MESA COUNTY

ORCHARD AVENUE CORRIDOR STUDY

08-01-2022

Rev.1

PREPARED BY

COLLINS ENGINEERS INC

FEHR PEERS

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ORCHARD AVENUE CORRIDOR STUDY

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Study Background

Study Purpose and Process

Mesa County, while working with the community, is undertaking a project to make Orchard Avenue an improved corridor for all users. This study helps identify opportunities and develop design alternatives for Orchard Avenue. As a result, a preferred design alternative was developed that balances the cost, comfort, and impacts to provide the community with an improved corridor.

Study Area Overview

The study area is focused on Orchard Avenue, from 29 ½ Road to Warrior Way in Grand Junction, Colorado.

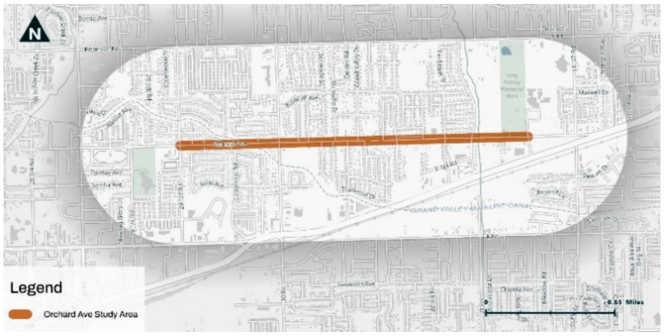
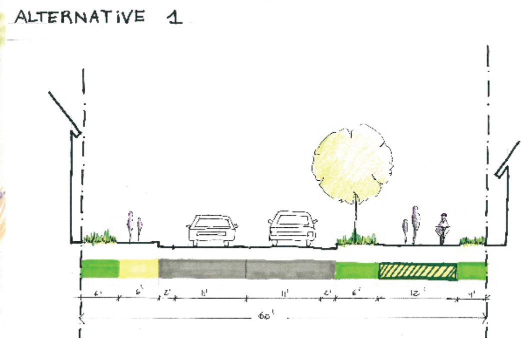


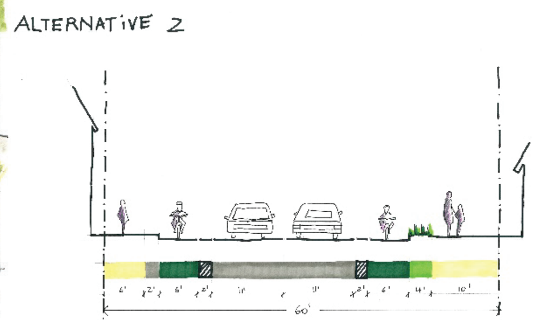
Figure 1: Section of Orchard Avenue in this study and the surrounding area

Design Alternative Concepts

Alternative 1



Alternative 2



Report Organization

This report is separated into the following sections:

- Study Background
- Transportation Plan
- Public Outreach & Engagement
- Civil Roadway Discussion
- Structure Selection
- Survey and ROW Discussion
- Environmental
- Geotechnical
- Hydraulic Report Canal
- Hydraulic Report Lewis Wash
- Conclusion
- Appendix

Section 2- Transportation

Transportation Plan

Introduction

This chapter documents the existing transportation and land use conditions along Orchard Avenue, from 29 ½ Road to Warrior Way. Key to supporting the transformation of the corridor, this study was initiated by developing a holistic understanding of Orchard Avenue's existing uses, including the following:

- Land Use and Zoning
- Roadway Characteristics
- Traffic
- Safety
- Transit
- Bicycle and Pedestrian

Data collected as part of the existing conditions research was used to inform the redesign of the corridor. In addition, high-level summaries of other transportation-relevant existing conditions from this study are included on the following pages.

Household and Employment Data

Information on current and projected household and employment totals within the study area was provided by Grand Valley MPO ("GVMPO"), which is the metropolitan planning organization (MPO) for Mesa County. The MPO provides data on the number of households, population, and jobs within small geographic areas called traffic analysis zones (TAZs) for existing and future conditions. For this study, the analysis focused on the base year of 2019 and a future horizon year of 2045.

Current Households

According to Mesa County data, there are over 3,000 households within one mile of the project area, with approximately 118 directly adjacent to the segment of Orchard Avenue in the study area. This data is shown in **Figure 2**.

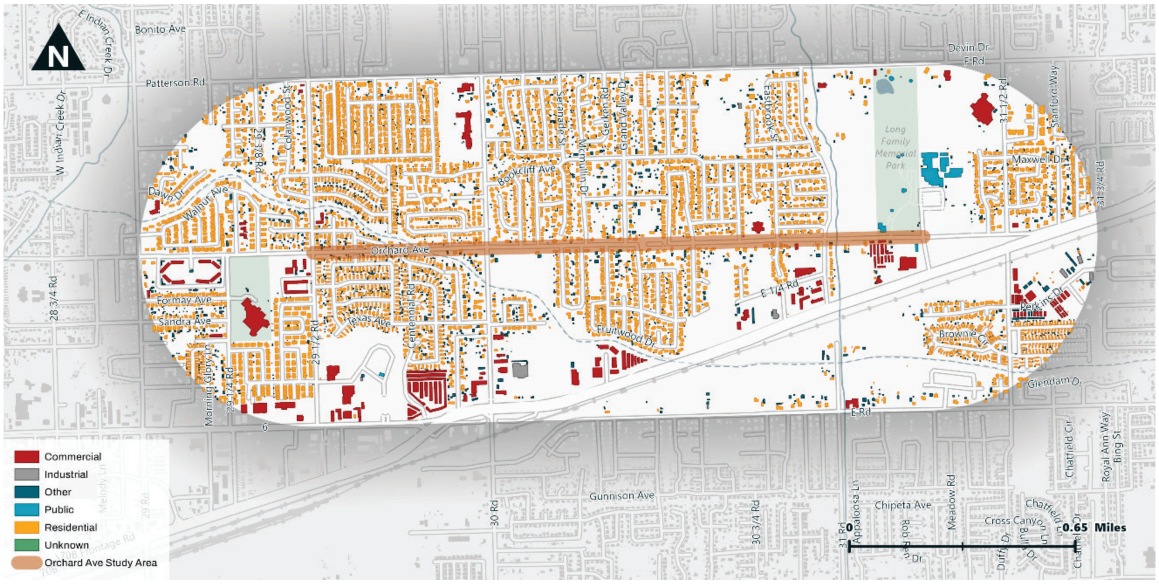


Figure 2: Building footprints in the study area

Figure 3 shows the areas with the highest number of households are:

- West of 29 ½ Road south of Orchard Avenue: 733 households
- West of 30 Road, north of Orchard Avenue: 506 households

The areas with the lowest number of households are:

- West of 31 ½ Road south of Orchard Avenue: three households
- West of 30 Road, south of Orchard Avenue: four households

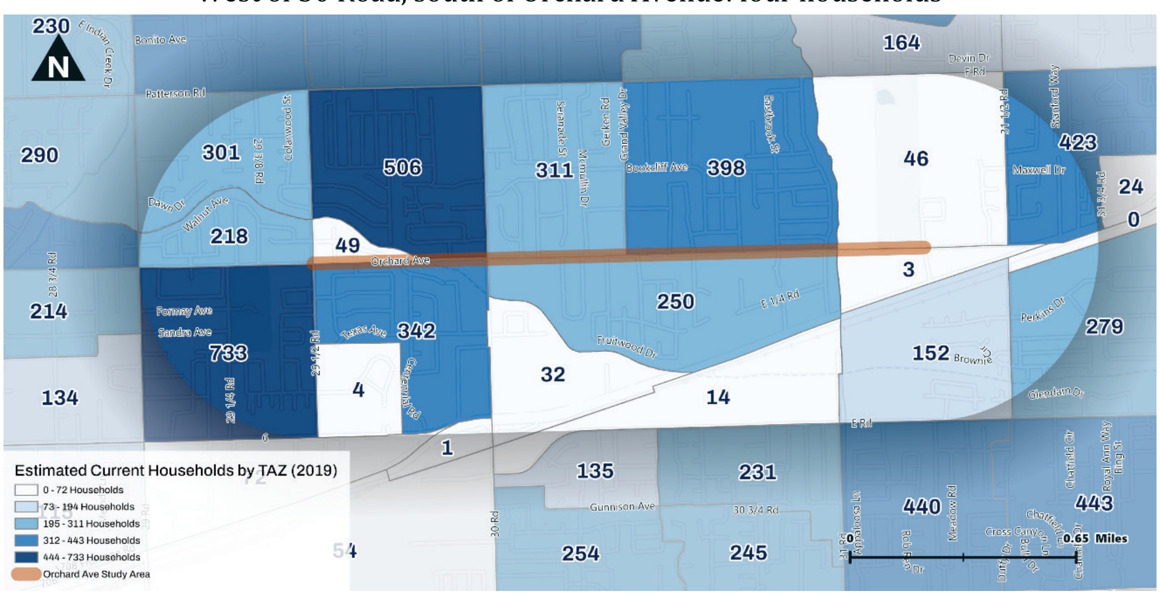


Figure 3: Estimated households by TAZ (2019)
Data source: Mesa County, GVMPO

Projected Change in Households

Figure 4 shows a small decline in households to the south of Orchard Avenue between 31 Road and 31 ½ Road, as well as an increase in additional housing, particularly to the south of I-70. New housing developments and other factors are driving the employment growth in this area.

