# I-40/CC Westbound On-Ramp and Right-Turn Lane

## CENE-486C

## 90% Update Presentation

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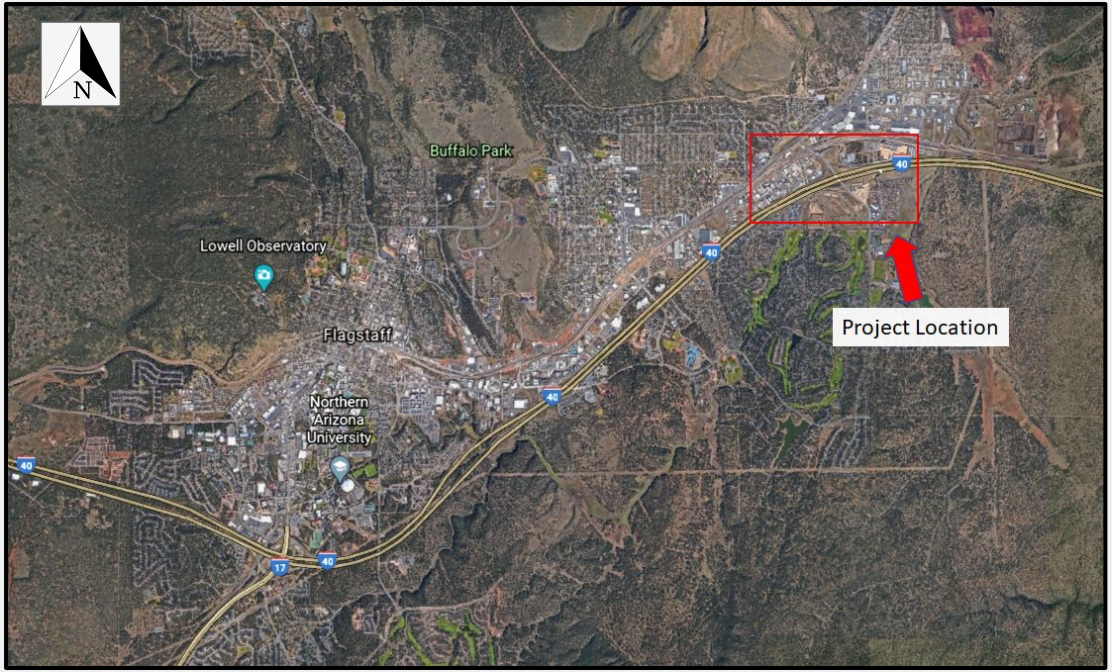
Ramon Lopez

# Project Overview

- **Client**: Arizona Department of Transportation (ADOT)
- **Location**: I-40 and Country Club Drive Traffic Interchange (Flagstaff, AZ)
- **Final Product**: 30% Design Concept Report


[1]

# Project Location and Vicinity Map


***From Left to Right**: Map of Arizona (NTS); Project Vicinity Map (NTS) [2][3]*

# Milestones

- 30% Report ✓
  - **Milestone 1**: Process Survey Data
  - **Milestone 2**: Input Existing Geometry
  - **Milestone 3**: Create Construction Alignments
  - **Milestone 4**: Create Existing Cross Sections
  - **Milestone 5**: Complete Existing Runoff Calculations
- 60% Report ✓
  - **Milestone 6**: Create Proposed Cross Sections
  - **Milestone 7**: Preliminary Intersection Design
  - **Milestone 8**: Preliminary On-Ramp Design

- 90% Report
  - **Milestone 9**: Final Intersection Design
  - **Milestone 10**: Final On-Ramp Design
  - **Milestone 11**: Final Drainage Design
  - **Milestone 12**: Capacity Analysis
  - **Milestone 13**: Impact Assessment

# 30% Summary - Processing Survey Data

- Contour Data was downloaded as a .shp file, and processed within Civil 3D
- Parcel information was exported from GIS into Civil 3D

Figure 2: Existing Contour Data (NTS)

# 30% Summary - Input Existing Geometry

- Project Aerial was georeferenced into Civil 3D
- Existing Geometry was drawn in using Aerial, within Civil 3D
- Various Layers and Line Types were used for Existing Geometry

*Figure 3: Existing Geometry (NTS)*

# 30% Summary - Existing Runoff Calculations

- Major Watershed was Delineated for Project Area
  - USGS Topo Maps
  - City Contour Data
- Peak Flows were Calculated Using National Stream Statistics (NSS)
  - Annual Precipitation (21 inches)
  - Watershed Area (2.02 square miles)
  - Region (Peak_Region_1_High_Elev_2014)
- Used flow from previous drainage report (more conservative flow)

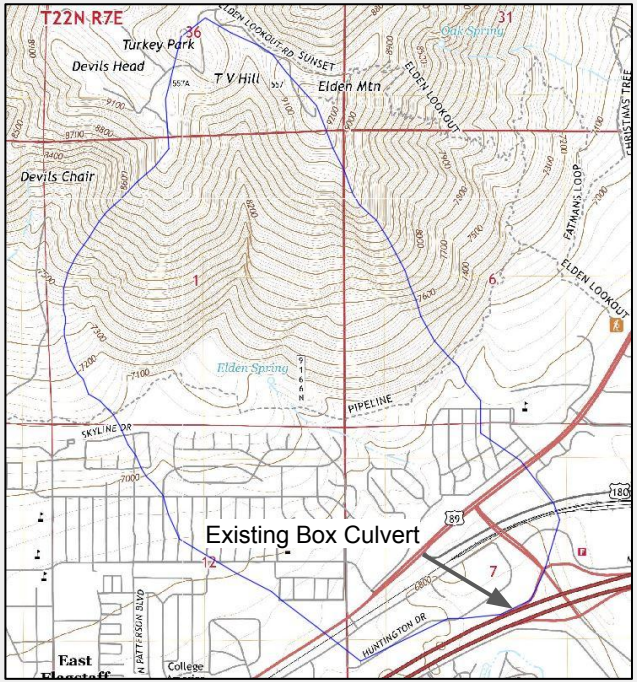



*Figure 4: Project Watershed (NTS)*

# 30% Summary - Existing Runoff Calculations Cont.

- Watershed was Delineated for Existing Catch Basin and 24” CMP
  - Rational Method
  - Bentley Flowmaster
- ADOT and COF Drainage Standards [2] [3]
- Existing Infrastructure is able to Accommodate Existing Flows [1]

