 AM	17	0	2	0	0	7	0	0	0	0	3	0	7	3	17	0	
8:30:00 AM	18	0	1	0	0	10	0	0	1	0	1	0	3	2	6	0	
8:45:00 AM	14	0	0	0	3	5	1	0	0	0	5	0	4	2	8	0	**Total**
	67	1	3	0	5	36	2	0	2	1	13	0	20	18	45	0	213

West side	From North				From East				From South				From West				
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	
3:45:00 PM	12	0	0	0	1	2	0	0	0	0	5	0	3	1	31	0	
4:00:00 PM	15	3	1	0	0	1	0	0	0	1	9	0	7	4	27	0	
4:15:00 PM	12	0	2	0	0	3	0	0	0	0	5	0	1	1	26	0	
4:30:00 PM	22	2	0	0	2	1	1	0	0	2	5	0	3	3	23	0	**Total**
	61	5	3	0	3	7	1	0	0	3	24	0	14	9	107	0	237

East side	From North				From East				From South				From West				
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	
8:00:00 AM	2	13	39	0	14	0	2	0	9	15	0	0	0	0	1	0	
8:15:00 AM	0	7	38	0	24	0	6	0	7	17	0	0	0	0	0	0	
8:30:00 AM	0	10	36	0	11	0	2	0	4	12	0	0	0	0	0	0	
8:45:00 AM	0	13	43	0	16	0	2	0	7	18	0	0	0	0	0	0	**Total**
	2	43	156	0	65	0	12	0	27	62	0	0	0	0	1	0	368

East side	From North				From East				From South				From West				
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	
3:45:00 PM	0	14	16	0	40	0	6	0	6	10	0	0	0	0	0	0	
4:00:00 PM	0	17	18	0	35	0	13	0	8	8	0	0	0	0	0	0	
4:15:00 PM	1	17	20	0	31	0	9	0	3	9	0	0	0	0	1	0	
4:30:00 PM	0	26	21	0	42	0	8	0	8	10	0	0	0	0	0	0	**Total**
	1	74	75	0	148	0	36	0	25	37	0	0	0	0	1	0	397

Appendix E: Photographs of Site Features

See the following pages for detailed photos of site features.

Conducting traffic counts on JWP Blvd. & Lake Mary Rd.

Conducting traffic counts on JWP Blvd. & S. Pulliam Dr.

Culvert at the furthest point downstream of channel

Looking upstream of the channel


Existing channel (looking upstream)


STA 1+82 cross section (looking upstream)


STA 1+52 cross section (looking upstream)

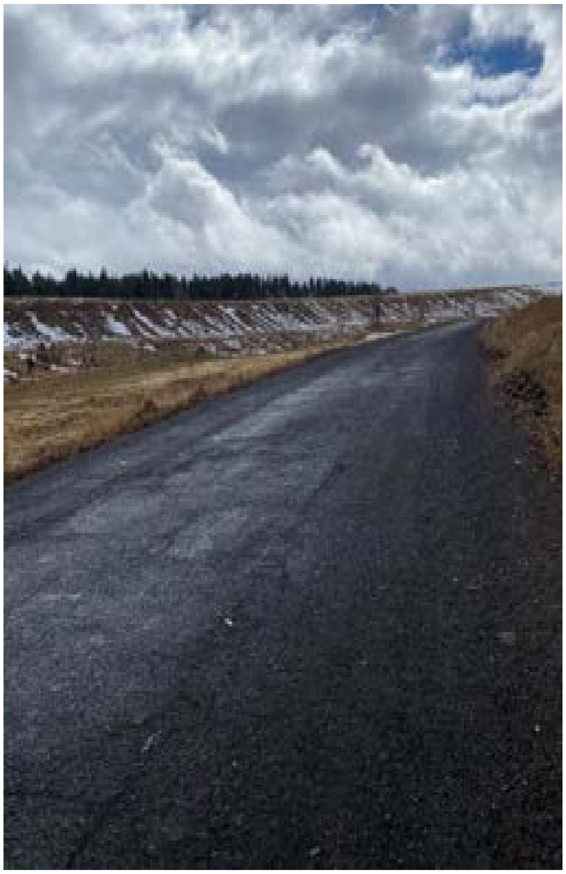

STA 1+22 cross section (looking upstream)

Riprap at the furthest upstream point of the existing channel

STA 0+00 looking downstream of the existing channel

Graded road from the east side of site

Graded road from east side of site



Further along the graded road

Existing wash with airport security fence along the upper ridge

Existing shallow concentrated flow channel

Existing weir further upstream

Closer view of the weir

Weir cross section at bottom level

Upstream side of the Weir

Midpoint of the proposed roadway

Level rod and benchmark (manhole)

Auto level setup

Staking out the downstream channel

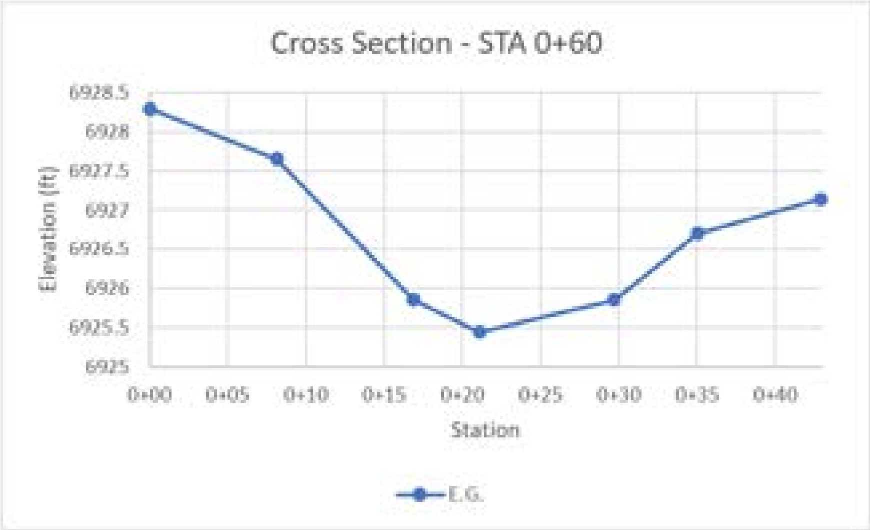
Staking out the upstream side of the channel

Appendix F: Existing Channel Cross Sections

See the following pages for the existing grade of channel cross sections.

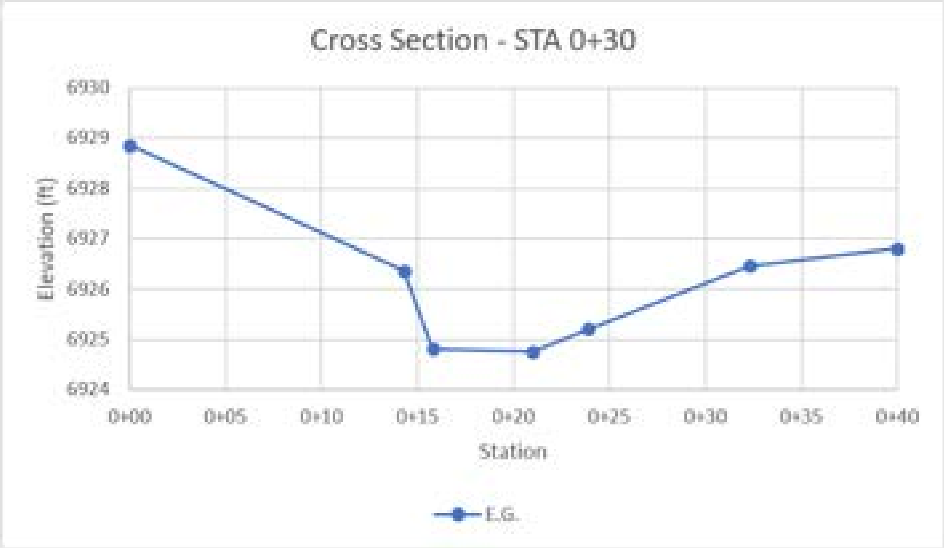
Downstream Cross Section (STA 0+60)

STA	B.S.	H.I.	S.S.	Elevation (ft.)
BM1	1.19			6932
		6933.19		
0+00			4.9	6928.29
0+08			5.54	6927.65
0+17			7.34	6925.85
0+21			7.75	6925.44
0+30			7.34	6925.85
0+35			6.49	6926.7
0+43			6.05	6927.14



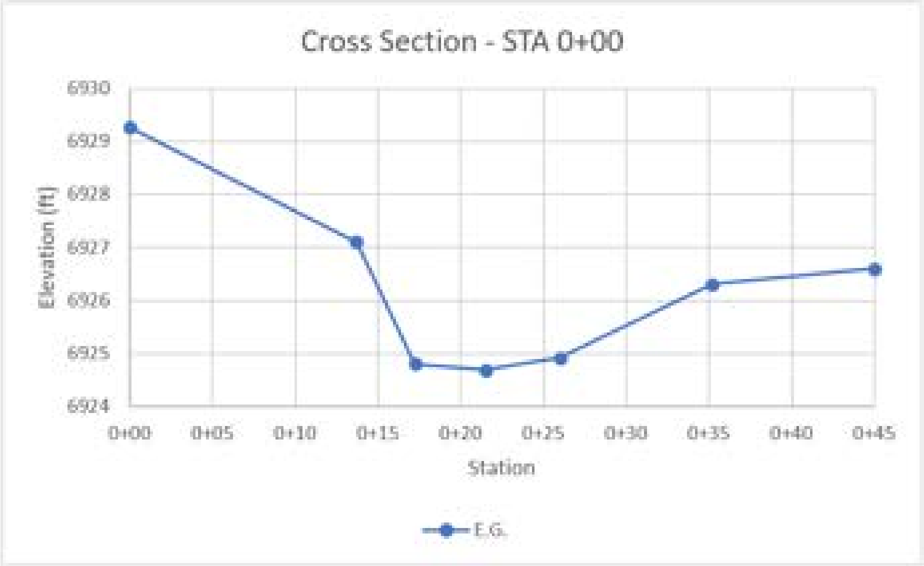
Downstream Cross Section (STA 0+30)

STA	B.S.	H.I.	S.S.	Elevation (ft.)
BM1	1.38			6932
		6933.38		
0+00			4.52	6928.86
0+14			7.01	6926.37
0+16			8.56	6924.82
0+21			8.62	6924.76
0+24			8.17	6925.21
0+32			6.91	6926.47
0+40			6.57	6926.81



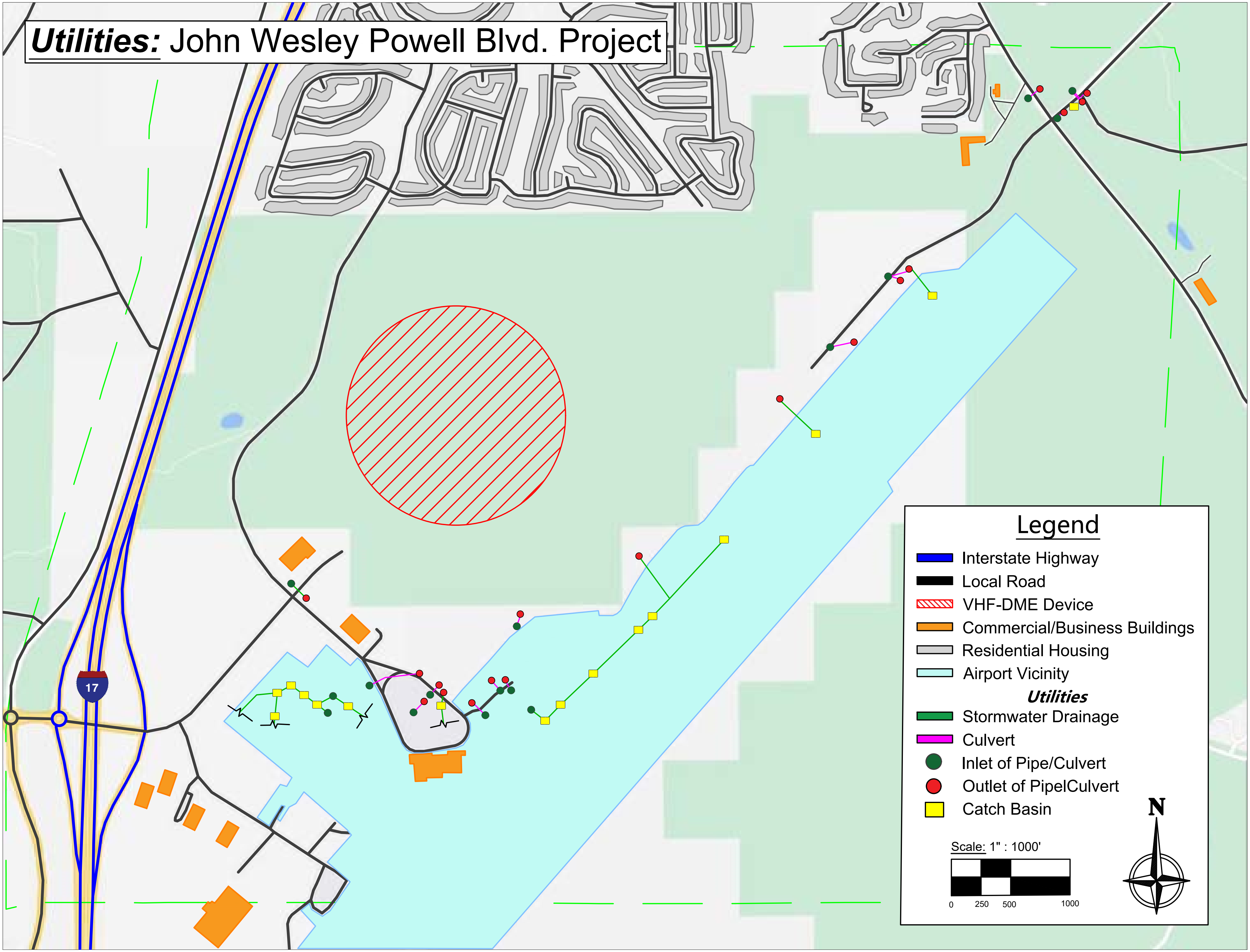
Downstream Cross Section (STA 0+00)

STA	B.S.	H.I.	S.S.	Elevation (ft.)
BM1	1.51			6932
		6933.51		
0+00			4.25	6929.26
0+14			6.4	6927.11
0+17			8.71	6924.8
0+22			8.82	6924.69
0+26			8.59	6924.92
0+35			7.2	6926.31
0+45			6.91	6926.6



Appendix G: Utility Map

See the following page for the utility map.



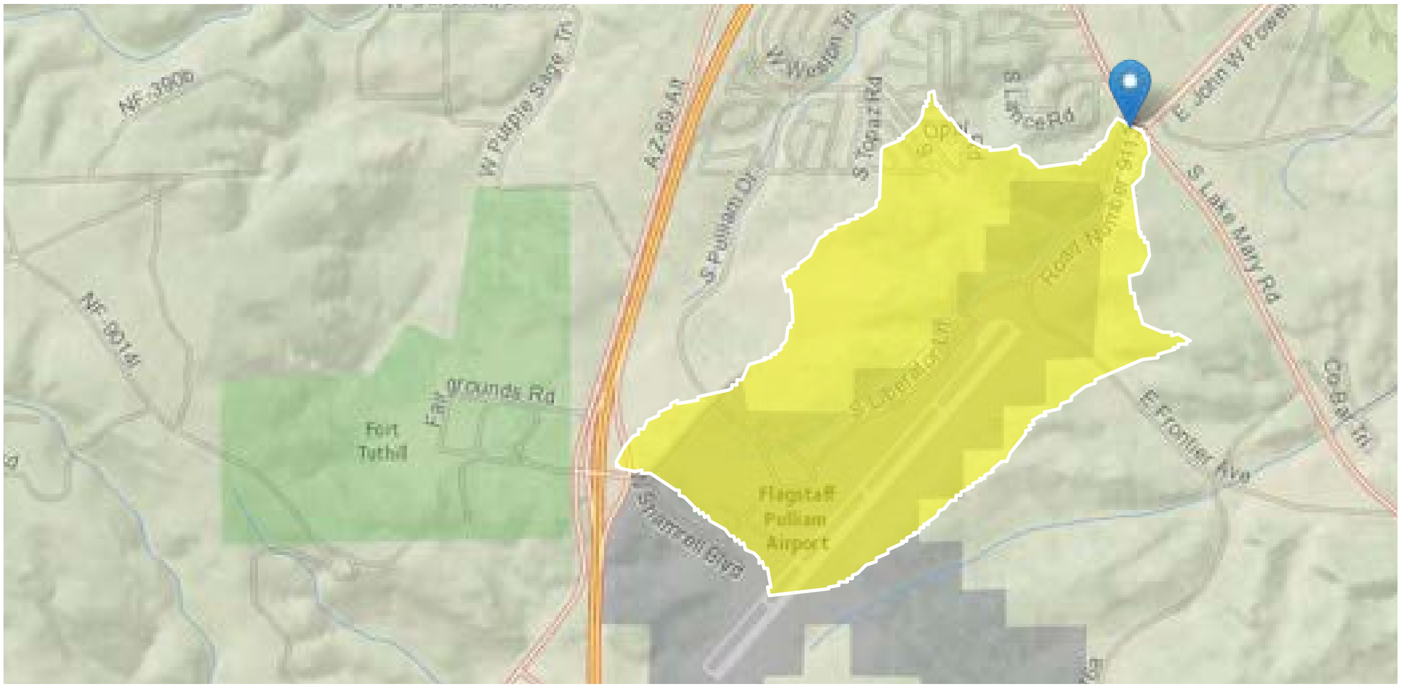
Utilities: John Wesley Powell Blvd. Project
17
Legend
Interstate Highway
Local Road
VHF-DME Device
Commercial/Business Buildings
Residential Housing
Airport Vicinity
Utilities
Stormwater Drainage
Culvert
Inlet of Pipe/Culvert
Outlet of PipelCulvert
Catch Basin
Scale: 1" : 1000'
0
250
500
1000
N

Appendix H: StreamStats Report

See the following pages for the StreamStats report.

StreamStats Report (JWP West)

Region ID: AZ
Workspace ID: AZ20240206232349911000
Clicked Point (Latitude, Longitude): 35.15393, -111.65789
Time: 2024-02-06 16:24:15 -0700



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
CONTDA	Area that contributes flow to a point on a stream	1.1	square miles
DRNAREA	Area that drains to a point on a stream	1.1	square miles
ELEV	Mean Basin Elevation	6998.097	feet
JANAVPRE	Mean January Precipitation	2.44	inches

Maximum Probable Flood Statistics

Maximum Probable Flood Statistics Parameters [Crippen Bue Region 16]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.1	square miles	0.1	1000

Maximum Probable Flood Statistics Flow Report [Crippen Bue Region 16]

Statistic	Value	Unit
Maximum Flood Crippen Bue Regional	9760	ft^3/s

Maximum Probable Flood Statistics Citations

Crippen, J.R. and Bue, Conrad D.1977, Maximum Floodflows in the Conterminous United States, Geological Survey Water-Supply Paper 1887, 52p. (https://pubs.usgs.gov/wsp/1887/report.pdf)

Bankfull Statistics

Bankfull Statistics Parameters [Intermontane Plateau D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.1	square miles	3.62934	7579.9152

Bankfull Statistics Parameters [Colorado Plateau P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.1	square miles	3.621618	3649.980906

Bankfull Statistics Parameters [USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.1	square miles	0.07722	59927.7393

Bankfull Statistics Disclaimers [Intermontane Plateau D Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Bankfull Statistics Flow Report [Intermontane Plateau D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	5.62	ft
Bieger_D_channel_depth	0.324	ft
Bieger_D_channel_cross_sectional_area	1.65	ft^2

Bankfull Statistics Disclaimers [Colorado Plateau P Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Bankfull Statistics Flow Report [Colorado Plateau P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	4.54	ft
Bieger_P_channel_depth	0.148	ft
Bieger_P_channel_cross_sectional_area	0.686	ft^2

Bankfull Statistics Flow Report [USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	12.8	ft
Bieger_USA_channel_depth	1.23	ft
Bieger_USA_channel_cross_sectional_area	18	ft^2

Bankfull Statistics Flow Report [Area-Averaged]

Statistic	Value	Unit
Bieger_D_channel_width	5.62	ft
Bieger_D_channel_depth	0.324	ft
Bieger_D_channel_cross_sectional_area	1.65	ft^2
Bieger_P_channel_width	4.54	ft
Bieger_P_channel_depth	0.148	ft
Bieger_P_channel_cross_sectional_area	0.686	ft^2
Bieger_USA_channel_width	12.8	ft
Bieger_USA_channel_depth	1.23	ft
Bieger_USA_channel_cross_sectional_area	18	ft^2

Bankfull Statistics Citations

Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p. (https://digitalcommons.unl.edu/usdaarsfacpub/1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF&utm_campaign=PDFCo

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Peak Region 2 Colorado Plateau 2014 5211]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
CONTDA	Contributing Drainage Area	1.1	square miles	0.103	16017
ELEV	Mean Basin Elevation	6998.097	feet		

Peak-Flow Statistics Flow Report [Peak Region 2 Colorado Plateau 2014 5211]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	55.8	ft^3/s	11.3	275	122
20-percent AEP flood	149	ft^3/s	42.4	523	87.2
10-percent AEP flood	247	ft^3/s	80.1	761	75.7
4-percent AEP flood	423	ft^3/s	149	1200	68.6
2-percent AEP flood	597	ft^3/s	215	1660	66.6
1-percent AEP flood	810	ft^3/s	291	2260	67.3
0.5-percent AEP flood	1070	ft^3/s	376	3040	68.8
0.2-percent AEP flood	1480	ft^3/s	495	4430	72.9

Peak-Flow Statistics Citations

Paretti, N.V., Kennedy, J.R., Turney, L.A., and Veilleux, A.G.,2014, Methods for estimating magnitude and frequency of floods in Arizona, developed with unregulated and rural peak-flow data through water year 2010: U.S. Geological Survey Scientific Investigations Report 2014-5211, 61 p., http://dx.doi.org/10.3133/sir20145211. (http://pubs.usgs.gov/sir/2014/5211/)

Application Version: 4.19.3
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

Appendix I: TR-55 Worksheets

See the following pages for worksheets 2-4.

Worksheet 2: Runoff curve number and runoff

Project	By	Date
JWP West	Logan McFarland	2/7/24
Location	**Checked**	**Date**
Flagstaff, Az	Logan McFarland	2/8/24

Check one: ☒ Present ☐ Developed

1. Runoff curve number

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN [1] Table 2-2	CN [1] Figure 2-3	CN [1] Figure 2-4	Area ☒ acres ☐ mi² ☐ %	Product of CN x area
,B	Paymaster family fine Sandy loam, 0 to 3 percent slopes	86			8.2	705
,D	Telephone gravelly Sandy loam, 0 to 15 percent slopes	84			32.8	2755
,D	Telephone – Daze Complex, 0 to 8 percent slopes	84			73.8	6199
				Totals ➡	114.8	9659

[1] Use only one CN source per line

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{9659}{114.8} = 84.14$; **Use CN** ➡ 84

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	10	50	100
Rainfall, P (24-hour)	in	3.08	4.12	4.60
Runoff, Q (Use P and CN with table 2-1, figure 2-1, or equations 2-3 and 2-4)	in	1.58	2.48	2.91

$S = \frac{1000}{84} - 10 = 1.9$

Worksheet 3: Time of Concentration (T_c) or travel time (T_t)

Project: JWP West	By: Logan McFarland	Date: 2/7/24
Location: Flagstaff, AZ	Checked: Logan McFarland	Date: 2/8/24

Check one: ☒ Present ☐ Developed

Check one: ☒ T_c ☐ T_t through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to Tc only)

Segment ID		Comments		
1. Surface description (table 3-1)	Grass			
2. Manning's roughness coefficient, n (table 3-1)	0.15			
3. Flow length, L (total L † 300 ft) ... ft	292			
4. Two-year 24-hour rainfall, P_2 ... in	2.13			
5. Land slope, s ... ft/ft	0.01027			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t ... hr	0.6158	+		= 0.6158

Shallow concentrated flow

Segment ID		Comments		
7. Surface description (paved or unpaved)	unpaved	Paved areas		
8. Flow length, L ... ft	7,214			
9. Watercourse slope, s ... ft/ft	0.0083			
10. Average velocity, V (figure 3-1) ... ft/s	1.5			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t ... hr	1.336	+		= 1.336

Channel flow

Segment ID		Comments		
12. Cross sectional flow area, a ... ft^2	105.22			
13. Wetted perimeter, p_w ... ft	27			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ... ft	3.897			
15 Channel slope, s ... ft/ft	0.0125			
16. Manning's roughness coefficient, n ...	0.025	rubble bottom		
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V ... ft/s	16.50			
18. Flow length, L ... ft	320			
19. $T_t = \frac{L}{3600\ V}$ Compute T_t ... hr	0.00539	+		= 0.00539
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) ... Hr				1.957

Worksheet 4: Graphical Peak Discharge method

Project	By	Date
JWP West	Logan McFarland	2/7/24
Location	**Checked**	**Date**
Flagstaff, Az	Logan McFarland	2/8/24

Check one: ☒ Present ☐ Developed

1. Data

Drainage area .... A_m = 0.18 mi² (acres/640)

Runoff curve number .... CN = 84 (From worksheet 2)

Time of concentration .... T_c = 1.957 hr (From worksheet 3)

Rainfall distribution .... = II (I, IA, (II), III)

Pond and swamp areas sprea throughout watershed .... = 0 percent of A_m (0.00 acres or mi² covered)

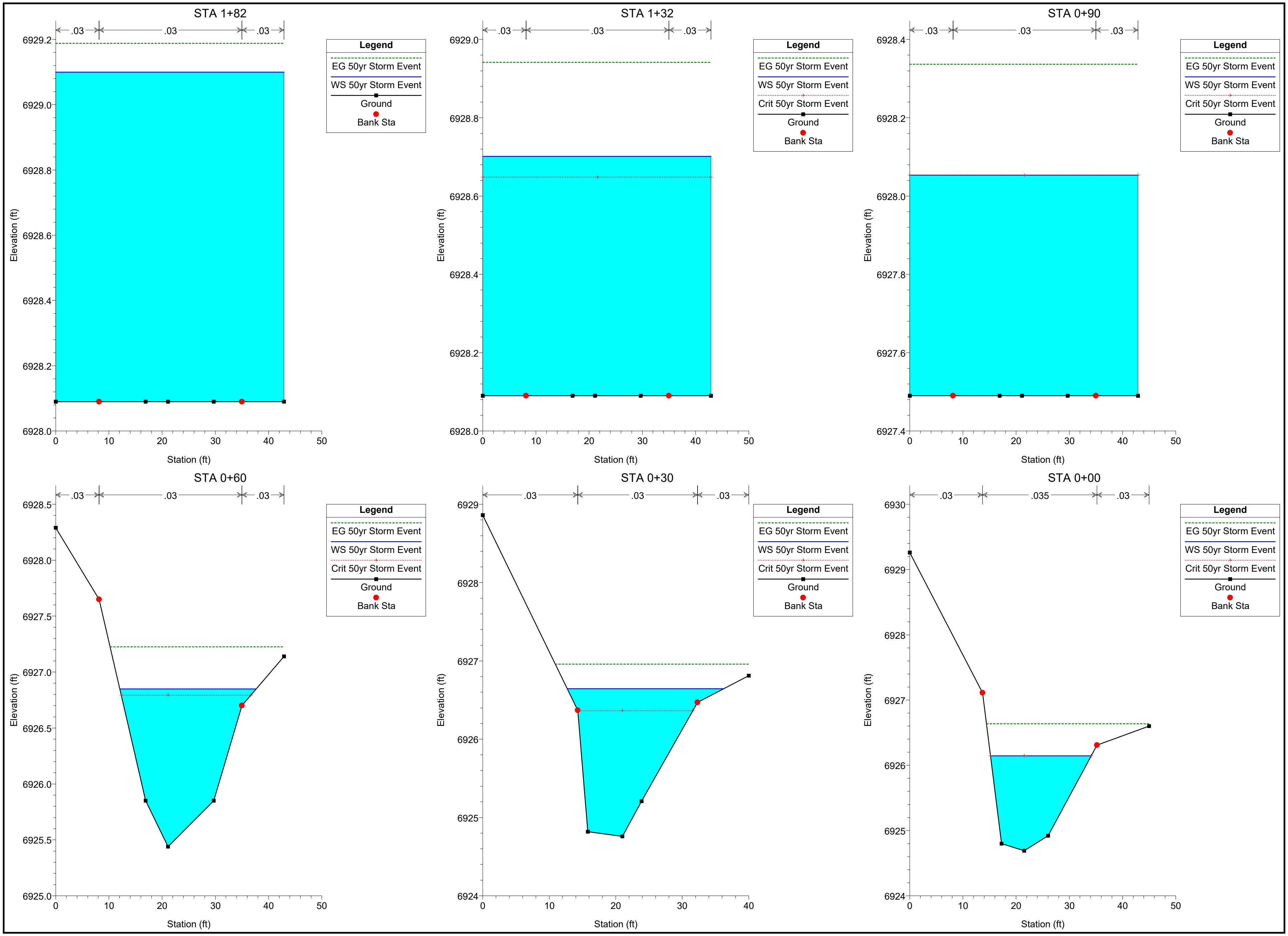
		Storm #1	Storm #2	Storm #3
2. Frequency	yr	10	50	100
3. Rainfall, P (24-hour)	in	3.08	4.12	4.60
4. Initial abstraction, I_a (Use CN with table 4-1)	in	0.381	0.381	0.381
5. Compute I_a/P		0.124	0.092	0.083
6. Unit peak discharge, q_u (Use T_c and I_a/P with exhibit 4– ____)	csm/in	230	230	230
7. Runoff, Q (From worksheet 2) Figure 2-6	in	1.58	2.48	2.91
8. Pond and swamp adjustment factor, F_p (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond ans swamp area.)		1.0	1.0	1.0
9. Peak discharge, q_p	ft³/s	65.4	102.3	120.5

(Where $q_p = q_u A_m Q F_p$)

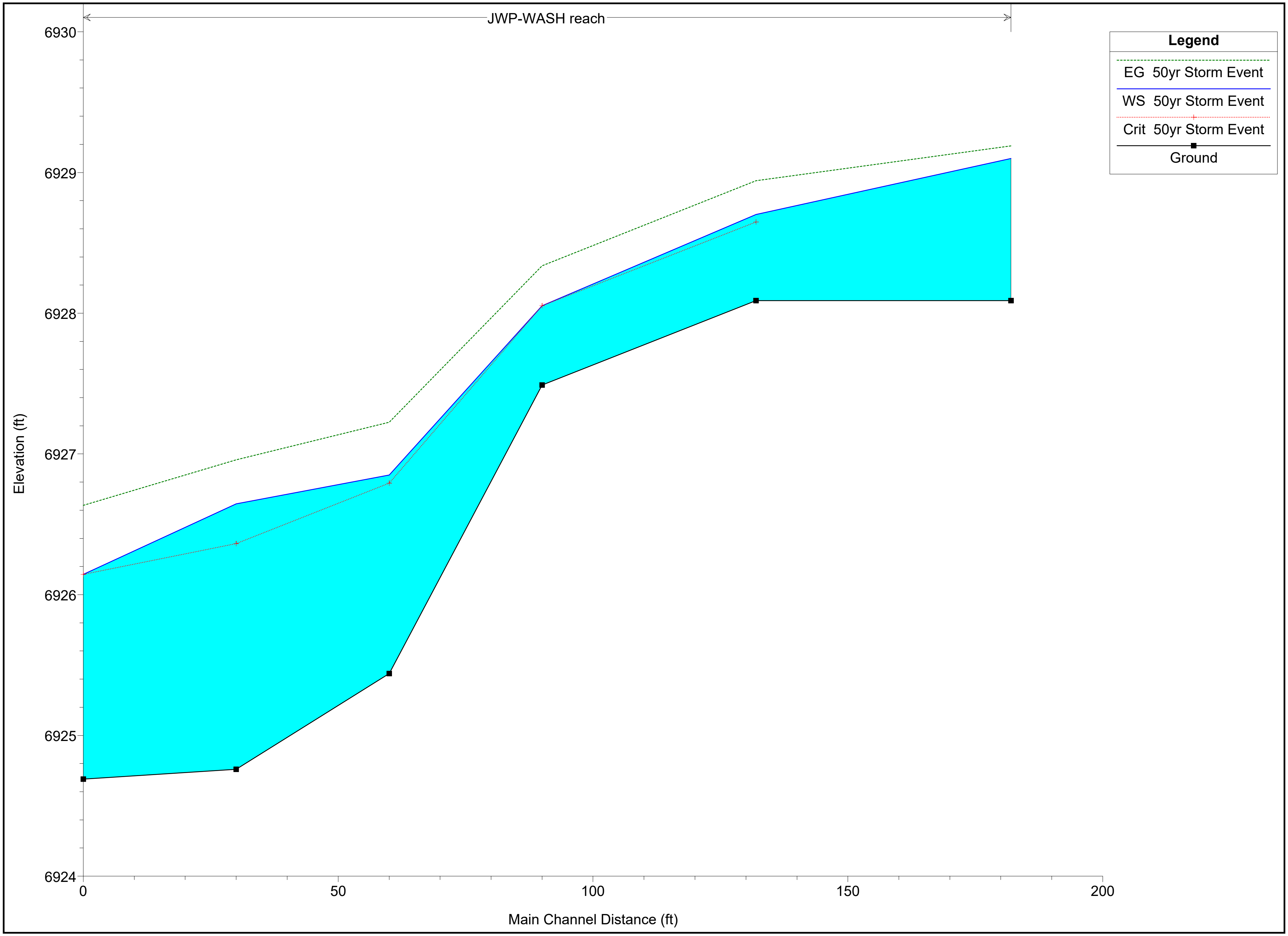
Appendix J: Existing Hydraulic Outputs from HEC-RAS

See the following pages for cross-sections, profile, and standard table outputs of existing conditions.