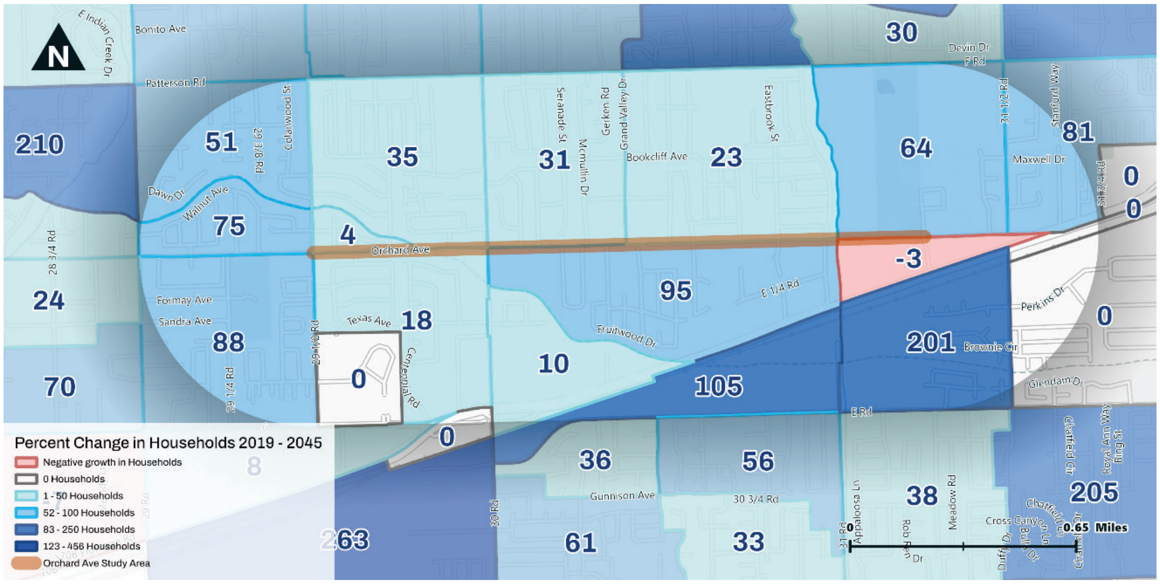


Figure 4: Projected change in households between 2019-2045

Data source: Mesa County

Current Employment

Like households, job concentrations can also contribute to corridor traffic and transit ridership. The GVMPO data indicated nearly 2,000 jobs within one mile of the project area.
This data is shown in **Figure 5**.

The area with the highest number of jobs is:

- East of 31 ½ Road south of Orchard Avenue: 805 jobs

The areas with the lowest number of jobs are:

- West of 31 Road south of Orchard Avenue: zero jobs
- West of 29 ½ Road, north of Orchard Avenue: four jobs
- East of 31 Road, north of Orchard Avenue: five jobs

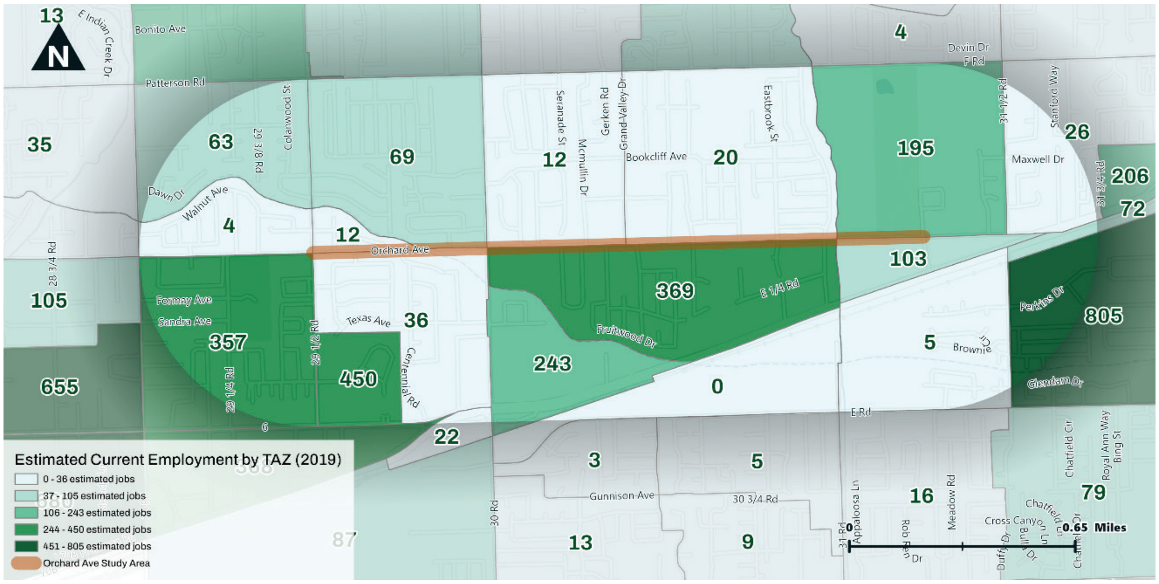


Figure 5: Estimated employment by TAZ (2019)

Data source: GVMPO, Mesa County

Projected Change in Employment

As seen in **Figure 6**, future growth patterns in the study area reflect interesting trends already underway: the model data suggests that a significant amount of additional employment growth is expected south of Orchard Avenue between 29 ½ Road and 30 Road.

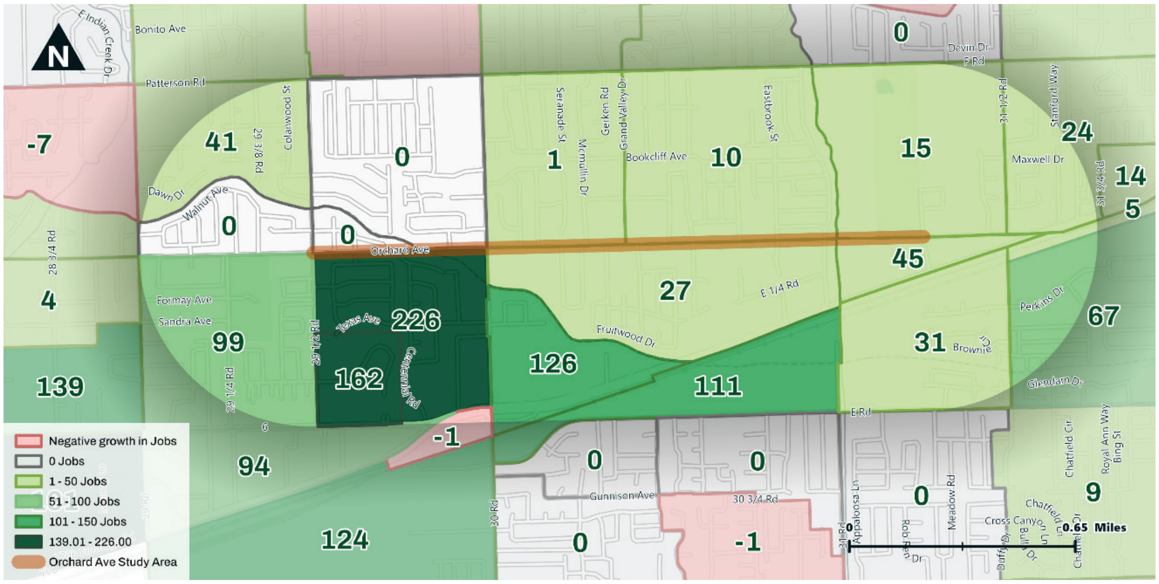


Figure 6: Projected change in jobs between 2019 and 2045 in the study area

Data source: Mesa County

Land Use Context

As seen in **Figure 7**, the land use along the corridor is mostly lower-density residential. Although many single-family homes have individual driveways adjacent to the corridor, many driveways have access to adjacent local roads. Just past the western extent of the study area is Bookcliff Middle School, and Central High School is found at the eastern end of the study area. There is a Walmart on the eastern end of the study area but little other commercial land use. There are also houses of worship for Bethel Assembly of God and The Church of Jesus Christ of Latter-day Saints on or near the corridor.