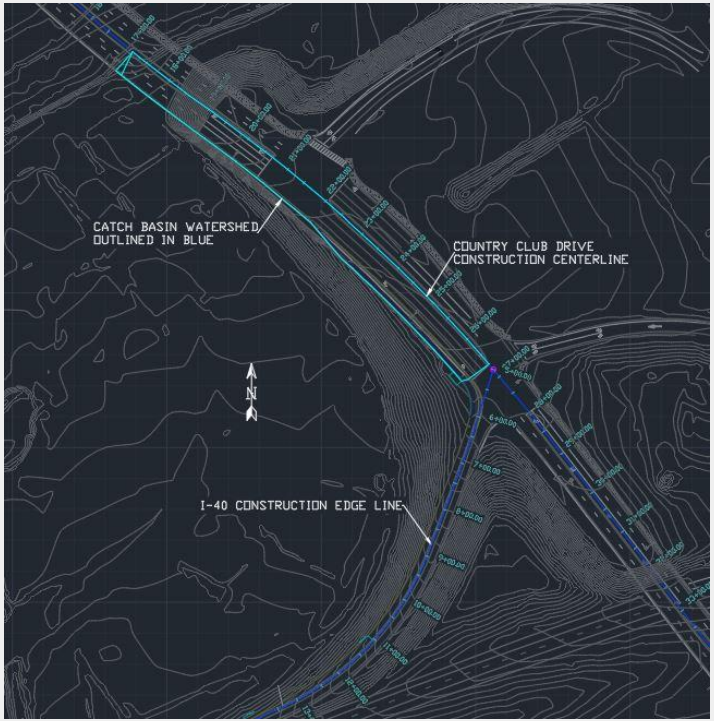



*Figure 5: Inlet Watershed (NTS)*

# 30% Summary - (Existing Cross-Sections)

- Obtained from As-Builts Provided by ADOT
- Drawn within Civil 3D
- Includes
  - Pavement Structure
  - Lane Widths and Usage
  - Curb and Gutter Detail Callouts
  - Cross-Slopes
  - Sidewalk Detail Callouts
  - Embankment Detail Callouts

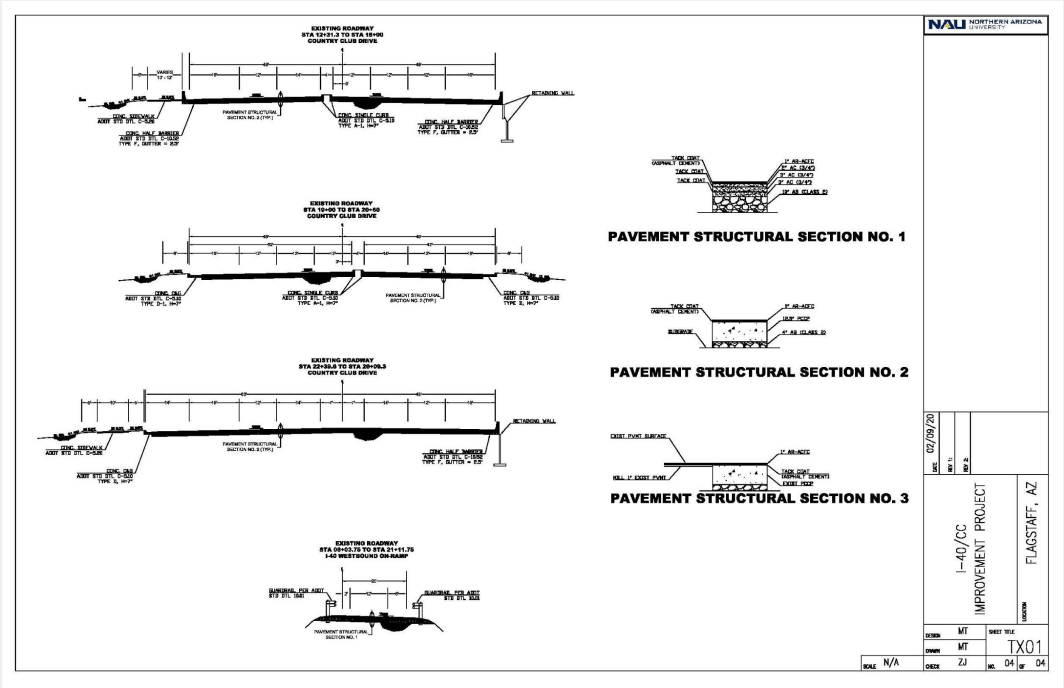



*Figure 9: Typical Cross-Sections (NTS)*

# 60% Summary - Preliminary Intersection Design

- FHWA Lane Taper [4] Recommendations
  - Taper Length = 96’
  - Taper Slope = 8:1
- Right-Turn Lane Extends 512’ to Existing Bridge Structure
- 12’ Lane Width
- 4’ Shoulder Width

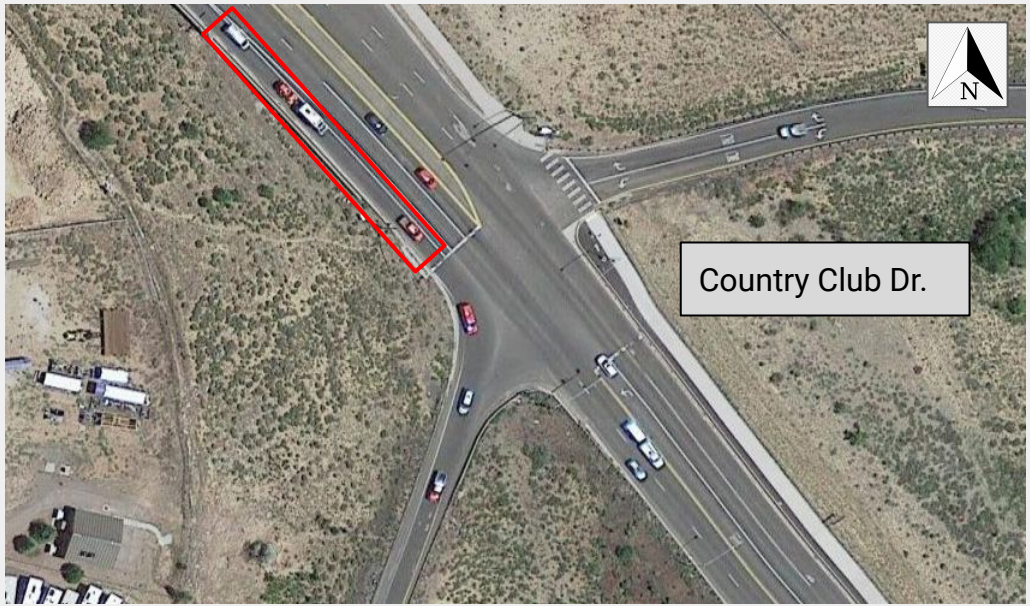
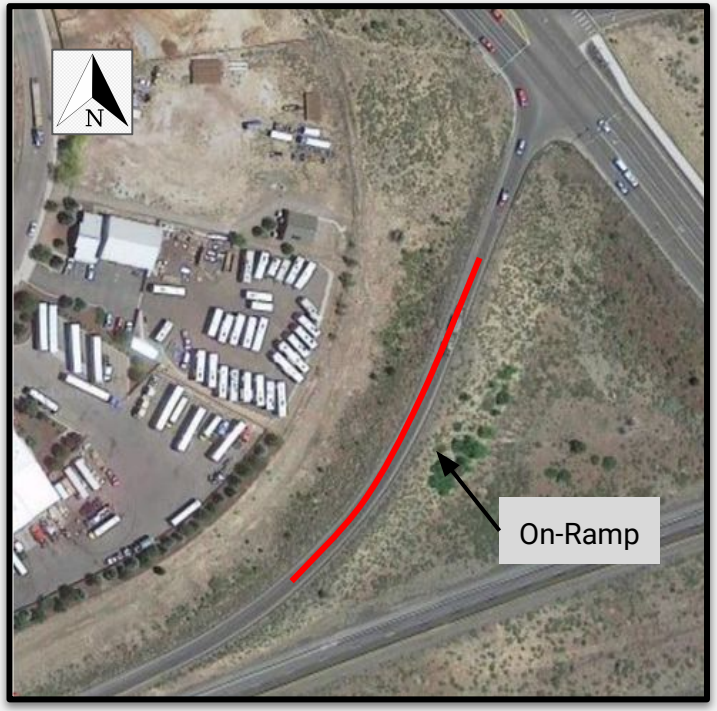