Existing Cross Sections *HEC-RAS* Outputs



Existing Profile *HEC-RAS* Output



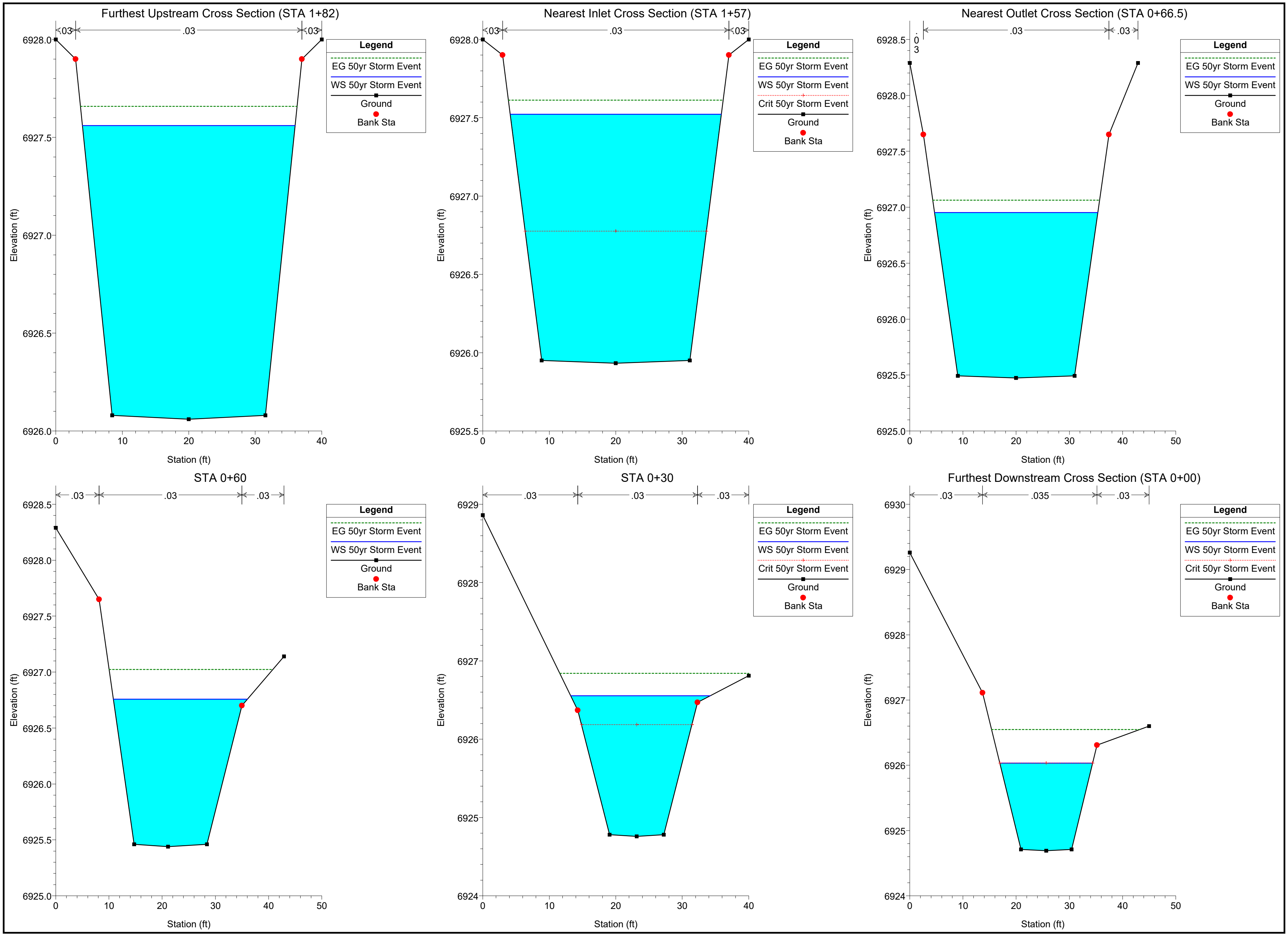
Standard Table of Existing Cross Sections *HEC-RAS*

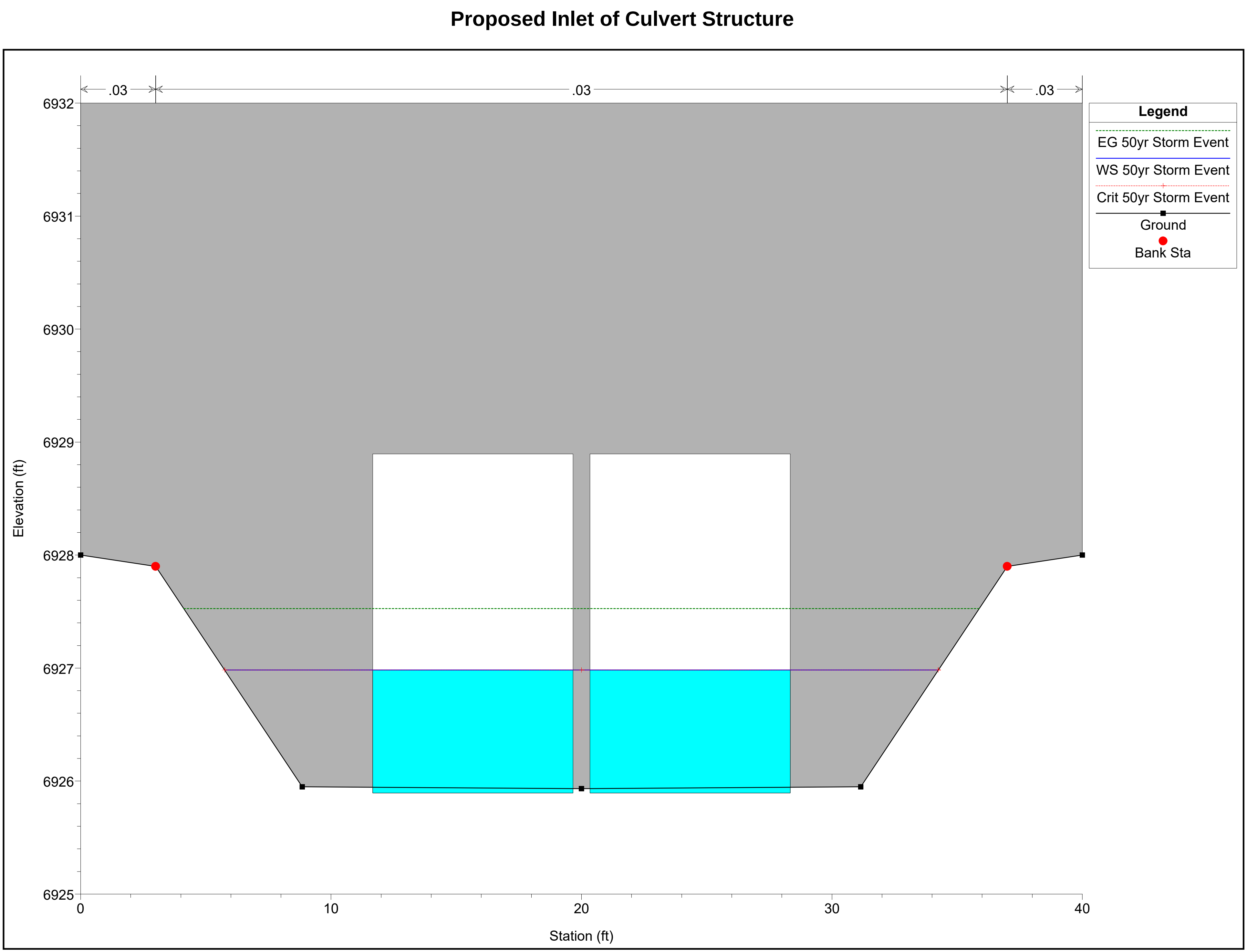
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
reach	182	50yr Storm Event	103	6928.09	6929.10		6929.19	0.002	2.45	43.34	42.90	0.43
reach	132	50yr Storm Event	103	6928.09	6928.70	6928.65	6928.94	0.013	4.00	26.25	42.90	0.90
reach	90	50yr Storm Event	103	6927.49	6928.05	6928.05	6928.34	0.016	4.34	24.15	42.90	1.02
reach	60	50yr Storm Event	103	6925.44	6926.85	6926.79	6927.23	0.011	4.92	21.10	25.65	0.91
reach	30	50yr Storm Event	103	6924.76	6926.65	6926.36	6926.96	0.006	4.49	23.38	23.57	0.70
reach	0	50yr Storm Event	103	6924.69	6926.14	6926.14	6926.64	0.019	5.62	18.32	18.92	1.01

Appendix K: Proposed Hydraulic Outputs from HEC-RAS

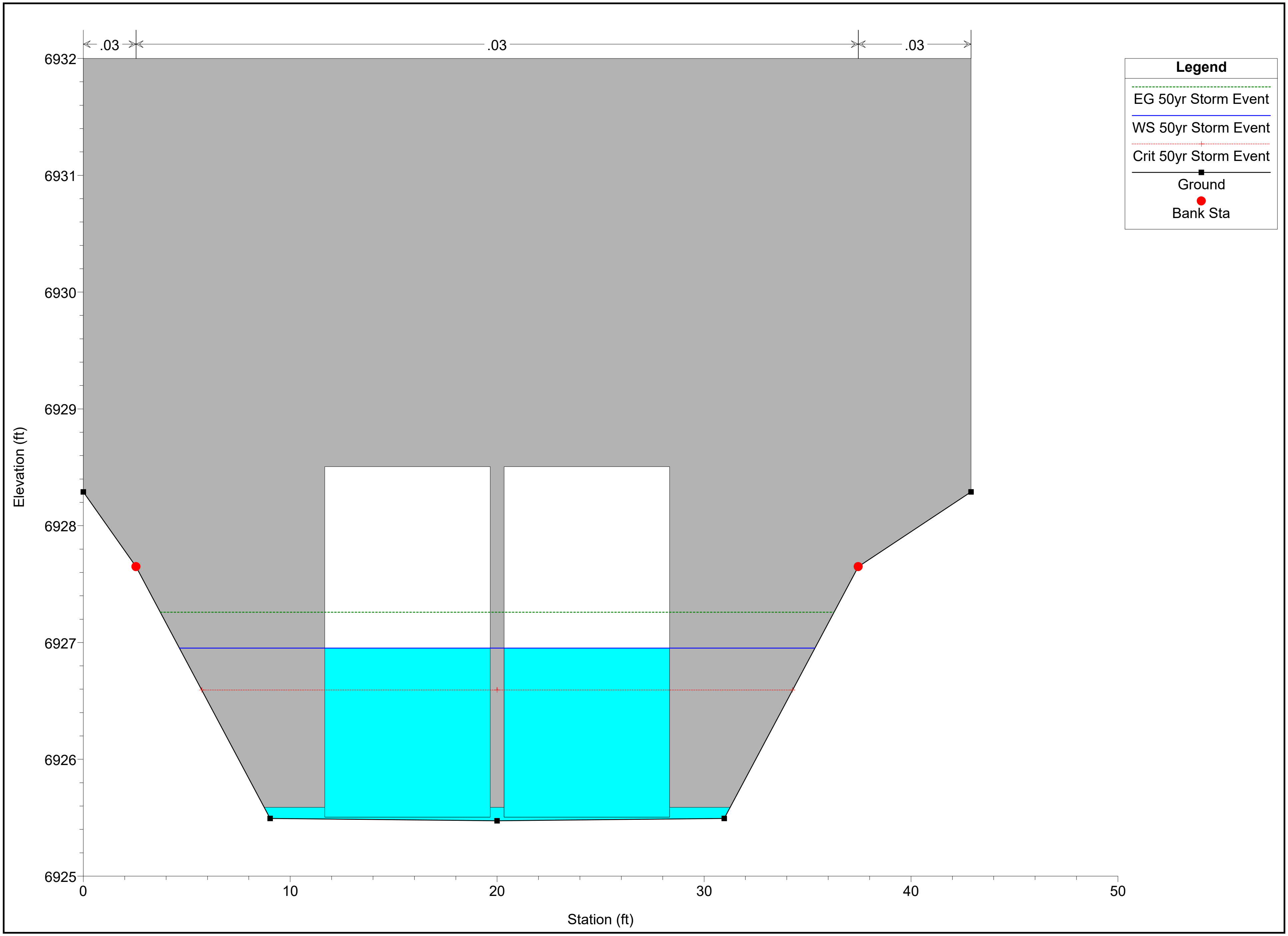
See the following pages for cross-sections, profile, and standard table outputs of proposed conditions.

Proposed Profile *HEC-RAS* Output

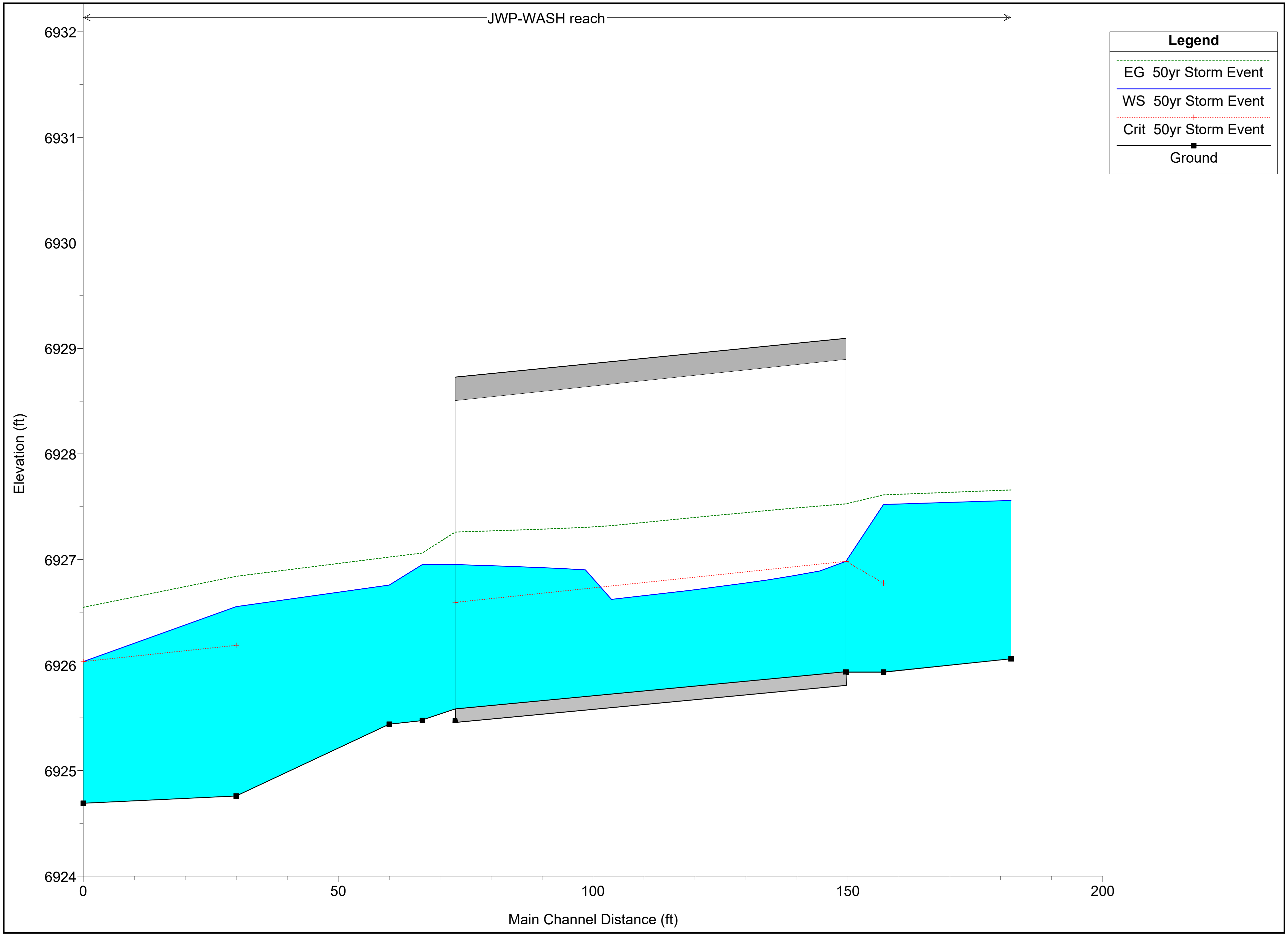



Proposed Inlet of Culvert Structure
.03
.03
.03
Legend
EG 50yr Storm Event
WS 50yr Storm Event
Crit 50yr Storm Event
Ground
Bank Sta
6932
6931
6930
6929
6928
6927
6926
6925
Elevation (ft)
0
10
20
30
40
Station (ft)

Proposed Outlet of Culvert Structure



Proposed Profile *HEC-RAS* Output



Standard Table of Proposed Cross Sections *HEC-RAS*

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
reach	182	50yr Storm Event	103	6926.06	6927.56		6927.66	0.0019	2.51	40.96	31.96	0.39
reach	157	50yr Storm Event	103	6925.93	6927.52	6926.78	6927.61	0.0016	2.41	42.69	31.73	0.37
reach	121		Culvert									
reach	66.5	50yr Storm Event	103	6925.47	6926.95		6927.06	0.0022	2.67	38.63	30.71	0.42
reach	60	50yr Storm Event	103	6925.44	6926.76		6927.02	0.0068	4.13	24.95	25.22	0.72
reach	30	50yr Storm Event	103	6924.76	6926.55	6926.19	6926.84	0.0054	4.30	24.10	20.93	0.66
reach	0	50yr Storm Event	103	6924.69	6926.03	6926.03	6926.55	0.0183	5.75	17.92	17.44	1.00

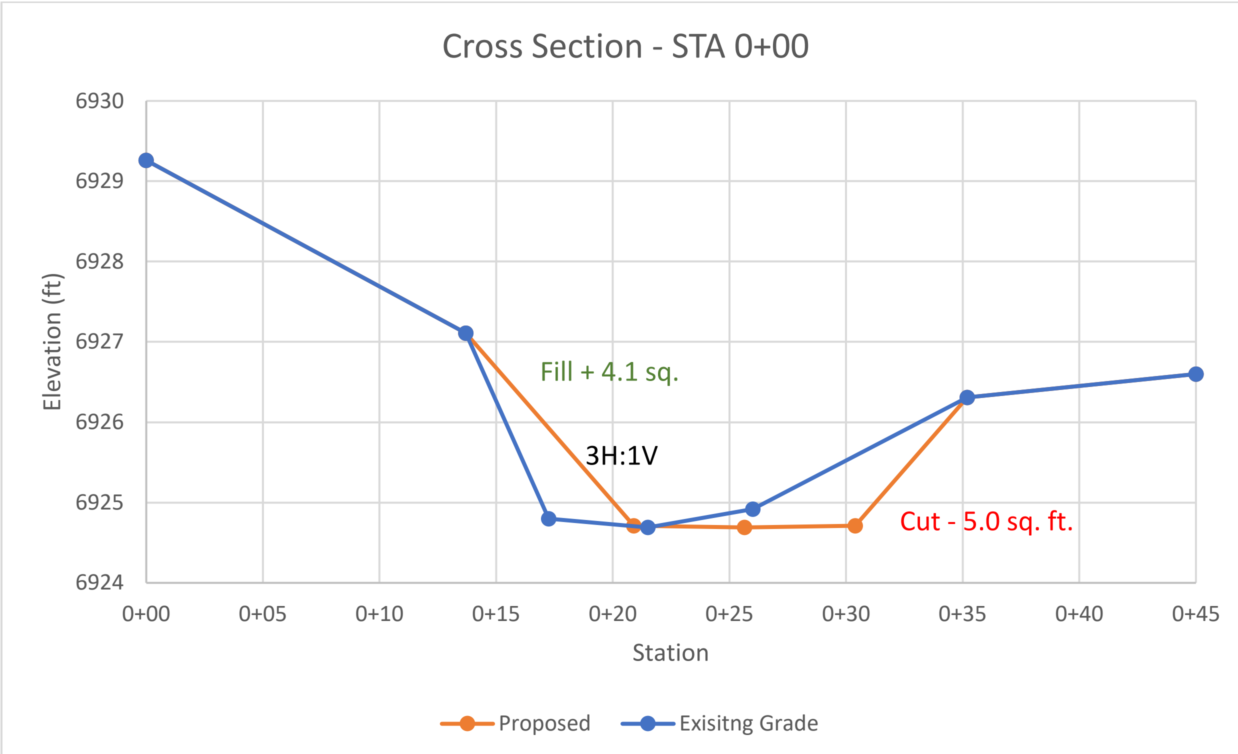
Culvert Table of Proposed Cross Sections *HEC-RAS*

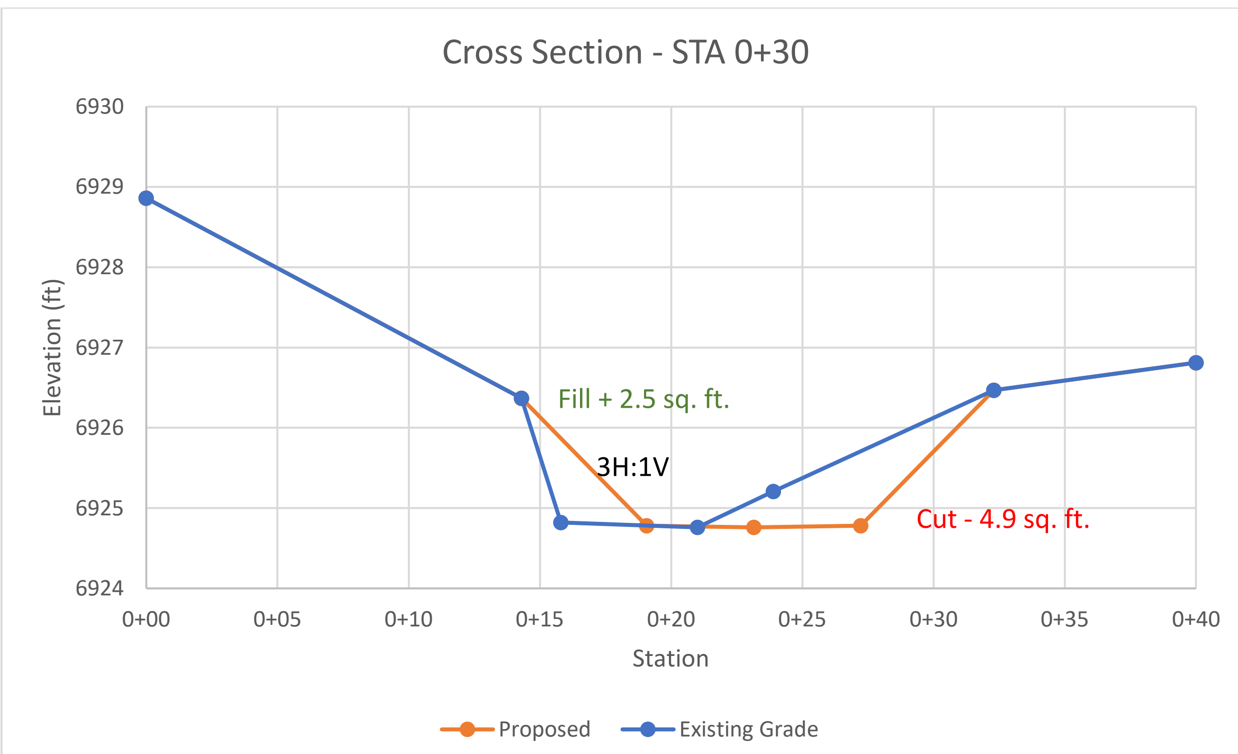
Reach	River Sta	Profile	E.G. US.	W.S. US.	E.G. IC	E.G. OC	Min El Weir Flow	Q Culv Group	Q Weir	Delta WS	Culv Vel US	Culv Vel DS
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(ft)	(ft/s)	(ft/s)
reach	121 Culvert	50yr Storm Event	6927.62	6927.52	6927.62	6927.64	6932.01	103.00		0.57	5.92	4.45

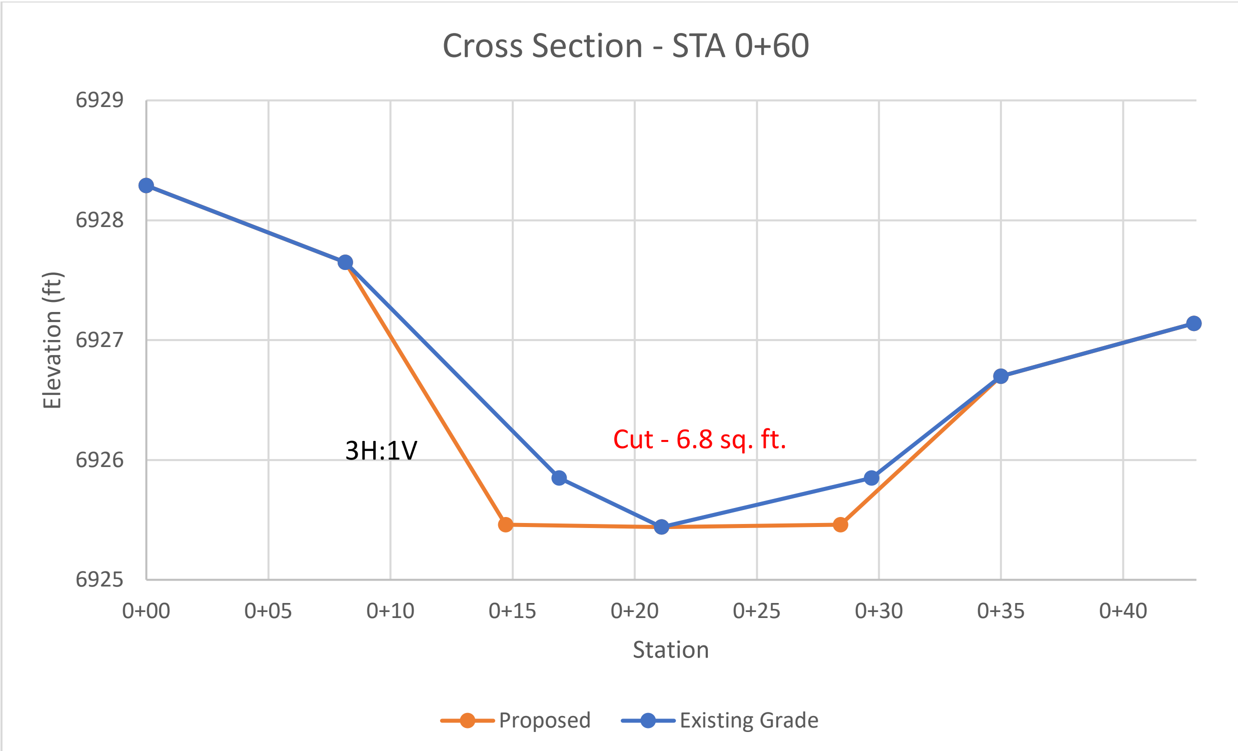
Appendix L: Cut & Fill Analysis for Hydraulic Structures

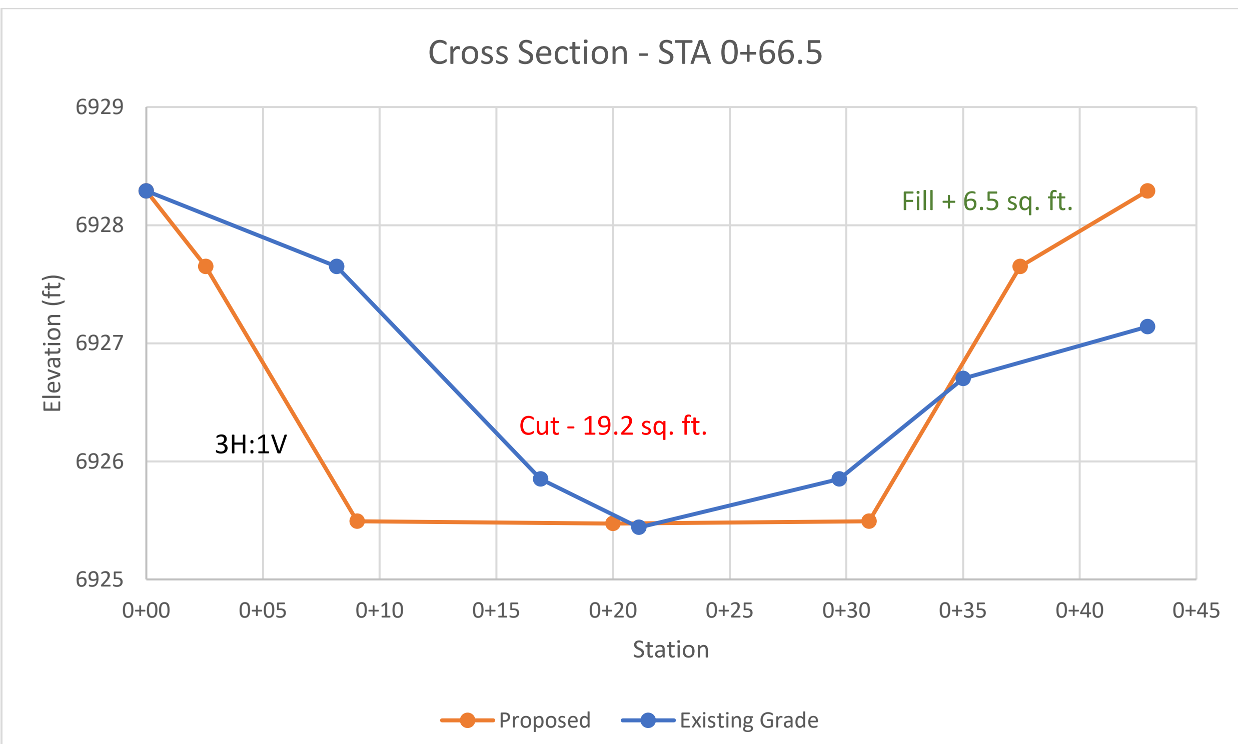
See the following pages for cut and fill analysis for hydraulic structures (culvert, channel, etc.).