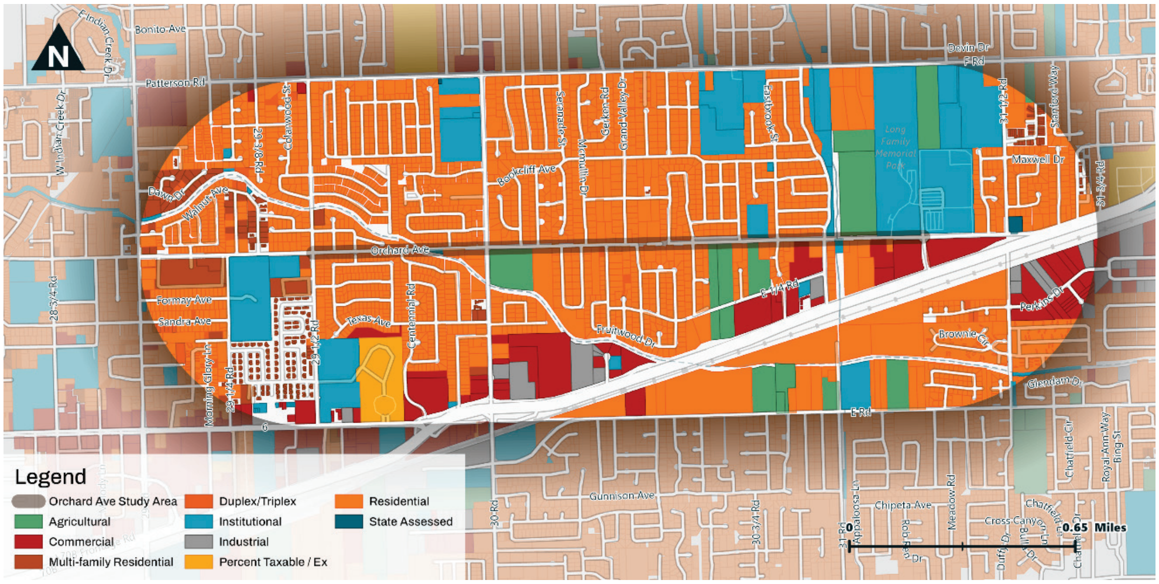


Figure 7: Current zoning in and around the study area

Data source: Mesa County

Future Land Use

Overall, no major land use changes are anticipated for the study area, as shown in **Figure 8**.

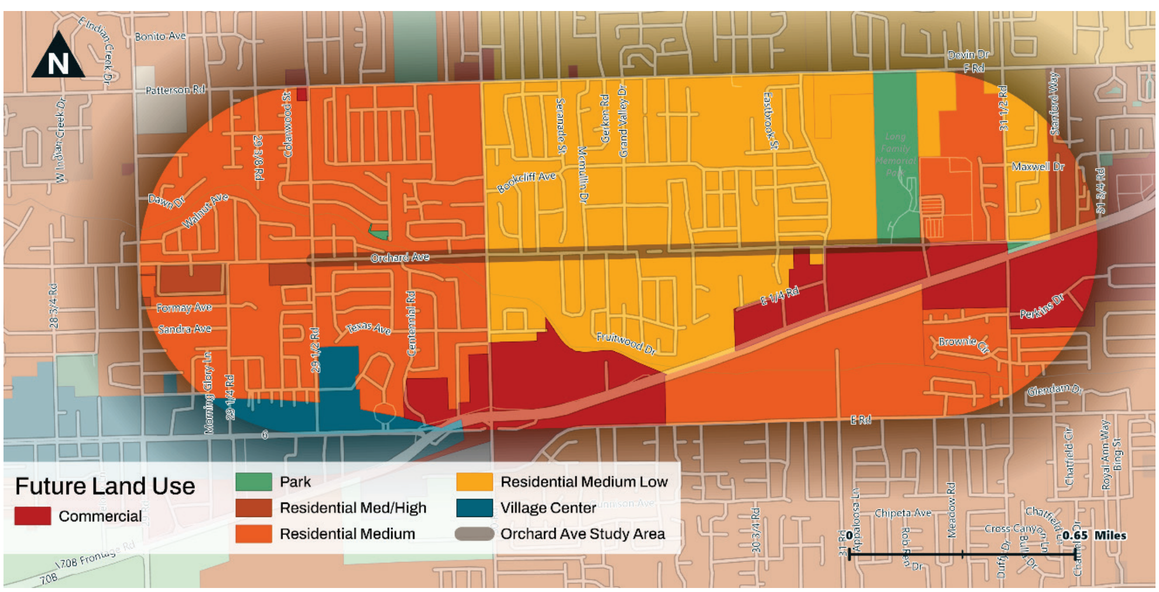


Figure 8: Future land use map

Data source: Mesa County Comprehensive Plan

Traffic

Roadway Geometry

Within the study area, the roadway generally provides one 11-foot vehicle lane in each direction with no center median or two-way left turn lane, though there are additional approach lanes at signalized intersections. At the Orchard Avenue / 29 ½ Road intersection, left turn pockets are provided on all approaches, as shown in **Figure 9**. At the Orchard Avenue / 30 Road intersection, left-turn pockets are provided on both the westbound and eastbound approaches, and a right-turn pocket is provided on the westbound approach, as shown in **Figure 10**. At the Orchard Avenue / Warrior Way intersection, dual left-turn pockets and a right-turn lane are provided, as shown in **Figure 11**. The curb-to-curb width ranges from 23 feet to 48 feet along the corridor.

Figure 9: Orchard Avenue and 29 1/2 Road intersection

Source: Google Earth

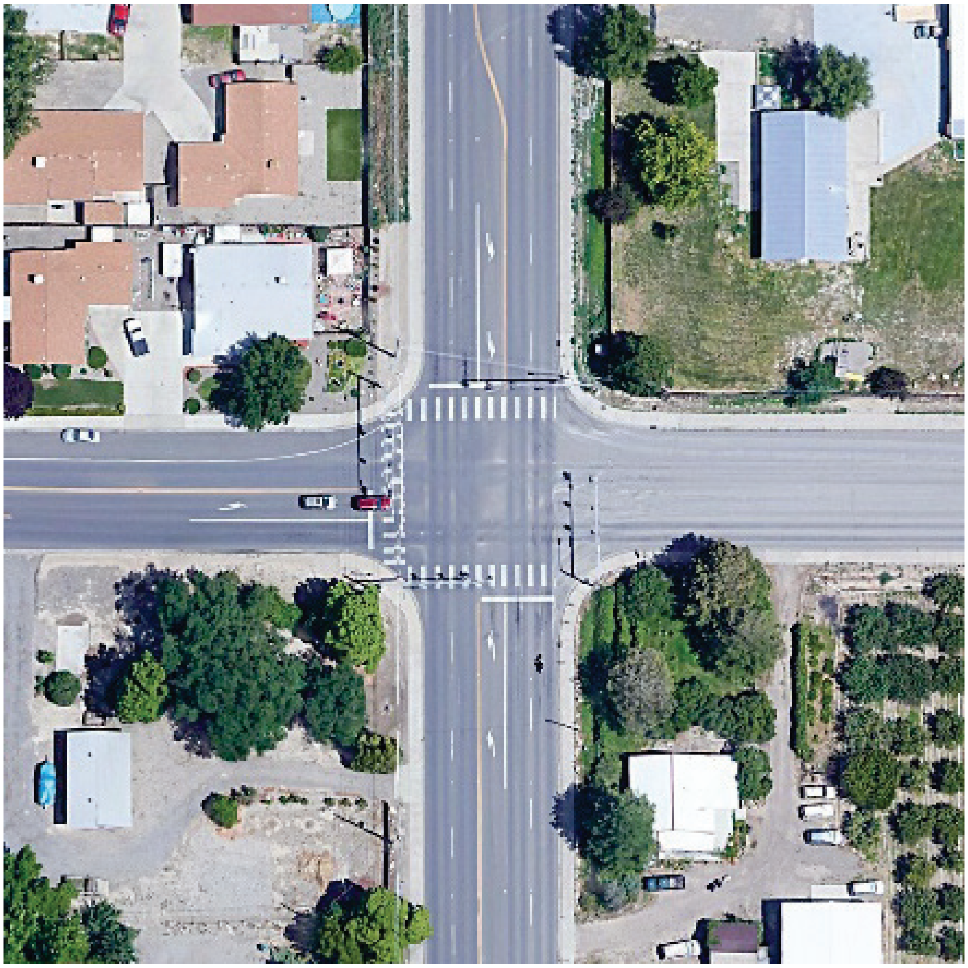


Figure 10: Orchard Avenue and 30 Road intersection

Source: Google Earth

Figure 11:Orchard Avenue and Warrior Way intersection

Source: Google Earth

Roadway Classifications

The Federal Highway Administration ("FHWA") organizes roads into groups called functional classifications based on a road's capacity and purpose. Roadway functional classifications reflect the role played by each piece of the roadway network in serving a wide variety of different travel needs. In addition to acting as a framework, roadway functional classifications also connote conventions about roadway design, including speed, volumes, and connection to current and future land use development. To better illustrate this, some of the more common characteristics of these roadway types are shown in **Table 1** and **Figure 12**.

Table 1. Roadway Functional Classifications, Typical Characteristics

	AADT	SPEEDS (MPH)	TRIP LENGTH	LANE #	DRIVEWAYS	TYPICAL ACCESS
Interstate	35,000+	55-75	Long trips (6+ miles)	6+	None	Interchanges (one-mile spacing)
Principal Arterial	20,000+	45-55	Longer trips (6+ miles)	4+	None	Intersections (½-mile spacing)
Minor Arterial	5,000-15,000	35-45	Medium-length trips (2-6 miles)	3-5	Major only	Intersections (¼-mile spacing)
Major and Minor Collector	1,000-8,000	30-35	Shorter trips (1-2 miles)	2-3	Frequent	Intersections (⅛-mile spacing)
Local Roads	<2,000	Low (<30)	Short trips (<1 mile)	2	Many	Unlimited

Source: FHWA, Fehr & Peers

The Colorado Department of Transportation ("CODOT") assigns these classifications to roadways across the region. A description of each and local instances are provided below and in **Figure 12**. Orchard Avenue itself is a major collector, with approximately 6,700 vehicles per day, as detailed in **Figure 13**.