*Figure 6: Intersection Plan View (NTS)*

# 60% Summary - Preliminary On-Ramp Design

- Federal Highway Administration (FHWA) Lane Taper Recommendations [4]:
  - Taper Length = 300’
  - Taper Slope = 25:1
- Total Lane Length is 800’
- Match Existing Superelevation
- Guardrail Per ADOT STD DTL 10.01 [5]




[3]

*Figure 7: On-Ramp Plan View (NTS)*

# 60% Summary - Create Alignments

- Country Club Drive CL Alignment
  - Stationing began at Intersection of US89
  - Placement Involved a split of ROW along Country Club Drive
- I-40 On-Ramp Edge Alignment
  - Stationing Began at Intersection of Country club Drive

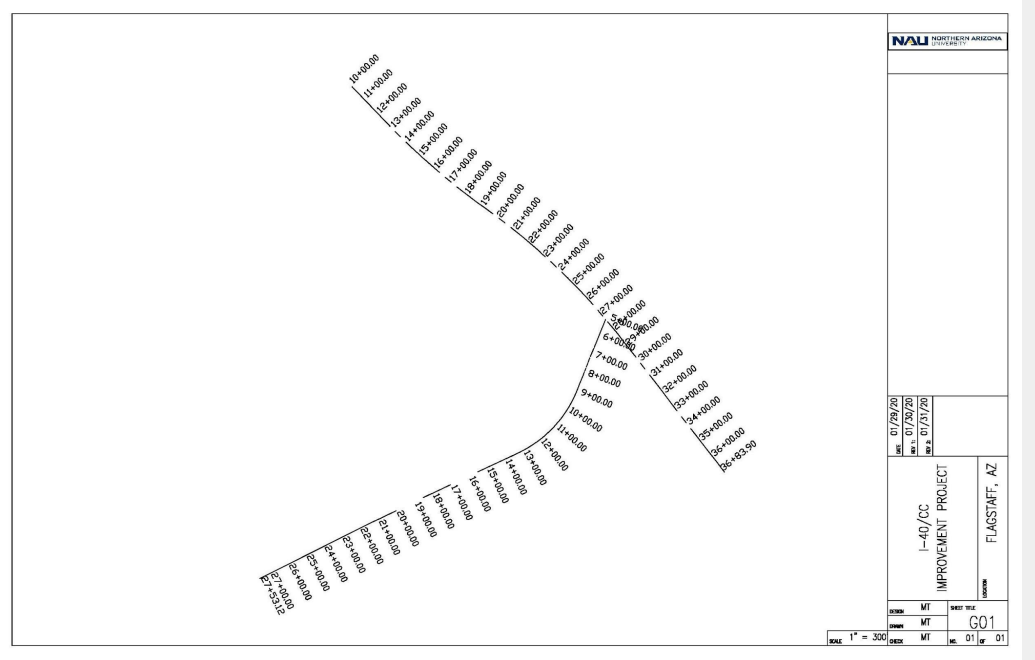



*Figure 8: Alignment Geometry (NTS)*

# 60% Summary - Create Proposed Cross-Sections

- 24” Saw Cut Offset from Existing Edge of Pavement
- Match Existing Infrastructure

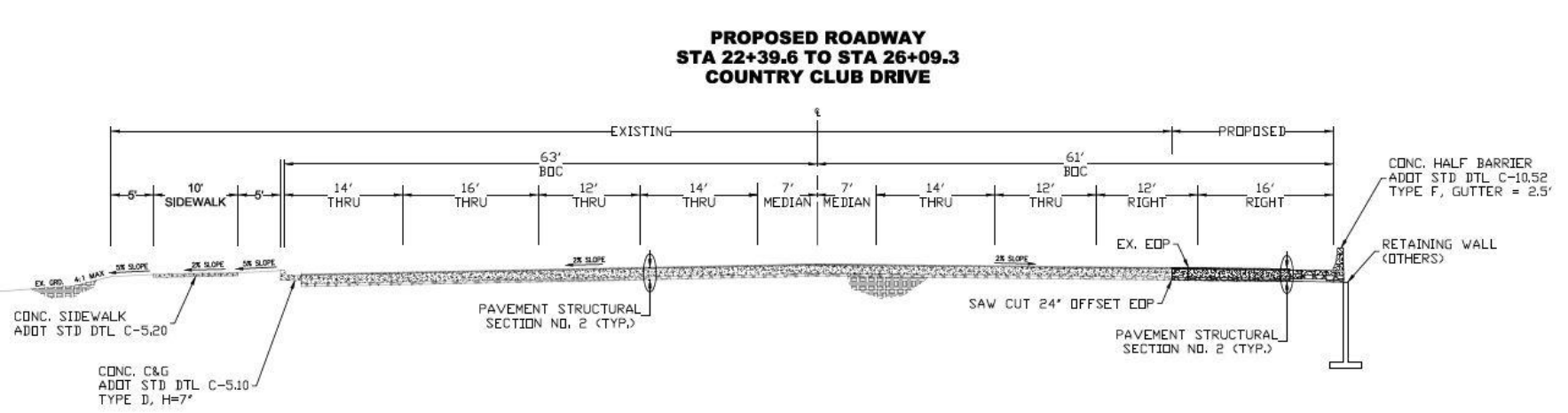
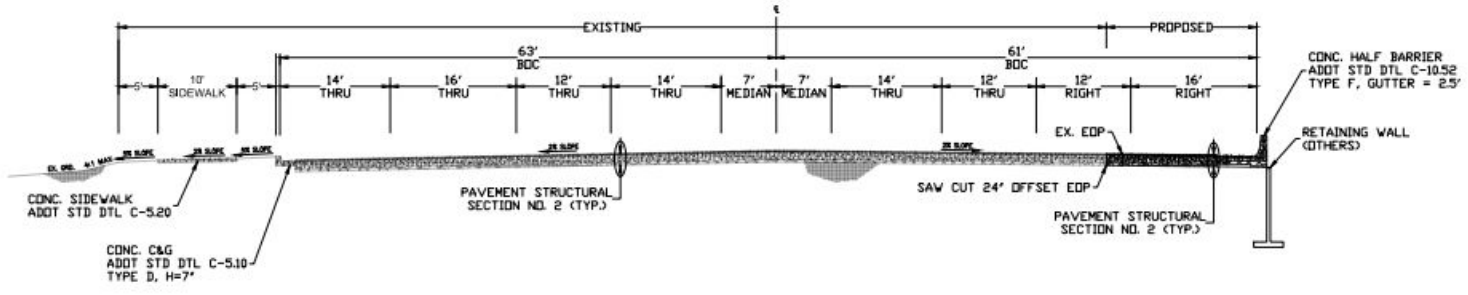