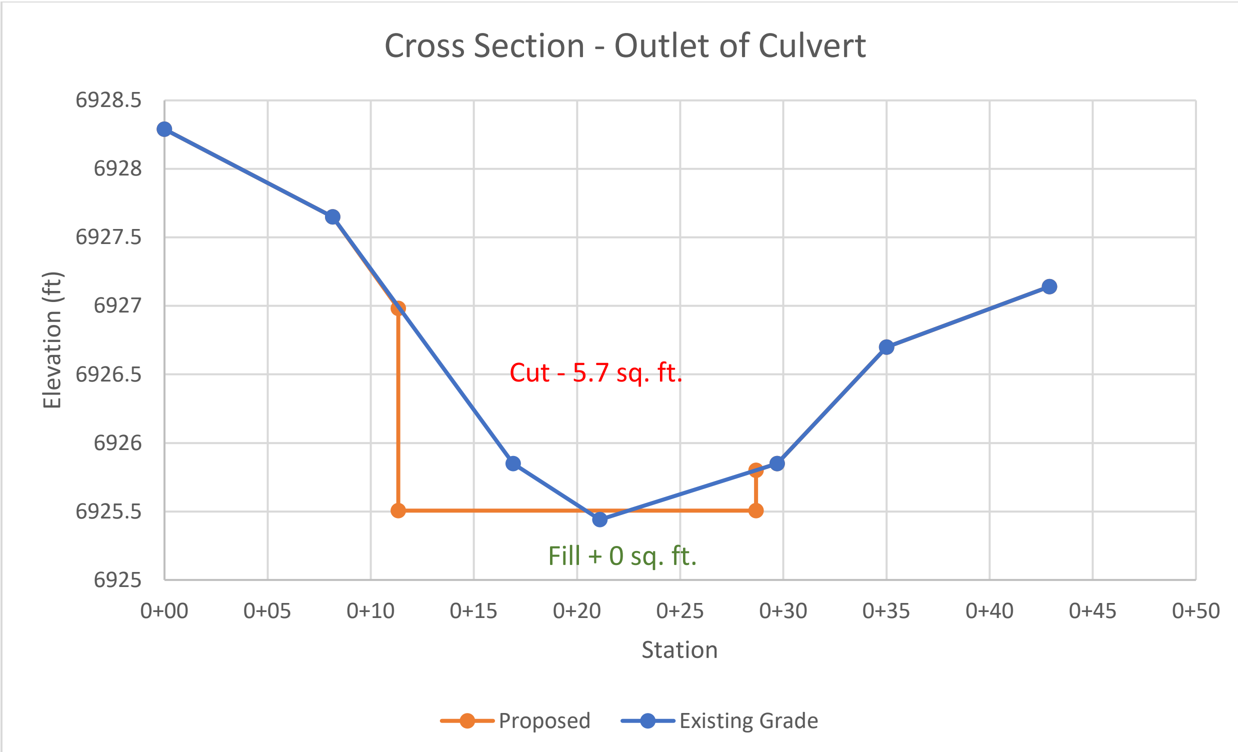
Earthwork (Cut/Fill) Analysis for Hydraulics and Channel:



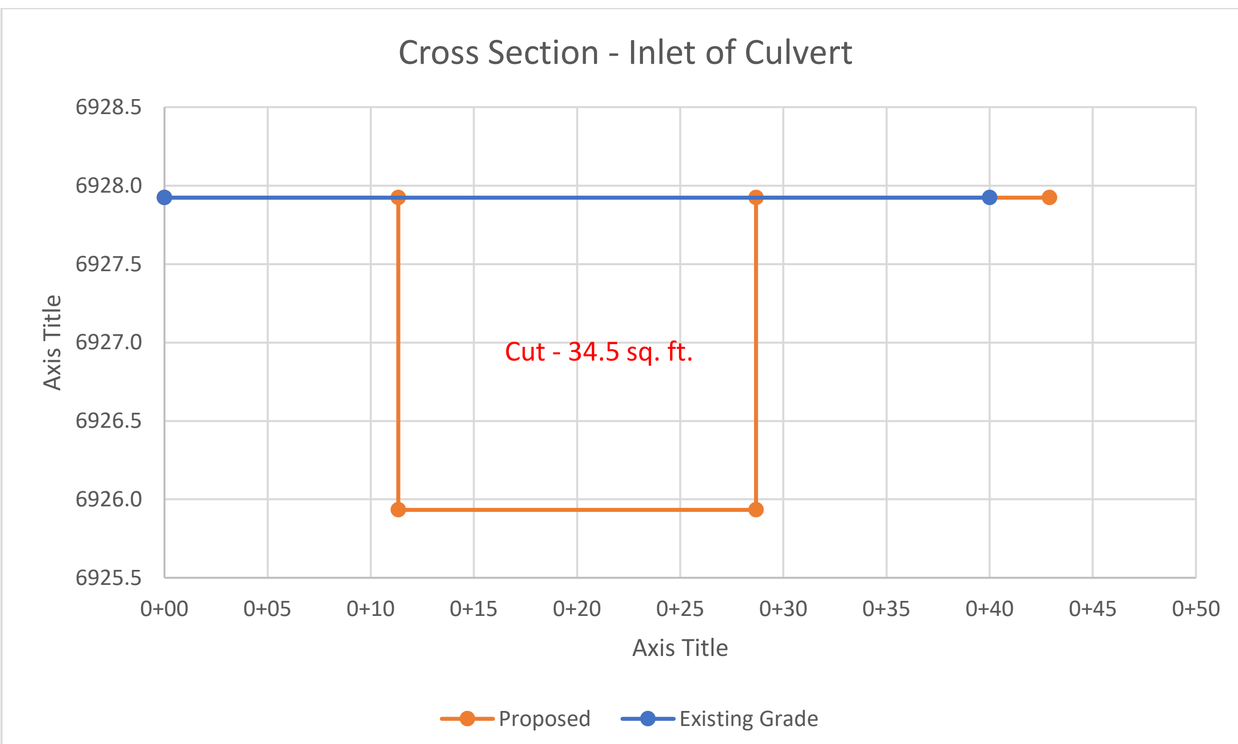



Cross Section - STA 0+60
6929
6928
6927
6926
6925
Elevation (ft)
3H:1V
Cut - 6.8 sq. ft.
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
Station
Proposed
Existing Grade

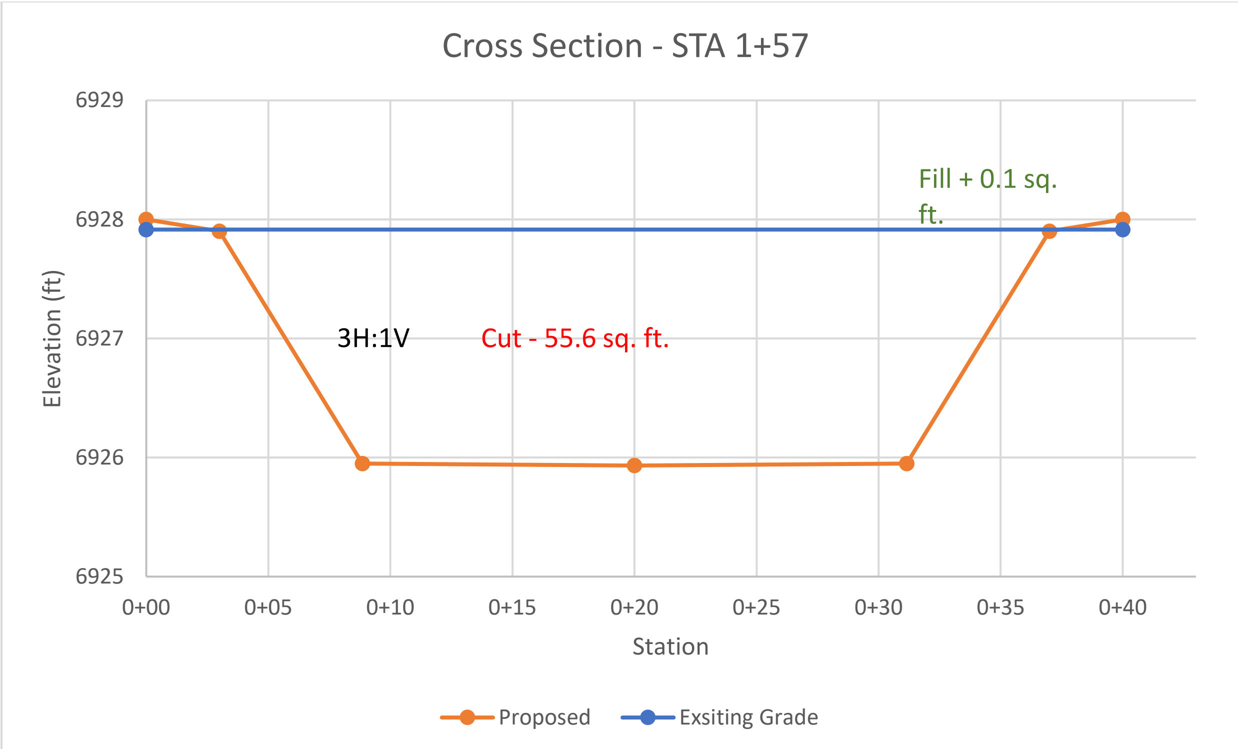

Cross Section - STA 0+66.5
6929
6928
6927
6926
6925
Elevation (ft)
Fill + 6.5 sq. ft.
3H:1V
Cut - 19.2 sq. ft.
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
Station
Proposed
Existing Grade

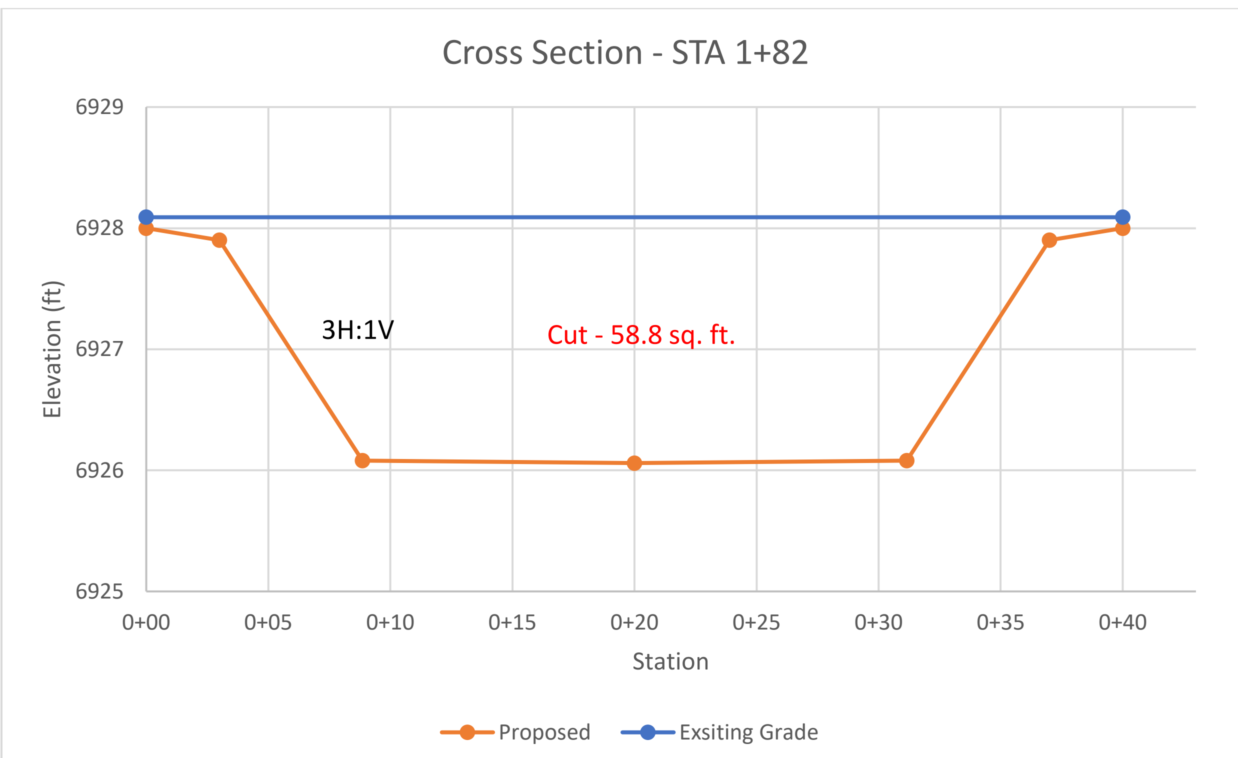


Cross Section - Outlet of Culvert
6928.5
6928
6927.5
6927
6926.5
6926
6925.5
6925
Elevation (ft)
Cut - 5.7 sq. ft.
Fill + 0 sq. ft.
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
Station
Proposed
Existing Grade



Cross Section - Inlet of Culvert
6928.5
6928.0
6927.5
6927.0
6926.5
6926.0
6925.5
Axis Title
Cut - 34.5 sq. ft.
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
Axis Title
Proposed
Existing Grade


Cross Section - STA 1+57
6929
6928
6927
6926
6925
Elevation (ft)
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
Station
Fill + 0.1 sq. ft.
3H:1V
Cut - 55.6 sq. ft.
Proposed
Exsiting Grade


Cross Section - STA 1+82
6929
6928
6927
6926
6925
Elevation (ft)
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
Station
3H:1V
Cut - 58.8 sq. ft.
Proposed
Exsiting Grade

<table>
<tr><th colspan="5">Channel Cut/Fill Analysis (cu. ft.)</th></tr>
<tr><td>Cross-Section</td><td colspan="2">Cut (-)</td><td colspan="2">Fill (+)</td></tr>
<tr><td>STA 0+00</td><td rowspan="3">326</td><td rowspan="2"></td><td rowspan="3">99</td><td rowspan="2"></td></tr>
<tr><td>STA 0+30</td></tr>
<tr><td>STA 0+60</td><td rowspan="2">85</td><td rowspan="2">21</td></tr>
<tr><td>STA 0+66.5</td><td rowspan="2">81</td><td rowspan="2">21</td></tr>
<tr><td>Outlet</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Inlet</td><td rowspan="2">329</td><td rowspan="2">0</td></tr>
<tr><td>STA 1+57</td><td rowspan="2">1429</td><td rowspan="2">1</td></tr>
<tr><td>STA 1+82</td><td></td><td></td></tr>
<tr><td>Total Cut:</td><td colspan="4">- 78 cu.yd.</td></tr>
</table>

Earth Work Calculations for Culvert		
Type	*Description*	*Cut/Fill Total (cu. yd.)*
Cut (-)	Excavation to place culvert	221.5
Cut (-)	Wingwall installation	8.4
Fill (+)	Fill wingwalls	19.3
Fill (+)	Fill above culvert to road	61.7
Fill (+)	Fill other parts of culvert	28
Total Cut:		**- 120.9 cu. yd.**

Cut/Fill Summary for Hydraulic	
Total Cut for Culvert	- 120.9 cu. yd.
Total Cut for Channel	- 78 cu.yd.
Summation of Total Cut	**- 198.9 cu.yd.**

Appendix M: Riprap Calculations

See the following pages for the riprap exiting the hydraulic structure.

Rectangular culvert:

$$\frac{\left(\frac{d_{50}}{H}\right)\left(\frac{Y_t}{H}\right)}{\frac{Q}{WH^{1.5}}} = 0.014 \qquad 11.3$$

d_{50} = median rock size, in feet,
D_c = culvert diameter, in feet,
Y_t = tailwater depth, in feet, and
Q = design peak discharge, in cfs.

Solving for d_{50}:

$$d_{50} = \frac{0.014QH^{0.5}}{WY_t} \qquad 11.4$$

where:

W = width of rectangular culvert, in feet, and
H = height of rectangular culvert, in feet.

Q (cfs)	W (ft)	H (ft)	Yt (ft)	Yn (ft)
103	16	3	1.48	1.48

d50 (ft)	0.105

$$H_a = \frac{(H + Y_n)}{2} \qquad 11.6$$

in which the maximum value of H_a shall not exceed H, and

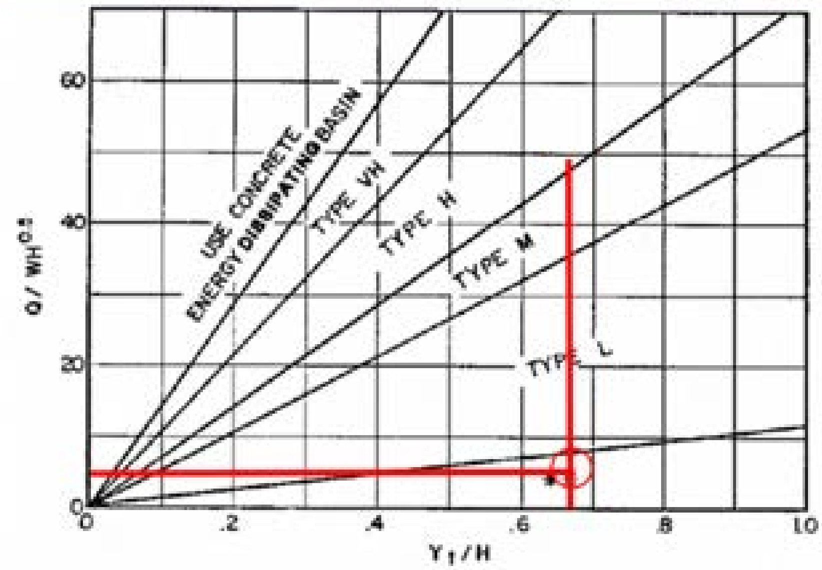
where:

D_a = parameter to use in place of D_c in Figure 11.2 when flow is supercritical,
D_c = diameter of circular culvert, in feet,
H_a = parameter to use in place of H in Figure 11.3 when flow is supercritical,
H = height of rectangular culvert, in feet, and
Y_n = normal depth of supercritical flow in the culvert.

Ha	2.24
Yt/H	0.660714
Q/WH^0.5	3.716692
Run length (ft)	9
Type L, D50 (in)	9

Figure 11.3 Riprap Protection at Rectangular Conduit Outlets

(from UDFCD, 2001)



Use H_c instead of H whenever culvert has supercritical flow in the barrel.
** Use Type L for a distance of 3H downstream.

Table 11.4 Classification and Gradation Of Ordinary Riprap

Table 11.4 Classification and Gradation Of Ordinary Riprap

Riprap Classification	D_{50} (inches)
Type VL	6
Type L	9
Type M	12
Type H	18
Type VH	24

Following Yavapai County's manual resulted in 9" stones at a run length of 9' that follows the width of the defined channel.

Appendix N: Construction Drawings

See the following sheets for the project's construction plans for the roadway and hydraulic structure.

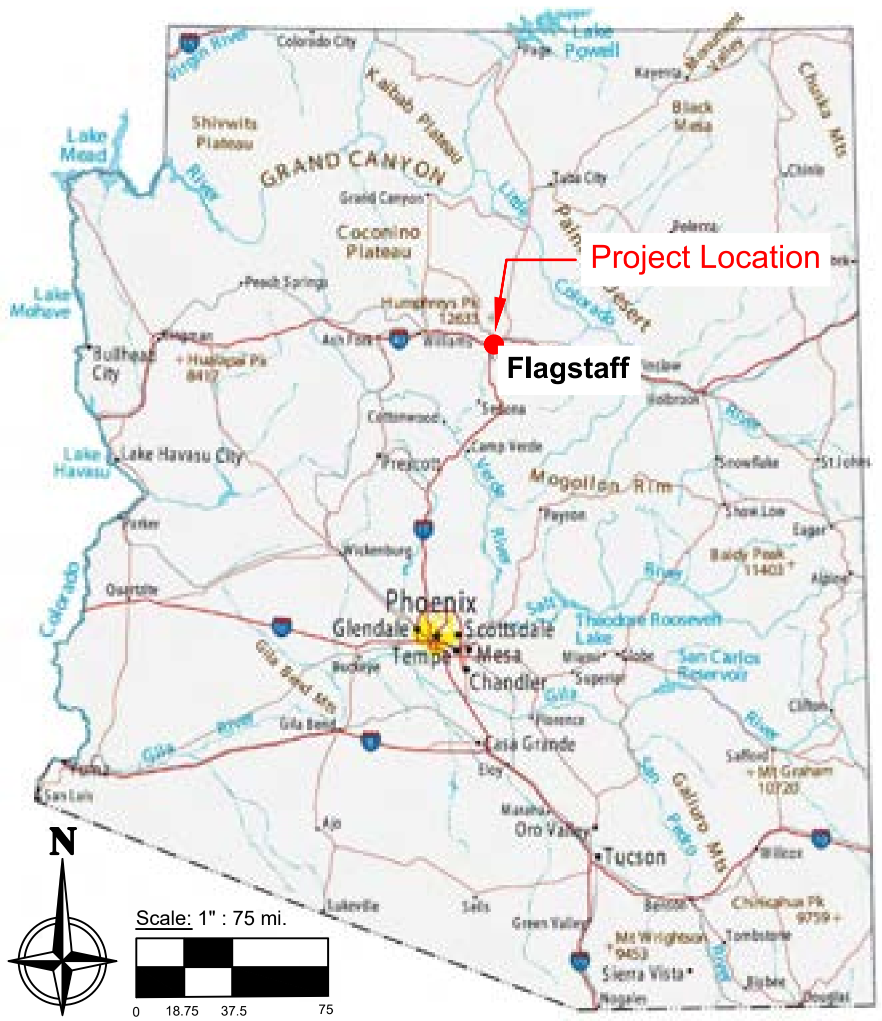
Construction Plans

for

John Wesley Powell Blvd. West Extension Design Project - City of Flagstaff

Located between
South Pulliam Drive & Lake Mary Road
West of Flagstaff, Arizona
35°8'39.39"N 111°40'44.25W & 35°9'14.02"N 111°39'26.14"

State Map of Arizona



Prepared for Jeff Baumen
PE, PTOE, Traffic Engineer, C.O.F

Cristine Aguila - Pavement Design Manager

Elijah Begay - Hydraulics Engineer

Logan McFarland - Head Engineer

Steven McKimmey - Highway Engineer

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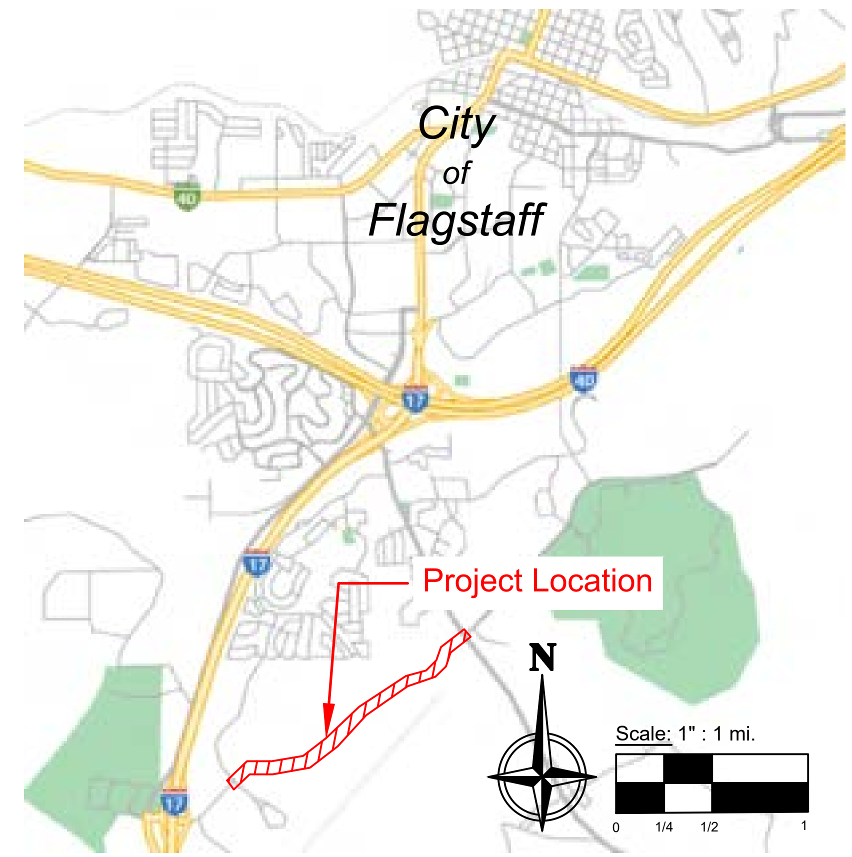
Vicinity Map: Flagstaff, Arizona



Sheet Index	
Sheet No.	**Description**
1	Cover Sheet
2	Roadway Cross Section
3	Typical Roadway Plan View
4	Vertical Profile with Alignment
5	Horizontal Alignments
6	Horizontal Alignments cont.
7	Horizontal Alignments cont.
8	Lake Mary Rd. and JWP Intersection
9	S. Pulliam Dr. and JWP Intersection
10	Culvert Structure Plan & Profile
11	Typical Inlet/Outlet of Culvert
12	Hydraulic Structure & JWP Blvd

JWP West Road Extension
Cover Sheet

SCALE: Varies
DATE: 4/25/2024
DRAWN: EAB
DESIGN: EAB
CHECKER: LSM

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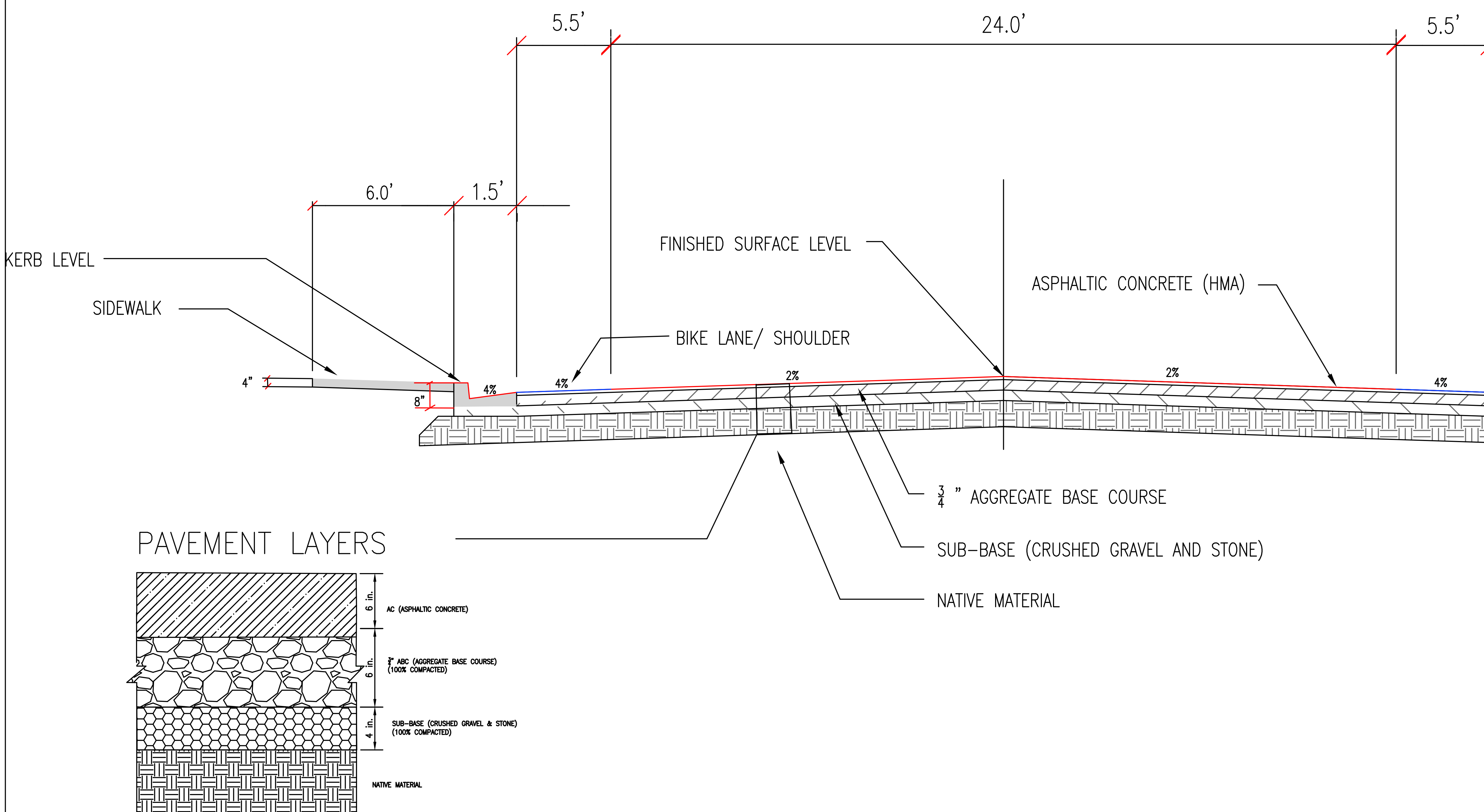
ROADWAY CROSS SECTION



FLAGSTAFF

ROADWAY

SCALE: 1' = 40'
DATE: 03/17/2024
DRAWN: CMA
DESIGN: CMA
CHECKER: SJM

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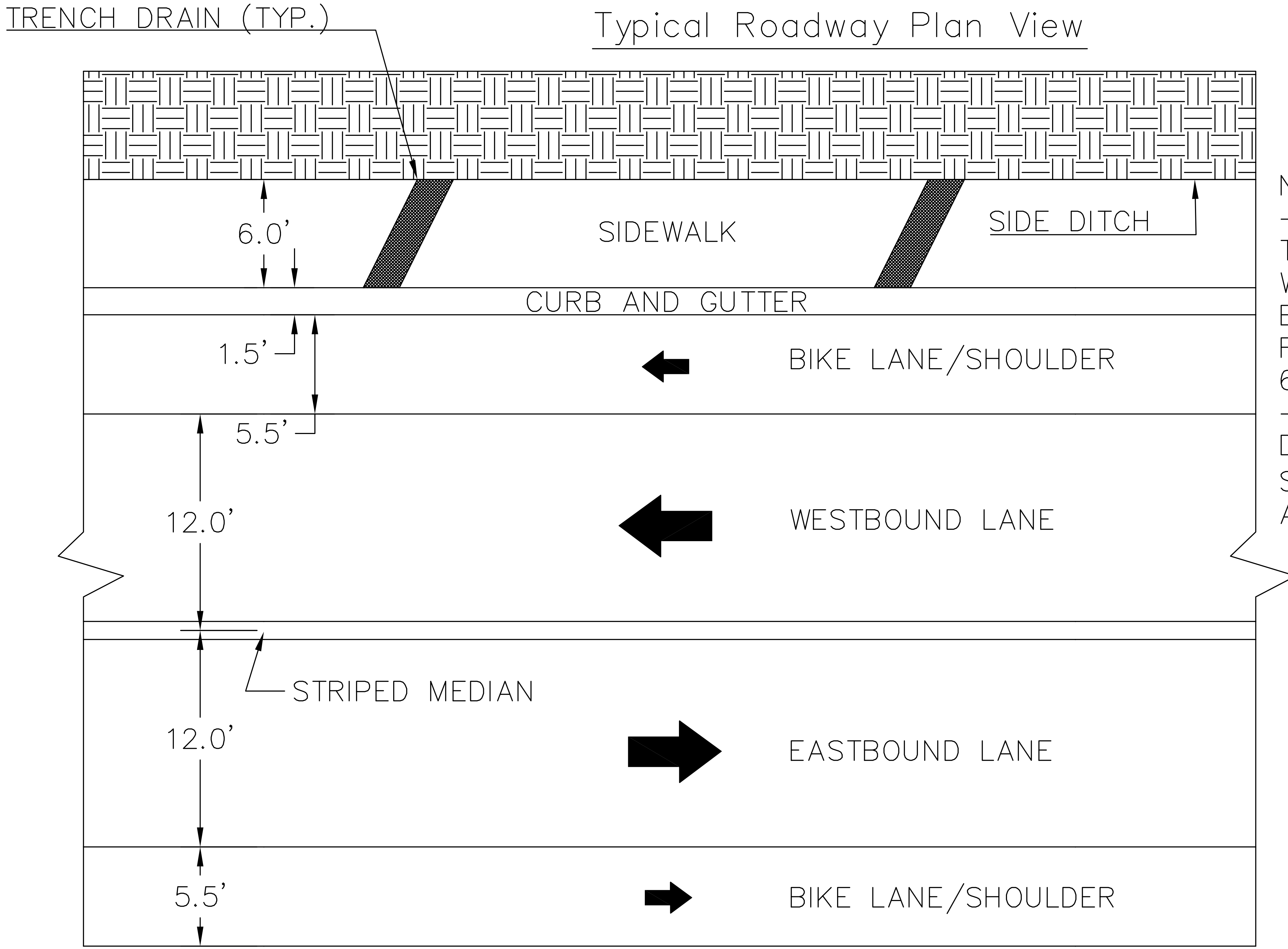
Typical Roadway Plan View



NOTES:
- SIDE DITCH IS TRAPEZIODAL WITH 3 FT. WIDE BOTTOM AND 3 FT. SIDES AT 6:1 SLOPES
- TRENCH DRAINS ARE SPACED 230' APART

N

JWP WEST EXT.

TYP. ROADWAY PLAN VIEW

SCALE: 1' = 6'
DATE: 04/14/2024
DRAWN: SJM
DESIGN: SJM
CHECKER: SJM

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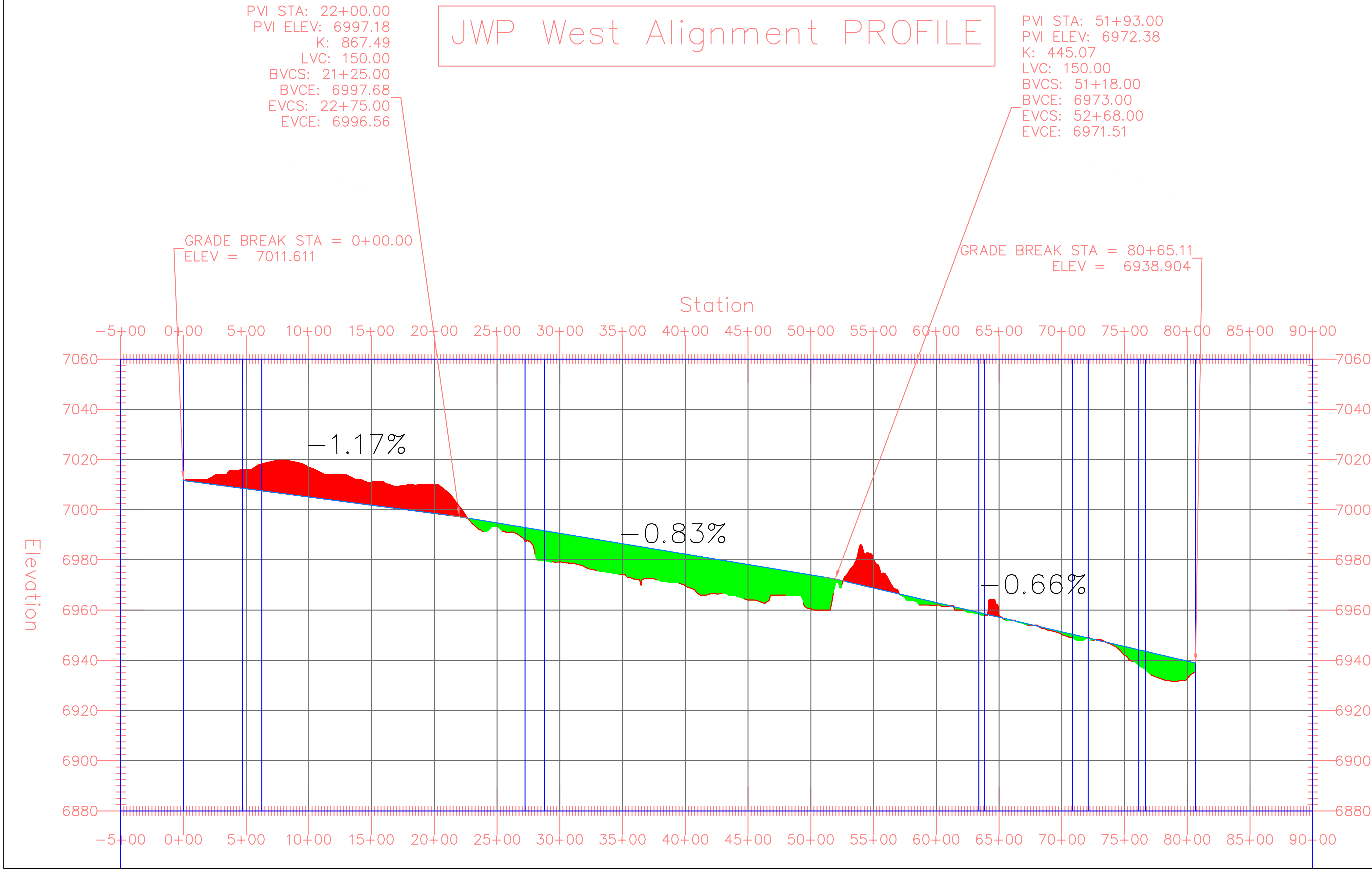
JWP West Alignment PROFILE



JWP WEST EXT.