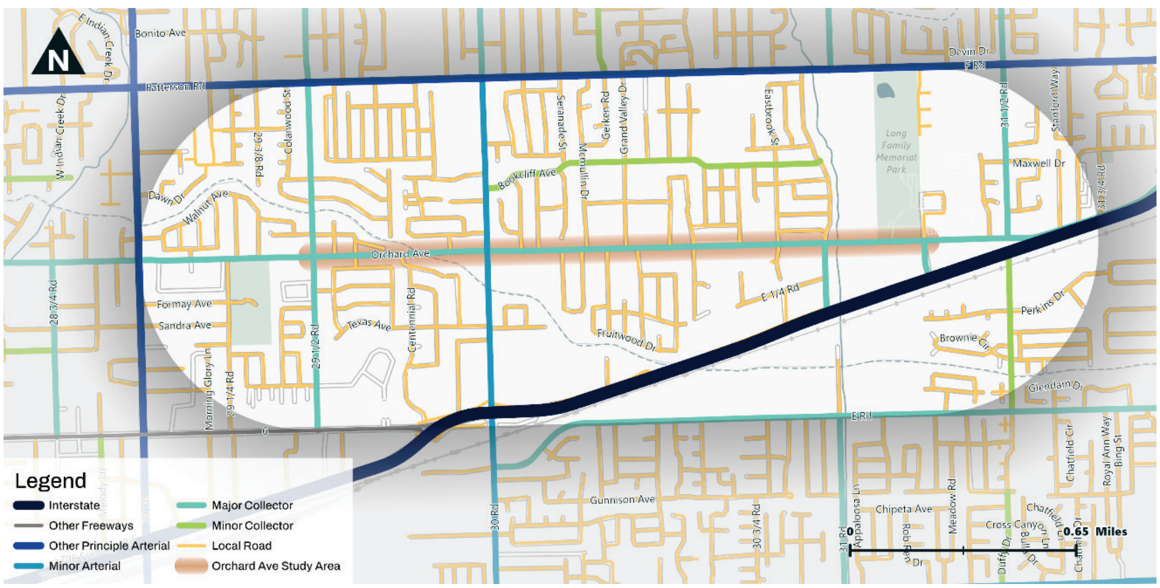


Figure 12: Functional Roadway Classification Source: CODOT

- ***Interstates*** are the highest classification of arterials. Designed and constructed for mobility and long-distance travel, I-70 is an example of an Interstate adjacent to Orchard Avenue.
- ***Principal Arterials*** connect between communities and major employment centers, providing high mobility and lower speed limits and traffic volumes than interstates. Instances of this classification adjacent to Orchard Avenue are Patterson Road and 29 Road.
- ***Minor Arterials*** serve medium-length trips and provide mobility and connectivity while providing a degree of local access. For instance, 30 Road is a Minor Arterial adjacent to Orchard Avenue.

- ***Major and Minor Collectors*** amass traffic from local roads and channel them to larger arterials, providing a balance between mobility and local access. Instances in the study area include Orchard Avenue, 29 ½ Road, 31 Road, and 31 ½ Road.

  Local Roads are the most common types of roadways in terms of mileage. Speed limits and traffic volumes are low, and the density of local accesses is high. Most residential roads in Mesa County are classified as Local Roads.

Average Annual Daily Traffic (AADT)

CDOT measures Average Annual Daily Traffic ("AADT") on CDOT facilities and local roads of regional importance. AADT reflects the number of vehicle trips made along a given roadway on a typical day and provides a starting point for assessing the relative importance and utilization of corridors such as Orchard Avenue. In the study area, Orchard Avenue sees an average of 6,700 vehicles per year as seen in **Figure 13**. The greatest change in AADT occurs on 29 Road, with an annual average of 7,800 vehicles south of Orchard Avenue and 10,000 vehicles north of Orchard Avenue. While not always the case, the changes in AADT on different intersection legs can indicate intersections with a greater volume of turning traffic, as seen on 30 Road, or through traffic, as seen on 29 ½ Road. Other areas of high AADT include Patterson Road west of 30 Road.

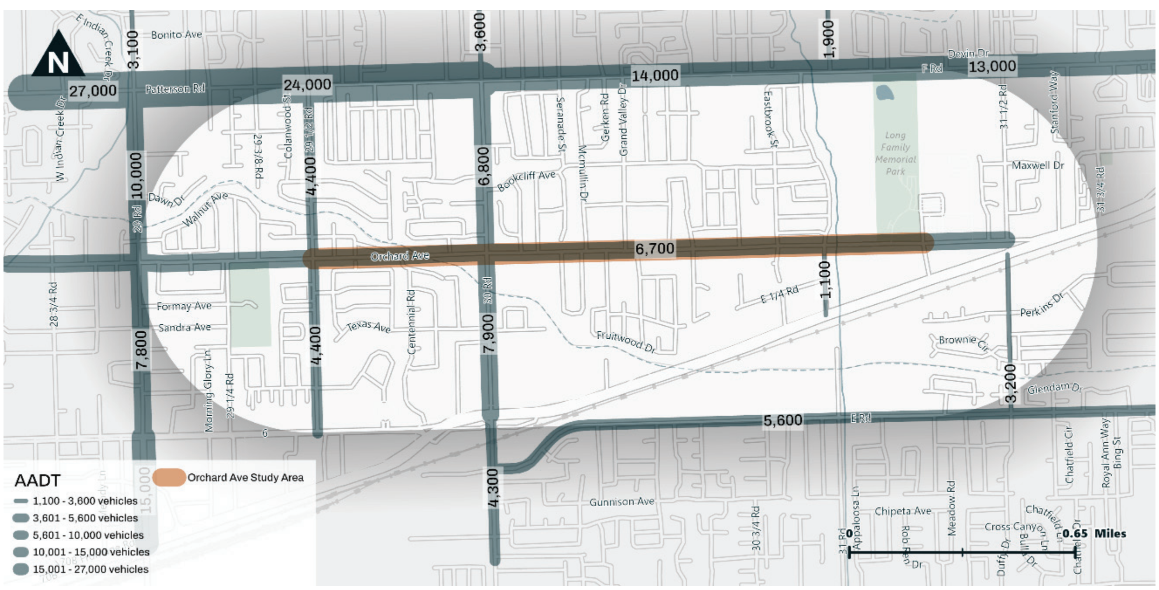


Figure 13: Annual Average Daily Traffic ("AADT")

Data Source: CODOT

Traffic Volumes and Speed Limits

Fehr & Peers collected daily traffic volume and speed data via tube counters on Orchard Ave on Thursday, August 19, 2021, at locations between Eastbrook Street and 31 Road and between 29 ½ Road and Hall Avenue. This was also supplemented with daily volumes previously collected between Garfield Dr and 29 ½ Road in March 2016. The total weekly traffic volumes on Orchard Avenue are between 4,963 and 5,415 vehicles, as illustrated in **Figure 14**. Also shown are speed limits.

The posted legal speed limit is 30 MPH west of 30 Road and 35 MPH to the east side of the study area. The 85th percentile speed is defined by FHWA as "the speed at or below which 85 percent of the drivers travel on a road segment" and is largely considered the high-end of what drivers perceive as the safe and reasonable speed based on roadway characteristics. On Orchard Avenue, the 85th percentile speed is between 38 and 42 MPH, suggesting that the corridor's legal speed and design speed may need further evaluation and that drivers perceive a higher safe speed than what is intended legally.