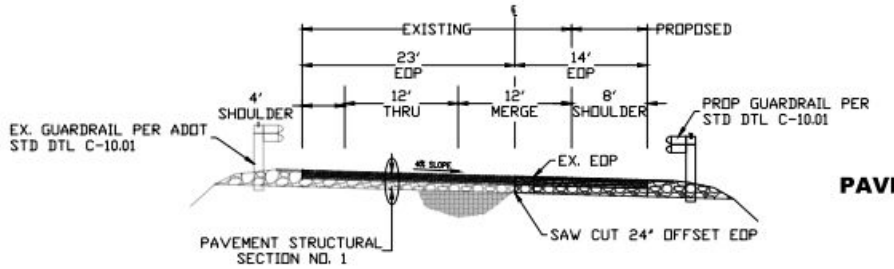

Figure 2: Proposed Cross-Sections

# Proposed Roadway & On-Ramp Cross-Sections

**PROPOSED ROADWAY**
**STA 22+39.6 TO STA 26+09.3**
**COUNTRY CLUB DRIVE**

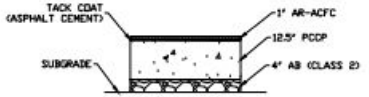



**PROPOSED ROADWAY**
**STA 06+03.75 TO STA 11+03.44**
**I-40 WESTBOUND ON-RAMP**




**PROPOSED ROADWAY**
**STA 06+03.75 TO STA 21+11.75**
**I-40 WESTBOUND ON-RAMP**

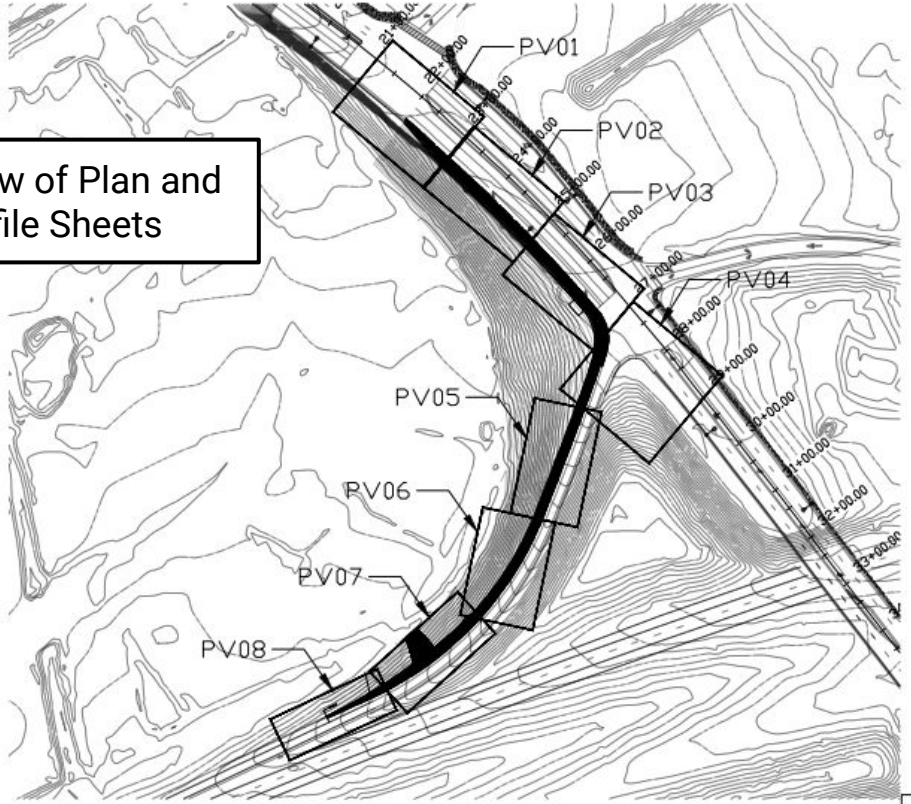

**PAVEMENT STRUCTURAL SECTION NO. 1**

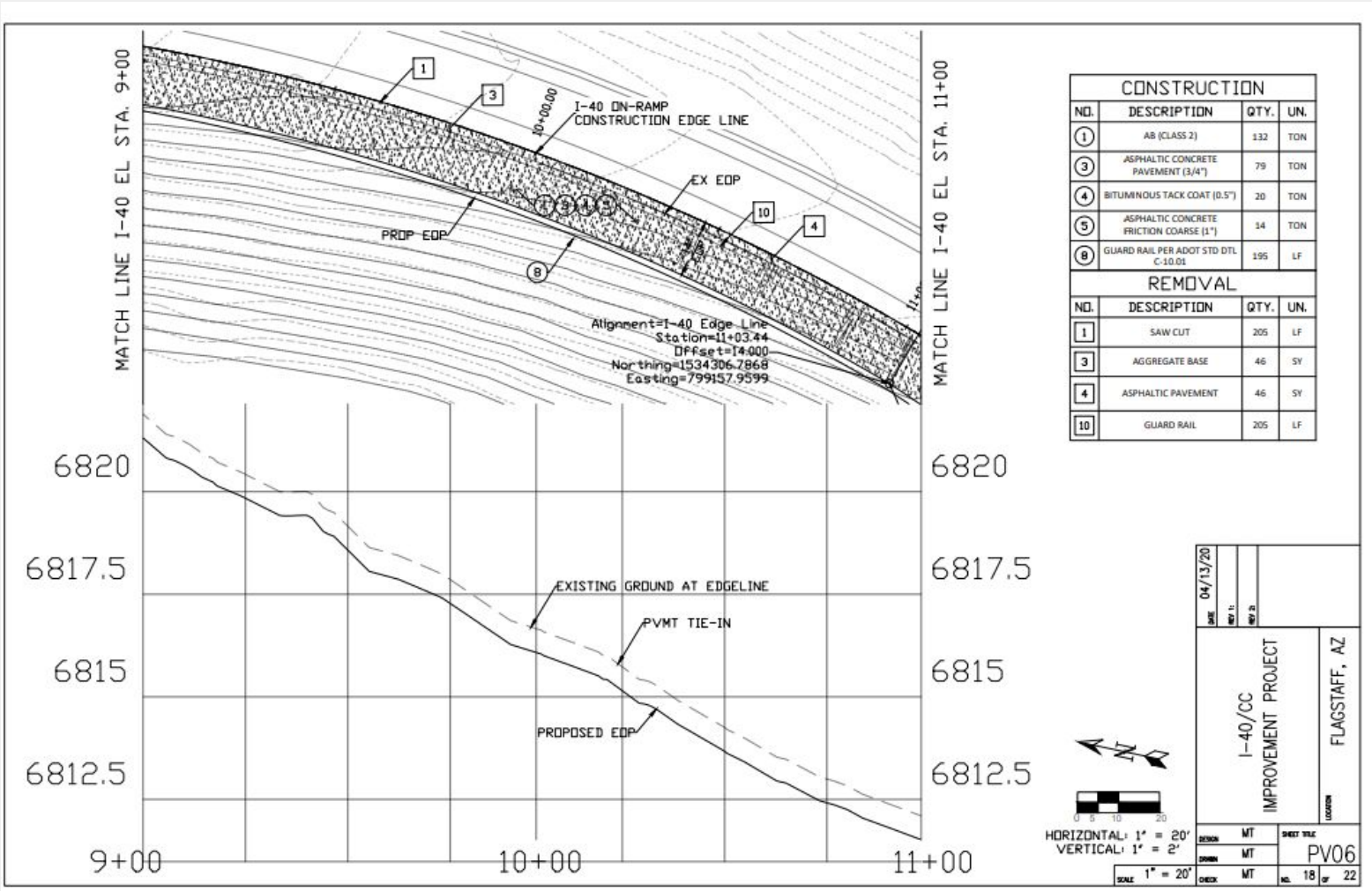



**PAVEMENT STRUCTURAL SECTION NO. 2**

| | | | |
|---|---|---|---|
| DATE | 04/13/20 | | |
| REV 1: | | | |
| REV 2: | | | |
| I-40/CC IMPROVEMENT PROJECT | | LOCATION | FLAGSTAFF, AZ |
| DESIGN | MT | SHEET TITLE | TX01 |
| DRAWN | MT | | |
| CHECK | ZJ | NO. 10 | OF 22 |

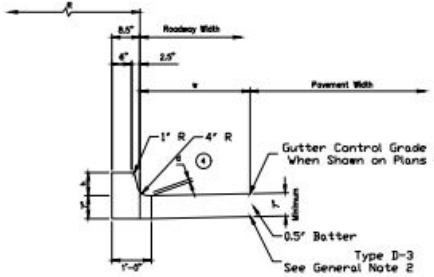
Overview of Plan and Profile Sheets



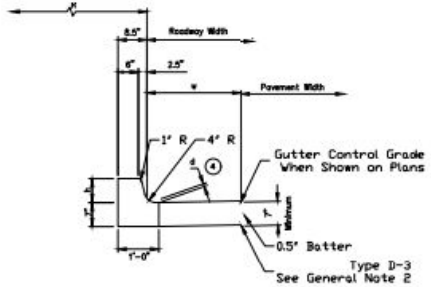



| CONSTRUCTION | | | |
|---|---|---|---|