Vertical Alignment Profile

SCALE: NTS
DATE: 04/14/2024
DRAWN: SJM
DESIGN: SJM
CHECKER: LSM

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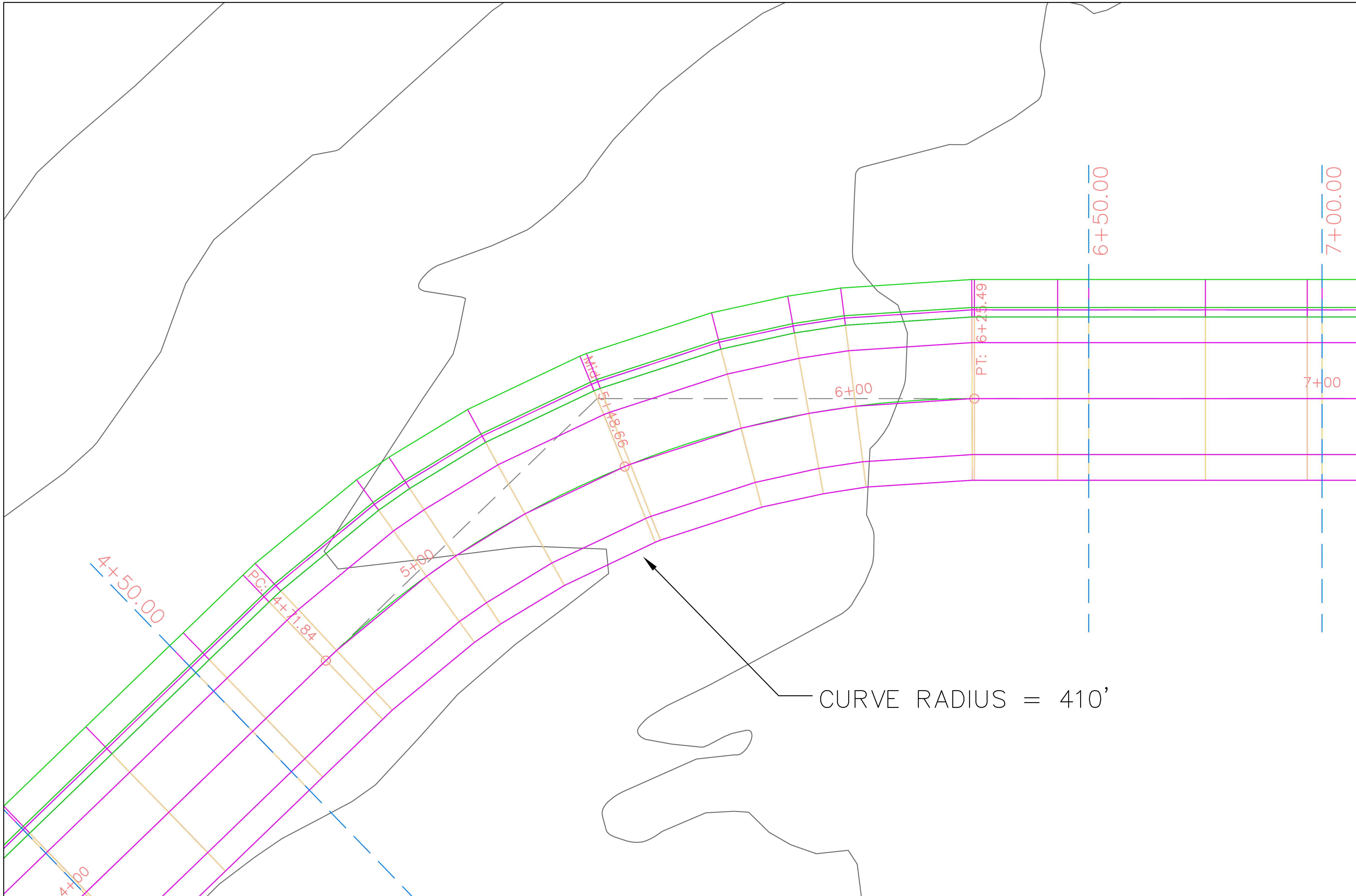

JWP WEST EXT.

HORIZONTAL ALIGNMENTS

SCALE: 1"= 20'
DATE: 5/6/2024
DRAWN: SJM
DESIGN: SJM
CHECKER: LSM

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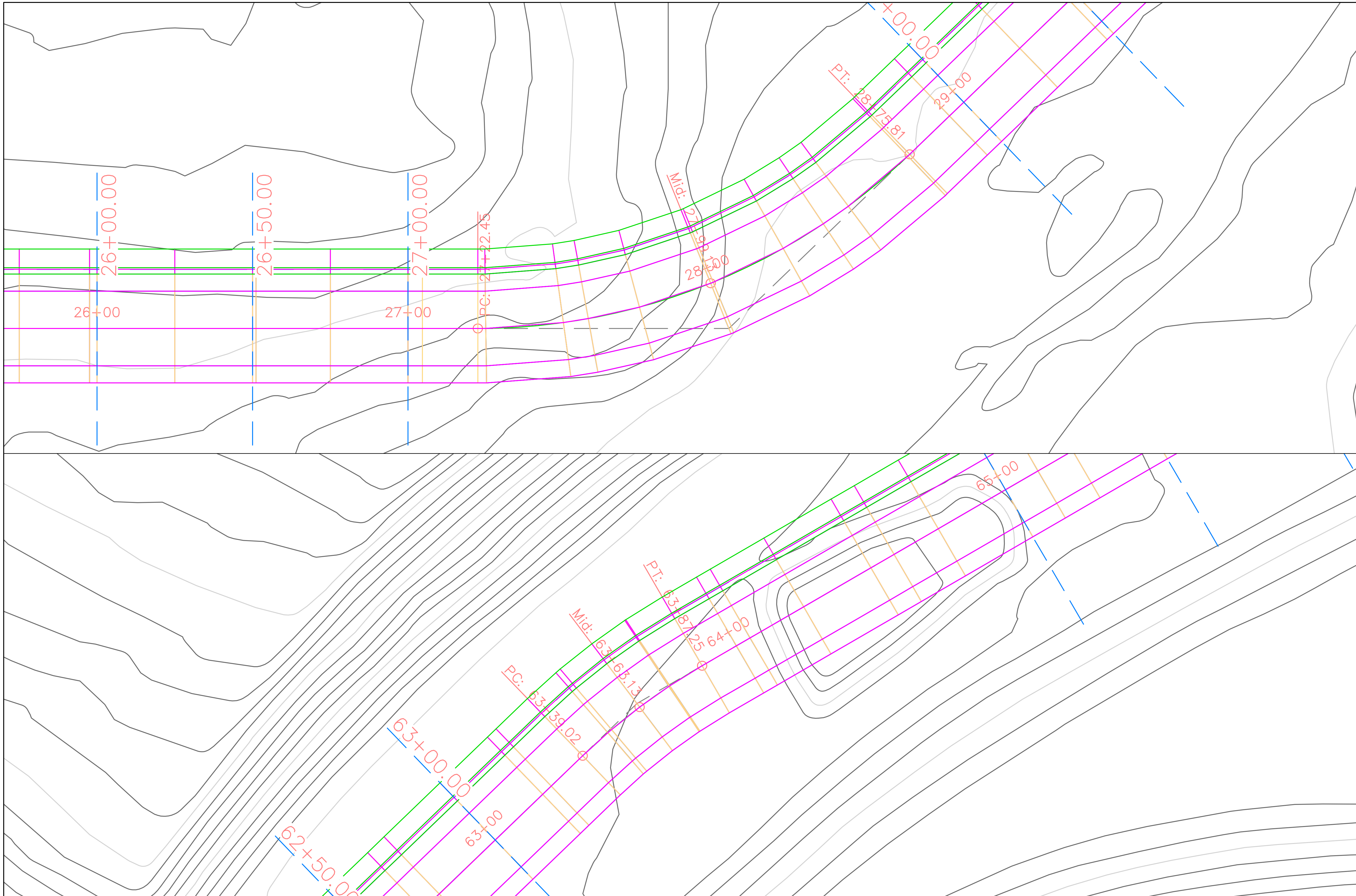
2			MBC
3			MBC

DRAWING NO.

SHT. NO 5 OF 12



JWP WEST EXT.

HORIZONTAL ALIGNMENTS

SCALE: 1"= 30'
DATE: 5/6/2024
DRAWN: SJM
DESIGN: SJM
CHECKER: LSM

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3			MBC

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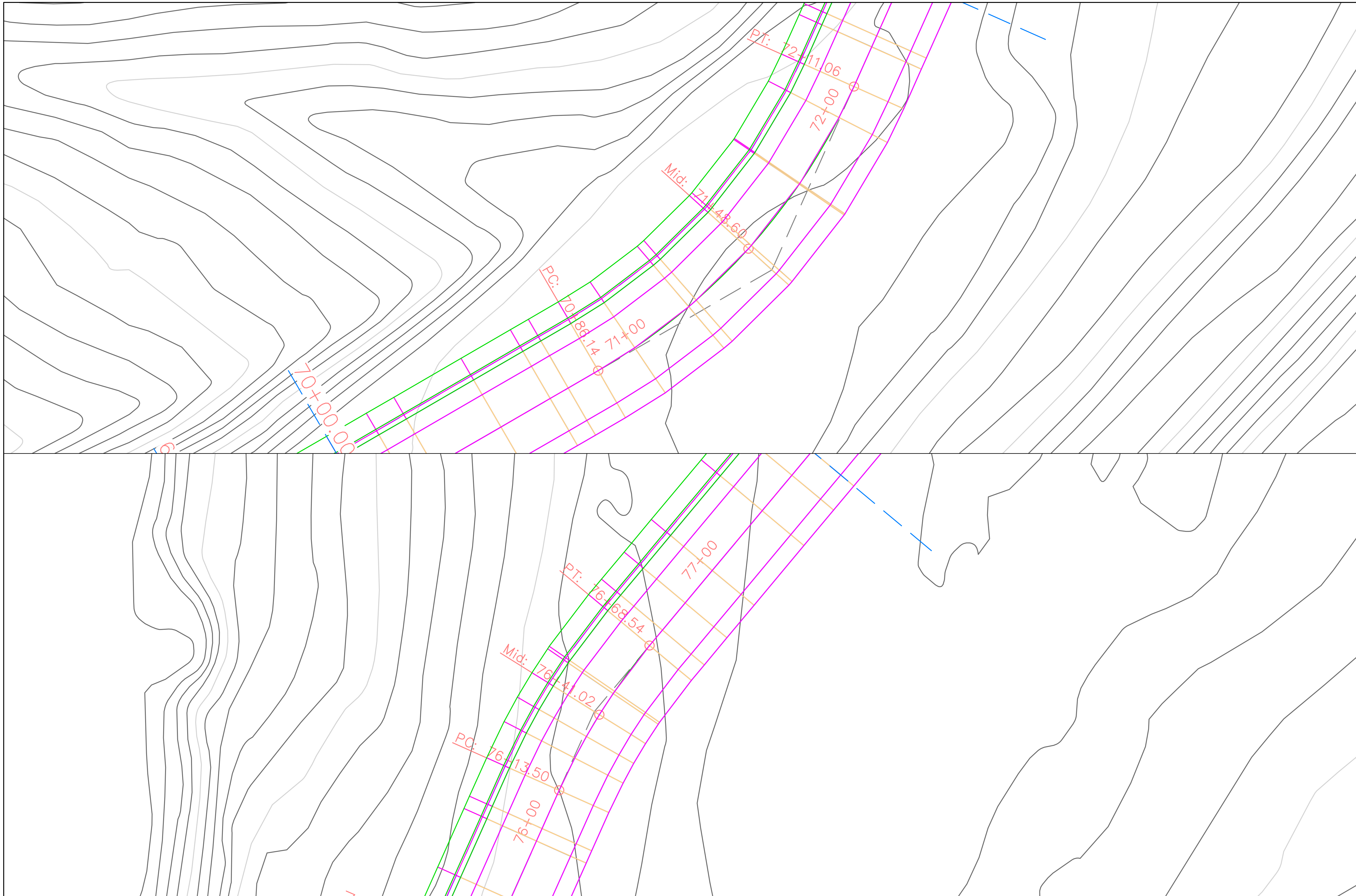

JWP WEST EXT.

HORIZONTAL ALIGNMENTS

SCALE: 1" = 30'
DATE: 5/6/2024
DRAWN: SJM
DESIGN: SJM
CHECKER: LSM

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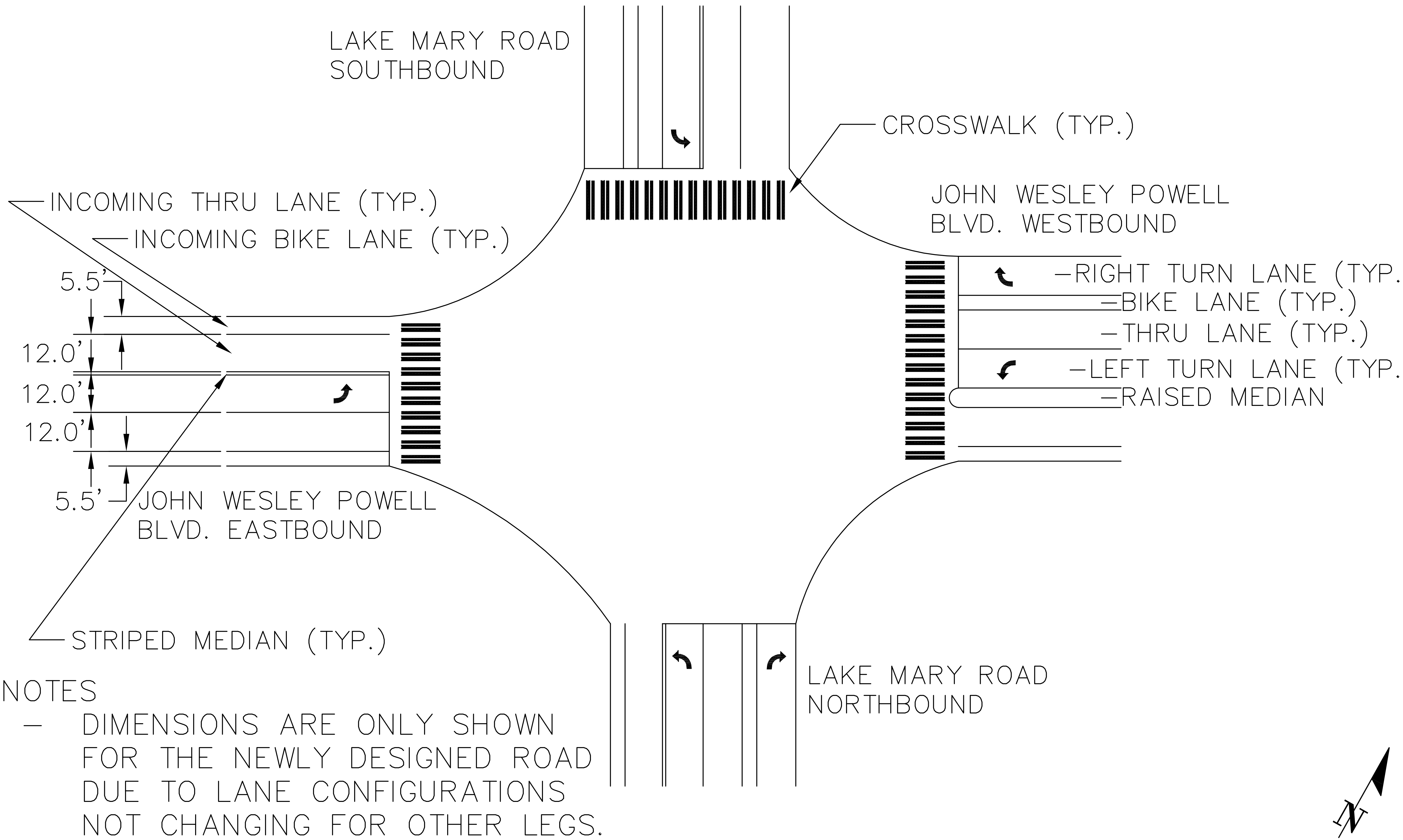
JWP BLVD. AND LAKE MARY RD.
INTERSECTION PLAN VIEW



NOTES

- DIMENSIONS ARE ONLY SHOWN FOR THE NEWLY DESIGNED ROAD DUE TO LANE CONFIGURATIONS NOT CHANGING FOR OTHER LEGS.

JWP WEST EXT.

JWP AND LAKE MARY

SCALE: 1' = 30'
DATE: 4/7/2024
DRAWN: SJM
DESIGN: SJM
CHECKER: LSM

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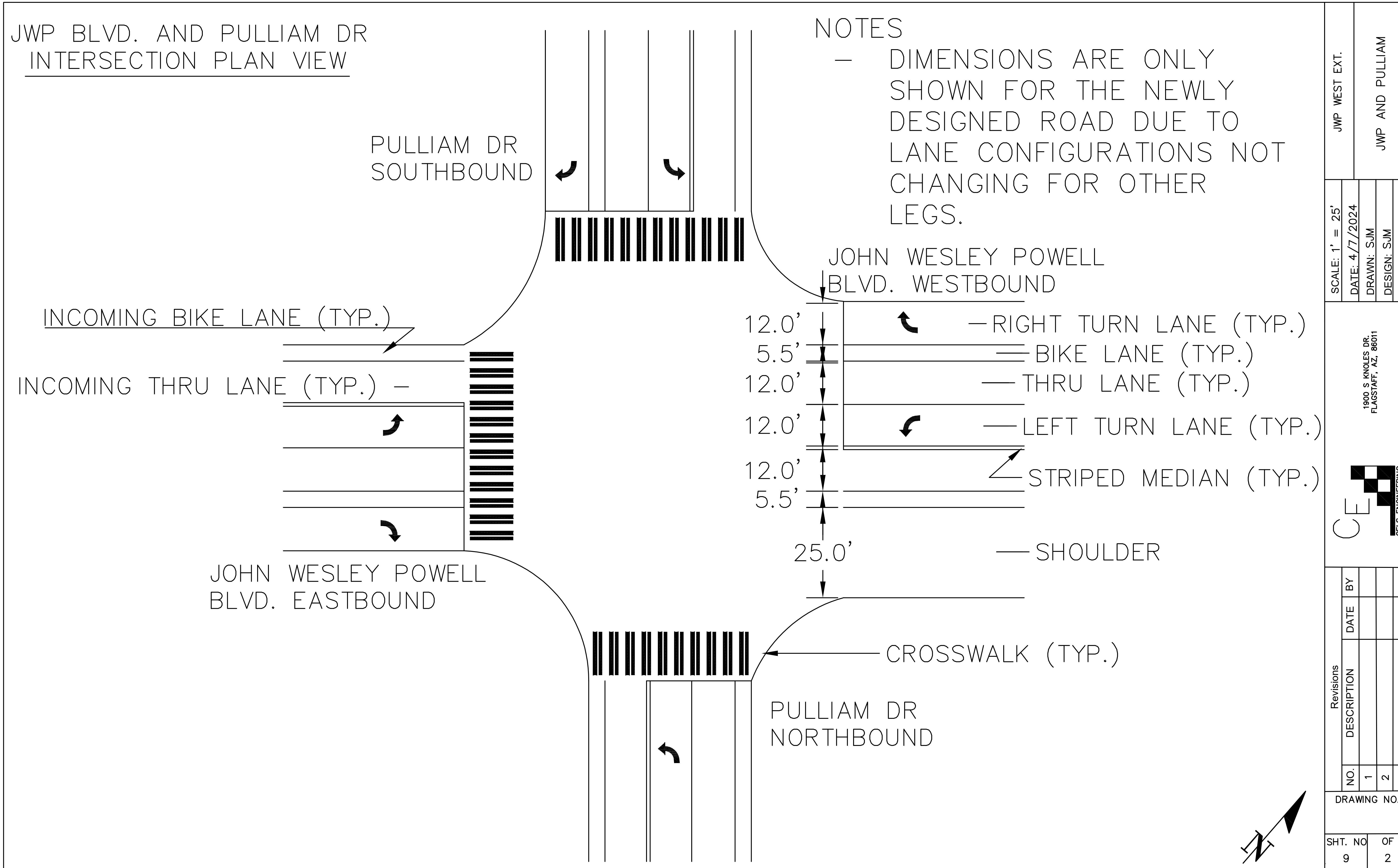
JWP BLVD. AND PULLIAM DR
INTERSECTION PLAN VIEW
NOTES
– DIMENSIONS ARE ONLY SHOWN FOR THE NEWLY DESIGNED ROAD DUE TO LANE CONFIGURATIONS NOT CHANGING FOR OTHER LEGS.
PULLIAM DR SOUTHBOUND
JOHN WESLEY POWELL BLVD. WESTBOUND
INCOMING BIKE LANE (TYP.)
INCOMING THRU LANE (TYP.)
12.0'
5.5'
12.0'
12.0'
12.0'
5.5'
25.0'
RIGHT TURN LANE (TYP.)
BIKE LANE (TYP.)
THRU LANE (TYP.)
LEFT TURN LANE (TYP.)
STRIPED MEDIAN (TYP.)
SHOULDER
JOHN WESLEY POWELL BLVD. EASTBOUND
CROSSWALK (TYP.)
PULLIAM DR NORTHBOUND
N
JWP WEST EXT.
JWP AND PULLIAM
SCALE: 1' = 25'
DATE: 4/7/2024
DRAWN: SJM
DESIGN: SJM
CHECKER: LSM
1900 S KNOLES DR.
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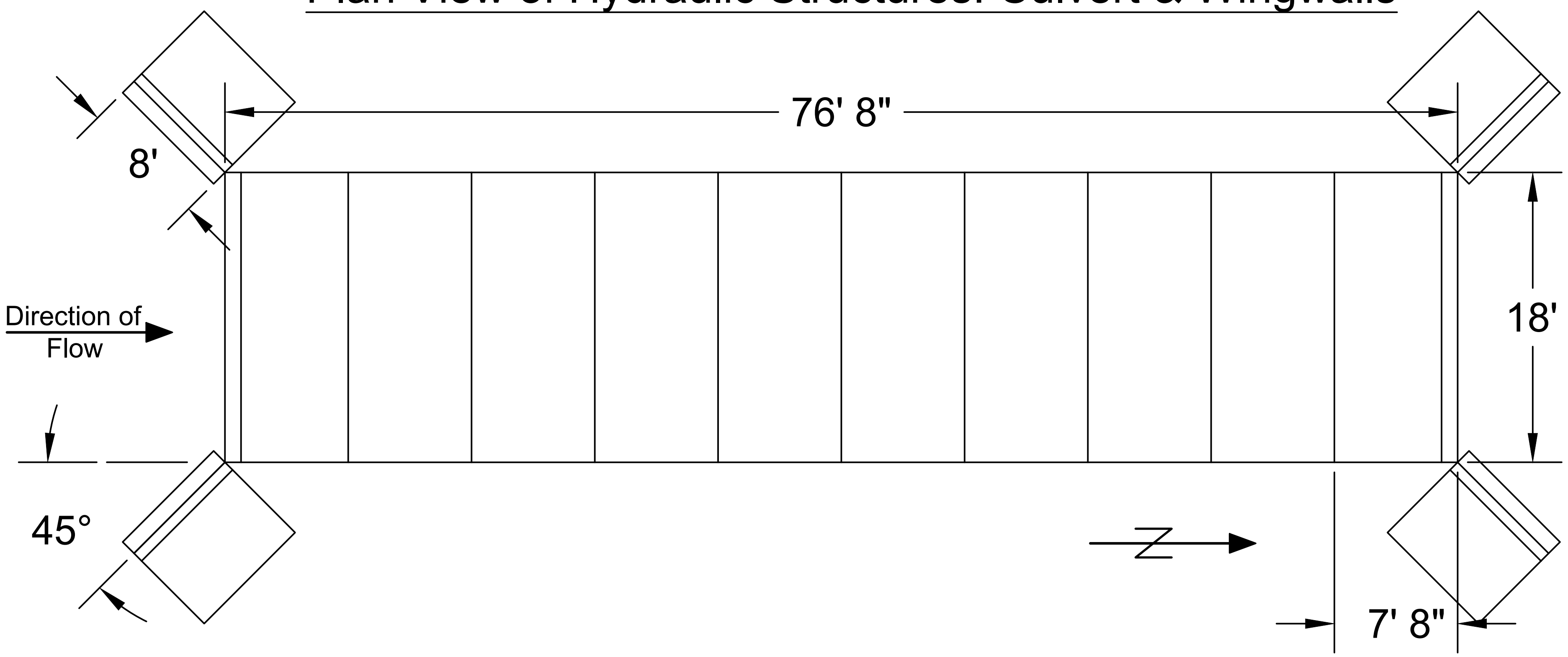
Plan View of Hydraulic Structures: Culvert & Wingwalls



Notes:

- 10 sections will be placed continuously to connect both up & downstream at a total run length of: 76' 8" (each typical section measures: 7' 8")
- Culvert structure will be sloped at -0.05% to ensure calculated flow is maintained.

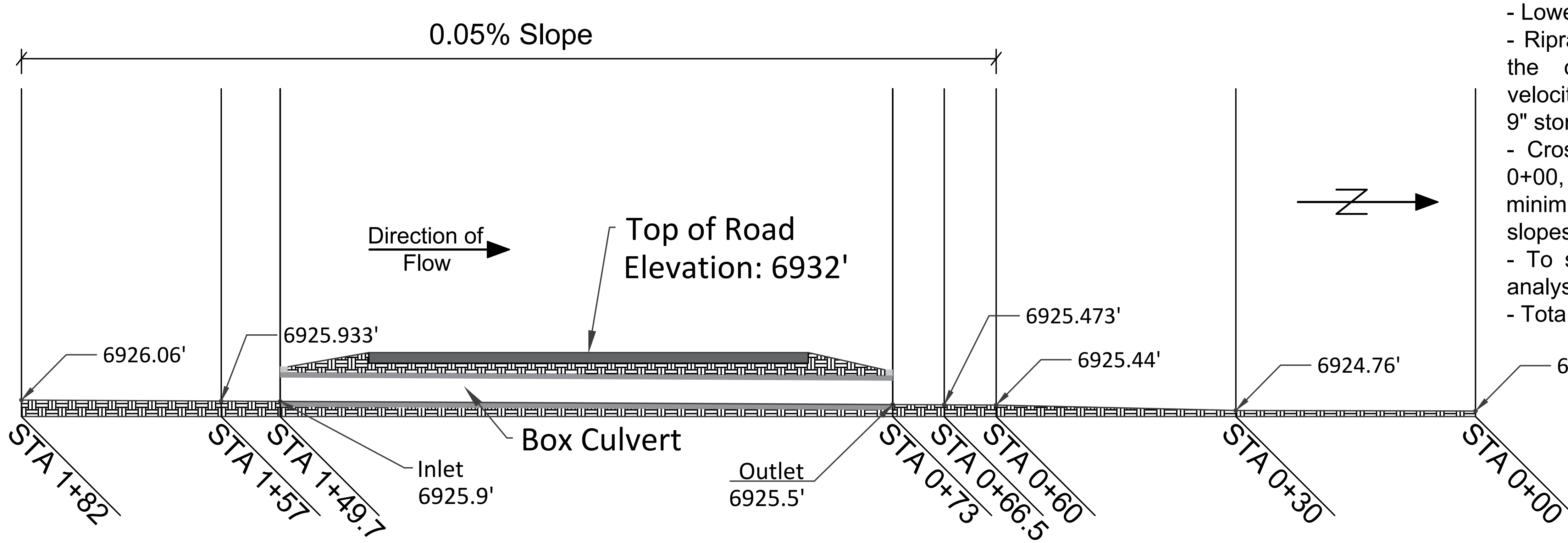
  Inlet Elevation: **6525.90 ft.**

  Outlet Elevation: **6925.51 ft.**
- Wingwalls are incorporated into as hydraulic structure. 4 walls will be used as a retaining wall, standing approximately equal to the top of the culvert. 2 walls are place both up & downstream. All walls will be flared 45° to the channel's flow direction. See next page for dimensions of wall.
- A headwall is incorporated into the design. It is placed at the top of the hydraulic structure to prevent excessive earth entering onto channel.

Scale: 1" : 10'

0 2½ 5 10

Profile of Hydraulic Structure & Channel



Notes:

- Section between STA 0+60 and STA 1+82, will be sloped at -0.05%.
- Top of road elevation is 6932 ft.
- Lowest height to fill above culvert is 14"
- Ripraps will be placed at the outlet of the culvert to maintain high flow velocities. A run apron length of 9' with 9" stones is requested.
- Cross Sections at downstream (STA 0+00, STA 0+30, & STA 0+60) will have minimum cut and maintain 3H:1V side slopes, for these sections see report.
- To see excavation sheets and cut/fill analysis, see report.
- Total earth removal: **198.9 cyd.**

Culvert Structure

Plan & Profile

SCALE: Varies

DATE: 4/25/2024

DRAWN: EAB

DESIGN: EAB & LSM

CHECKER: LSM

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DRAWING NO.

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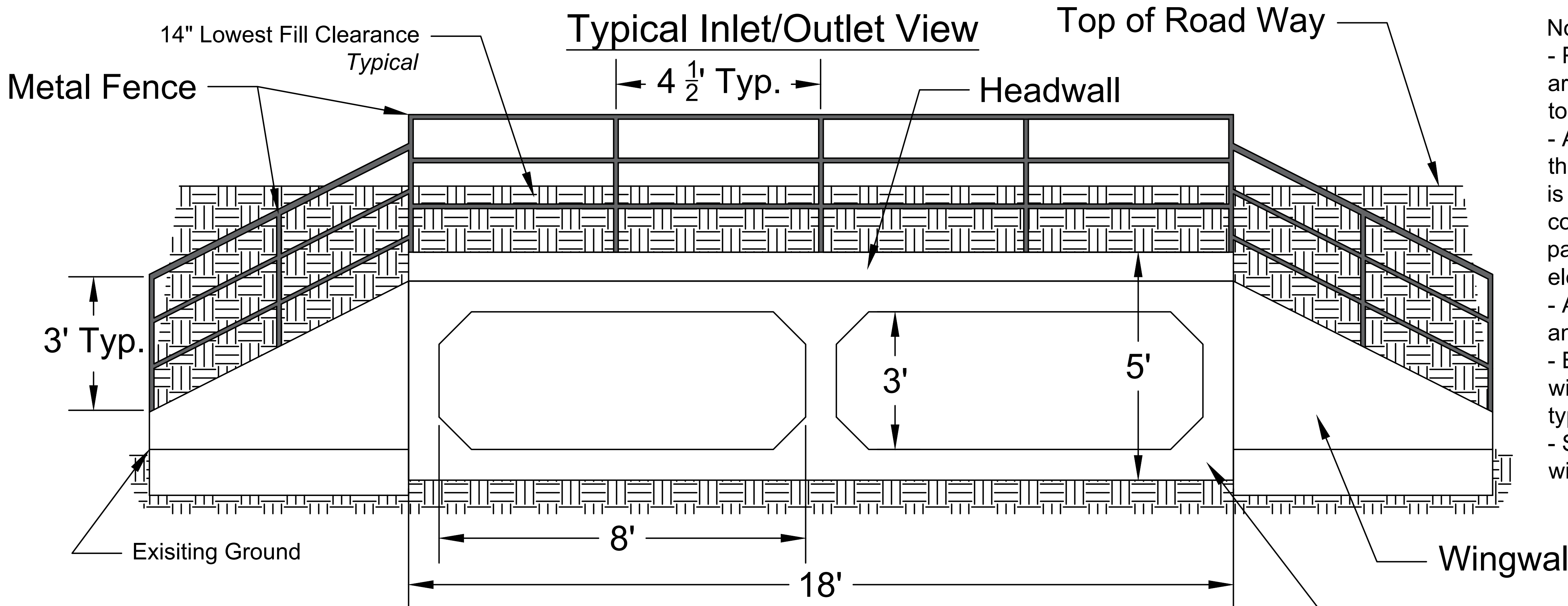
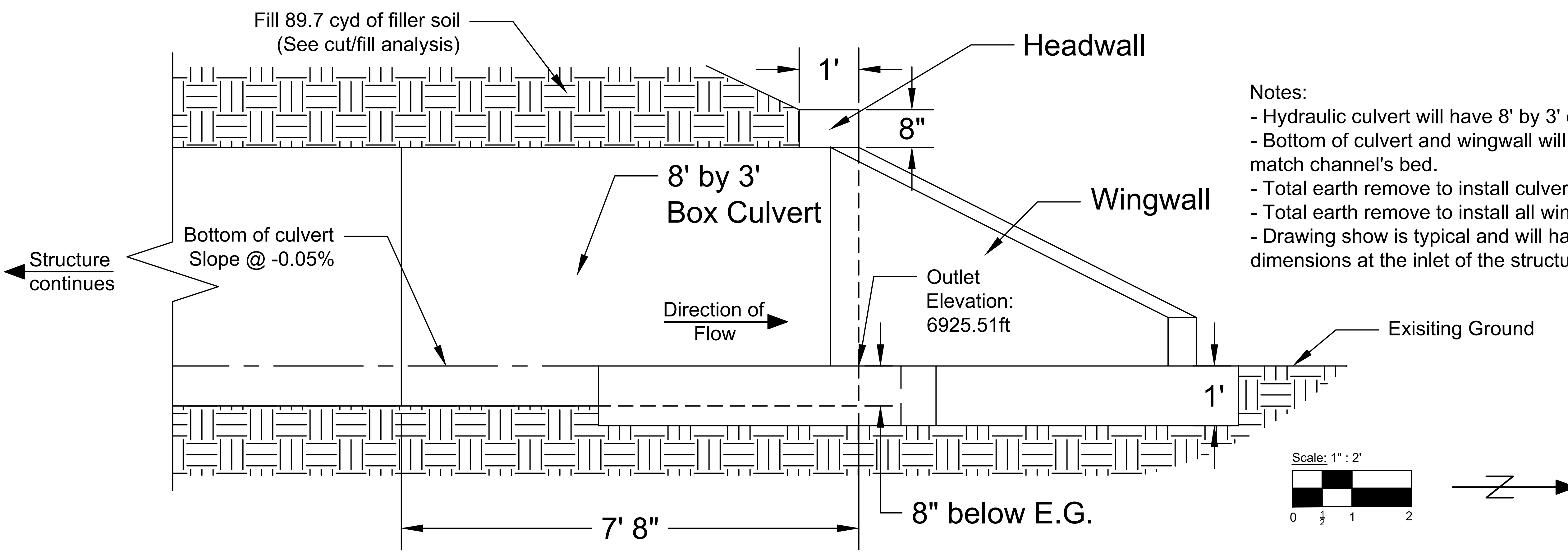
Typical Inlet/Outlet View



Notes:
- Precast concrete box culvert sections are pre-manufactured and will be planned to install onsite.
- A minimum fill of 14" is expected above the culvert, other heights will be more and is ensure that earth is filled and compacted correctly for the road pavement to be placed adequately at an elevation of 6932 ft.
- A metal fence will be posted on ends and top to ensure pedestrian safety.
- Both the inlet and outlet of the culvert will have the exact dimensions and are typical.
- See typical dimensions of culvert and wingwalls in design report.