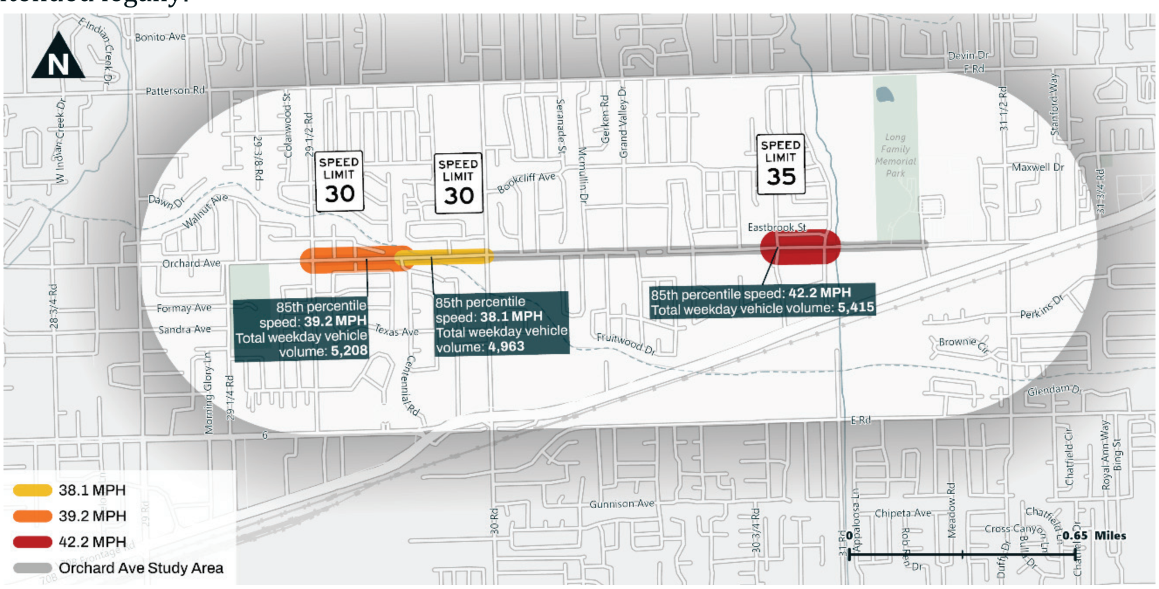


Figure 14: Traffic Volumes and Speed Limits

Data source: Mesa County

Existing Levels of Service

Level of Service (LOS) is a term that describes the operating performance of an intersection or roadway. LOS is measured quantitatively and reported on a scale from A to F, with A representing the best performance and F the worst. Typically, LOS D or better is considered acceptable for urban areas. **Table 2** briefly describes each LOS letter designation and an accompanying average delay per vehicle for both signalized and unsignalized intersections. The Highway Capacity Manual 6th Edition (HCM 6) methodology was used in this study to remain consistent with "state of the practice" professional standards. This methodology has different quantitative evaluations for signalized and unsignalized intersections. For signalized intersections, the LOS is provided for the overall intersection (weighted average of all approach delays). For unsignalized intersections, the LOS is provided for the average delay per vehicle on the worst-performing movement. Fehr & Peers used Synchro to analyze all study intersections.

Table 2. Level of Service Descriptions

LOS	Description	Signalized Intersections	Unsignalized Intersections
		Avg. Delay (sec/veh)[1]	Avg. Delay (sec/veh)[2]
A	**Free Flow / Insignificant Delay** Extremely favorable progression. Individual users are virtually unaffected by others in the traffic stream.	< 10.0	< 10.0
B	**Stable Operations / Minimum Delays** Good progression. The presence of other users in the traffic stream becomes noticeable.	> 10.0 to 20.0	> 10.0 to 15.0
C	**Stable Operations / Acceptable Delays** Fair progression. The operation of individual users is affected by interactions with others in the traffic stream	> 20.0 to 35.0	> 15.0 to 25.0
D	**Approaching Unstable Flows / Tolerable Delays** Marginal progression. Operating conditions are noticeably more constrained.	> 35.0 to 55.0	> 25.0 to 35.0
E	**Unstable Operations / Significant Delays Can Occur** Poor progression. Operating conditions are at or near capacity.	> 55.0 to 80.0	> 35.0 to 50.0
F	**Forced, Unpredictable Flows / Excessive Delays** Unacceptable progression with forced or breakdown of operating conditions.	> 80.0	> 50.0

1. Overall intersection LOS and average delay (seconds/vehicle) for all approaches. Roundabout intersection operations are measured under these conditions as well.
2. Worst movement LOS and delay (seconds/vehicle) only.

Source: Fehr & Peers descriptions, based on Highway Capacity Manual 6th Edition.

The intersections with 29 ½ Road, 30 Road, and 31 Road were analyzed in the AM and PM peak hours. The delay and levels of service for each intersection are shown in **Table 3**. The signalized intersections at 29 ½ Road and at 30 Road operate at acceptable levels of service in both the AM and PM peak hours, while the unsignalized intersection of 31 Road operates at an unacceptable level of service in the AM peak due to the long delays experienced by southbound vehicles. This is "side street delay". The AM and PM peak hour volumes are presented in **Figure 15**.

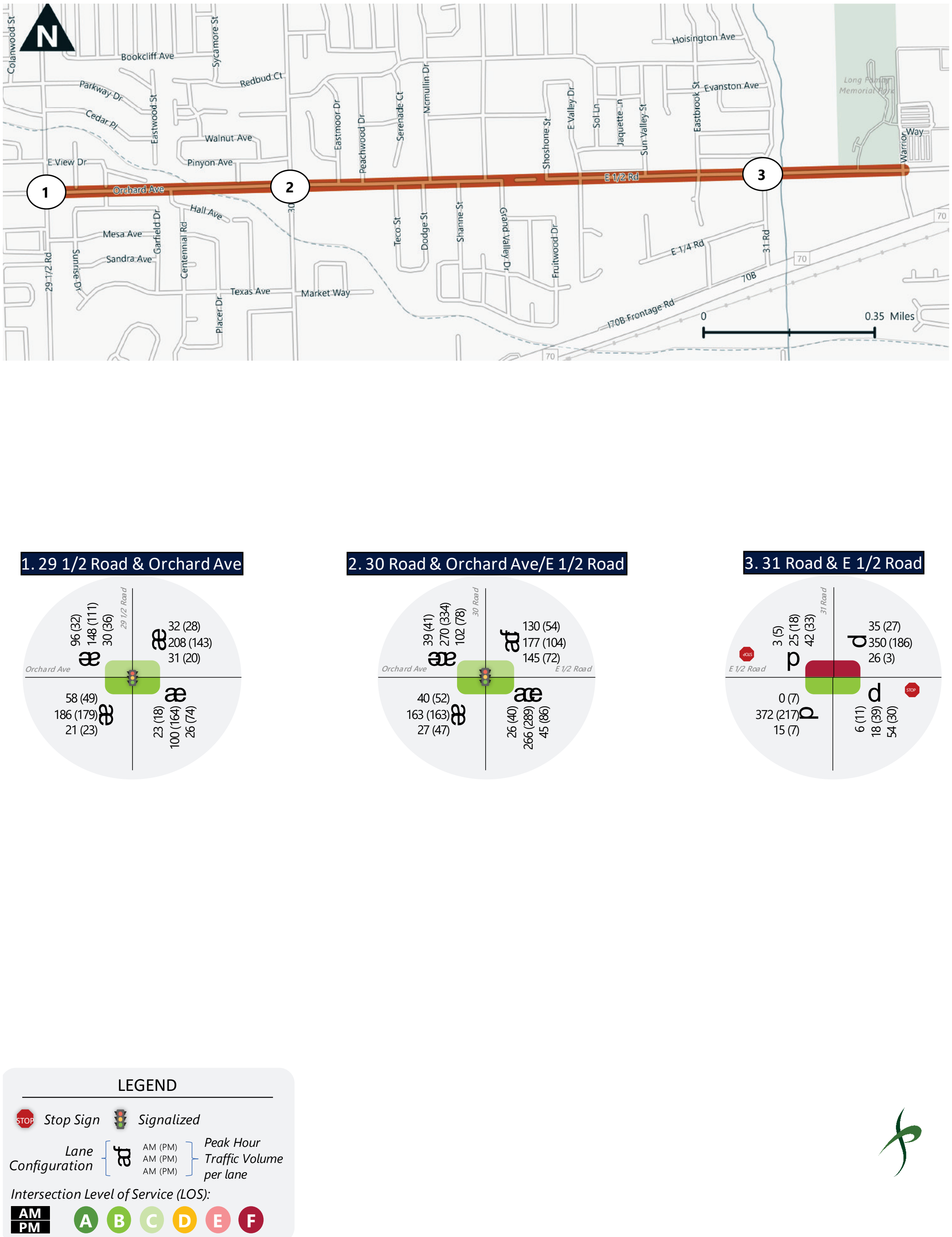


Figure 15: Existing Intersection Volumes

Table 3. Existing Level of Service for Orchard Ave Intersections

Intersection				Worst Movement[1]			Overall Intersection[2]	
ID	Location	Period	Control	Movement[3]	Delay Sec/Veh	LOS	Delay Sec/Veh	LOS
1	**29 ½ Road & Orchard Ave**	AM	Signal	-	-	-	21	C
		PM		-	-	-	19	B
2	**30 Road & Orchard Ave**	AM	Signal	-	-	-	20	C
		PM		-	-	-	18	B
3	**31 Road & Orchard Ave**	AM	NB/SB Stop	SB	72	F	-	-
		PM		SB	14	B	-	-

1. This represents the worst movement LOS and is only reported for unsignalized intersections using HCM 6 methodology.
2. This represents the overall intersection LOS and is only reported for signalized intersections using the HCM 6 methodology.
3. NB=Northbound, SB=Southbound, EB=Eastbound, WB=Westbound

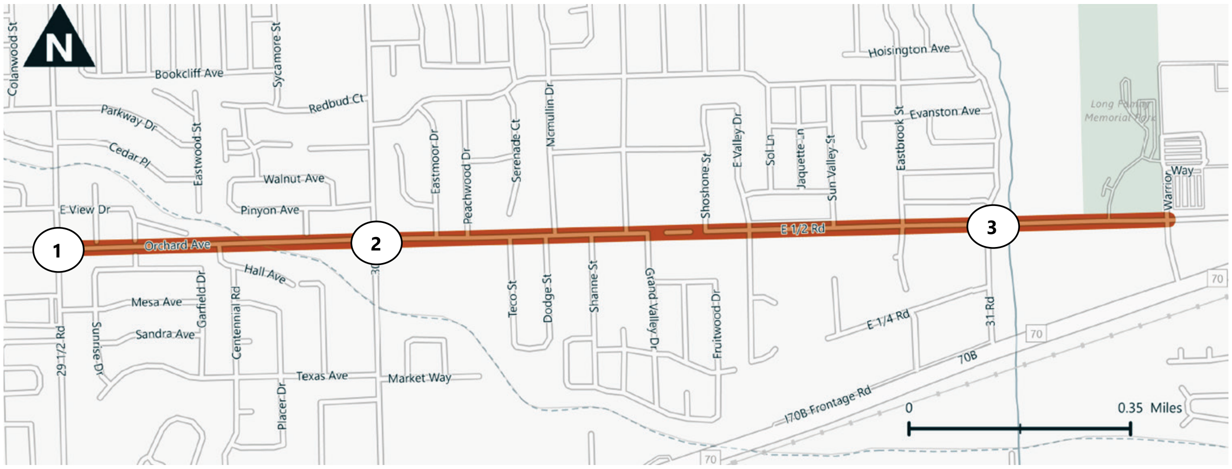
Source: Fehr & Peers.