| NO. | DESCRIPTION | QTY. | UN. |
| 1 | AB (CLASS 2) | 132 | TON |
| 3 | ASPHALTIC CONCRETE PAVEMENT (3/4") | 79 | TON |
| 4 | BITUMINOUS TACK COAT (0.5") | 20 | TON |
| 5 | ASPHALTIC CONCRETE FRICTION COARSE (1") | 14 | TON |
| 8 | GUARD RAIL PER ADOT STD DTL C-10.01 | 195 | LF |

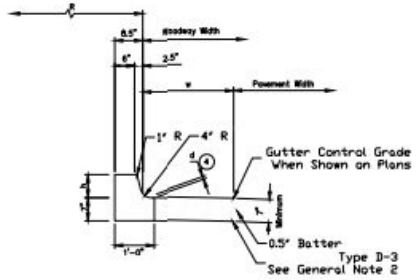
| REMOVAL | | | |
|---|---|---|---|
| NO. | DESCRIPTION | QTY. | UN. |
| 1 | SAW CUT | 205 | LF |
| 3 | AGGREGATE BASE | 46 | SY |
| 4 | ASPHALTIC PAVEMENT | 46 | SY |
| 10 | GUARD RAIL | 205 | LF |



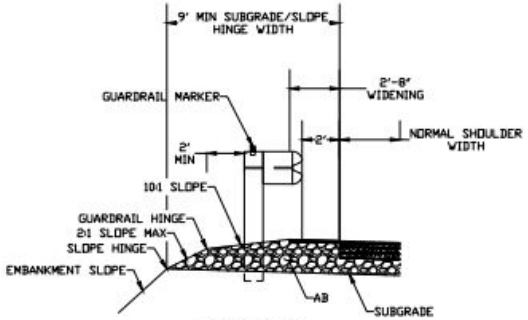

ADOT STD DTL C-5.10
TYPE D-1, H=7"



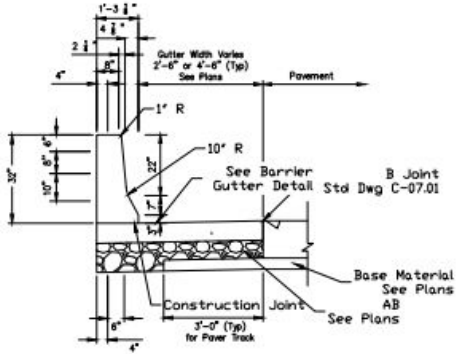

ADOT STD DTL C-5.10
TYPE D, H=7"




ADOT STD DTL C-5.10
TYPE D-3, H=7"




ADOT STD DTL
C-10.01
NO EMBANKMENT CURB
GUARDRAIL




ADOT STD DTL C-10.52
TYPE F, GUTTER = 2.5'
CONCRETE HALF BARRIER

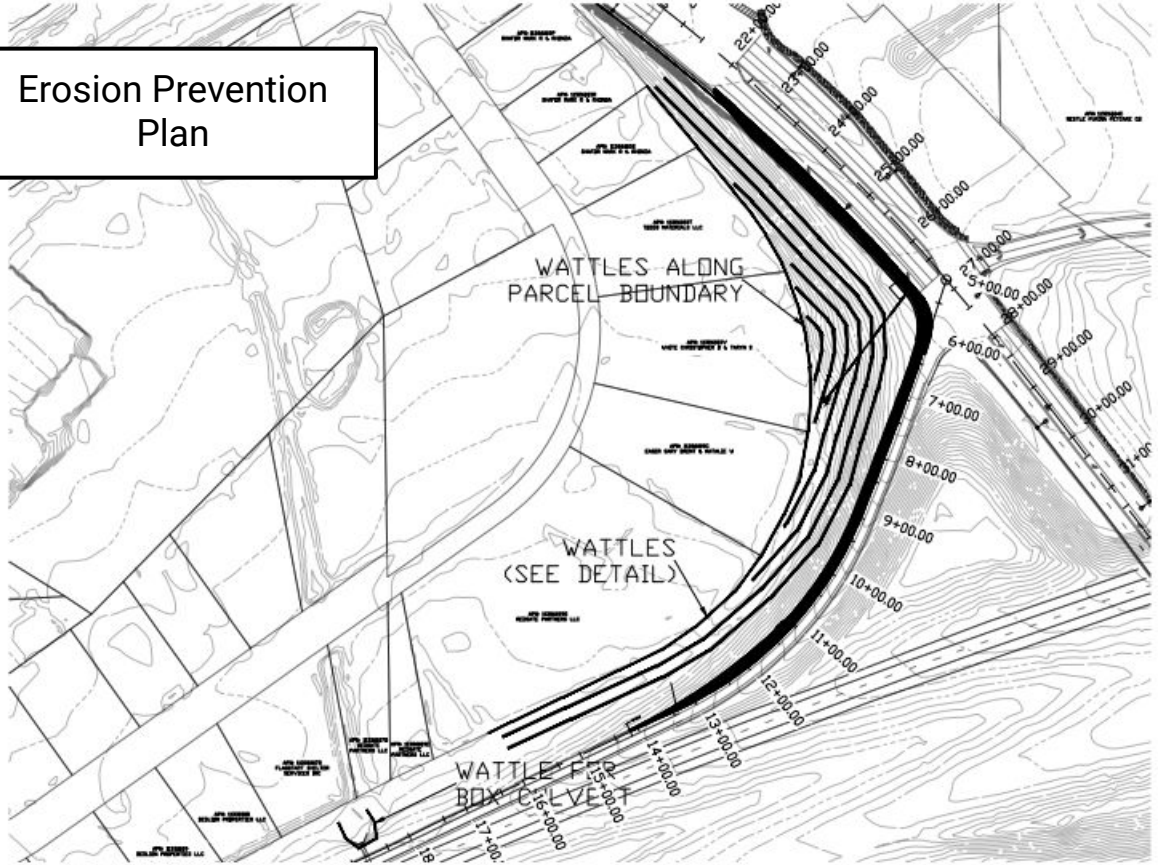
| | | | |
|---|---|---|---|
| DATE | 04/13/20 | | |
| REV 1: | | | |
| REV 2: | | | |