Typical Elevation View of Hydraulic Structures



Notes:
- Hydraulic culvert will have 8' by 3' entrances/exit.
- Bottom of culvert and wingwall will be leveled to match channel's bed.
- Total earth remove to install culvert: 221.5 cyd
- Total earth remove to install all wingwall: 19.3 cyd
- Drawing show is typical and will have exact dimensions at the inlet of the structure.

Culvert Structure

TYP Inlet/Outet

SCALE: Varies
DATE: 4/25/2024
DRAWN: EAB
DESIGN: EAB & LSM
CHECKER: LSM

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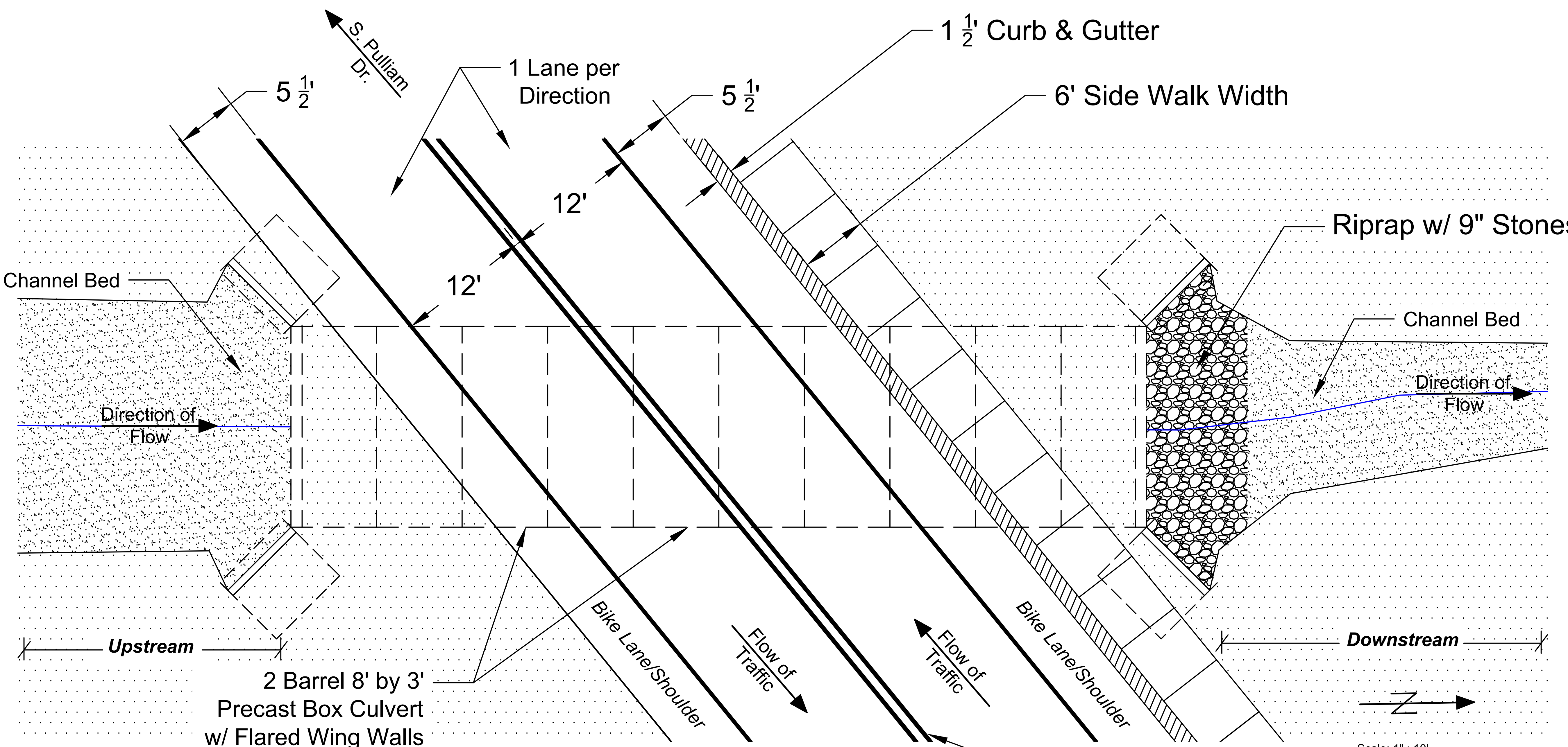
Hydraulic Structure & Proposed J.W.P Blvd.



Notes:

- Drawing is a composition of the hydraulic structure with the proposed J.W.P Blvd.
- Once culvert is installed onsite, further road construction of the J.W.P alignment can be continued
- See dimensions of hydraulic structures (i.e. culvert, wingwalls, headwalls) on sheet 10 & 11.
- Culvert will convey 50 year storm event: 103 cfs.
- A trapezoidal ditch will be incorporated into the final design, in which it will follow the road alignment and then channeling into the downstream of the system. See sheet 3 for ditch.
- J.W.P will a have typical cross section length of 42 1/2'
- Excavation will be done upstream to ease water flow in.

Composite Drawing

Hydraulic Structure & JWP

SCALE: Varies
DATE: 4/25/2024
DRAWN: EAB
DESIGN: EAB & LSM
CHECKER: LSM

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Appendix O: Intersections Design Reports

See the following pages for design reports generated from VISTRO Version 2021 (SP0-4).

Vistro File: C:\...\Lake Mary and JWP.vistro
Report File: C:\...\Intersection Reports.pdf

Scenario: Base Scenario
3/6/2024

Intersection Analysis Summary

ID	Intersection Name	Control Type	Method	Worst Mvmt	V/C	Delay (s/veh)	LOS
1	JWP and Lake Mary	Signalized	HCM 6th Edition	NB Thru	0.477	23.8	C
2	Pulliam Dr and JWP	Signalized	HCM 6th Edition	NB Left	0.478	12.1	B

V/C, Delay, LOS: For two-way stop, these values are taken from the movement with the worst (highest) delay value. For all other control types, they are taken for the whole intersection.

Intersection Level Of Service Report
Intersection 1: JWP and Lake Mary

Control Type:	Signalized	Delay (sec / veh):	23.8
Analysis Method:	HCM 6th Edition	Level Of Service:	C
Analysis Period:	15 minutes	Volume to Capacity (v/c):	0.477

Intersection Setup

Name	Lake Mary			Lake Mary			JWP			JWP		
Approach	Northbound			Southbound			Eastbound			Westbound		
Lane Configuration												
Turning Movement	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Lane Width [ft]	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
No. of Lanes in Entry Pocket	1	0	1	1	0	1	1	0	0	1	0	1
Entry Pocket Length [ft]	160.00	100.00	100.00	180.00	100.00	180.00	100.00	100.00	100.00	300.00	100.00	100.00
No. of Lanes in Exit Pocket	0	0	0	0	0	0	0	0	0	0	0	0
Exit Pocket Length [ft]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Speed [mph]	40.00			40.00			40.00			40.00		
Grade [%]	0.00			0.00			0.00			0.00		
Curb Present	No			No			No			No		
Crosswalk	No			Yes			Yes			Yes		

Volumes

Name	Lake Mary			Lake Mary			JWP			JWP		
Base Volume Input [veh/h]	45	100	65	350	150	158	200	164	50	40	333	425
Base Volume Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Heavy Vehicles Percentage [%]	4.00	2.00	2.00	2.00	2.00	4.00	4.00	4.00	2.00	2.00	4.00	2.00
Growth Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
In-Process Volume [veh/h]	0	0	0	0	0	0	0	0	0	0	0	0
Site-Generated Trips [veh/h]	0	0	0	0	0	0	0	0	0	0	0	0
Diverted Trips [veh/h]	0	0	0	0	0	0	0	0	0	0	0	0
Pass-by Trips [veh/h]	0	0	0	0	0	0	0	0	0	0	0	0
Existing Site Adjustment Volume [veh/h]	0	0	0	0	0	0	0	0	0	0	0	0
Other Volume [veh/h]	0	0	0	0	0	0	0	0	0	0	0	0
Right Turn on Red Volume [veh/h]	0	0	25	0	0	25	0	0	15	0	0	75
Total Hourly Volume [veh/h]	45	100	40	350	150	133	200	164	35	40	333	350
Peak Hour Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Other Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Total 15-Minute Volume [veh/h]	11	25	10	88	38	33	50	41	9	10	83	88
Total Analysis Volume [veh/h]	45	100	40	350	150	133	200	164	35	40	333	350
Presence of On-Street Parking	No		No	No		No	No		No	No		No
On-Street Parking Maneuver Rate [/h]	0	0	0	0	0	0	0	0	0	0	0	0
Local Bus Stopping Rate [/h]	0	0	0	0	0	0	0	0	0	0	0	0
v_do, Outbound Pedestrian Volume crossing	0			15			0			15		
v_di, Inbound Pedestrian Volume crossing m	0			15			0			15		
v_co, Outbound Pedestrian Volume crossing	0			15			15			0		
v_ci, Inbound Pedestrian Volume crossing mi	0			15			15			0		
v_ab, Corner Pedestrian Volume [ped/h]	0			0			0			0		
Bicycle Volume [bicycles/h]	0			0			0			0		

Intersection Settings

Located in CBD	No
Signal Coordination Group	-
Cycle Length [s]	100
Coordination Type	Time of Day Pattern Coordinated
Actuation Type	Fixed time
Offset [s]	0.0
Offset Reference	Lead Green - Beginning of First Green
Permissive Mode	SingleBand
Lost time [s]	0.00

Phasing & Timing

Control Type	ProtPer	Permiss	Permiss	ProtPer	Permiss	Permiss	ProtPer	Permiss	Permiss	ProtPer	Permiss	Permiss
Signal Group	1	6	0	5	2	0	3	8	0	7	4	0
Auxiliary Signal Groups												
Lead / Lag	Lead	-	-	Lead	-	-	Lead	-	-	Lead	-	-
Minimum Green [s]	6	6	0	6	6	0	6	6	0	6	6	0
Maximum Green [s]	30	30	0	30	30	0	30	30	0	30	30	0
Amber [s]	3.0	3.0	0.0	3.0	3.0	0.0	3.0	3.0	0.0	3.0	3.0	0.0
All red [s]	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0
Split [s]	10	32	0	13	35	0	10	45	0	10	45	0
Vehicle Extension [s]	3.0	3.0	0.0	3.0	3.0	0.0	3.0	3.0	0.0	3.0	3.0	0.0
Walk [s]	0	7	0	0	7	0	0	7	0	0	7	0
Pedestrian Clearance [s]	0	21	0	0	21	0	0	10	0	0	27	0
Delayed Vehicle Green [s]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rest In Walk		No			No			No			No	
I1, Start-Up Lost Time [s]	2.0	2.0	0.0	2.0	2.0	0.0	2.0	2.0	0.0	2.0	2.0	0.0
I2, Clearance Lost Time [s]	2.0	2.0	0.0	2.0	2.0	0.0	2.0	2.0	0.0	2.0	2.0	0.0
Minimum Recall	No	No		No	No		No	No		No	No	
Maximum Recall	No	No		No	No		No	No		No	No	
Pedestrian Recall	No	No		No	No		No	No		No	No	
Detector Location [ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Detector Length [ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I, Upstream Filtering Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Exclusive Pedestrian Phase

Pedestrian Signal Group	0
Pedestrian Walk [s]	0
Pedestrian Clearance [s]	0

Lane Group Calculations

Lane Group	L	C	R	L	C	R	L	C	L	C	R
C, Cycle Length [s]	100	100	100	100	100	100	100	100	100	100	100
L, Total Lost Time per Cycle [s]	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
l1_p, Permitted Start-Up Lost Time [s]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
l2, Clearance Lost Time [s]	0.00	2.00	2.00	0.00	2.00	2.00	0.00	2.00	0.00	2.00	2.00
g_i, Effective Green Time [s]	41	28	28	41	31	31	51	41	51	41	41
g / C, Green / Cycle	0.41	0.28	0.28	0.41	0.31	0.31	0.51	0.41	0.51	0.41	0.41
(v / s)_i Volume / Saturation Flow Rate	0.03	0.05	0.03	0.25	0.08	0.09	0.17	0.11	0.03	0.18	0.23
s, saturation flow rate [veh/h]	1322	1870	1589	1425	1870	1488	1143	1785	1277	1840	1531
c, Capacity [veh/h]	576	524	445	639	580	461	556	732	671	754	628
d1, Uniform Delay [s]	18.05	27.38	26.59	22.68	25.88	26.02	14.61	19.59	12.56	21.25	22.32
k, delay calibration	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
I, Upstream Filtering Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
d2, Incremental Delay [s]	0.26	0.81	0.40	3.35	1.08	1.57	1.81	0.92	0.17	1.87	3.55
d3, Initial Queue Delay [s]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rp, platoon ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
PF, progression factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Lane Group Results

X, volume / capacity	0.08	0.19	0.09	0.55	0.26	0.29	0.36	0.27	0.06	0.44	0.56
d, Delay for Lane Group [s/veh]	18.32	28.19	26.99	26.03	26.96	27.59	16.41	20.51	12.73	23.12	25.87
Lane Group LOS	B	C	C	C	C	C	B	C	B	C	C
Critical Lane Group	No	Yes	No	Yes	No	No	Yes	No	No	No	Yes
50th-Percentile Queue Length [veh/ln]	0.65	1.88	0.73	6.28	2.76	2.50	2.60	3.11	0.45	5.70	6.48
50th-Percentile Queue Length [ft/ln]	16.13	46.95	18.33	157.01	68.88	62.56	64.97	77.74	11.30	142.47	161.91
95th-Percentile Queue Length [veh/ln]	1.16	3.38	1.32	10.39	4.96	4.50	4.68	5.60	0.81	9.61	10.65
95th-Percentile Queue Length [ft/ln]	29.03	84.52	32.99	259.76	123.99	112.61	116.94	139.92	20.34	240.34	266.26

Movement, Approach, & Intersection Results

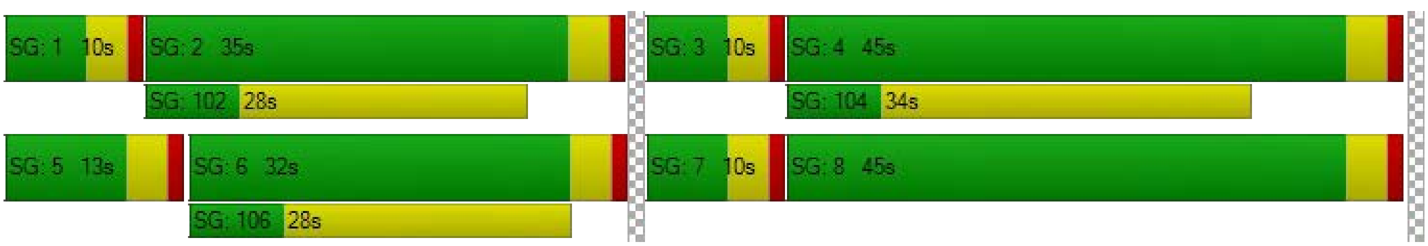
d_M, Delay for Movement [s/veh]	18.32	28.19	26.99	26.03	26.96	27.59	16.41	20.51	20.51	12.73	23.12	25.87
Movement LOS	B	C	C	C	C	C	B	C	C	B	C	C
d_A, Approach Delay [s/veh]	25.53			26.58			18.46			23.88		
Approach LOS	C			C			B			C		
d_I, Intersection Delay [s/veh]	23.80											
Intersection LOS	C											
Intersection V/C	0.477											

Other Modes

g_Walk,mi, Effective Walk Time [s]	0.0	11.0	11.0	11.0
M_corner, Corner Circulation Area [ft²/ped]	0.00	0.00	0.00	0.00
M_CW, Crosswalk Circulation Area [ft²/ped]	0.00	176.77	256.50	0.00
d_p, Pedestrian Delay [s]	0.00	39.61	39.61	39.61
I_p,int, Pedestrian LOS Score for Intersection	0.000	2.743	2.399	2.859
Crosswalk LOS	F	B	B	C
s_b, Saturation Flow Rate of the bicycle lane	2000	2000	2000	2000
c_b, Capacity of the bicycle lane [bicycles/h]	560	620	820	820
d_b, Bicycle Delay [s]	25.92	23.81	17.41	17.41
I_b,int, Bicycle LOS Score for Intersection	0.834	1.573	1.171	1.804
Bicycle LOS	A	A	A	A

Sequence

Ring 1	1	2	3	4	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	5	6	7	8	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-



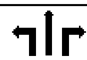
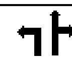
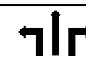
Generated with PTV VISTRO

Version 2021 (SP 0-4)

Intersection Level Of Service Report
Intersection 2: Pulliam Dr and JWP

Control Type:	Signalized	Delay (sec / veh):	12.1
Analysis Method:	HCM 6th Edition	Level Of Service:	B
Analysis Period:	15 minutes	Volume to Capacity (v/c):	0.478

Intersection Setup

Name	Pulliam			Pulliam			JWP			JWP		
Approach	Northbound			Southbound			Eastbound			Westbound		
Lane Configuration												
Turning Movement	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Lane Width [ft]	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
No. of Lanes in Entry Pocket	1	0	1	1	0	1	1	0	0	1	0	1
Entry Pocket Length [ft]	250.00	100.00	410.00	240.00	100.00	150.00	150.00	100.00	100.00	150.00	100.00	150.00
No. of Lanes in Exit Pocket	0	0	0	0	0	0	0	0	0	0	0	0
Exit Pocket Length [ft]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Speed [mph]	40.00			40.00			40.00			40.00		
Grade [%]	0.00			0.00			0.00			0.00		
Curb Present	No			No			No			No		
Crosswalk	Yes			Yes			No			No		

Volumes

Name	Pulliam			Pulliam			JWP			JWP		
Base Volume Input [veh/h]	125	30	95	90	20	70	400	325	75	25	350	125
Base Volume Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Heavy Vehicles Percentage [%]	2.00	2.00	4.00	4.00	2.00	2.00	2.00	6.00	2.00	3.00	4.00	3.00
Growth Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
In-Process Volume [veh/h]	0	0	0	0	0	0	0	0	0	0	0	0
Site-Generated Trips [veh/h]	0	0	0	0	0	0	0	0	0	0	0	0
Diverted Trips [veh/h]	0	0	0	0	0	0	0	0	0	0	0	0
Pass-by Trips [veh/h]	0	0	0	0	0	0	0	0	0	0	0	0
Existing Site Adjustment Volume [veh/h]	0	0	0	0	0	0	0	0	0	0	0	0
Other Volume [veh/h]	0	0	0	0	0	0	0	0	0	0	0	0
Right Turn on Red Volume [veh/h]	0	0	0	0	0	0	0	0	0	0	0	0
Total Hourly Volume [veh/h]	125	30	95	90	20	70	400	325	75	25	350	125
Peak Hour Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Other Adjustment Factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Total 15-Minute Volume [veh/h]	31	8	24	23	5	18	100	81	19	6	88	31
Total Analysis Volume [veh/h]	125	30	95	90	20	70	400	325	75	25	350	125
Presence of On-Street Parking	No		No	No		No	No		No	No		No
On-Street Parking Maneuver Rate [/h]	0	0	0	0	0	0	0	0	0	0	0	0
Local Bus Stopping Rate [/h]	0	0	0	0	0	0	0	0	0	0	0	0
v_do, Outbound Pedestrian Volume crossing		0			0			0			0	
v_di, Inbound Pedestrian Volume crossing m		0			0			0			0	
v_co, Outbound Pedestrian Volume crossing		0			0			0			0	
v_ci, Inbound Pedestrian Volume crossing mi		0			0			0			0	
v_ab, Corner Pedestrian Volume [ped/h]		0			0			0			0	
Bicycle Volume [bicycles/h]		0			0			0			0	

Intersection Settings

Located in CBD	No
Signal Coordination Group	-
Cycle Length [s]	60
Coordination Type	Time of Day Pattern Coordinated
Actuation Type	Semi-actuated
Offset [s]	0.0
Offset Reference	Lead Green - Beginning of First Green
Permissive Mode	SingleBand
Lost time [s]	0.00

Phasing & Timing

Control Type	Permiss	Overlap	Permiss	Permiss	Permiss	Permiss	Permiss	Permiss	Permiss	Permiss	Permiss	Permiss
Signal Group	0	8	0	0	4	0	0	2	0	0	6	0
Auxiliary Signal Groups		8										
Lead / Lag	-	-	-	-	-	-	-	-	-	-	-	-
Minimum Green [s]	0	15	0	0	15	0	0	6	0	0	6	0
Maximum Green [s]	0	30	0	0	30	0	0	30	0	0	30	0
Amber [s]	0.0	3.0	0.0	0.0	3.0	0.0	0.0	3.0	0.0	0.0	3.0	0.0
All red [s]	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0
Split [s]	0	19	0	0	19	0	0	41	0	0	41	0
Vehicle Extension [s]	0.0	3.0	0.0	0.0	3.0	0.0	0.0	3.0	0.0	0.0	3.0	0.0
Walk [s]	0	7	0	0	7	0	0	7	0	0	7	0
Pedestrian Clearance [s]	0	10	0	0	10	0	0	14	0	0	14	0
Delayed Vehicle Green [s]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rest In Walk		No			No			No			No	
I1, Start-Up Lost Time [s]	0.0	2.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0
I2, Clearance Lost Time [s]	0.0	2.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0
Minimum Recall		No			No			No			No	
Maximum Recall		No			No			No			No	
Pedestrian Recall		No			No			No			No	
Detector Location [ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Detector Length [ft]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I, Upstream Filtering Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Exclusive Pedestrian Phase

Pedestrian Signal Group	0
Pedestrian Walk [s]	0
Pedestrian Clearance [s]	0

Lane Group Calculations

Lane Group	L	C	R	L	C	R	L	C	L	C	R
C, Cycle Length [s]	60	60	60	60	60	60	60	60	60	60	60
L, Total Lost Time per Cycle [s]	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
l1_p, Permitted Start-Up Lost Time [s]	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00	2.00	0.00	0.00
l2, Clearance Lost Time [s]	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
g_i, Effective Green Time [s]	15	15	15	15	15	15	37	37	37	37	37
g / C, Green / Cycle	0.25	0.25	0.25	0.25	0.25	0.25	0.62	0.62	0.62	0.62	0.62
(v / s)_i Volume / Saturation Flow Rate	0.09	0.02	0.06	0.07	0.01	0.04	0.39	0.23	0.03	0.19	0.08
s, saturation flow rate [veh/h]	1392	1870	1564	1357	1870	1589	1031	1752	977	1840	1577
c, Capacity [veh/h]	408	462	386	395	462	393	631	1085	585	1140	977
d1, Uniform Delay [s]	20.75	17.28	18.11	20.44	17.19	17.79	12.47	5.63	8.45	5.36	4.72
k, delay calibration	0.11	0.11	0.11	0.11	0.11	0.11	0.50	0.50	0.50	0.50	0.50
I, Upstream Filtering Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
d2, Incremental Delay [s]	0.42	0.06	0.33	0.29	0.04	0.21	4.80	0.96	0.14	0.70	0.27
d3, Initial Queue Delay [s]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rp, platoon ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
PF, progression factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Lane Group Results

X, volume / capacity	0.31	0.06	0.25	0.23	0.04	0.18	0.63	0.37	0.04	0.31	0.13
d, Delay for Lane Group [s/veh]	21.17	17.34	18.43	20.73	17.23	18.00	17.27	6.59	8.59	6.06	4.99
Lane Group LOS	C	B	B	C	B	B	B	A	A	A	A
Critical Lane Group	Yes	No	No	No	No	No	Yes	No	No	No	No
50th-Percentile Queue Length [veh/ln]	1.41	0.29	0.97	0.99	0.19	0.70	4.15	1.84	0.16	1.52	0.48
50th-Percentile Queue Length [ft/ln]	35.16	7.21	24.19	24.80	4.78	17.46	103.72	46.08	4.01	37.88	12.00
95th-Percentile Queue Length [veh/ln]	2.53	0.52	1.74	1.79	0.34	1.26	7.47	3.32	0.29	2.73	0.86
95th-Percentile Queue Length [ft/ln]	63.29	12.99	43.54	44.65	8.61	31.43	186.70	82.94	7.22	68.19	21.59

Movement, Approach, & Intersection Results

d_M, Delay for Movement [s/veh]	21.17	17.34	18.43	20.73	17.23	18.00	17.27	6.59	6.59	8.59	6.06	4.99
Movement LOS	C	B	B	C	B	B	B	A	A	A	A	A
d_A, Approach Delay [s/veh]	19.67			19.28			11.93			5.92		
Approach LOS	B			B			B			A		
d_I, Intersection Delay [s/veh]	12.08											
Intersection LOS	B											
Intersection V/C	0.478											

Other Modes

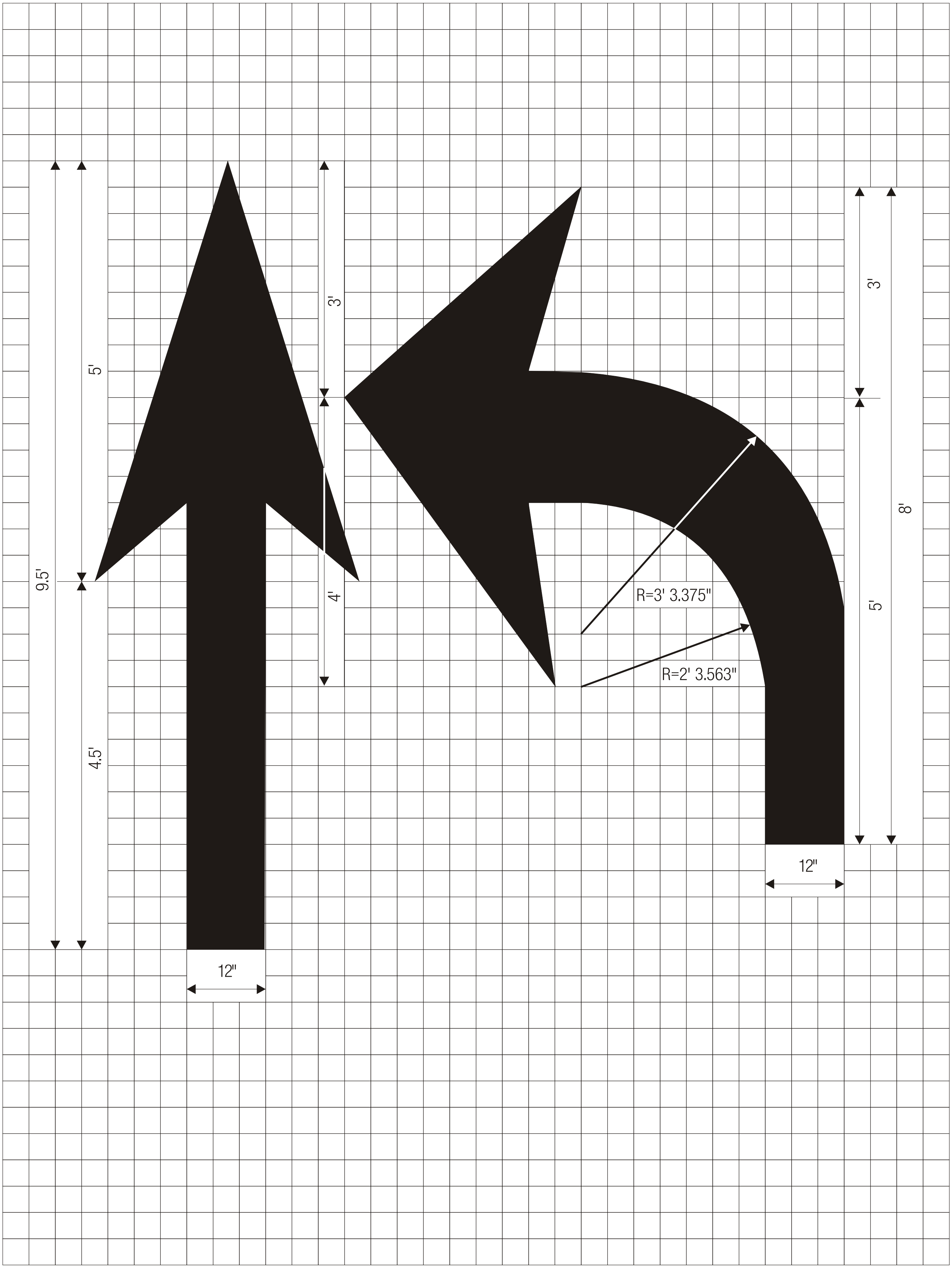
g_Walk,mi, Effective Walk Time [s]	11.0	11.0	0.0	0.0
M_corner, Corner Circulation Area [ft²/ped]	0.00	0.00	0.00	0.00
M_CW, Crosswalk Circulation Area [ft²/ped]	0.00	0.00	0.00	0.00
d_p, Pedestrian Delay [s]	20.01	20.01	0.00	0.00
I_p,int, Pedestrian LOS Score for Intersection	2.264	2.916	0.000	0.000
Crosswalk LOS	B	C	F	F
s_b, Saturation Flow Rate of the bicycle lane	2000	2000	2000	2000
c_b, Capacity of the bicycle lane [bicycles/h]	500	500	1233	1233
d_b, Bicycle Delay [s]	16.88	16.88	4.41	4.41
I_b,int, Bicycle LOS Score for Intersection	1.972	1.857	2.880	2.385
Bicycle LOS	A	A	C	B

Sequence

Ring 1	-	2	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	-	6	-	8	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix P: Image of Signage and Striping

See the following pages for an example of the signage and striping that will be used.