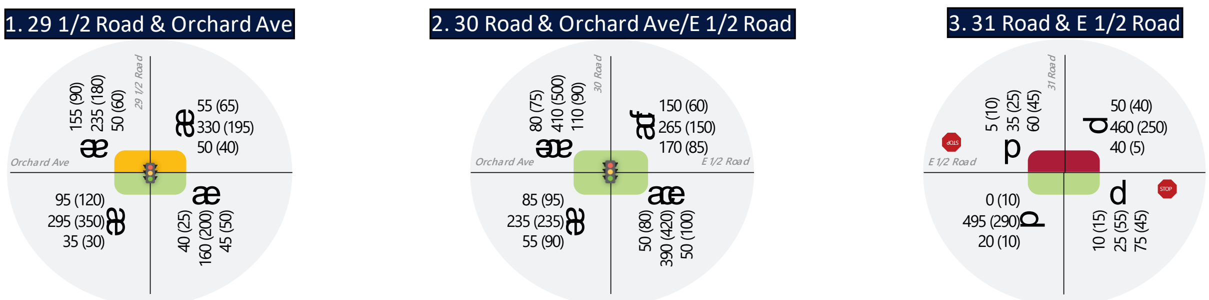
Projected 2045 Intersection Level of Service

Projected 2045 daily traffic volumes in the study area were compared with base year daily volumes to estimate the following growth rates:

- Orchard Ave west of Hall Ave: 2.2%
- Orchard Ave between Hall Ave and 30 Road: 2.3%
- E ½ Road between 30 Road and Eastbrook St: 1.0%
- E ½ Road between Eastbrook St and 31 Road: 1.2%
- E ½ Road east of 31 Road: 1.3%

The existing volumes for the intersections with 29 ½ Road, 30 Road, and 31 Road were projected using these growth factors, and the no-build scenario was analyzed in the AM and PM peak hours. For the north/south legs, the average growth rate of the east/west legs of Orchard Ave / E ½ Road were used. The AM and PM peak hour volumes are presented in **Figure 16.** The delay and levels of service for each intersection are shown in **Table 4**. The signalized intersections at 29 ½ Road and at 30 Road are anticipated to continue to operate at acceptable levels of service in both the AM and PM peak hours, while the intersection of 31 Road is anticipated to continue to operate at an unacceptable level of service in the AM peak due to the long delays experienced by southbound vehicles.





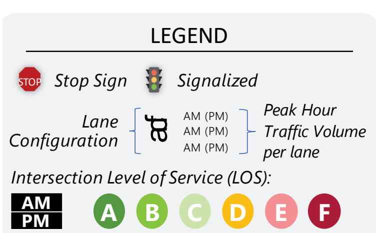


Figure 16: Existing Intersection Volumes

Table 4. Existing Level of Service for Orchard Ave Intersections

Intersection				Worst Movement[1]			Overall Intersection[2]	
ID	Location	Period	Control	Movement[3]	Delay Sec/Veh	LOS	Delay Sec/Veh	LOS
1	**29 ½ Road & Orchard Ave**	AM	Signal	-	-	-	42	D
		PM		-	-	-	22	C
2	**30 Road & Orchard Ave**	AM	Signal	-	-	-	26	C
		PM		-	-	-	22	C
3	**31 Road & Orchard Ave**	AM	NB/SB Stop	SB	802	F	-	-
		PM		SB	19	C	-	-

1. This represents the worst movement LOS and is only reported for unsignalized intersections using HCM 6 methodology.
2. This represents the overall intersection LOS and is only reported for signalized intersections using the HCM 6 methodology.
3. NB=Northbound, SB=Southbound, EB=Eastbound, WB=Westbound

Source: Fehr & Peers.

Safety

Safety and collision data is an important statistic in tracking and analyzing safety along the corridor. Collision data was obtained from Mesa County Public Works for crashes between July 2015 and June 2020.

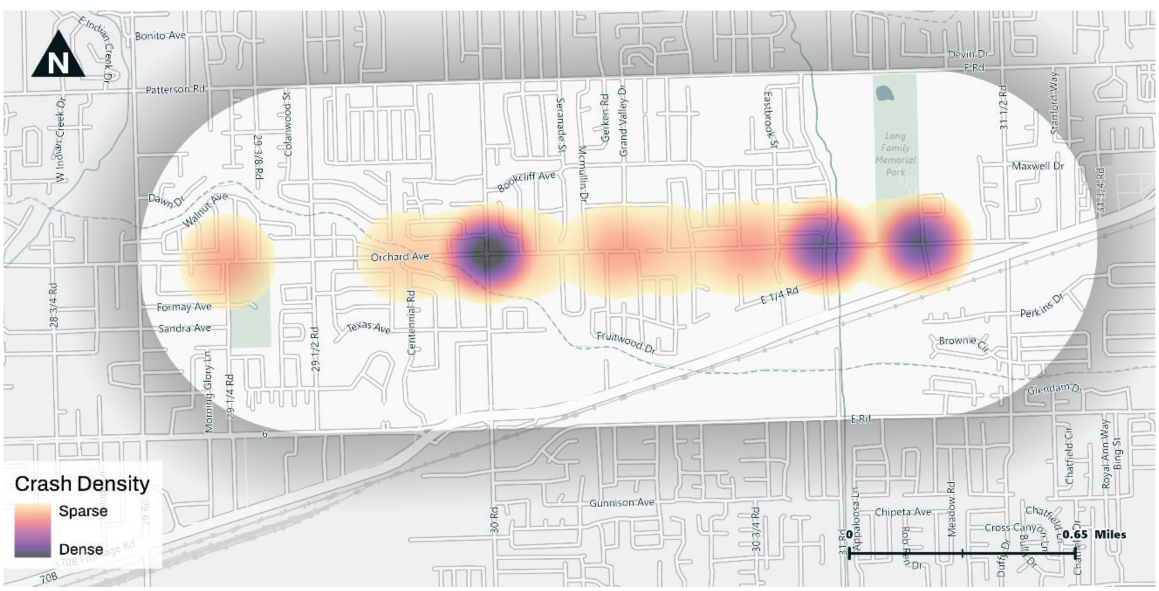


Figure 17: Crash Density (2015-2020)

Data source: Mesa County

In this time frame, there were a total of 65 crashes on the corridor, including 20 crashes with injuries and two fatal crashes. The crashes by year are summarized in **Figure 17,** and the crash severity by year is summarized in **Figure 18** and 2015 data is only July through December 2020 data is for only January through June.

Note that for both graphs, 2015 and 2020 are both partial years. There does not appear to be any major trend in crashes over time. The two fatalities occurred in 2016 and 2017.