I-40/CC IMPROVEMENT PROJECT

LOCATION: FLAGSTAFF, AZ

| | | | |
|---|---|---|---|
| DESIGN | RL | SHEET TITLE | DT01 |
| DRAWN | MT | | |
| CHECK | ZJ | NO. 04 | OF 22 |

# Erosion Prevention Plan



# Milestone 9: Final Intersection Design

- FHWA Lane Taper [4] Recommendations
  - Taper Length = 96’
  - Taper Slope = 8:1
- Right-Turn Lane Extends 512’ to Existing Bridge Structure
- 12’ Lane Width
- 4’ Shoulder Width

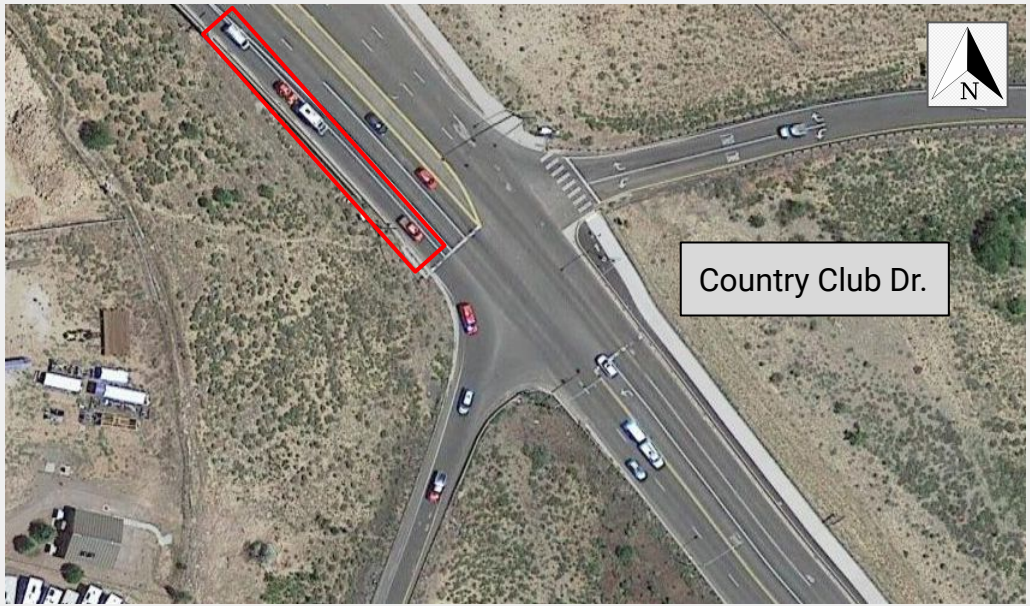
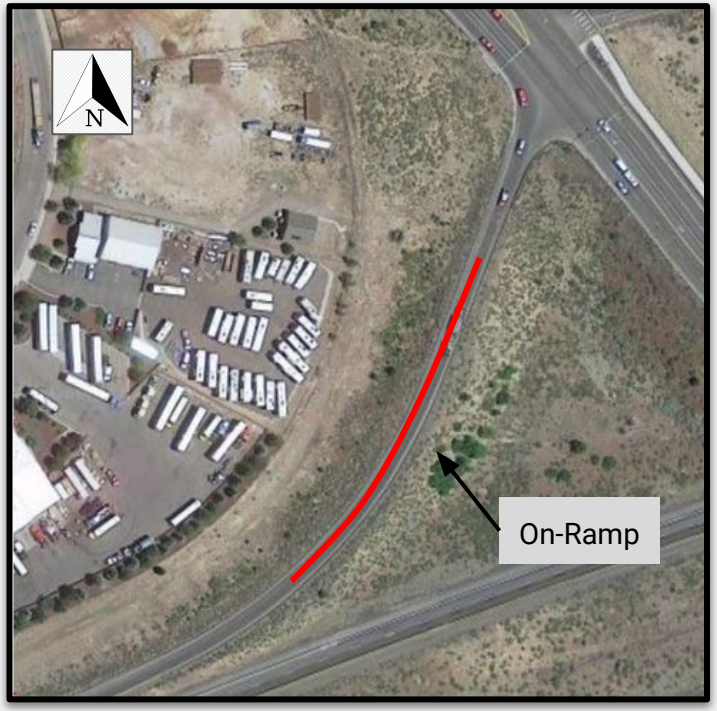



*Figure 10: Intersection Plan View (NTS)*

# Milestone 10: Final On-Ramp Design

- Federal Highway Administration (FHWA) Lane Taper Recommendations [4]:
  - Taper Length = 300’
  - Taper Slope = 25:1
- Total Lane Length is 800’
- Match Existing Superelevation
- Guardrail Per ADOT STD DTL 10.01 [5]




[3]

*Figure 11: On-Ramp Plan View (NTS)*

# Milestone 11: Final Drainage Design

- Proposed catch basin located at intersection of of On-Ramp and Country Club Dr
- Storm Pipe will require up-sizing from 18” to 24” due to increased runoff from proposed roadway