9.5'
5'
4.5'
12"
3'
4'
R=3' 3.375"
R=2' 3.563"
3'
5'
8'
12"

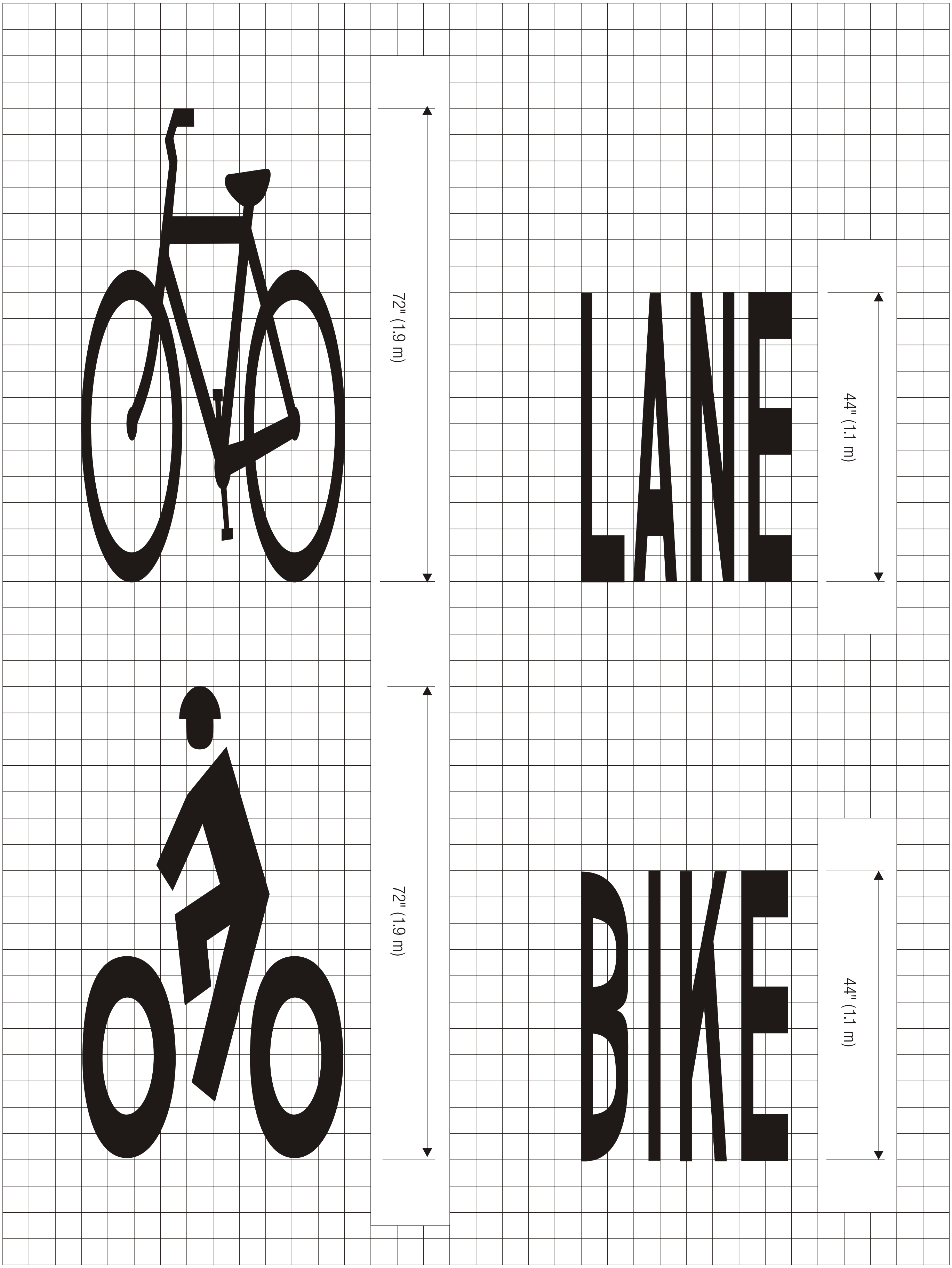
R2-1

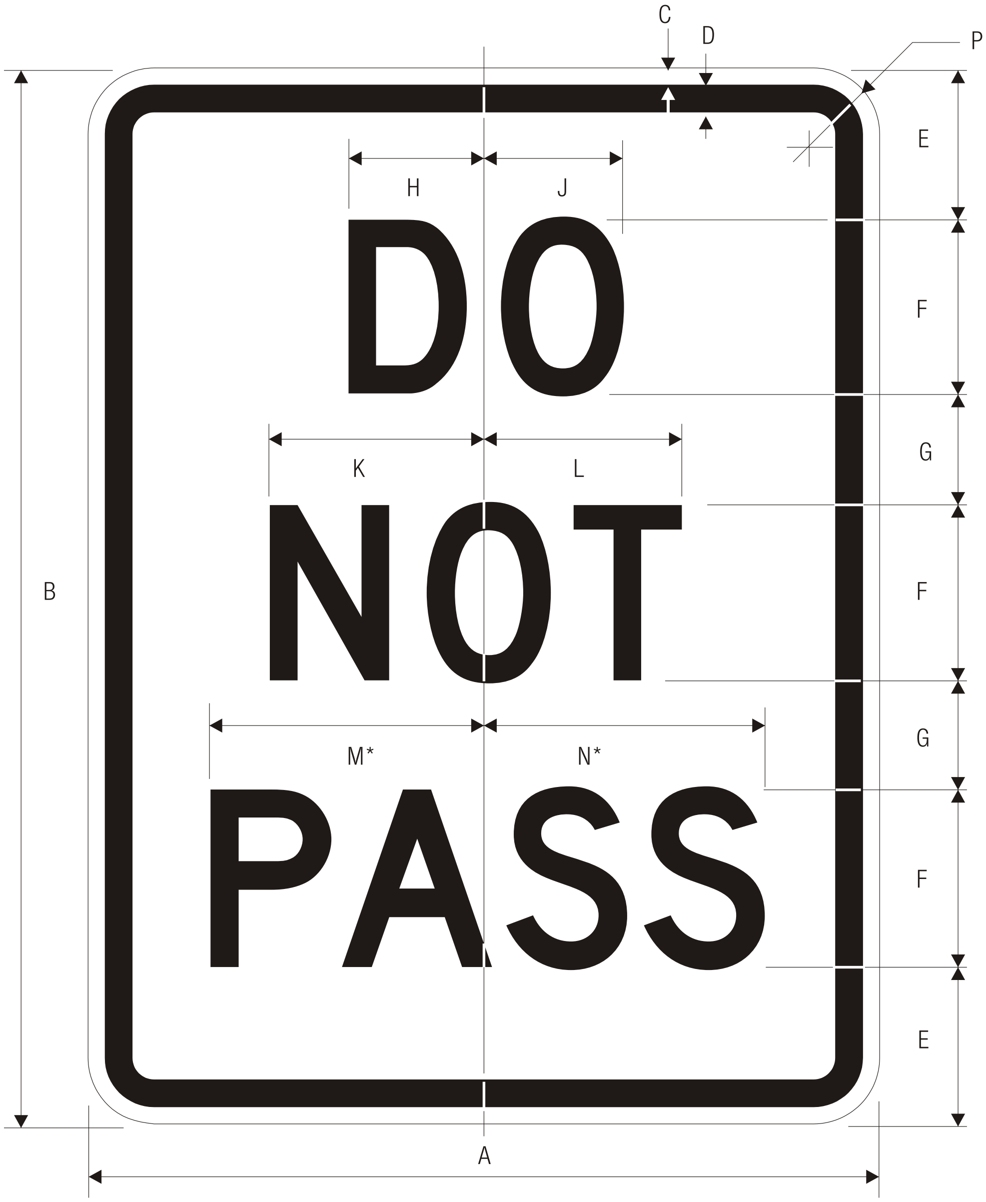
SPEED LIMIT (ENGLISH)

*Optically space numerals about centerline

	A	B	C	D	E	F	G	H	J	K	L
	18	24	.375	.625	3	3 E	2	8 E	7.188	5.5	1.5
C	24	30	.375	.625	4	4 E	2	10 E	9.563	7.313	1.5
	36	48	.625	.875	6	6 E	5	14 E	14.375	11	2.25
	48	60	.75	1.25	8	8 E	6	16 E	19.125	14.625	3

COLORS: LEGEND — BLACK
BACKGROUND — WHITE (RETROREFLECTIVE)


72" (1.9 m)
72" (1.9 m)
LANE
BIKE
44" (1.1 m)
44" (1.1 m)



R4-1
DO NOT PASS

*Reduce spacing to fit.

	A	B	C	D	E	F	G	H	J	K	L
	12	18	.375	.438	2.875	2.75 D	2	2.125	2.188	3.188	3.438
	18	24	.375	.625	3.5	4 D	2.5	3.125	3.313	4.75	4.875
C	24	30	.375	.625	3.5	6 D	2.5	4.688	5	7.125	7.375
	36	48	.625	.875	7	8 D	5	6.25	6.625	9.5	9.75
	48	60	.75	1.25	8	10 D	7	7.75	8.313	11.875	12.25

M	N	P
4.188	4.438	1.5
6.25	6.5	1.5
9.375	9.75	1.5
12.5	13	2.25
15.625	16.25	3

COLORS: LEGEND — BLACK
BACKGROUND — WHITE (RETROREFLECTIVE)

Appendix Q: Referenced Roadway Cost Template

See the following pages for roadway cost template.

City of Flagstaff, AZ
211 W Aspen Ave.
Flagstaff, AZ 86001

Eagle Mountain Construction
3100 N Caden Ct.
Flagstaff, AZ 86004

GUARANTEED MAXIMUM PRICE

Project: Beulah Blvd. Extension & University Ave. Realignment - CMAR
Project #: COF# ST3040
Dwgs: SWI Engineering; stamped 8-25-222
Submitted: 11/9/2022

EMC #	Keynote	DESCRIPTION	QTY	Unit	Unit Cost	Total
CITY TRANSPORTATION SCOPE						
DEMOLITION						
10	101	SAWCUT EXISTING PAVEMENT	4,250	LF	$ 3.00	$ 12,750.00
20	102	REMOVE EXISTING AC PAVEMENT	17,553	SY	$ 8.00	$ 140,424.00
30	103	REMOVE AND DISPOSE OF EXISTING CONCRETE CURB	4,907	LF	$ 3.00	$ 14,721.00
40	105	SAWCUT AND REMOVE EXISTING CONCRETE	22,991	SF	$ 2.00	$ 45,982.00
50	106	REMOVE AND DISPOSE OF EXT LIGHT POLE SALVAGE MAST ARM	7	EA	$ 1,500.00	$ 10,500.00
60	106.1	REMOVE AND DISPOSE OF EXT LIGHT POLE	1	EA	$ 1,500.00	$ 1,500.00
70	106.2	REMOVE AND SALVAGE EXISTING LIGHT POLE	2		$ 1,500.00	$ 3,000.00
80	106.3	REMOVE EXSITING STREET LIGHT MAST ARM AND LUMINAIRE	2	EA	$ 3,500.00	$ 7,000.00
90	110	REMOVE EXISTING WATER SERVICE - SALVAGE WATER METER	1	EA	$ 350.00	$ 350.00
100	111	REMOVE AND DISPOSE OF EXISTING WATER METER	1	EA	$ 300.00	$ 300.00
110	111.1	REMOVE AND RELOCATE EXISTING WATER METER	2	EA	$ 900.00	$ 1,800.00
120	111.2	REMOVE AND RELOCATE EXISTING WATER METER, Bf, IRR BF & METER	1	EA	$ 750.00	$ 750.00
130	112	REMOVE EXISTING FIRE HYDRANT ASSEMBLY	3	EA	$ 750.00	$ 2,250.00
140	113	REMOVE AND DISPOSE OF EXISTING VB&C	2	EA	$ 325.00	$ 650.00
150	115	REMOVE EXISTING WATER LINE	637	LF	$ 12.00	$ 7,644.00
160	116	REMOVE AND SALVAGE EXISTING FIRE HYDRANT	1	EA	$ 750.00	$ 750.00
170	117	REMOVE AND DISPOSE OF EXISTING CATCH BASIN	5	EA	$ 550.00	$ 2,750.00
180	118	REMOVE AND DISPOSE OF EXISTING STORM DRAIN PIPE	667	LF	$ 16.00	$ 10,672.00
190	119	REMOVE AND DISPOSE OF EXISTING STORM DRAIN MANHOLE	1	EA	$ 550.00	$ 550.00
200	122.1	REMOVE AND DISPOSE OF EXISTING SEWER MANHOLE	5	EA	$ 550.00	$ 2,750.00
210	123	REMOVE AND DISPOSE OF EXISTING SEWER MAIN	729	LF	$ 15.00	$ 10,935.00
220	123.5	REMOVE AND DISPOSE OF EXISTING SEWER LINE PER M.A.G. SPEC. SEC. 350	1,035	LF	$ 15.00	$ 15,525.00
230	123.7	PLUG UPSTREAM INVERT INSIDE OF EXISTING MANHOLE	1	EA	$ 1,250.00	$ 1,250.00
240	123.8	PLUG EXISTING TEE PER M.A.G. SPEC. SEC. 350	1	EA	$ 1,251.00	$ 1,251.00
250	124.1	ABANDON EXISTING SEWER IN PLACE	0	LF	$ 2.00	$ -
260	126	CUT, CAP, AND ABANDON SEWER IN PLACE PER M.A.G. 350	117	LF	$ 10.00	$ 1,170.00
270	128	REMOVE ANY REMAINING CONCRETE VAULTS BY EXISTING RUSSIAN OLIVE TREE	1	EA	$ 1,250.00	$ 1,250.00
280	133	REMOVE AND SALVAGE EXISTING TRAFFIC SIGNAL PER ADOT	1	LS	$ 13,500.00	$ 13,500.00
290	134	REMOVE EXISTING RAILING AND RETAINING WALL	114	LF	$ 10.00	$ 1,140.00
300	136	REMOVE AND DISPOSE OF EXISTING MONUMENT SIGN	4	EA	$ 300.00	$ 1,200.00
310	137	REMOVE AND SALVAGE EXISTING RIPRAP FOR REUSE	712	SF	$ 2.00	$ 1,424.00
320	138	REMOVE ANY EXISTING BRICK/FLAGSTONE PATH BEHIND OLD HOME	1	EA	$ 550.00	$ 550.00
330	139	OBLITERATE EXISTING STRIPING - HYDRO-JET METHOD	1,769	LF	$ 3.00	$ 5,307.00
340	140	OBLITERATE EXISTING PAVEMENT MARKINGS - HYDRO-JET METHOD	9	EA	$ 450.00	$ 4,050.00
350	142	PROTECT EXISTING MAILBOX IN PLACE	3	NPI	$ -	$ -
360	143	PROTECT EXISTING WATER METER IN PLACE.	3	EA	$ 100.00	$ 300.00
370	144	REMOVE AND DISPOSE OF EXISTING CHAINLINK FENCE	795	LF	$ 2.00	$ 1,590.00
380	145	MILL 2' WIDE AND 2" DEEP STRIP NEXT TO FULL STRUCTURAL SECTION	1,053	LF	$ 26.00	$ 27,378.00
390	148.1	REMOVE AND DISPOSE OF EXISTING FENCE	505	LF	$ 2.00	$ 1,010.00
400	150	REMOVE AND DISPOSE OF EXISTING TREE AND ROOTBALL	556	EA	$ 170.00	$ 94,520.00
410	153.1	REMOVE AND SALVAGE EXISTING MAILBOX	1	EA	$ 150.00	$ 150.00
420	156	REMOVE AND SALVAGE SIGN	25	EA	$ 75.00	$ 1,875.00
430	158	REMOVE-MONUMENT SIGN	1	EA	$ 750.00	$ 750.00
440	160	COORDINATE WITH MOUNTAIN LINE FOR REMOVAL OF BUS SHELTER	1	EA	$ 850.00	$ 850.00
450	163	PROTECT EXISTING LIGHT IN PLACE	1	EA	$ 150.00	$ 150.00
					DEMOLITION SUBTOTAL :	**$ 454,218.00**
ROADWAY WORK						
500	-	ROADWAY EARTHWORK (CUT & FILL)	45,700.0	CY	$ 21.00	$ 959,700.00
510	-	EXPORT (INCLUDES HAULING FOR 30 MIN ROUND NO DUMP FEES)	52,200.0	LCY	$ 9.00	$ 469,800.00
520	120	INSTALL SURVEY MARKER	18	EA	$ 1,200.00	$ 21,600.00
530	200A	CONSTRUCT AC SECTION 6" \ 10"; DT03 - DTL 1	17,201	SY	$ 78.00	$ 1,341,678.00
540	200C	CONSTRUCT AC SECTION 4" \ 12"; DT03 - DTL 3	615	SY	$ 75.00	$ 46,125.00
550	200D	CONSTRUCT AC SECTION 6" \ 10"; DT03 - DTL 16 (ROUNDABOUT)	2,161	SY	$ 90.00	$ 194,490.00
560	203	INSTALL PLATED SCUPPER PER M.A.G. STD. DTL. 203	1	EA	$ 2,350.00	$ 2,350.00
570	205	CONSTRUCT CONCRETE PAVEMENT SEC (10") PER DETAIL 4 ON DWG DT03.	657	SF	$ 16.00	$ 10,512.00
580	206	INSTALL CONCRETE SCUPPER AND SPILLWAY PER M.A.G. STD. DTL. 206	1	EA	$ 4,250.00	$ 4,250.00
590	209	INSTALL SALVAGED TARGET MONUMENT SIGN. COORDINATE WITH TARGET	1	EA	$ 4,500.00	$ 4,500.00
600	213	INSTALL 6' CHAIN LINK FENCE PER MAG DETAIL 160	1,548	LF	$ 18.00	$ 27,864.00
610	220A	CONSTRUCT VERTICAL CURB AND GUTTER	5,545	LF	$ 25.00	$ 138,625.00
620	220D	CONSTRUCT ROLL CURB AND GUTTER	505	LF	$ 26.00	$ 13,130.00
630	221	CONSTRUCT CURB TRANSITION	1	EA	$ 75.00	$ 75.00
640	222	CONSTRUCT CURB TERMINATION	8	EA	$ 75.00	$ 600.00
650	222B	CONSTRUCT SINGLE CURB TYPE 'B' AND DETAIL 'X' ON DWG DT03	4,689	LF	$ 26.00	$ 121,914.00
660	223	CONSTRUCT MEDIAN NOSE TRANSITION	13	EA	$ 750.00	$ 9,750.00
670	223.2	CONSTRUCT MEDIAN NOSE TRANSITION PER M.A.G. STD. DTL. 223 MODIFIED TO BE 2' TRANSITION.	18	EA	$ 550.00	$ 9,900.00
680	224.1	INSTALL CONCRETE SECTION (10" \ 10") PER DETAIL 4 ON DWG DT03.	5,680	SF	$ 18.00	$ 102,240.00
690	226	INSTALL STAMPED CONCRETE-PER ADOT C-05.40	1,986	SF	$ 28.00	$ 55,608.00
700	227	CONSTRUCT CURB TRANSITION	2	EA	$ 75.00	$ 150.00
710	229	INSTALL PAVERS, MATCH EXISTING PAVERS	47	SF	$ 28.00	$ 1,316.00
720	230	CONSTRUCT CONCRETE SIDEWALK - 5'	16,146	SF	$ 9.00	$ 145,314.00

City of Flagstaff, AZ
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GUARANTEED MAXIMUM PRICE

Project: Beulah Blvd. Extension & University Ave. Realignment - CMAR
Project #: COF# ST3040
Dwgs: SWI Engineering; stamped 8-25-222
Submitted: 11/9/2022

EMC #	Keynote	DESCRIPTION	QTY	Unit	Unit Cost	Total
730	230.1	CONSTRUCT CONCRETE SIDEWALK PER M.A.G. STD. DTL. 230 (MATCH EXISTING WIDTH) AND DETAIL '8' ON DWG DT03, MODIFIED FOR 6" CONCRETE OVER 4" AB	2,704	SF	$ 10.00	$ 27,040.00
740	231	CONSTRUCT FUTS - 11' - COLD JOINTS TO INCLUDE PAVING CAP SEAL PER WESTEC BARRIER TECHNOLOGIES PER EXPANSION BOARD CAP SEAL SYSTEM	38,175	SF	$ 13.00	$ 496,275.00
750	231.2	CONSTRUCT CONCRETE SIDEWALK PER M.A.G. STD. DTL. 230 (WIDTH PER PLAN 8' TYPICAL) AND DETAIL '8' ON DWG DT03, MODIFIED FOR 6" CONCRETE OVER 4" AB	6,809	LF	$ 10.00	$ 68,090.00
760	232	CONSTRUCT STAIRS AND RAILING PER NORRIS DESIGN AND SIRIUS STRUCTURES	139	SF	$ 65.00	$ 9,035.00
770	234	CONSTRUCT TURNDOWN PER DETAIL 11 ON SHEET PV15	56	LF	$ 85.00	$ 4,760.00
780	235	CONSTRUCT BIKE RAMP PER DTL 12	13	EA	$ 1,300.00	$ 16,900.00
790	236	RAIDAL CURB RAMP PER M.A.G. STD. DTL. 236.5.	2	EA	$ 750.00	$ 1,500.00
800	238.1	CONSTRUCT CONCRETE PERPENDICULAR SIDEWALK RAMP	4	EA	$ 1,750.00	$ 7,000.00
810	239	CONCSTRUCT CONCRETE SIDEWALK RAMP PER ADOT	6	EA	$ 1,850.00	$ 11,100.00
820	243	PLUG EXISTING CURB OPENING	1	EA	$ 350.00	$ 350.00
830	245	CONSTRUCT DEPRESSED CONCRETE PEDESTRIAN ISLAND REFUGE.	255	SF	$ 15.00	$ 3,825.00
840	246	CONSTRUCT CONCRETE PEDESTRIAN ISLAND REFUGE	2,024	SF	$ 15.00	$ 30,360.00
850	248	INSTALL TRUNCATED DOME PER C.O.F. STD. DTL. 10-10-043.	25	EA	$ 650.00	$ 16,250.00
860	250.1	CONSTRUCT DRIVEWAY WITH DETACHED SIDEWALK PER M.A.G. STD. DTL. 250-1	311	SF	$ 16.00	$ 4,976.00
870	250.2	CONSTRUCT DRIVEWAY WITH ATTACHED SIDEWALK PER M.A.G. STD. DTL. 250-2	145	SF	$ 16.00	$ 2,320.00
880	251	CONSTRUCT RETURN TYPE DRIVEWAY PER C.O.F. STD. DTL. 10-10-041 AND M.A.G. STD. DTL. 251.	4,155	SF	$ 13.00	$ 54,015.00
890	251.1	CONSTRUCT RETURN TYPE DRIVEWAY PER C.O.F. STD. DTL. 10-10-041.	1,047	SF	$ 13.00	$ 13,611.00
900	252	CONSTRUCT DRIVEWAY WITH SIDEWALK SETBACK PER ADOT	531	SF	$ 16.00	$ 8,496.00
910	259	CONSTRUCT ROCK WALL PER DETAIL "18" ON SHEET DT03.	96	LF	$ 175.00	$ 16,800.00
920	268	INSTALL D50=6" RIPRAP 12" THICK \ MIRAFI 140N FF	382	SF	$ 35.00	$ 13,370.00
930	269	INSTALL D50=6" RIPRAP 12" THICK \ MIRAFI 140N FF, DTL 18 ON SHEET DR01	632	SF	$ 38.00	$ 24,016.00
940	329	INSTALL SALVAGED WATER METER, WITH NEW BOX	1	EA	$ 750.00	$ 750.00
950	391	ADJUST EXISTING WATER VB&C	2	EA	$ 750.00	$ 1,500.00
960	623	INSTALL 30 MPH SIGN	2	EA	$ 750.00	$ 1,500.00
970	711	CONSTRUCT AC SECTION 6" AC \ 10" AB; DTL 1.1 ON DT03 (Assumed to be 6" AC; if match existing sections are diferent, CMAR reserves rights to submit for additional costs)	4,602	SY	$ 95.00	$ 437,190.00
980	712	CONSTRUCT 2" AC OVERLAY PER ADOT	240	SY	$ 120.00	$ 28,800.00
990	725	CONSTRUCT CURB OPENING DETAIL PER DETAIL '17' ON SHEET DT03.	13	EA	$ 950.00	$ 12,350.00
1000	733	CONSTRUCT TYPE 1 CATCH BASIN PER ADOT STD. DETAIL C-15.10 ON 3" AB	1	EA	$ 9,250.00	$ 9,250.00
1010	736	CONSTRUCT DEPRESSED CONCRETE PEDESTRIAN ISLAND REFUGE PER ADOT	132	SF	$ 18.00	$ 2,376.00
1020	745	INSTALL CONCRETE CAP PER M.A.G. STD. DTL. 404.	147	LF	$ 20.00	$ 2,940.00
1030	753	CONSTRUCT CONCRETE SIDWALK PER ADOT	3,959	SF	$ 16.00	$ 63,344.00
1040	754	CONSTRUCT CURB AND GUTTER TYPE D PER ADOT	739	LF	$ 30.00	$ 22,170.00
1050	755	CONSTRUCT SINGLE CURB PER ADOT	837	LF	$ 35.00	$ 29,295.00
1060	756	CONSTRUCT VALLEY GUTTER PER ADOT (950 SF)	118	LF	$ 175.00	$ 20,650.00
1070	769	CONSTRUCT MEDIAN NOSE TRANSITION PER M.A.G. STD. DTL. 223	5	EA	$ 750.00	$ 3,750.00
1080	770	CONSTRUCT MEDIAN STAMPED CONCRETE PER ADOT STANDARD DRAWING C-05.40	788	SF	$ 28.00	$ 22,064.00
1090		STREET LIGHT POLE, ARM, LIGHT FIXTURE, AND FOUNDATION, PULL BOX & CONDUIT	35	EA	$ 6,850.00	$ 239,750.00
					ROADWAY WORK SUBTOTAL :	**$ 5,409,259.00**
STRIPING AND SIGNAGE						
1300	600	INSTALL WHITE BIKE LANE STRIPING PER C.O.F. STD. DETAIL 16-06-010. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA). PAVEMENT MARKINGS WITHIN	2,611	LF	$ 2.00	$ 5,222.00
1310	601	INSTALL WHITE BIKE LANE DASHED STRIPING PER C.O.F. STD. DETAIL 16-06-010 PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA). PAVEMENT MARKINGS	702	LF	$ 2.00	$ 1,404.00
1320	602	INSTALL WHITE BIKE LANE PAVEMENT MARKINGS PER C.O.F. STD. DETAIL 16-06-010. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA). PAVEMENT	41	EA	$ 10.00	$ 410.00
1330	602.1	INSTALL WHITE BIKE LANE PAVEMENT MARKINGS PER C.O.F. STD. DETAIL 16-06-010. NO ARROW. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA).	4	EA	$ 500.00	$ 2,000.00
1340	603	INSTALL 8" WHITE INTERSECTION LANE STRIPING PER C.O.F. STD. DETAIL 16-06-010 PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA). PAVEMENT	2,383	LF	$ 3.00	$ 7,149.00
1350	607	INSTALL 4" DOUBLE YELLOW CENTERLINE STRIPING PER C.O.F. STD. DETAIL 16-06-010 PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA). PAVEMENT	1,472	LF	$ 1.00	$ 1,472.00
1360	610	INSTALL CROSSWALK MARKING PER C.O.F. STD. DETAIL 16-06-010. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA). PAVEMENT MARKINGS WITHIN	139	LF	$ 2.00	$ 278.00
1370	610.1	INSTALL CROSSWALK MARKING PER FIGURE 4-27 OF THE FORT WORTH, TEXAS TRANSPORTATION ENGINEERING MANUAL ON SHEET DT03. 24" WIDE STRIPE WITH 24" SPACING, BICYCLE SYMBOL WITHOUT	194	LF	$ 2.00	$ 388.00
1380	610.2	INSTALL CROSSWALK MARKING PER MUTCD SECTION 3B.18. 12" WIDE STRIPE WITH 12" SPACING. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA).	45	LF	$ 2.00	$ 90.00
1390	611	INSTALL 18" WHITE STOP BAR PER C.O.F. STD. DETAIL 16-06-010 PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA). PAVEMENT MARKINGS WITHIN ADOT	131	LF	$ 2.00	$ 262.00
1400	616	INSTALL 6" SOLID YELLOW LINE PER MUTCD SECTION 9C.03. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA). PAVEMENT MARKINGS WITHIN ADOT ROW	4,014	LF	$ 4.00	$ 16,056.00
1410	617	INSTALL YIELD LINE WITH MINIMUM DIMENSIONS PER MUTCD SECTION 3B.14. SPACE 6 INCHES APART. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA).	45	LF	$ 20.00	$ 900.00
1420	618	INSTALL YIELD LINE WITH MAXIMUM DIMENSIONS PER MUTCD SECTION 3B.16. SPACE 12 INCHES APART. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA).	49	LF	$ 20.00	$ 980.00
1430	619	INSTALL 15 MPH SPEED LIMIT SIGN (R2-1) PER MUTCD	1	EA	$ 750.00	$ 750.00

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GUARANTEED MAXIMUM PRICE

Project: Beulah Blvd. Extension & University Ave. Realignment - CMAR
Project #: COF# ST3040
Dwgs: SWI Engineering; stamped 8-25-222
Submitted: 11/9/2022

EMC #	Keynote	DESCRIPTION	QTY	Unit	Unit Cost	Total
1440	621	INSTALL STOP SIGN (R-1) PER MUTCD	7	EA	$ 550.00	$ 3,850.00
1450	623	INSTALL 30 MPH SPEED LIMIT SIGN (R2-1) PER MUTCD	2	EA	$ 750.00	$ 1,500.00
1460	626	INSTALL BEGIN RIGHT TURN LANE SIGN (R4-4) PER COF STD DTL 10-10-020 AND MUTCD	1	EA	$ 750.00	$ 750.00
1470	627	INSTALL 8" WHITE CHEVRON MARKING WITH 5' LONGITUDIONAL SPACING PER MUTCD. 5' LONGITUDIONAL SPACING. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE	809	SF	$ 12.00	$ 9,708.00
1480	629	INSTALL "ADVANCE INTERSECTION LANE CONTROL" SIGN (R3-8) PER MUTCD	6	EA	$ 750.00	$ 4,500.00
1490	630	INSTALL "NARROW KEEP RIGHT" SIGN (R04-07C) WITH OM-3L SIGN PER MUTCD AND COF STD DTL 10-06-011	4	EA	$ 550.00	$ 2,200.00
1500	631	INSTALL ROUNDABOUT SIGN (R6-4a) PER MUTCD	4	EA	$ 550.00	$ 2,200.00
1510	632	INSTALL 4" WHITE DOTTED LINE PER MUTCD SECTION 3A.06 WITH 2 FT LINE SEGMENTS AND 2- TO 6 FT GAPS. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE	57	LF	$ 20.00	$ 1,140.00
1520	634	INSTALL "STREET NAME" SIGN (D3-1) PER MUTCD. UPPER CASE LETTERS TO BE 6" TALL AND LOWER CASE LETTERS 4" TALL	4	EA	$ 550.00	$ 2,200.00
1530	637	INSTALL LEFT TURN ONLY SIGN (R3-5L) WITH LANE CONTROL PLAQUE "LEFT LANE" (R3-5B)	2	EA	$ 550.00	$ 1,100.00
1540	638	INSTALL RIGHT TURN ONLY SIGN (R3-5R) PER MUTCD	5	EA	$ 550.00	$ 2,750.00
1550	640	INSTALL NO U TURN SIGN (R3-4) PER MUTCD	2	EA	$ 550.00	$ 1,100.00
1560	641	INSTALL GREEN CONTINUOUS BIKE LANE EPOXY OR PREFORMED THERMOPLASTIC MARKINGS FROM ENNIS FLINT, OR APPROVED EQUAL. BICYCLE LANES THROUGH INTERSECTION SHALL BE INSTALLED AS PER	90	LF	$ 10.00	$ 900.00
1570	642	INSTALL GREEN DASHED BIKE LANE EPOXY OR PREFORMED THERMOPLASTIC MARKINGS FROM ENNIS FLINT, OR APPROVED EQUAL. MARKING SHALL BE 2 FT SEGMENTS WITH 6' SPACING.BICYCLE LANES	40	LF	$ 12.00	$ 480.00
1580	643	INSTALL EXISTING SALVAGED "NO OVERNIGHT PARKING OR CAMPING" SIGN	1	EA	$ 550.00	$ 550.00
1590	644	INSTALL EXISTING SALVAGED "TARGET PARKING ONLY" SIGN	1	EA	$ 550.00	$ 550.00
1600	645	INSTALL EXISTING SALVAGED "NO PARKING BIKE LANE" SIGN (R79A)	1	EA	$ 550.00	$ 550.00
1610	647	INSTALL BIKE LANE ENDS SIGN (R3-17 & R3-17BP) PER MUTCD	1	EA	$ 550.00	$ 550.00
1620	648	INSTALL EXISTING SALVAGED SIGN PER MUTCD	1	EA	$ 350.00	$ 350.00
1630	657	INSTALL SPEED HUMP MARKING PER FIGURE 3B-30 "PAVEMENT MARKINGS FOR SPEED TABLES OR SPEED HUMPS WITH CROSSWALKS", OPTION, PER MUTCD. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU	13	EA	$ 550.00	$ 7,150.00
1640	658	INSTALL 6" YELLOW SOLID / 6" YELLOW BROKEN STRIPE (10' SEGMENT WITH 30' GAPS), PER ADOT DWG. M-2 PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE	690	LF	$ 3.00	$ 2,070.00
1650	659	INSTALL 12" WHITE STRIPING (YIELD LINE), 3' SEGMENTS WITH 3' GAPS PER MUTCD SECTION 3A.06 PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA).	217	LF	$ 3.00	$ 651.00
1660	661	INSTALL 8" DOTTED WHITE STRIPING (3' GAP AND 1' LINE) PER MUTCD SECTION 3A.06 AND C.O.F. STD. DTL. 16-06-010 PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL	125	LF	$ 3.00	$ 375.00
1670	663	INSTALL 8' WHITE MERGING ARROW, PREFORMED PAVEMENT MARKING TYPE I PER ADOT DWGS. M-10 AND M-11. HORIZONTAL PLACEMENT AS SHOWN PLANS. PAVEMENT MARKINGS WITHIN CITY ROW OR	3	EA	$ 750.00	$ 2,250.00
1680	665	INSTALL 6" NORMAL BROKEN WHITE LINE STRIPING CONSISTING OF 10' SEGMENTS WITH 30' GAPS PER MUTCD SECTION 3A.06 PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL	1,249	LF	$ 3.00	$ 3,747.00
1690	666	INSTALL 6" DOTTED WHITE PER MUTCD SECTION 3A.06 AND C.O.F. STD. DTL. 16-06-010	76	LF	$ 2.00	$ 152.00
1700	669	INSTALL 6" NORMAL WHITE PER MUTCD SECTION 3A.06 AND C.O.F. STD. DTL. 16-06-010	1,783	LF	$ 3.00	$ 5,349.00
1710	671	INSTALL "BIKE LANE ENDS" SIGN (R3-17) AND (R317bP) PER MUTCD	2	EA	$ 550.00	$ 1,100.00
1720	672	INSTALL PEDESTRIAN SYMBOL PER THE "SMALL TOWN AND RURAL DESIGN GUIDE" - "PEDESTRIAN LANE" AND PER MANUFACTURER'S RECOMMENDATION. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU	35	EA	$ 650.00	$ 22,750.00
1730	677	INSTALL "YIELD" SIGN (R1-2) PER MUTCD. HORIZONTAL PLACEMENT	8	EA	$ 550.00	$ 4,400.00
1740	679	INSTALL "ONE WAY" SIGN (R6-1R) PER MUTCD AND 6' OFF THE GROUND	4	EA	$ 550.00	$ 2,200.00
1750	680	INSTALL "NO LEFT TURN" SIGN (R3-2) PER MUTCD. HORIZONTAL PLACEMENT	2	EA	$ 550.00	$ 1,100.00
1760	685	INSTALL PEDESTRIAN SIGN (W11-15) WITH DIRECTIONAL ARROW (W16-7P) PER MUTCD	12	EA	$ 550.00	$ 6,600.00
1770	686	INSTALL "LANE ENDS MERGE LEFT" (W9-2) PER MUTCD. HORIZONTAL PLACEMENT	1	EA	$ 500.00	$ 500.00
1780	687	INSTALL "OFF STREET SHARED USE PATH AHEAD" SIGN. HORIZONTAL RECTANGULAR WHITE PLAQUE (36"X30") WITH A BLACK BORDER AND THE WORDS "OFF STREET SHARED USE PATH AHEAD" IN BLACK ON	4	EA	$ 500.00	$ 2,000.00
1790	777	INSTALL SALVAGED "ADOT" SIGN (96") REINSTALL PER ADOT STANDARD DETAIL S-3 (6/16)	1	EA	$ 350.00	$ 350.00
1800	778	INSTALL SALVAGED "NAU" SIGN (54") REINSTALL PER ADOT STANDARD DETAIL S-3 (5/16)	1	EA	$ 350.00	$ 350.00
1810	787	INSTALL 12" SINGLE WHITE LANE STRIPE IN ACCORDANCE WITH ADOT STANDARD 709 (EPOXY).	1,665	LF	$ 5.00	$ 8,325.00
1820	788	INSTALL 6" DOUBLE YELLOW STRIPE IN ACCORDANCE WITH ADOT SPECIFICATION 709 (EPOXY).	348	LF	$ 4.00	$ 1,392.00
1830	789	INSTALL PAVEMENT MARKING ARROW IN ACCORDANCE WITH ADOT STANDARD DETAILS M-10 & M-11. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE (MMA).	51	EA	$ 125.00	$ 6,375.00
1840	790	INSTALL 16" HIGH WHITE ON GREEN FLEXIBLE DELINEATOR (F1GW) PER ADOT DTL M-26.	1	EA	$ 350.00	$ 350.00
1850	791	INSTALL PAVEMENT MARKING LEGEND "ONLY" IN ACCORDANCE WITH ADOT STANDARD DETAILS M-6 & M-11. PAVEMENT MARKINGS WITHIN CITY ROW OR NAU PROPERTY SHALL BE METHYL METHACRYLATE	3	EA	$ 350.00	$ 1,050.00
1860	792	INSTALL 3" x 4' YELLOW FLEXIBLE DELINEATOR (F1Y) PER ADOT DTL M-26.	3	EA	$ 350.00	$ 1,050.00
1870	793	INSTALL 18" WHITE STOP BAR PER ADOT STANDARD DETAIL M2 IN ACCORDANCE WITH ADOT STANDARD SPECIFICATION 709 (EPOXY)	92	LF	$ 4.00	$ 368.00
1880	796	INSTALL 6" WHITE STRIPING CONSISTING OF 10' SEGMENTS WITH 30' GAPS PER ADOT DWG. M-4 IN ACCORDANCE WITH ADOT STANDARD SPECIFICATION 709 (EPOXY)	1,503	LF	$ 4.00	$ 6,012.00
1890	797	INSTALL HIGH-VISIBILITY CROSSWALK MARKING PER ADOT STANDARD DETAIL M2 IN ACCORDANCE WITH ADOT STANDARD SPECIFICATION 709 (EPOXY).	146	LF	$ 5.00	$ 730.00
1900	798	INSTALL 6" WHITE STRIPING (SKIP LINE), 1' SEGMENT WITH 3' GAPS PER ADOT DWG. M-2 IN ACCORDANCE WITH ADOT STANDARD SPECIFICATION 709 (EPOXY)	642	LF	$ 4.00	$ 2,568.00
1910	799	INSTALL CURB MARKINGS FOR RAISED MEDIAN AND ISLANDS PER ADOT DWG. M-1.	3	EA	$ 250.00	$ 750.00
					STRIPING AND SIGNAGE SUBTOTAL :	**$ 166,353.00**