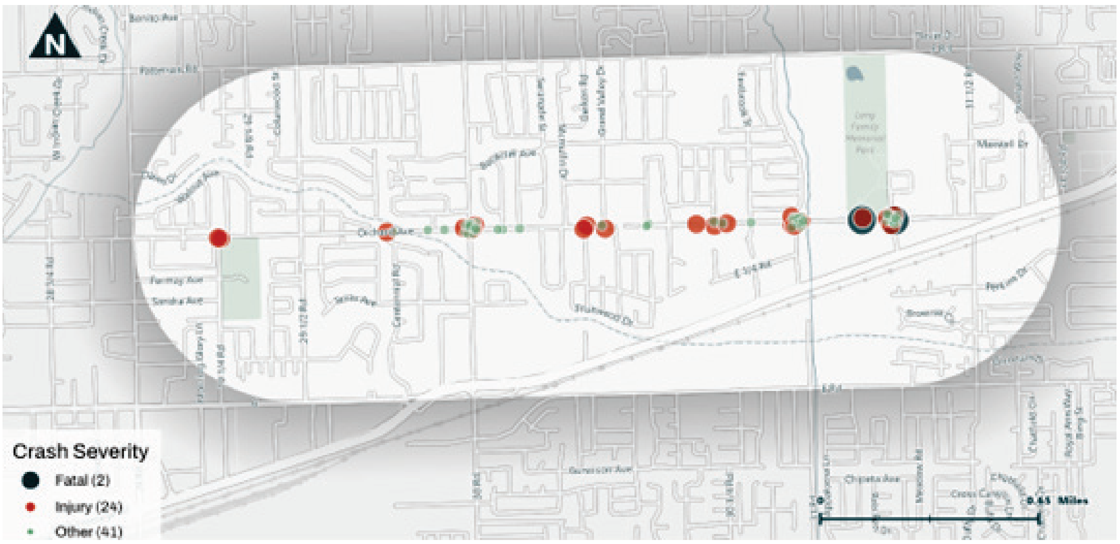


Figure 18: Crash Severity by Year
Data source: Mesa County

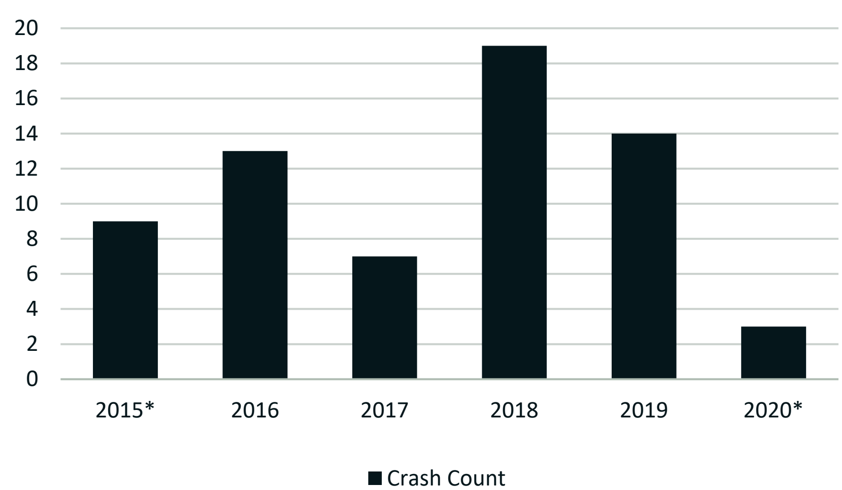


Figure 18: Crash Count by Year

**2015 data is for only July through December, 2020 data is for only January through June*

Data source: Mesa County

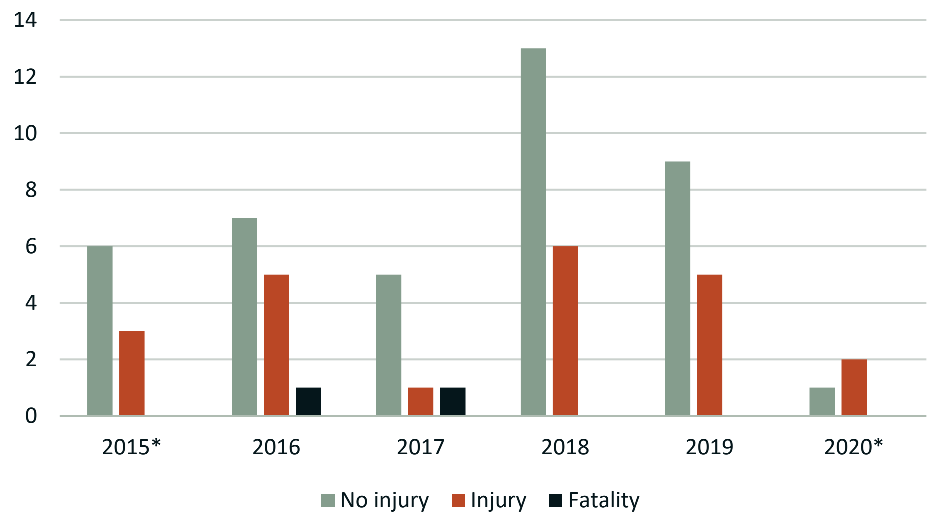


Figure 19: Crash severity by year

**2015 data is for only July through December, 2020 data is for only January through June*

Data source: Mesa County

There were two fatalities on the corridor in the observed time frame: one involving a motorcyclist in June 2016, and the other a pedestrian in daylight in July 2017.

The share of each type of crash is presented in **Figure 20**. The most common types of crashes are rear-end and broadside collisions, with each accounting for 32% and 34% of all crashes, respectively. Bicycle and approach turn crashes are the next most common with 9% each.

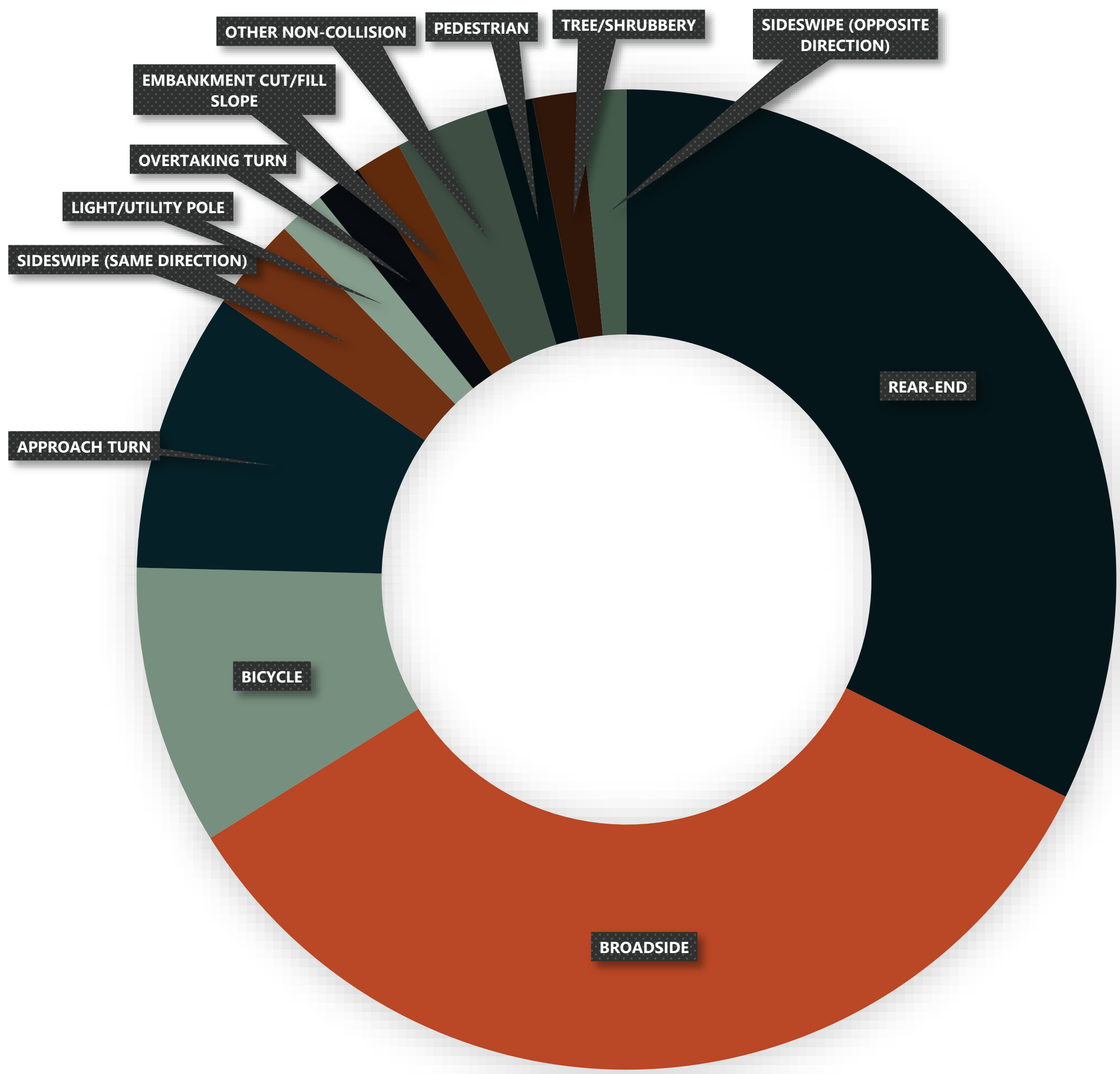


Figure 20: Crash Type

Data source: Mesa County

Weather does not appear to be a major contributor to crashes, although lighting may play a small role:

- 91% of crashes were reported to have no weather contributing factors,
- 77% of crashes occurred in daylight,
- 8% of crashes occurred in dark but lighted conditions, and
- 9% of crashes occurred in dark and unlighted conditions.

Transit

The corridor is served by the Grand Valley Transit Route 3, which has seven stops in the study area with 60-minute headways. The route connects the corridor with the downtown transfer station, Grand Junction High School, and Maverick Center at Colorado Mesa University to the west and the Clifton transfer station to the east. The first bus departs the downtown transfer facility at 5:15 am, and the last bus arrives at the downtown transfer facility as its final destination at 8:05 pm. The route runs seven days a week.

Existing Public Transit Service & Ridership

Grand Valley Transit ("GVT") is the primary public transit service provider in the study area. As shown in **Figure 21-25** and **Table 5,** and **Table 6**, GVT operates four fixed-route bus lines with 14 bus stops along the study area.