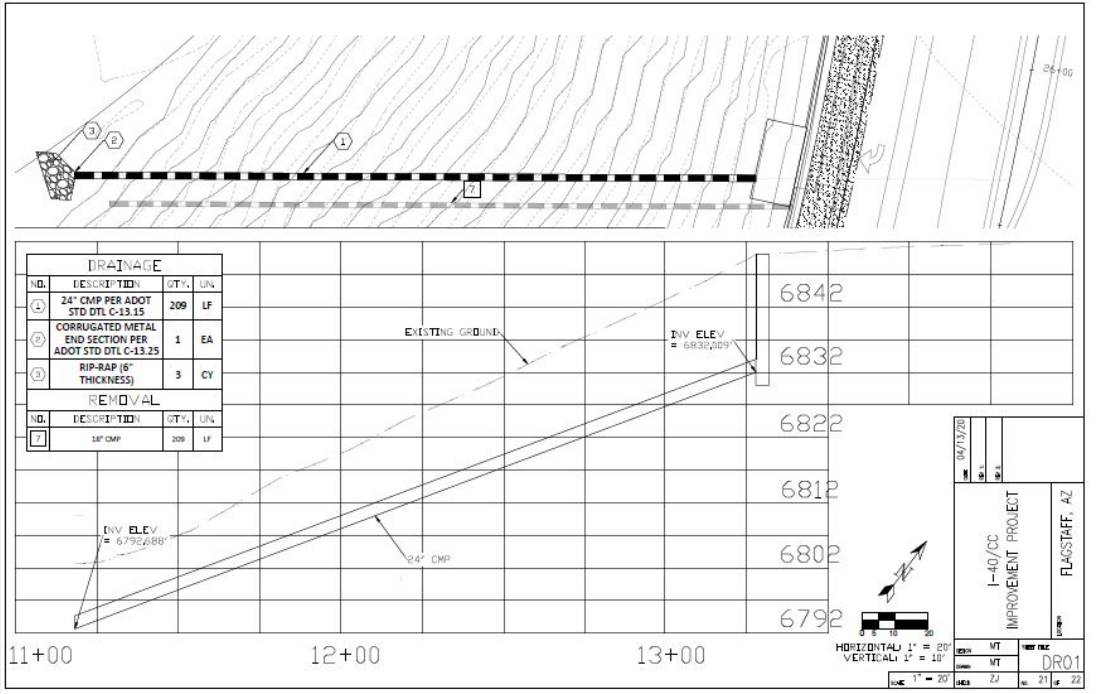



*Figure 12: Storm Drain Pipe Plan Sheet Profile (NTS)*

# Milestone 12: Synchro Capacity Analysis

**Equation 1 - Phase Duration:**

The duration of an actuated phase is found by the equation below:

$$g = D_p - l_1 - l_2$$

Where:

$g$ = *Effective green time.*
$l_2$ = *clearance lost time* = $Y + R_c - e$ $(s)$.
$e$ = *extension of effective green* = 2.0 $(s)$.

**Equation 2 - Effective Green Time:**

The effective green time for the phase is found by the equation below:

$$D_p = l_1 + g_s + g_e + Y + R_c$$

Where:

$D_p$ = *Phase duration* $(s)$.
$l_1$ = *Start − up lost time* = 2.0 $(s)$.
$g_s$ = *queue service time* $(s)$.
$g_e$ = *green extension time* $(s)$.
$Y$ = *yellow change interval* $(s)$.
$R_c$ = *red clearance interval* $(s)$.

- Equation 1 and Equation 2 are the first two equations needed to calculate the capacity of a roadway
- Both equations are found in the Highway Capacity Manual [6]

# Milestone 12: Synchro Capacity Analysis

**Equation 3 - Adjusted Saturation Flow Rate:**

The capacity of the additional right turn lane was “analyzed” using methods presented within the Highway Capacity Manual. The adjusted saturation flow rate for a lane is found using the following equation:

$$s = s_0 f_w f_{HV_g} f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{L_p b} f_{R_p b} f_{wz} f_{ms} f_{sp}$$

- Equation 3 represents the Adjusted Saturation Flow Rate for a roadway which is needed in the Capacity equation [6]
- All variables are adjustment factors which can be found in tables in the Highway Capacity Manual [6]

# Milestone 12: Synchro Capacity Analysis

**Equation 4 - Capacity:**

The capacity of a lane or lane group is found by the capacity equation below:

$$c = N\,s\,\frac{g}{C}$$

Where:

$c = Capacity.$

$s = Adjusted\ Saturated\ Flow\ Rate\ (veh/h/ln).$

$N = Number\ of\ Lanes.$

$g = Effective\ Green\ Time.$

$C = Cycle\ Length.$

- Equation 4 displays the capacity one or more lanes
- It is assumed that the signal timing will not change with the addition of the proposed Right Turn Lane
- Capacity will Double with implementation of proposed roadway

# Milestone 13: Impacts

## Environmental Impacts

- Increase in stormwater pollution
- Increase in impervious area
- Increase in emissions
- Creating a Low Impact Development (LID)

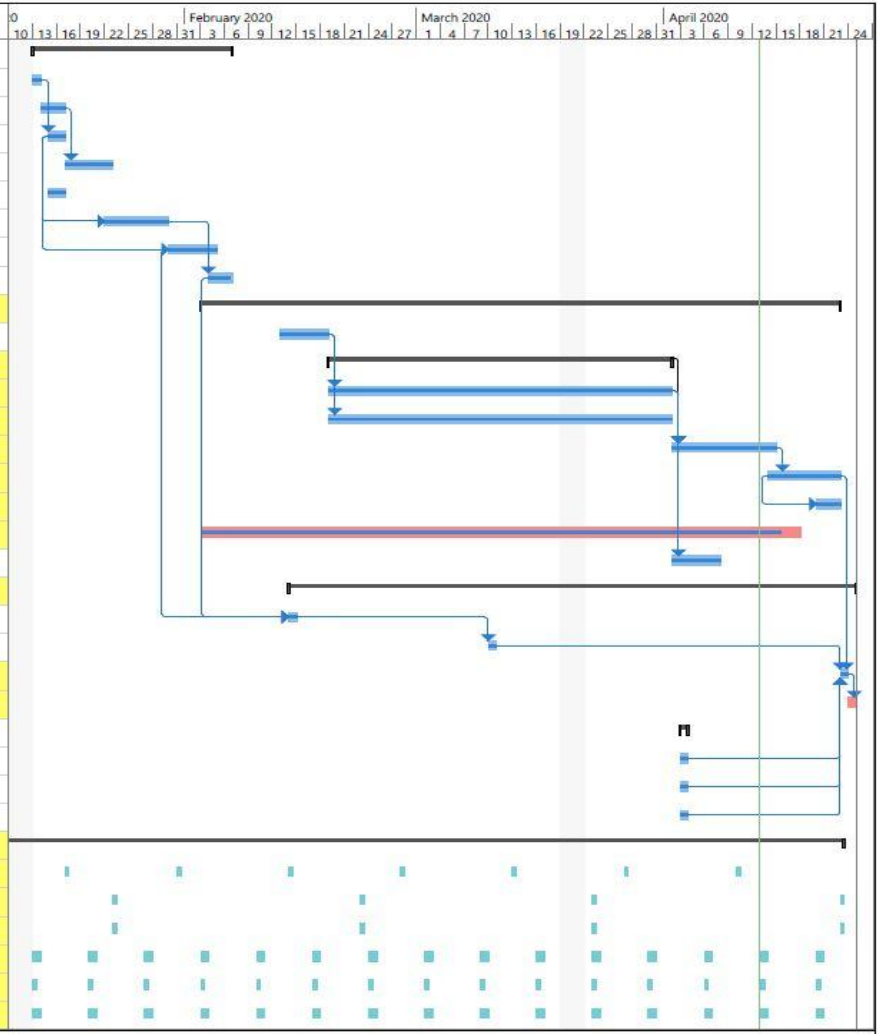
## Social Impacts

- Increased roadway capacity
- Less time on roadway, more time getting to their destination
- More time with family or friends