City of Flagstaff, AZ
211 W Aspen Ave.
Flagstaff, AZ 86001

Eagle Mountain Construction
3100 N Caden Ct.
Flagstaff, AZ 86004

GUARANTEED MAXIMUM PRICE

Project: Beulah Blvd. Extension & University Ave. Realignment - CMAR
Project #: COF# ST3040
Dwgs: SWI Engineering; stamped 8-25-222
Submitted: 11/9/2022

EMC #	Keynote	DESCRIPTION	QTY	Unit	Unit Cost	Total
MILTON ROAD/UNIVERSITY AVENUE TRAFFIC SIGNAL						
2000	731040	POLE (TYPE R)	4	EA	$ 16,250.00	$ 65,000.00
2010	7310010	POLE (TYPE A)	1	EA	$ 1,400.00	$ 1,400.00
2020	7310320	POLE FOUNDATION (TYPE R)	4	EA	$ 6,750.00	$ 27,000.00
2030	7310200	POLE FOUNDATION (TYPE A)	1	EA	$ 2,500.00	$ 2,500.00
2040	7310610	MAST ARM (50 FT.) (TAPERED)	3	EA	$ 10,925.00	$ 32,775.00
2050		MAST ARM (55 FT.) (TAPERED)	1	EA	$ 11,130.00	$ 11,130.00
2060	7320050	ELECTRICAL CONDUIT (2") (PVC)	9	LF	$ 150.00	$ 1,350.00
2070	7320070	ELECTRICAL CONDUIT (3") (PVC)	1,000	LF	$ 45.00	$ 45,000.00
2080	7320291	ELECTRICAL CONDUIT (4") (PVC)	8	LF	$ 50.00	$ 400.00
2090	7320420	PULL BOX (NO. 7)	3	EA	$ 1,250.00	$ 3,750.00
2100	7320421	PULL BOX (NO. 7 W/ EXTENSION)	1	EA	$ 1,000.00	$ 1,000.00
2110	7320650	CONDUCTORS	1	EA	$ 16,500.00	$ 16,500.00
2120	7330060	TRAFFIC SIGNAL FACE (TYPE F)	10	LS	$ 850.00	$ 8,500.00
2130	7330135	TRAFFIC SIGNAL FACE (TYPE G)	10	EA	$ 1,100.00	$ 11,000.00
2140	7330210	TRAFFIC SIGNAL FACE (PEDESTRIAN)(MAN/HAND)	4	EA	$ 550.00	$ 2,200.00
2150	7330220	PEDESTRIAN PUSH BUTTON	4	EA	$ 3,000.00	$ 12,000.00
2160	7330310	TRAFFIC SIGNAL MOUNTING ASSEMBLY (TYPE II)	16	EA	$ 300.00	$ 4,800.00
2170	7330340	TRAFFIC SIGNAL MOUNTING ASSEMBLY (TYPE V)	8	EA	$ 750.00	$ 6,000.00
2180	7340101	CONTROLLER CABINET (INCLUDES R&R METER/COMBO BBU)	1	EA	$ 35,700.00	$ 35,700.00
2190	7340105	CONTROLLER CABINET FOUNDATION	1	EA	$ 1,850.00	$ 1,850.00
2200	7340115	LOAD CENTER CABINET	1	EA	$ 13,500.00	$ 13,500.00
2210	7340306	LOAD CENTER CABINET FOUNDATION	1	EA	$ 1,500.00	$ 1,500.00
2220	7350030	VIDEO DETECTION SYSTEM	1	EA	$ 50,000.00	$ 50,000.00
2230		EMERGENCY VEHICLE PREEMPTION	1	LS	$ 45,000.00	$ 45,000.00
2240	7360030	LUMINAIRE (HORIZONTAL MOUNT)	4	EA	$ 2,650.00	$ 10,600.00
2250		INTERNALLY ILLUMINATED STREET NAME SIGN	4	EA	$ 2,750.00	$ 11,000.00
2260		PEDESTRIAN SIGNS	14	EA	$ 750.00	$ 10,500.00
2270		TRAFFIC SIGNAL ENGINEERING	1	LS	$ 10,390.00	$ 10,390.00
		MILTON ROAD/UNIVERSITY AVENUE TRAFFIC SIGNAL SUBTOTAL :				**$ 442,345.00**
BEULAH BOULEVARD PEDESTRIAN SIGNAL						
2400	7310130	POLE (TYPE Q) (INCLUDES LUMINAIRE)	2	EA	$ 12,500.00	$ 25,000.00
2410	7310010	POLE (TYPE A)	2	EA	$ 2,250.00	$ 4,500.00
2420	7310310	POLE FOUNDATION (TYPE Q)	2	EA	$ 6,500.00	$ 13,000.00
2430	7310200	POLE FOUNDATION (TYPE A)	2	EA	$ 5,750.00	$ 11,500.00
2440	7310563	MAST ARM (25 FT.) (TAPERED)	2	EA	$ 7,200.00	$ 14,400.00
2450	7320070	ELECTRICAL CONDUIT (3") (PVC)	135	LF	$ 45.00	$ 6,075.00
2460	7320420	PULL BOX (NO. 7)	5	EA	$ 1,250.00	$ 6,250.00
2470	7320650	CONDUCTORS	1	EA	$ 4,500.00	$ 4,500.00
2480	7330135	TRAFFIC SIGNAL FACE (TYPE D)	12	EA	$ 500.00	$ 6,000.00
2490	7330210	TRAFFIC SIGNAL FACE (PEDESTRIAN)(MAN/HAND)	4	EA	$ 500.00	$ 2,000.00
2500	7330220	PEDESTRIAN PUSH BUTTON	4	EA	$ 2,600.00	$ 10,400.00
2510	7330310	TRAFFIC SIGNAL MOUNTING ASSEMBLY (TYPE II)	4	EA	$ 365.00	$ 1,460.00
2520	7330360	TRAFFIC SIGNAL MOUNTING ASSEMBLY (TYPE VII)(MOD)	6	EA	$ 800.00	$ 4,800.00
2530	7340101	CONTROLLER CABINET	1	EA	$ 16,750.00	$ 16,750.00
2540	7340105	CONTROLLER CABINET FOUNDATION	1	EA	$ 2,600.00	$ 2,600.00
2550	7340115	LOAD CENTER CABINET	1	EA	$ 13,000.00	$ 13,000.00
2560	7340306	LOAD CENTER CABINET FOUNDATION	1	EA	$ 1,000.00	$ 1,000.00
2570		PEDESTRIAN SIGNS	12	EA	$ 650.00	$ 7,800.00
2580		WATERBRONE-TYPE II PAVEMENT MARKING (PAINTED) (WHITE)	48	LF	$ 25.00	$ 1,200.00
		BEULAH BOULEVARD PEDESTRIAN SIGNAL SUBTOTAL :				**$ 152,235.00**
LANDSCAPE/IRRIGATION						
		EMC PROVIDED ROCK EX, CONSTRUCTION WATER, SERVICE LINES, SLEEVES	1	LS	$ 9,800.25	$ 9,800.25
2700	1800	4" PERFORATED PVC DRAINAGE PIPE SYSTEM	2,522	LF	$ 29.00	$ 73,138.00
2710	1810	ROCK EXCAVATION, STOCKPILE AND PLACE TOPSOIL FOR PLANTING MEDIUM IN ROCK CUT AREAS	875	CY	$ 33.00	$ 28,875.00
2720	1820	DRYLAND NATIVE SEED (NOT IRRIGATED)	16,613	SF	$ 0.30	$ 4,983.90
2730	1821	DRYLAND NATIVE SEED (IRRIGATED)	60,664	SF	$ 0.25	$ 15,166.00
2740	1822	WETLAND SEED (NOT IRRIGATED)	7,433	SF	$ 0.35	$ 2,601.55
2750	1823	EROSION CONTROL MAT (FOR FILL SLOPE SEEDED AREAS)	10,000	SF	$ 2.50	$ 25,000.00
2760	1830	ROCK MULCH BED W/ SHRUBS AND GROUNDVOVER 3" DEPTH W/ WEED BARRIER (INCLUDES SOIL PREP)	17,916	SF	$ 2.00	$ 35,832.00
2770	1831	ROCK MULCH BED 3" DEPTH W/ WEED BARRIER (NO SHRUBS)	18,306	SF	$ 1.75	$ 32,035.50
2780	1832	MALAPAI BOULDERS (1/2 TON AVERAGE)	150	TN	$ 279.00	$ 41,850.00
2790	1841	ROOT BARRIER SYSTEM	1,184	LF	$ 16.00	$ 18,944.00
2800	1850	CANOPY TREE (2" CALIPER)	86	EA	$ 486.00	$ 41,796.00
2810	1851	EVERGREEN TREE (6' HEIGHT)	12	EA	$ 325.00	$ 3,900.00
2820	1852	ORNAMENTAL TREE (2" CALIPER)	26	EA	$ 430.00	$ 11,180.00
2830	1853	SHRUBS (5 GAL.)	200	EA	$ 35.00	$ 7,000.00
2840	1854	SHRUBS (1 GAL.)	411	EA	$ 15.00	$ 6,165.00
2850	1900	1-1/2" TAP	1	EA	$ 750.00	$ 750.00
2860	1910	CONTROLLER	1	EA	$ 4,200.00	$ 4,200.00
2870	1920	1-1/2" BACKFLOW PREVENTOR	1	EA	$ 4,890.00	$ 4,890.00

GUARANTEED MAXIMUM PRICE

Project: Beulah Blvd. Extension & University Ave. Realignment - CMAR
Project #: COF# ST3040
Dwgs: SWI Engineering; stamped 8-25-222
Submitted: 11/9/2022

EMC #	Keynote	DESCRIPTION	QTY	Unit	Unit Cost	Total
2880	1921	BACKFLOW PREVENTOR ENCLOSURE	1	EA	$ 2,400.00	$ 2,400.00
2890	1922	TYPE K COPPER SERVICE LINE (METER TO BACKFLOW) 1-1/2"	20	LF	$ 13.00	$ 260.00
2900	1930	1" MASTER VALVE	1	EA	$ 1,205.00	$ 1,205.00
2910	1931	1" FLOW SENSOR	1	EA	$ 1,125.00	$ 1,125.00
2920	1932	BRONZE BALL VALVE	15	EA	$ 300.00	$ 4,500.00
2930	1933	DRIP ZONE VAVLE W/ BOX	18	EA	$ 967.00	$ 17,406.00
2940	1934	SPRAY ZONE VAVLE W/ BOX	11	EA	$ 825.00	$ 9,075.00
2950	1935	CONTROL WIRE (14G)	28,024	LF	$ 0.70	$ 19,616.80
2960	1935	COMMON WIRE (12G)	7,500	LF	$ 0.80	$ 6,000.00
2970	1936	4" SCH 40 PVC SLEEVE	2,000	LF	$ 15.00	$ 30,000.00
2980	1937	SCHEDULE 40 PVC MAINLINE INCLUDE TRACER WIRE 1-1/2"	7,125	LF	$ 8.50	$ 60,562.50
2990	1938	SCHEDULE 40 PVC LATERAL - 1"	5,213	LF	$ 5.00	$ 26,065.00
3000	1939	MULTIPORT EMITTERS	1,000	EA	$ 28.30	$ 28,300.00
3010	1940	TREE BUBBLERS	26	EA	$ 38.00	$ 988.00
3020	1941	POP UP SPRAY HEADS W/ JOINT	228	EA	$ 51.00	$ 11,628.00
3030	1942	QUICK COUPLER	7	EA	$ 375.00	$ 2,625.00
3040	1943	FLUSH END CAPS W/ BOX	29	EA	$ 53.00	$ 1,537.00
					LANDSCAPE/IRRIGATION SUBTOTAL :	**$ 591,400.50**
WATER DISTRIBUTION SYSTEM						
3200	304.1	INSTALL 8" C900 WATERLINE - FULLY RESTRAINED	2,391	LF	$ 105.00	$ 251,055.00
3210	304.3	INSTALL 8" C900WATERLINE	1,172	LF	$ 90.00	$ 105,480.00
3220	302	INSTALL NEW WATER SERVICE WITH METER BOX	11	EA	$ 2,005.00	$ 22,055.00
3230	304.2	INSTALL 10" C900 WATERLINE PER ADOT SPECS SLURRY BACKFILL - FULLY RESTRAINED	51	LF	$ 195.00	$ 9,945.00
3240	305.4	INSTALL 8" C900 WATERLINE PER ADOT SPECS SLURRY BACKFILL - FULLY RESTRAINED	49	LF	$ 175.00	$ 8,575.00
3250	305.5	INSTALL 8" C900 WATERLINE PER ADOT SPECS SLURRY BACKFILL	147	LF	$ 160.00	$ 23,520.00
3260	310.1	INSTALL 8", 22.5 DEG; JOINT RESTRAINTS	2	EA	$ 650.00	$ 1,300.00
3270	310.2	INSTALL 8", 11.25 DEG; JOINT RESTRAINTS	4	EA	$ 650.00	$ 2,600.00
3280	310.5	INSTALL 8", 22.5 DEG; JOINT RESTRAINTS	6	EA	$ 650.00	$ 3,900.00
3290	311.1	INSTALL 1" AIR RELEASE VALVE	6	EA	$ 2,950.00	$ 17,700.00
3300	312	INSTALL 8” GATE VALVE	7	EA	$ 2,350.00	$ 16,450.00
3310	312.1	INSTALL 8” GATE VALVE	14	EA	$ 2,350.00	$ 32,900.00
3320	312.2	INSTALL 10” GATE VALVE	1	EA	$ 2,550.00	$ 2,550.00
3330	312.3	INSTALL 6” GATE VALVE	1	EA	$ 1,950.00	$ 1,950.00
3340	313	INSTALL 8", 90 DEG	1	EA	$ 750.00	$ 750.00
3350	315	INSTALL 8", 22.5 DEG	1	EA	$ 750.00	$ 750.00
3360	323	REINSTALL REDUCED BACKFLOW PREVENTION ASSEMBLY AND HOT BOX.	1	EA	$ 1,750.00	$ 1,750.00
3370	324	INSTALL NEW 2" WATER SERVICE LINE PER C.O.F. STD. DTL. 9-03-070 ON DWG DT01	1	EA	$ 550.00	$ 550.00
3380	328	INSTALL NEW WATER SERVICE WITH METER BOX	1	EA	$ 1,880.00	$ 1,880.00
3390	331	INSTALL 8"x6" REDUCER DIP CLASS 250, WITH JOINT RESTRAINTS	2	EA	$ 900.00	$ 1,800.00
3400	333.1	INSTALL 8"x10" TEE DIP CLASS 250, WITH JOINT RESTRAINTS	1	EA	$ 950.00	$ 950.00
3410	333.11	INSTALL 8"x6" TEE DIP CLASS 250, WITH JOINT RESTRAINTS	4	EA	$ 950.00	$ 3,800.00
3420	333.12	INSTALL 8"x8" TEE DIP CLASS 250, WITH JOINT RESTRAINTS	4	EA	$ 900.00	$ 3,600.00
3430	333.2	INSTALL 8"x8" TEE DIP CLASS 250, WITH JOINT RESTRAINTS	5	EA	$ 950.00	$ 4,750.00
3440	341.1	CONNECT NEW 8" WATERLINE TO EXT 8"	4	EA	$ 950.00	$ 3,800.00
3450	341.11	CONNECT EXISTING WAERLINE TO NEW TEE	5	EA	$ 750.00	$ 3,750.00
3460	341.2	CONNECT NEW 8" WATERLINE TO EXT 6"	2	EA	$ 950.00	$ 1,900.00
3470	341.3	CONNECT NEW 10" WATERLINE	1	EA	$ 1,025.00	$ 1,025.00
3480	360	INSTALL FIRE HYDRANT ASSEMBLY	7	EA	$ 6,750.00	$ 47,250.00
3490	360.1	INSTALL FIRE HYDRANT ASSEMBLY SLURRY BACKFILL PER ADOT	1	EA	$ 6,950.00	$ 6,950.00
3500	361	INSTALL FIRE HYDRANT ASSEMBLY PER M.A.G STD. DTL. 360-3 EXCLUDE HYDRANT	1	EA	$ 1,850.00	$ 1,850.00
3510	363	INSTALL 8"x8" TEE DIP CLASS 250, WITH JOINT RESTRAINTS	1	EA	$ 750.00	$ 750.00
3520	365	ADJUST EXISTING WATER VALVE COVER TO FINISH GRADE PER C.O.F. STD. DTL. 9-03-060 ON SHEET DT01.	8	EA	$ 975.00	$ 7,800.00
3530	366	CONSTRUCT 8” DIP CLASS 350 RESTRAINED WATER VERTICAL REALIGNMENT	2	EA	$ 3,500.00	$ 7,000.00
3540	368.2	CONSTRUCT 10” DIP CLASS 350 RESTRAINED WATER VERTICAL REALIGNMENT	1	EA	$ 4,350.00	$ 4,350.00
3550	369	CONSTRUCT 8” DIP CLASS 350 RESTRAINED WATER VA (4 - 45DEG)	4	EA	$ 3,500.00	$ 14,000.00
3560	369.1	CONSTRUCT 8” DIP CLASS 350 RESTRAINED WATER VA (2 - 45DEG)	1	EA	$ 2,750.00	$ 2,750.00
3570	390	INSTALL END OF LINE TEMPORARY BLOWOFF	3	EA	$ 2,950.00	$ 8,850.00
					WATER DISTRIBUTION SYSTEM SUBTOTAL :	**$ 632,585.00**
SEWER COLLECTION SYSTEM						
3700	401.2	INSTALL 8" SEWER MAIN	238	LF	$ 85.00	$ 20,230.00
3710	401.4	INSTALL 8" SEWER MAIN - ADOT SLURRY BACKFILL	948	LF	$ 160.00	$ 151,680.00
3720	404	INSTALL EXTRA PROTECTION MAG 404	1	EA	$ 950.00	$ 950.00
3730	414	CONNECT OLD SEWER SERVICE TO NEW MANHOLE	1	EA	$ 1,350.00	$ 1,350.00
3740	420	INSTALL 48" DIA. SEWER PRE-CAST (WATER-TIGHT) MANHOLE	3	EA	$ 6,850.00	$ 20,550.00
3750	420.1	INSTALL 48" DIA. SEWER PRE-CAST (WATER-TIGHT) MANHOLE	3	EA	$ 7,250.00	$ 21,750.00
3760	420.2	INSTALL 60" DIA. SEWER PRE-CAST (WATER-TIGHT) MANHOLE	2	EA	$ 7,500.00	$ 15,000.00
3770	420.2	INSTALL 60" DIA. SEWER PRE-CAST (WATER-TIGHT) MANHOLE	5	EA	$ 7,500.00	$ 37,500.00
3780	422	ADJUST EXT MANHOLE F&C PER M.A.G. 422 AND PER C.O.F. 9-03-062.	10	EA	$ 1,250.00	$ 12,500.00
3790	423	CONNECT EXISTING SEWER TO NEW MANHOLE	1	EA	$ 1,450.00	$ 1,450.00
3800	427	INSTALL CAP AND BLOCK ON SANITARY SEWER	3	EA	$ 750.00	$ 2,250.00
3810	428	INSTALL 8" SEWER MAIN STUB	190	LF	$ 85.00	$ 16,150.00

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GUARANTEED MAXIMUM PRICE

Project: Beulah Blvd. Extension & University Ave. Realignment - CMAR
Project #: COF# ST3040
Dwgs: SWI Engineering; stamped 8-25-222
Submitted: 11/9/2022

EMC #	Keynote	DESCRIPTION	QTY	Unit	Unit Cost	Total
3820	440	INSTALL 6" SERVICE & CONNECTION; "S" TOC MARKING	1	EA	$ 1,250.00	$ 1,250.00
		SEWER COLLECTION SYSTEM SUBTOTAL :				$ 302,610.00
STORM DRAINAGE						
4000	271	INSTALL ELEVATED CLEANOUT PER M.A.G. STD. DTL. 440-3.	4	EA	$ 950.00	$ 3,800.00
4010	511	INSTALL 12" DIA SMOOTH SRP (14 GA.) PER M.A.G. 510 AND SPEC. SECTION 621	18	LF	$ 90.00	$ 1,620.00
4020	501.1	CONSTRUCT U TYPE HEADWALL PER M.A.G. STD. DETAIL. 501.	2	EA	$ 6,700.00	$ 13,400.00
4030	511.1	INSTALL 18" DIA SMOOTH SRP (14 GA.)	592	LF	$ 115.00	$ 68,080.00
4040	511.2	INSTALL 24" DIA SMOOTH SRP (14 GA.)	829	LF	$ 128.00	$ 106,112.00
4050	511.3	INSTALL 30" DIA SMOOTH SRP	838	LF	$ 235.00	$ 196,930.00
4060	511.5	INSTALL 48" DIA SMOOTH SRP (14 GA.)	38	LF	$ 735.00	$ 27,930.00
4070	512.1	INSTALL 18" DIA RGRCP (CLASS 5)	49	LF	$ 165.00	$ 8,085.00
4080	512.2	INSTALL 24" DIA RGRCP (CLASS 5)	562	LF	$ 195.00	$ 109,590.00
4090	512.3	INSTALL 30" DIA RGRCP (CLASS 5)	103	LF	$ 205.00	$ 21,115.00
4100	520	INSTALL 48" DIA. STORM DRAIN MANHOLE	7	EA	$ 6,950.00	$ 48,650.00
4110	521	INSTALL 60" DIA. STORM DRAIN MANHOLE	14	EA	$ 8,950.00	$ 125,300.00
4120	523	CONSTRUCT TYPE "C" CATCH BASIN PER M.A.G. STD. DETAIL 532.	1	EA	$ 8,550.00	$ 8,550.00
4130	527	INSTALL CAP ON STORM DRAIN, FOR FUTURE USE.	1	EA	$ 1,250.00	$ 1,250.00
4140	530	CONSTRUCT TYPE "A" CATCH BASIN PER M.A.G. STD. DETAIL 530	8	EA	$ 6,950.00	$ 55,600.00
4150	532.1	INSTALL CONTECH HEL-COR TEE (30"x36"x48").	1	EA	$ 2,560.00	$ 2,560.00
4160	533	CONSTRUCT TYPE "D" CATCH BASIN PER M.A.G. STD. DETAIL 533-1., 3' WING	4	EA	$ 6,950.00	$ 27,800.00
4170	533.1	CONSTRUCT TYPE "D" CATCH BASIN PER M.A.G. STD. DETAIL 533-1.,DUAL 3' WINGS	3	EA	$ 7,550.00	$ 22,650.00
4180	533.6	CONSTRUCT TYPE "D" CATCH BASIN PER M.A.G. STD. DETAIL 533-1., DUAL 6' WING	2	EA	$ 8,750.00	$ 17,500.00
4190	534	CONSTRUCT TYPE "E" CATCH BASIN PER M.A.G. STD. DETAIL 534	1	EA	$ 7,950.00	$ 7,950.00
4200	535	INSTALL 4" PERFORATED HDPE UNDERDRAIN PIPE AND CLEANOUTS PER PLAN PER DETAIL '17' ON SHEET D	206	EA	$ 55.00	$ 11,330.00
4210	535.1	INSTALL 4" SOLID HDPE DRAIN PIPE AND CLEANOUTS PER PLAN PER DETAIL '17' ON SHEET DR01.	79	EA	$ 75.00	$ 5,925.00
4220	537	CONSTRUCT TYPE "G" CATCH BASIN PER M.A.G. STD. DETAIL 537.	1	EA	$ 8,750.00	$ 8,750.00
4230	576	CONNECT 48" STORM DRAIN PIPE TO EXISTING STORM DRAIN.	1	EA	$ 1,750.00	$ 1,750.00
4240	743	INSTALL 18" DIA SMOOTH SRP (14 GA.) ADOT - SLURRY BACKFILL	77	LF	$ 205.00	$ 15,785.00
4250	744	INSTALL 24" DIA SMOOTH SRP (14 GA.) ADOT - SLURRY BACKFILL	147	LF	$ 225.00	$ 33,075.00
		STORM DRAINAGE SUBTOTAL :				$ 951,087.00
DRY UTILITIES						
4500		APS ELECTRIC & SHARED DRY UTIL (1 - 2.5" DB120; TRENCH S)	1,450	LF	$ 42.00	$ 60,900.00
4510		SUDDENLINK CABLE (ASSUME (2) 2" PVC SCH 40 PVC - FACILITIES IN APS TRENCH)	6,800	LF	$ 15.00	$ 102,000.00
4520		CENTURYLINK COMM (ASSUME (2) 4" SCH 40 PVC - FACILITIES IN APS TRENCH)	6,800	LF	$ 18.00	$ 122,400.00
4530		UNISOURCE GAS TRENCHING AND BACKFILL ONLY	2,600	LF	$ 18.00	$ 46,800.00
4540	784	INSTALL ADOT NO. 7 PULL BOX	12	EA	$ 1,250.00	$ 15,000.00
4550	785	INSTALL (2) 3 INCH DIA. SCHEDULE 80 PVC CONDUIT PER C.O.F. ENGINEERING STANDARDS SECTION 13-16-(	890	LF	$ 45.00	$ 40,050.00
4560	786	INSTALL (1) 2 INCH DIA. SCHEDULE 80 PVC CONDUIT PER C.O.F. ENGINEERING STANDARDS SECTION 13-16-(	40	LF	$ 40.00	$ 1,600.00
4570	801	INSTALL COF NO. 9 PULL BOX PER C.O.F. STD. DTL. 16-03-010	8	EA	$ 7,800.00	$ 62,400.00
4580	802	INSTALL (2 - 4" SCH 80 WITH SWEEPS) - FIBER OPTIC	3,612	LF	$ 48.00	$ 173,376.00
		DRY UTILITIES SUBTOTAL :				$ 624,526.00
		CITY TRANSPORTATION SCOPE SUBTOTAL :				$ 9,726,618.50

EMC #	Keynote	DESCRIPTION	QTY	Unit	Unit Cost	Total
WATER SERVICES - SEWER OVERSIZING AND EXTENSION SCOPE PLUS WATER UPSIZE						
WATER COLLECTION UPSIZING						
4700	304.3	UPSIZE PIPE FROM 8" TO 12" WATER WITH C.O.F. TRENCHING AND BACKFILL	1,712	LF	$ 53.00	$ 90,736.00
4710	305.5	UPSIZE PIPE FROM 8" TO 12" WATER WITH ADOT TRENCHING AND BACKFILL	147	LF	$ 115.00	$ 16,905.00
4720	305.5	UPSIZE PIPE FROM 10" TO 12" WATER WITH ADOT TRENCHING AND BACKFIL	384	LF	$ 115.00	$ 44,160.00
4730	310.1	UPSIZE 8" 22.50 DEG. HORIZONTAL BEND TO 12"	2	EA	$ 750.00	$ 1,500.00
4740	310.2	UPSIZE 8" 11.25 DEG. HORIZONTAL BEND TO 12"	4	EA	$ 1,650.00	$ 6,600.00
4750	310.4	UPSIZE 10" 45 DEG. HORIZONTAL BEND TO 12"	2	EA	$ 750.00	$ 1,500.00
4760	312	UPSIZE 8" GATE VALVE TO 12"	7	EA	$ 1,950.00	$ 13,650.00
4770	312	UPSIZE 10" GATE VALVE TO 12"	3	EA	$ 750.00	$ 2,250.00
4780	313.1	UPSIZE 10" 90 DEG. HORIZONTAL BEND TO 12"	1	EA	$ 950.00	$ 950.00
4790	330.1	ADD REDUCER FROM 12" TO 8"; 12" X 8" REDUCERS	1	EA	$ 750.00	$ 750.00
4800	333.1	UPSIZE 8" X 10" TEE TO 12" X 10" TEE	1	EA	$ 1,225.00	$ 1,225.00
4810	333.1	UPSIZE 10" X 10" TEE TO 12" X 10" TEE	1	EA	$ 750.00	$ 750.00
4820	333.2	UPSIZE 8" X 8" TEE TO 12" X 8" TEE	5	EA	$ 1,650.00	$ 8,250.00
4830	333.2	UPSIZE 10" X 8" TEE TO 12" X 8" TEE	2	EA	$ 1,150.00	$ 2,300.00
4840	363	UPSIZE 8" X 8" TEE TO 12" X 8" TEE & CONNECT EXT 8"	1	EA	$ 1,850.00	$ 1,850.00
4850	369	UPSIZE 8" VERTICAL RELIGNMENT TO 12" VERTICAL REALIGNMENT	4	EA	$ 1,850.00	$ 7,400.00
4860	369.1	UPSIZE 8" VERTICAL RELIGNMENT TO 12" VERTICAL REALIGNMENT	1	EA	$ 1,850.00	$ 1,850.00
4870	369.1	UPSIZE UPSIZE 10" VERTICAL RELIGNMENT TO 12" VERTICAL REALIGNMENT	2	EA	$ 1,250.00	$ 2,500.00
		WATER COLLECTION UPSIZING SUBTOTAL :				$ 205,126.00

City of Flagstaff, AZ
211 W Aspen Ave.
Flagstaff, AZ 86001

Eagle Mountain Construction
3100 N Caden Ct.
Flagstaff, AZ 86004

GUARANTEED MAXIMUM PRICE

Project: Beulah Blvd. Extension & University Ave. Realignment - CMAR
Project #: COF# ST3040
Dwgs: SWI Engineering; stamped 8-25-222
Submitted: 11/9/2022

EMC #	Keynote	DESCRIPTION	QTY	Unit	Unit Cost	Total
SEWER COLLECTION UPSIZING						
5000	400.4	12" DIP SEWER MAIN	354	LF	$ 180.00	$ 63,720.00
5010	401.4	UPSIZE FROM 8" TO 12" PVC SEWER MAIN.	948	LF	$ 95.00	$ 90,060.00
5020	401.4	12" PVC SDR 35 ADOT; SLURRY BACKFILL	293	LF	$ 118.00	$ 34,574.00
5030	420.2	UPSIZE 48" MH TO 60" MH	3	EA	$ 2,750.00	$ 8,250.00
5040	423	CONNECT EXT SEWER TO NEW MANHOLE	1	EA	$ 1,450.00	$ 1,450.00
5050	441	INSTALL SEWER CLEANOUT PER MAG 441	1	EA	$ 950.00	$ 950.00
					SEWER COLLECTION UPSIZING SUBTOTAL :	**$ 199,004.00**
					WATER SERVICES - SEWER OVERSIZING AND EXTENSION SCOPE PLUS WATER UPSIZE SUBTOTAL :	**$ 404,130.00**