## Economic Impacts

- Less time waiting at intersection, quicker to get to jobs or businesses
- Less waiting for semi trucks to deliver goods quicker

| ID | Task Name | Duration | Start | Finish | Predecessors |
|---|---|---|---|---|---|
| 1 | **Task 1: Existing Studies** | **19 days** | **Mon 1/13/20** | **Thu 2/6/20** | |
| 2 | 1.1: Site Visit | 1 day | Mon 1/13/20 | Mon 1/13/20 | |
| 3 | 1.2: Process Survey Data from GIS | 3 days | Tue 1/14/20 | Thu 1/16/20 | |
| 4 | 1.3: Studying/Analyzing Existing Drainage Studies/As-Built Inf | 2 days | Wed 1/15/20 | Thu 1/16/20 | 2 |
| 5 | 1.4: Runoff Calculations | 4 days | Fri 1/17/20 | Wed 1/22/20 | 3 |
| 6 | 1.5: Analyze Existing Geotechnical Information | 2 days | Wed 1/15/20 | Thu 1/16/20 | |
| 7 | 1.6: Enter Existing Geometry into Civil3D | 6 days | Wed 1/22/20 | Wed 1/29/20 | 4SS |
| 8 | 1.7: Create Existing Cross-Sections | 4 days | Thu 1/30/20 | Tue 2/4/20 | 4SS |
| 9 | 1.8: Create Roadway Alignments/Base Files | 3 days | Tue 2/4/20 | Thu 2/6/20 | 7 |
| 10 | Task 2: Design | 54 days | Mon 2/3/20 | Wed 4/22/20 | |
| 11 | 2.1: Create Proposed Cross-Sections | 4 days | Thu 2/13/20 | Tue 2/18/20 | |
| 12 | 2.2: Initial Design | 27 days | Wed 2/19/20 | Wed 4/1/20 | |
| 13 | 2.2.1: Intersection Design | 27 days | Wed 2/19/20 | Wed 4/1/20 | 11 |
| 14 | 2.2.1: On-Ramp Design | 27 days | Wed 2/19/20 | Wed 4/1/20 | 11 |
| 15 | 2.4: Final Design Geometry/Cross-Sections | 9 days | Thu 4/2/20 | Tue 4/14/20 | 12,13 |
| 16 | 2.5: Final Drainage Design | 7 days | Tue 4/14/20 | Wed 4/22/20 | 15 |
| 17 | 2.6: Stormwater Pollution Prevention Control Plan | 3 days | Mon 4/20/20 | Wed 4/22/20 | 16SS |
| 18 | 2.7: Construction Plan Set | 51 days | Mon 2/3/20 | Fri 4/17/20 | |
| 19 | 2.8 Synchro Analysis and Traffic Analysis Recommendation | 4 days | Thu 4/2/20 | Tue 4/7/20 | 13 |
| 20 | Task 3: Deliverables | 47 days | Fri 2/14/20 | Fri 4/24/20 | |
| 21 | 3.1: 30% Submittal | 1 day | Fri 2/14/20 | Fri 2/14/20 | 8SS,9SS |
| 22 | 3.2: 60% Submittal | 1 day | Tue 3/10/20 | Tue 3/10/20 | 21 |
| 23 | 3.3: 90% Submittal | 1 day | Thu 4/23/20 | Thu 4/23/20 | 22,26,27,28,16 |
| 24 | 3.4: Final Design Report | 1 day | Fri 4/24/20 | Fri 4/24/20 | 23 |
| 25 | **Task 4: Impacts** | **1 day** | **Fri 4/3/20** | **Fri 4/3/20** | |
| 26 | 4.1: Social Impacts Assessment | 1 day | Fri 4/3/20 | Fri 4/3/20 | |
| 27 | 4.2: Economic Impacts Assessment | 1 day | Fri 4/3/20 | Fri 4/3/20 | |
| 28 | 4.3: Environmental Impacts Assessment | 1 day | Fri 4/3/20 | Fri 4/3/20 | |
| 29 | Task 5 Project Management | 70.5 days | Mon 12/16/1 | Thu 4/23/20 | |
| 30 | 5.1: Grading Instructor Meetings | 56.5 days | Fri 1/17/20 | Fri 4/10/20 | |
| 38 | 5.2: Client Meetings | 61.5 days | Thu 1/23/20 | Thu 4/23/20 | |
| 43 | 5.3: Technical Advisor Meetings | 61.5 days | Thu 1/23/20 | Thu 4/23/20 | |
| 48 | 5.4: Team Meetings | 67 days | Mon 1/13/20 | Mon 4/20/20 | |
| 64 | 5.5: Schedule Management | 67.5 days | Mon 12/16/1 | Mon 4/20/20 | |
| 84 | 5.6: Cost/Resource Management | 68 days | Mon 12/16/1 | Mon 4/20/20 | |



# References


- **[1]** "Arizona Department of Transportation Logo", *En.wikipedia.org*, 2020. [Online]. Available: *https://en.wikipedia.org/wiki/Arizona_Department_of_Transportation.* [Accessed: 12- Mar- 2020].
- **[2]** "County Map of Arizona", *Mapsales.com*, 2020. [Online]. Available: *https://www.mapsales.com/county-wall-maps/arizona.aspx.* [Accessed: 12- Mar- 2020].
- **[3]** "Map of Project Site", *Google Maps*, 2020. [Online]. Available: https://www.google.com/maps/@35.2173383,-111.5841945,457m/data=!3m1!1e3. [Accessed: 12- Mar- 2020].
- **[4]** Federal Highway Administration, 2013. *Guide For Highway Capacity And Operations Analysis Of Active Transportation And Demand Management Strategies*. United States Department of Transportation, p.55.
- **[5]** Arizona Department of Transportation (2020). *Roadway Design Guidelines*. Arizona Department of Transportation, pp.600-6, Appendix C.
- **[6]** Highway Capacity Manual 2020. *Capacity Analysis Formula,* Appendix F.

# References Cont.


- **[7]** Primatech (2020). *Interstate 40 East Flagstaff Traffic Interchange at SR 89 and US 66*. [online] Arizona Department of Transportation, pp.7, 8, 16, 18. Available at: http://file:///C:/Users/mlt289/AppData/Local/Downloads/SR89%20and%20US66%20TI.pdf [Accessed 9 Feb. 2020].

- **[8]** City of Flagstaff Engineering Division (2009). *CITY OF FLAGSTAFF STORMWATER MANAGEMENT DESIGN MANUAL*. Flagstaff: City of Flagstaff, pp.3-1, 3-3, 3-4.

- **[9]** Arizona Department of Transportation (2020). *Roadway Design Guidelines*. Arizona Department of Transportation, pp.600-6, Appendix C.

# Questions?