EMC #	Keynote	DESCRIPTION	QTY	Unit	Unit Cost	Total
PEDESTRIAN UNDERPASS SCOPE						
DEMOLITION						
5200	101	SAWCUT EXISTING PAVEMENT	948	LF	$ 3.00	$ 2,844.00
5210	102	REMOVE EXISTING AC PAVEMENT	27,431	SY	$ 1.00	$ 27,431.00
5220	103	REMOVE AND DISPOSE OF EXISTING CONCRETE CURB	618	LF	$ 3.00	$ 1,854.00
5230	113	REMOVE AND DISPOSE OF EXISTING VB&C	1	EA	$ 185.00	$ 185.00
5240	115	REMOVE EXISTING WATER LINE PER COF 13-09-03-007(G) AND MAG 350	210	LF	$ 25.00	$ 5,250.00
5250	123	REMOVE AND DISPOSE OF EXISTING SEWER MAIN PER MAG 350	126	LF	$ 45.00	$ 5,670.00
5260	123.9	REMOVE EXISTING WATER LINE PER MAG 350	269	LF	$ 30.00	$ 8,070.00
5270	150	REMOVE AND DISPOSE OF EXISTING TREE AND ROOTBALL	9	EA	$ 750.00	$ 6,750.00
5280	158	REMOVE MONUMENT SIGN (Not Relocating!)	1	EA	$ 750.00	$ 750.00
					DEMOLITION SUBTOTAL :	**$ 58,804.00**
UNDERPASS INSTALL						
5500		EXCAVATION (INCLUDES ROCK)	4,300	CY	$ 58.00	$ 249,400.00
5505		EXPORT (INCLUDES HAULING FOR 30 MIN ROUND NO DUMP FEES)	4,945	LCY	$ 9.00	$ 44,505.00
5510	200C	CONSTRUCT AC SECTION (4"\12") DETAIL 3 ON DT03 (TARGET PL;(Assumed to be 4" AC; if match existing sections are diferent, CMAR reserves rights to submit for additional costs)	1,136	SY	$ 75.00	$ 85,200.00
5520	222B	CONSTRUCT SINGLE CURB TYPE 'B' AND DETAIL 7 ON DWG DT03	483	LF	$ 28.00	$ 13,524.00
5530	255	INSTALL UNDERPASS (STRUC SLABS, TOPPER SLAB; SOIL NAIL; NIGHT WORK COSTS)	1	EA	$ 348,690.00	$ 348,690.00
5540	256.1	SOIL NAIL WALL PER PRINTZ ENGINEERING (EAST & WEST RAMP RETAINING WALLS)	1	LS	$ 750,300.00	$ 750,300.00
5550	256.2	RETAINING WALLS PER SIRIUS STRUCTURES	1	LS	$ 361,910.00	$ 361,910.00
5560	257	CONSTRUCT STAIR (EAST SIDE ONLY)	1	EA	$ 56,300.00	$ 56,300.00
5570	258	CONSTRUCT UNDERPASS ADA RAMP	1	EA	$ 22,000.00	$ 22,000.00
5580	633	PAINT 4" WHITE PARKING STRIPE	445	LF	$ 3.00	$ 1,335.00
5590	711	CONSTRUCT AC SECTION 6" AC \ 10" AB; DTL 1.1 ON DT03 (Assumed to be 6" AC; if match existing sections are diferent, CMAR reserves rights to submit for additional costs)	742	SY	$ 95.00	$ 70,490.00
5600	753	CONSTRUCT CONCRETE SIDWALK PER ADOT	1,392	SF	$ 15.00	$ 20,880.00
5610	-	PRECAST ARCH UNITS 20X12 UNDERPASS (115 LF)	1	LS	$ 215,000.00	$ 215,000.00
5620	-	PRECAST ARCH FOUNDATION (115 LF)	1	LS	$ 118,000.00	$ 118,000.00
5630	-	PRECAST HEADWALLS WITH HARDWARE	1	LS	$ 24,000.00	$ 24,000.00
5640		ADOT BARRIER (MOMENT SLAB ONLY)	2	EA	$ 13,445.00	$ 26,890.00
5650		ADOT RAILING	44	LF	$ 650.00	$ 28,600.00
5660		2.5" SCH. 40 PVC CONDUIT	1	LS	$ 1,750.00	$ 1,750.00
5670	-	100AMP, 120/240V, 1-PHASE, 3 WIRE ELECTRICAL SERVICE ENTRANCE SECTION, INCLUDING BREAKERS AND LIGHTING CONTROL EQUIPMENT	1	EA	$ 13,500.00	$ 13,500.00
5680	-	UNDERPASS CCTV CAMERAS	2	EA	$ 8,500.00	$ 17,000.00
5690	-	#5 CONCRETE PULL BOX	2	EA	$ 2,400.00	$ 4,800.00
5700	-	UNDERPASS LIGHT FIXTURE	20	EA	$ 950.00	$ 19,000.00
5710	-	UNDERPASS ENTRY LIGHT FIXTURE	2	EA	$ 1,700.00	$ 3,400.00
5720	-	TUNNEL WIRE & CONDUIT TO SES	1	LS	$ 12,000.00	$ 12,000.00
					UNDERPASS INSTALL SUBTOTAL :	**$ 2,508,474.00**
LANDSCAPE/HARDSCAPE/IRRIGATION						
5800		EMC - ROCK EX, CONSTRUCTION WATER, SERVICE LINE, SLEEVES	1	LS	$ 7,350.00	$ 7,350.00
5810	3700	1' WIDE CONCRETE WALL W/ STONE CAP (UNDER 5' HEIGHT) - *INCLUDED ABOVE*	1,425	SF	$ -	$ -
5820	3701	TALL STRUCTURAL CONCRETE WALL PATTERNING ALLOWANCE - *INCLUDED ABOVE*	1	LS	$ -	$ -
5830	3710	STANDARD GRAY CONCRETE FLATWORK (4" CONCRETE OVER 3" ABC) - *INCLUDED ABOVE*	3,970	SF	$ -	$ -
5840	3713	STANDARD GRAY CONCRETE THICKENED EDGE (2' TALL MAX.) - *INCLUDED ABOVE*	150	LF	$ -	$ -
5850	3714	STANDARD GRAY CONCRETE STEPS - *INCLUDED ABOVE*	280	SF	$ -	$ -
5860	3715	STANDARD GRAY CONCRETE SEAT PLATFORM W/ STONE CAP	40	SF	$ 195.00	$ 7,800.00
5870	3720	MONUMENT COLUMN	1	EA	$ 18,940.00	$ 18,940.00
5880	3730	STAIR AND RAMP RAILING	581	LF	$ 44.00	$ 25,564.00
5890	3731	GUARDRAIL	748	LF	$ 65.00	$ 48,620.00
5900	3750	INSET WALL LIGHTS	31	EA	$ 350.00	$ 10,850.00
5910	3810	STOCKPILE AND PLACE TOPSOIL FOR PLANTING MEDIUM IN ROCK CUT AREAS	15	CY	$ 85.00	$ 1,275.00
5920	3830	ROCK MULCH BED W/ SHRUBS AND GROUNDVOVER 3" W/ WEED BARRIER	4,514	SF	$ 4.50	$ 20,313.00
5930	3832	MALAPAI BOULDERS (1/2 TON AVERAGE)	9	TON	$ 400.00	$ 3,600.00
5940	3850	CANOPY TREE (2" CALIPER)	2	EA	$ 510.00	$ 1,020.00
5950	3852	ORNAMENTAL TREE (2" CALIPER)	7	EA	$ 455.00	$ 3,185.00
5960	3853	SHRUBS (5 GAL.)	68	EA	$ 40.00	$ 2,720.00
5970	3854	SHRUBS (1 GAL.)	170		$ 22.00	$ 3,740.00

GUARANTEED MAXIMUM PRICE

Project: Beulah Blvd. Extension & University Ave. Realignment - CMAR
Project #: COF# ST3040
Dwgs: SWI Engineering; stamped 8-25-222
Submitted: 11/9/2022

EMC #	Keynote	DESCRIPTION	QTY	Unit	Unit Cost	Total
5980	3901	DRIP ZONE VAVLE W/ BOX	2	EA	$ 1,000.00	$ 2,000.00
5990	3903	CONTROL WIRE (14G)	276	EA	$ 1.00	$ 276.00
6000	3904	4" SCH 40 PVC SLEEVE	500	LF	$ 15.00	$ 7,500.00
6010	3905	SCHEDULE 40 PVC MAINLINE 1-1/2"	46	LF	$ 15.00	$ 690.00
6020	3906	SCHEDULE 40 PVC LATERAL - 3/4"	2,132	LF	$ 6.00	$ 12,792.00
6030	3907	MULTIPORT EMITTERS	15	EA	$ 36.00	$ 540.00
6040	3910	QUICK COUPLER	1	EA	$ 400.00	$ 400.00
6050	3911	FLUSH END CAPS W/ BOX	13	EA	$ 58.00	$ 754.00
		LANDSCAPE/HARDSCAPE/IRRIGATION SUBTOTAL :				**$ 179,929.00**
WATER DISTRIBUTION SYSTEM						
6100	305.5	INSTALL 10" WATERLINE ADOT - SLURRY BACKFILL	384	LF	$ 185.00	$ 71,040.00
6110	310.4	INSTALL 10", 45 DEG	2	EA	$ 1,850.00	$ 3,700.00
6120	312	INSTALL 10" GATE VALVE WITH CLASS 250	3	EA	$ 2,550.00	$ 7,650.00
6130	312.1	INSTALL 8" GATE VALVE WITH CLASS 250	2	EA	$ 2,350.00	$ 4,700.00
6140	312.2	INSTALL 10" GATE VALVE WITH CLASS 250	1	EA	$ 2,650.00	$ 2,650.00
6150	313.1	INSTALL 10", 90 DEG	1	EA	$ 1,250.00	$ 1,250.00
6160	333.1	INSTALL 10"x 10" TEE DIP CLASS 250	1	EA	$ 1,950.00	$ 1,950.00
6170	333.2	INSTALL 10"x 8" TEE DIP CLASS 250	2	EA	$ 1,850.00	$ 3,700.00
6180	341.4	CONNECT TO EXISTING 10" WATERLINE. USE RESTAINED FITTINGS	1	EA	$ 1,550.00	$ 1,550.00
6190	341.5	CONNECT TO EXISTING 8" WATERLINE. USE RESTAINED FITTINGS	2	EA	$ 1,250.00	$ 2,500.00
6200	369.1	CONSTRUCT 10" DIP CLASS 350 RESTRAINED WATER MAIN VERTICAL REALIGNMENT	2	EA	$ 6,500.00	$ 13,000.00
		WATER DISTRIBUTION SYSTEM SUBTOTAL :				**$ 113,690.00**
SEWER COLLECTION SYSTEM						
6300	401.3	INSTALL 10" SEWER MAIN	330	LF	$ 115.00	$ 37,950.00
6310	404	INSTALL EXTRA PROTECTION PER M.A.G. STD. DTL. 404.	1	EA	$ 950.00	$ 950.00
6320	420	INSTALL 48" DIA. SEWER PRE-CAST (WATER-TIGHT) MANHOLE	2	EA	$ 7,250.00	$ 14,500.00
		SEWER COLLECTION SYSTEM SUBTOTAL :				**$ 53,400.00**
STORM DRAINAGE						
6400	512.1	INSTALL 18" DIA RGRCP (CLASS 5)	126	LF	$ 165.00	$ 20,790.00
6410	537	CONSTRUCT TYPE "G" CATCH BASIN PER M.A.G. STD. DETAIL 537.	3	EA	$ 6,750.00	$ 20,250.00
6420	563	INSTALL TRENCH DRAIN K100-KLASSIKDRAIN-LOAD CLASS A	57	LF	$ 105.00	$ 5,985.00
6430	575	CONSTRUCT PUMP ASSEMBLY PER DETAIL ON UP02	1	EA	$ 64,250.00	$ 64,250.00
		STORM DRAINAGE SUBTOTAL :				**$ 111,275.00**
		PEDESTRIAN UNDERPASS SCOPE SUBTOTAL :				**$ 3,025,572.00**

MOUNTAIN LINE SCOPE						
STREET WORK						
6500	150	REMOVE AND DISPOSE OF EXISTING TREE AND ROOTBALL PER M.A.G. SPEC. SEC. 350	9	EA	$ 750.00	$ 6,750.00
6510	200A	CONSTRUCT AC SECTION 6" \ 10"; DT03 - DTL 1	2,702	SY	$ 78.00	$ 210,756.00
6520	290	CONSTRUCT CONCRETE TURN DOWN PER DETAIL 11 ON THIS SHEET. INSTALL SALVAGED RAILING FROM EX	92	LF	$ 15.00	$ 1,380.00
6530	291	INSTALL 6' - 10" W X 25' - 8" L CONCRETE PAD AND SHELTER STOP LAYOUT PER EXHIBIT H-FIGURE 3, SHOW	176	SF	$ 18.00	$ 3,168.00
6540	292	INSTALL SALVAGED BUS SHELTER FROM EXISTING BUS STOP.	1	EA	$ 3,500.00	$ 3,500.00
6550	293	INSTALL NO TRESPASSING SIGN, NO PARKING/ROUTE SIGN, PEAK HOURS SIGN, AND NO SMOKING SIGN.	1	EA	$ 550.00	$ 550.00
6560	294	INSTALL CONCRETE PAD EXHIBIT H-FIGURE 3	720	SF	$ 18.00	$ 12,960.00
6570	668	INSTALL WHITE PREFORMED PAVEMENT MARKING "BUS ONLY" TYPE I PER ADOT DWGS	6	EA	$ 450.00	$ 2,700.00
6580	674	INSTALL "BUS LANE AHEAD" SIGN (R3-12f) PER MUTCD.	2	EA	$ 500.00	$ 1,000.00
6590	675	INSTALL "BUS LANE ENDS" SIGN (R3-12g) PER MUTCD.	2	EA	$ 500.00	$ 1,000.00
		STREET WORK SUBTOTAL :				**$ 243,764.00**
		MOUNTAIN LINE SCOPE SUBTOTAL :				**$ 243,764.00**

MISCELLANEOUS						
7000		MOBILIZATION	1.00	LS	$ 145,000.00	$ 145,000.00
7010		SURVEY & STAKING	1.00	LS	$ 225,000.00	$ 225,000.00
7020		SWPPP INSTALLATION & MAINTENANCE	1.00	LS	$ 35,000.00	$ 35,000.00
7030		TRAFFIC CONTROL & MAINTENACE	1.00	LS	$ 250,000.00	$ 250,000.00
7040		AS-BUILTS\RECORD DRAWINGS	1.00	LS	$ 17,500.00	$ 17,500.00
7050		PUBLIC RELATIONS	1.00	LS	$ 95,000.00	$ 95,000.00
7060		TRENCH ROCK EXCAVATION	1.00	LS	$ 550,000.00	$ 550,000.00
7070		UNSUITABLE MATERIAL FOR UTILITY TRENCHES	250	CY	$ 75.00	$ 18,750.00
7080		SUBGRADE STABILIZATION	1,000	SY	$ 35.00	$ 35,000.00
7090		TEMP AC PATCH	2,000	SY	$ 85.00	$ 170,000.00
		MISCELLANEOUS SUBTOTAL :				**$ 1,541,250.00**
		Cost of Work Subtotal:				**$ 14,941,334.50**
GENERAL CONDITIONS						
9000	PE	PROJECT EXECUTIVE	6.00	MO	$ 10,000.00	$ 60,000.00
9010	PM	PROJECT MANAGER	18.00	MO	$ 9,750.00	$ 175,500.00

City of Flagstaff, AZ
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Eagle Mountain Construction
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GUARANTEED MAXIMUM PRICE

Project: Beulah Blvd. Extension & University Ave. Realignment - CMAR
Project #: COF# ST3040
Dwgs: SWI Engineering; stamped 8-25-222
Submitted: 11/9/2022

EMC #	Keynote	DESCRIPTION	QTY	Unit	Unit Cost	Total
9020	GS	GENERAL SUPERINTENDENT	12.00	MO	$ 8,750.00	$ 105,000.00
9030	PS	PROJECT SUPERINTENDENT	24.00	MO	$ 7,750.00	$ 186,000.00
9040	GF	GENERAL FOREMAN	24.00	MO	$ 5,500.00	$ 132,000.00
9050	8TPU	SUPER PICK-UP TRUCK	24.00	MO	$ 1,250.00	$ 30,000.00
9060	PA	PROJECT ADMIN	18.00	MO	$ 2,500.00	$ 45,000.00
9070	Lab	CLEAN UP, SNOW REMOVAL & MAKE SAFE LABOR	16.00	MO	$ 3,100.00	$ 49,600.00
9080	2C1001	CONSTUCTION WATER	3,500	MGAL	$ 4.00	$ 14,000.00
9090	8TWT 4K	4,000 GA WATER TRUCK	2,400	HR	$ 25.00	$ 60,000.00
9100	T03	DRIVER - WATER TRUCK	2,400	MH	$ 28.00	$ 67,200.00
9110	2CONEX	OFFICE, STORAGE & SITE FACILITIES	24.00	MO	$ 3,850.00	$ 92,400.00
9120	9Y0021	TEMP TOILETS (2 EA)	24.00	MO	$ 850.00	$ 20,400.00
9130	8BH420	SITE EQUIPMENT	24.00	MO	$ 5,000.00	$ 120,000.00
9140	3*LH	PPE SAFETY SUPPLIES	1.00	LS	$ 2,500.00	$ 2,500.00
9150	3*LH	PUNCH LIST & DEMOB	1.00	LS	$ 10,000.00	$ 10,000.00
					GENERAL CONDITIONS SUBTOTAL :	**$ 1,169,600.00**

BEULAH & UNIVERSITY CMAR SUMMARY			
ITEM	**DESCRIPTION**		**TOTAL**
1	COST OF WORK		$ 14,941,334.50
2	GENERAL CONDITIONS (GC'S) (Percent of Cost of the Work)	7.83%	$ 1,169,600.00
3	**SUBTOTAL #1 - Cost of the Work + GC's**		**$ 16,110,934.50**
4	CONSTRUCTION FEE (Fee) (Percentage of Subtotal #1)	8.00%	$ 1,288,874.76
5	**SUBTOTAL #2 - Cost of the Work + GC's + Fee**		**$ 17,399,809.26**
6	PERFORMANCE & PAYMENT BOND (Percentage of Subtotal #2)	0.80%	$ 139,198.47
7	**SUBTOTAL #3 - Cost of the Work + GC's + Fee + Bonds**		**$ 17,539,007.73**
8	INSURANCE (Percentage of Subtotal #3)	0.80%	$ 141,171.47
9	**SUBTOTAL #4 - Cost of the Work + GC's + Fee + Bonds + Insurance**		**$ 17,680,179.21**
10	SALES TAX (Percentage of GMP)	5.968%	$ 1,055,153.80
11	**GUARENTEED MAXIMUM PRICE**		**$ 18,735,333.00**
12	CMAR CONTINGENCY & PRICE ESCALATION FUNDING	1.84%	$ 275,000.00
13	OWNERS CONTINGENCY (Percentage of Cost of the Work)	2.00%	$ 299,000.00
14	**CONTRACT PRICE**		**$ 19,309,333**

Appendix R: Cost Estimate for Culvert

See the following page for culvert cost estimate.

WIESER CONCRETE
2815 Riley Road * Portage, WI 53901
(608) 742-4464 * (800) 362-7220
Email: markw@wieserconcrete.com * lorih@wieserconcrete.com * Website: www.wieserconcrete.com

March 15, 2024

Logan McFarland |
Lsm252@nau.edu

PRICE ESTIMATE

Location: Flagstaff, AZ 86401 (Assumed Freight Distance of 145 miles For Prices)

1 EA	Precast Concrete Box Culvert 46 LF of 8' Span x 3' Rise Twin Cell Max Weight: 65,167 lbs. 10 Sections (Assumed Standard Length of 7'-8") 12" Haunches	$ 66,375.00 EA
2 EA	Inlet/Outlet Headwall Attached to Outlet Section of Box Culvert 6-12" Tall Chamfered Edge	$ 2,500.00 EA
4 EA	Flared Wingwalls Freestanding Design	$ 3,750.00 EA
12 EA	Freight	$ 1,500.00 EA
Total Price		$ 104,375 LS

All Prices Include:
- Delivery
- Joint Sealant
- Joint Wrap
- Joint Ties
- Shop Drawings
- Precast Design

Does Not Include:
- Unloading of our Trucks
- Installation
- Toe Walls
- Apron

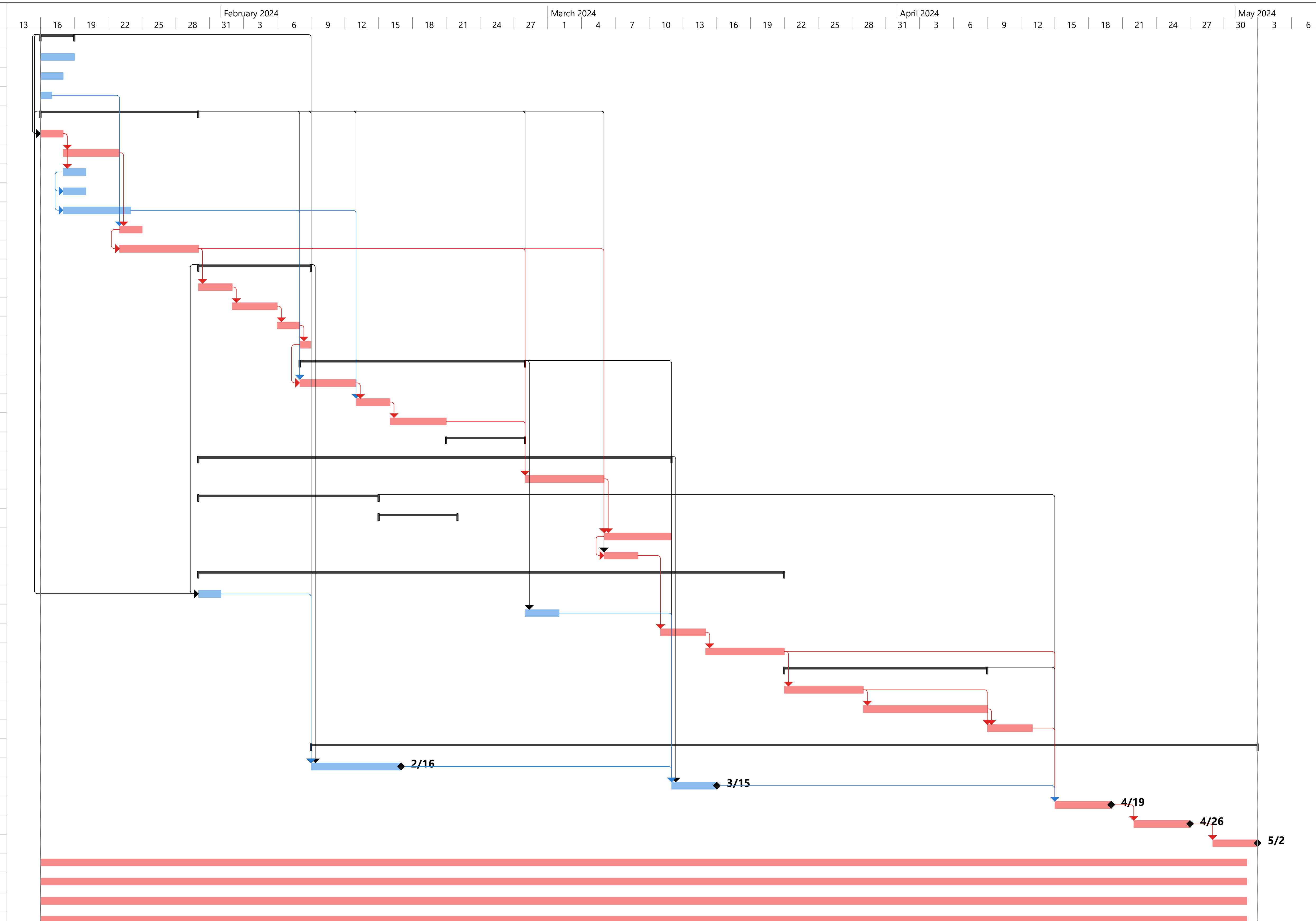
Sales taxes are not included in these prices.
Prices are an Estimate for Educational Purposes ONLY

Adam Wieser, Project Engineer
Office: 800-362-7220

Appendix S: Proposed Gantt Chart

See the following page for the project's proposed scheduling.

ID	Task Name
1	**TASK 1: Research and Data Collection**
2	1.1 Review Codes and Standards
3	1.2 Identify Design Vehicle
4	1.3 Collect Existing Geotechnical Data
5	**TASK 2: Site Investigation**
6	2.1 Site Visit Planning
7	2.2 Land Surveying
8	2.3 Traffic Counts
9	2.4 Photograph Site Features
10	2.5 Collect Existing Hydraulic Structure Data
11	2.6 Geotech Analysis
12	2.7 Topographic Map
13	**TASK 3: Hydrologic Analysis**
14	3.1 Watershed Delineation
15	3.2 Time of Concentration
16	3.3 Storm Intensity
17	3.4 Calculate Peak Flow
18	**TASK 4: Hydraulic Analysis**
19	4.1 Existing Culvert Analysis
20	4.2 Existing Channel Analysis
21	4.3 Post Improvement Hydrologic Analysis
22	**4.4 Proposed Culvert and Channel Design**
26	**TASK 5: Roadway Design**
27	5.1 Roadway Geometry
28	**5.2 Intersection Design**
32	**5.3 Pavement Design**
36	5.4 Sidewalk Design
37	5.5 Sinage and Striping
38	**TASK 6: Construction Plans**
39	6.1 Cover Sheet
40	6.2 Existing Site Plan
41	6.3 Plans and Profiles
42	6.4 Details Sheet
43	**TASK 7: Economic Analysis**
44	7.1 Construction Cost
45	7.2 Operation and Maintenance Cost
46	TASK 8: Impact Analysis
47	**TASK 9: Deliverables**
48	9.1 30% Submittal
49	9.2 60% Submittal
50	9.3 90% Submittal
51	9.4 Final Presentation
52	9.5 Final Submittal
53	**TASK 10: Project Management**
54	10.1 Meetings
55	10.2 Schedule Management
56	10.3 Resource Management



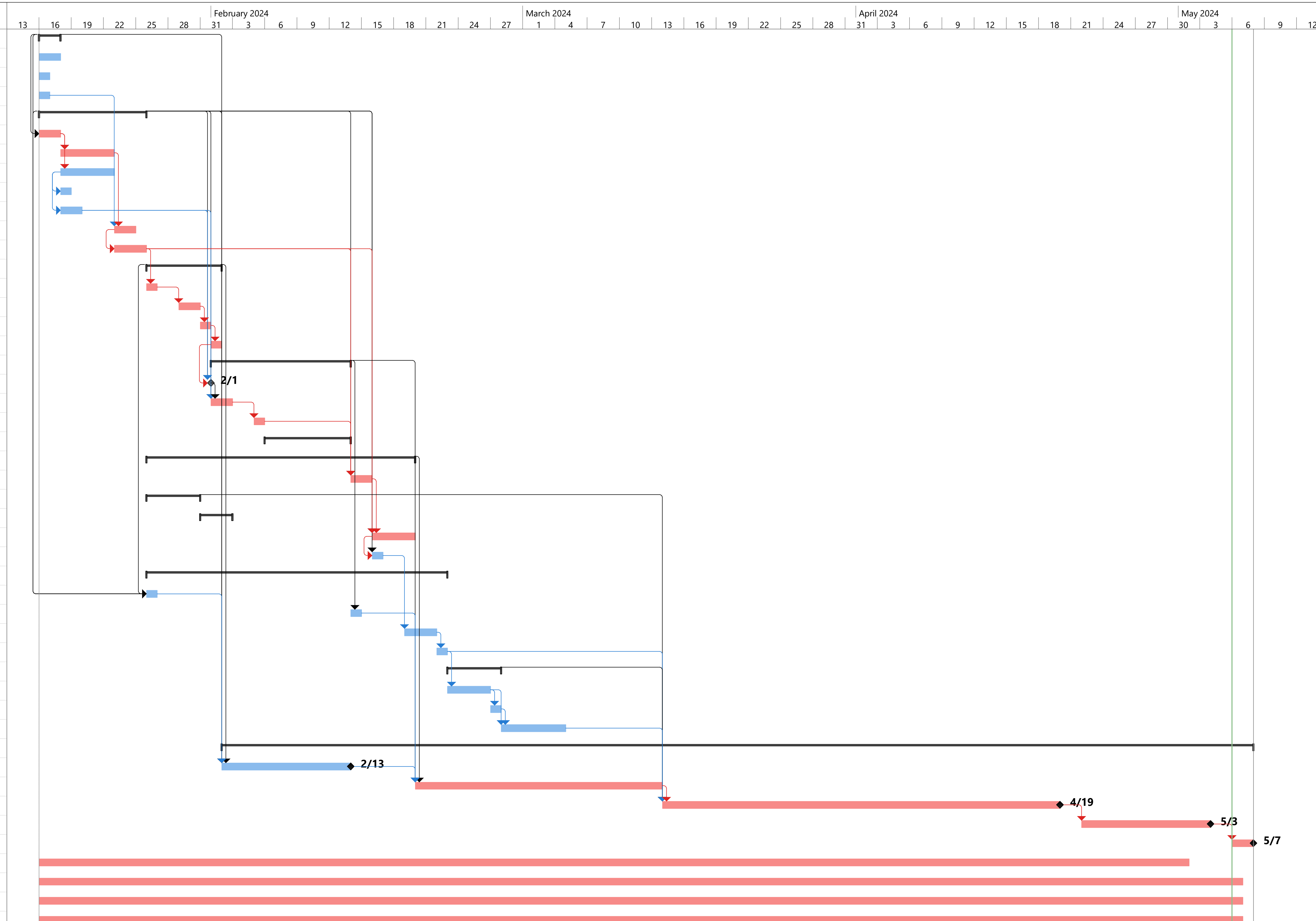
Project: Project Gantt 11-28
Date: Mon 12/11/23

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

Appendix T: Final Gantt Chart

See the following page for the project's final scheduling.

ID	Task Name
1	**TASK 1: Research and Data Collection**
2	1.1 Review Codes and Standards
3	1.2 Identify Design Vehicle
4	1.3 Collect Existing Geotechnical Data
5	**TASK 2: Site Investigation**
6	2.1 Site Visit Planning
7	2.2 Land Surveying
8	2.3 Traffic Counts
9	2.4 Photograph Site Features
10	2.5 Collect Existing Hydraulic Structure Data
11	2.6 Geotech Analysis
12	2.7 Topographic Map
13	**TASK 3: Hydrologic Analysis**
14	3.1 Watershed Delineation
15	3.2 Time of Concentration
16	3.3 Storm Intensity
17	3.4 Calculate Peak Flow
18	**TASK 4: Hydraulic Analysis**
19	4.1 Existing Culvert Analysis
20	4.2 Existing Channel Analysis
21	4.3 Post Improvement Hydraulic Analysis
22	**4.4 Proposed Culvert and Channel Design**
26	**TASK 5: Roadway Design**
27	5.1 Roadway Geometry
28	**5.2 Intersection Design**
32	**5.3 Pavement Design**
36	5.4 Sidewalk Design
37	5.5 Sinage and Striping
38	**TASK 6: Construction Plans**
39	6.1 Cover Sheet
40	6.2 Existing Site Plan
41	6.3 Plans and Profiles
42	6.4 Details Sheet
43	**TASK 7: Economic Analysis**
44	7.1 Construction Cost
45	7.2 Operation and Maintenance Cost
46	TASK 8: Impact Analysis
47	**TASK 9: Deliverables**
48	9.1 30% Submittal
49	9.2 60% Submittal
50	9.3 90% Submittal
51	9.4 Final Presentation
52	9.5 Final Submittal
53	**TASK 10: Project Management**
54	10.1 Meetings
55	10.2 Schedule Management
56	10.3 Resource Management



Project: Project Gantt 11-28
Date: Mon 5/6/24

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

Appendix U: Final Timesheet

See the following pages for the timesheet used in the project's design phase.

Task	SENG	ENG	TECH	INT	Total Hours
1.0 Research and Data Collection					**25**
1.1 Review Codes and Standards	0	14	0	7	21
1.2 Identify Design Vehicle	1	1	0.5	1	3.5
1.3 Collect Existing Geotechnical Data	0	0.5	0	0	0.5
2.0 Site Investigation					47.15
2.1 Site Visit Planning	0	1	1.5	2	4.5
2.2 Land Survey	0	2.5	2.5	2.5	7.5
2.3 Traffic Counts	0	3	3	8	14
2.4 Photographs of Site Features	0	0.5	0.5	0.5	1.5
2.5 Collect Existing Hydraulic Structure Data	0	0	1.5	0	1.5
2.6 Geotech Analysis	0	1	0	0.5	1.5
2.7 Topographic Map	0	13.15	2	1.5	16.65
3.0 Hydrologic Analysis					**12**
3.1 Watershed Delineation	0	0	3	0	3
3.2 Time of Concentration	0	3	0	1	4
3.3 Storm Intensity	0	0	0	1.5	1.5
3.4 Calculate Peak Flow	0	3	0	0.5	3.5
4.0 Hydraulic Analysis					**88.5**
4.1 Existing Culvert Analysis	0	0	0	0	0
4.2 Existing Channel Analysis	0	9	4	8	21
4.3 Post-Improvement Hydrologic Analysis	0	4	5.5	7.5	17
4.4 Proposed Culvert and Channel Design	0	5	9	6	20
4.4.1 Determine Criteria	0	3	0	1	4
4.4.2 Develop Alternatives	0	3	9	1	13
4.4.3 Analyze Alternatives and Select Best	4.5	4	1	4	13.5
5.0 Roadway Design					**124.2**
5.1 Roadway Geometry	4	22	0	9	35
5.2 Intersection Design	5	18	0	7.5	30.5
5.2.1 Determine Criteria	0	2	0	2	4
5.2.2 Develop Alternatives	0	4	0	0	4
5.2.3 Analyze Alternatives and Select Best	3	1.5	1	0.5	6
5.3 Pavement Design	0	2	0	1	3

5.3.1 Determine Criteria	0	7.5	0	0	7.5
5.3.2 Develop Alternatives	0	5.7	0	0	5.7
5.3.3 Analyze Alternatives and Select Best	2	9	0.5	1.5	13
5.4 Sidewalk Design	0	8.5	0	1	9.5
5.5 Signage and Striping	1	2	0	3	6
6.0 Construction Plans					**76.5**
6.1 Cover Sheet	0	3	2	1.5	6.5
6.2 Existing Site Plan	0	0	5	3	8
6.3 Plans and Profiles	3	14	9	17	43
6.4 Details Sheets	1	3	13	2	19
7.0 Economic Analysis					**16**
7.1 Construcion Cost	1	5	5	5	16
7.2 Operation and Maintenance Cost	0	0	0	0	0
8.0 Impact Analysis	0	3	2	3	**8**
9.0 Deliverables					**191.25**
9.1 30% Submittal	7	24	17.25	15	63.25
9.2 60% Submittal	12.5	28	9	13.5	63
9.3 90% Submittal	0	10	11	18	39
9.4 Final Submittal	8	9	5	4	26
10.0 Project Management					**60.3**
10.1 Meetings	3	16.7	7.8	10.8	38.3
10.2 Schedule Management	4	1.5	2	3.5	11
10.3 Resource Management	1	7	3	0	11
Summary					
Total Hours	61	277.05	135.55	175.3	**648.9**