Table 5. Bus Routes Serving the Study Area (2021)

Route #	Route Description / Intercept
RT3	Orchard Avenue 29 1/2 Rd. to E 1/2 Warrior Way
RT5	Crosses Orchard at 29 1/2 Road
RT6	Crosses Orchard at 29 1/2 Road
RT10	Loop 29 1/2, Orchard Avenue, 30 Road

Source: Grand Valley Transit

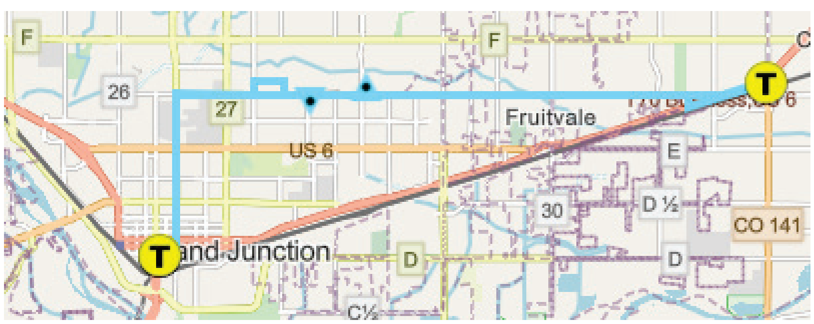


Figure 21 - Route 3 : Source GVT

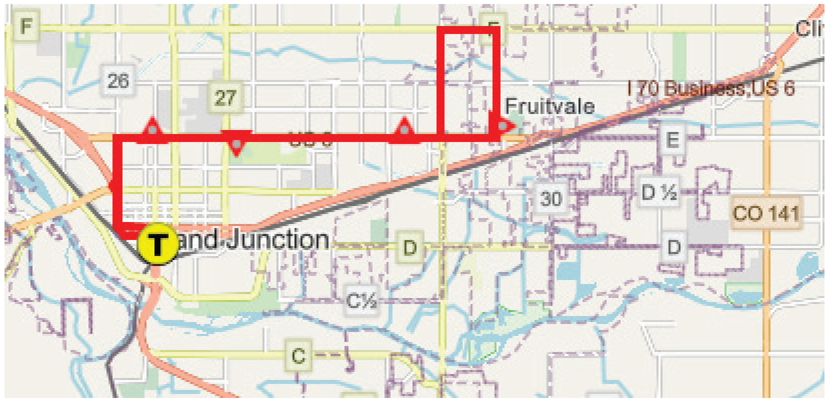


Figure 22 - Route 5 : Source GVT

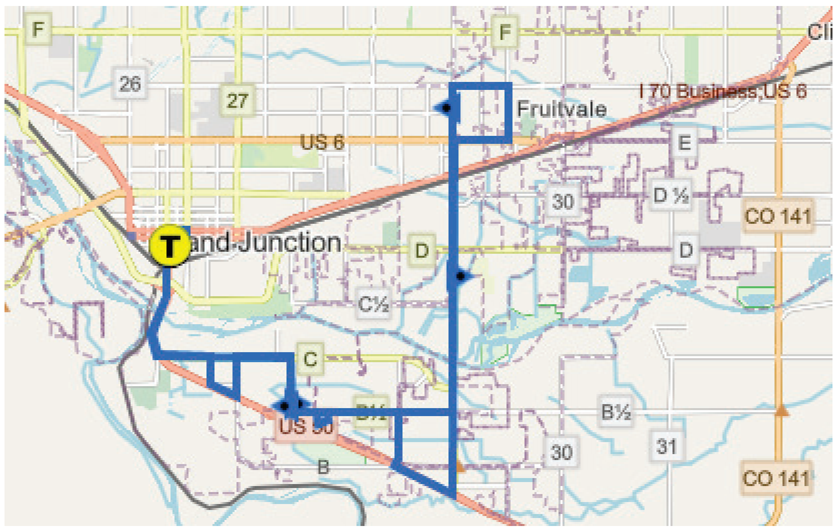


Figure 23 - Route 6 : Source GVT

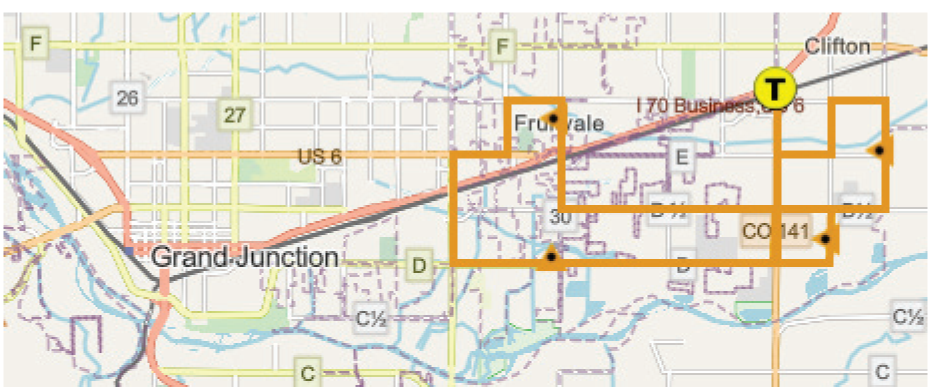


Figure 24 - Route 10 : Source GVT

Table 6. Bus Stops in the Study Area (2021)

Stop #	Stop Name	Annual Boardings (March 2020 - March 2021)	Amenities	Route #
S22	**E ½ Road east of Sun Valley Drive**	**14**	None	3
S28	**E ½ Road east of East Valley Drive**	**15**	Bench	3
S24	**E ½ Road and Peachwood Drive**	**25**	Bench	3
S29	**E ½ Road east of Hoover Court**	**35**	Bench	3
S26	**Orchard Avenue east of 30 Road**	**65**	Bench	3
S27	**E ½ Road East of Grand Valley Drive**	**97**	None	3
S78	**Orchard Avenue west of Hall Avenue**	**132**	None	3, 10
S21	**E ½ Road west of 31 Road**	**133**	Bench	3
S23	**E ½ Road west of Grand Valley Drive**	**257**	None	3
S344	**Orchard Avenue east of 29 ½ Road**	**333**	None	3, 10
S81	**Orchard Avenue west of 30 Road**	**354**	None	3, 10
S80	**Orchard Avenue east of 29 ½ Road**	**377**	None	3, 10
S30	**E ½ Road west of Warrior Way (Long Family Memorial Park / Walmart)**	**879**	Bench/Shelter	3
S396	**E ½ Road west of Warrior Way (Walmart)**	**1467**	None	3

Source: GVT

Figure 25:Overlay of all current transit routes and bus stops in the study area : Source Mesa County

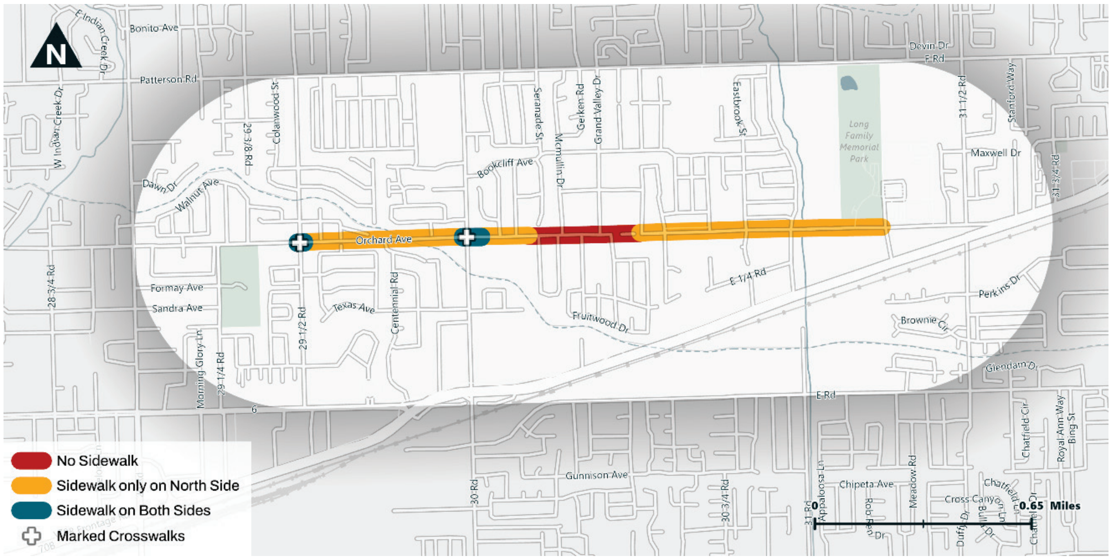


Figure 26: Sidewalk presence and crosswalk locations on the corridor : Source Mesa County

Active Transportation Facilities

Active transportation involves all human-powered forms of traveling from one point to another. This primarily includes walking and bicycling but also includes skateboarding, scootering, etc.

There are minimal accommodations for bicyclists and pedestrians in the study area. As seen in **Figure 22**, there is a sidewalk on the north side of the road for most of the corridor, with the only exception being the roughly ¼-mile stretch from Teco St. to Shoshone St. There are no sidewalks on the south side of the road except for in the immediate areas near the signalized intersections of 29 ½ Road, 30 Road, and Warrior Way. There are marked crosswalks on all four legs of each of the three signalized intersections, but no other crosswalks are indicated.

There are approximately 4.5 miles of trail in the study area, most of which are within the Long Family Memorial Park, as shown in **Figure 23**. However, some portions of the East ½ Road trail run along the north side of Orchard Avenue. While this trail is currently fragmented, there are plans proposed to complete the trail and connect from Bookcliff Middle School to just east of 31 ¾ Road by the City Market, as seen in **Figure 24**.

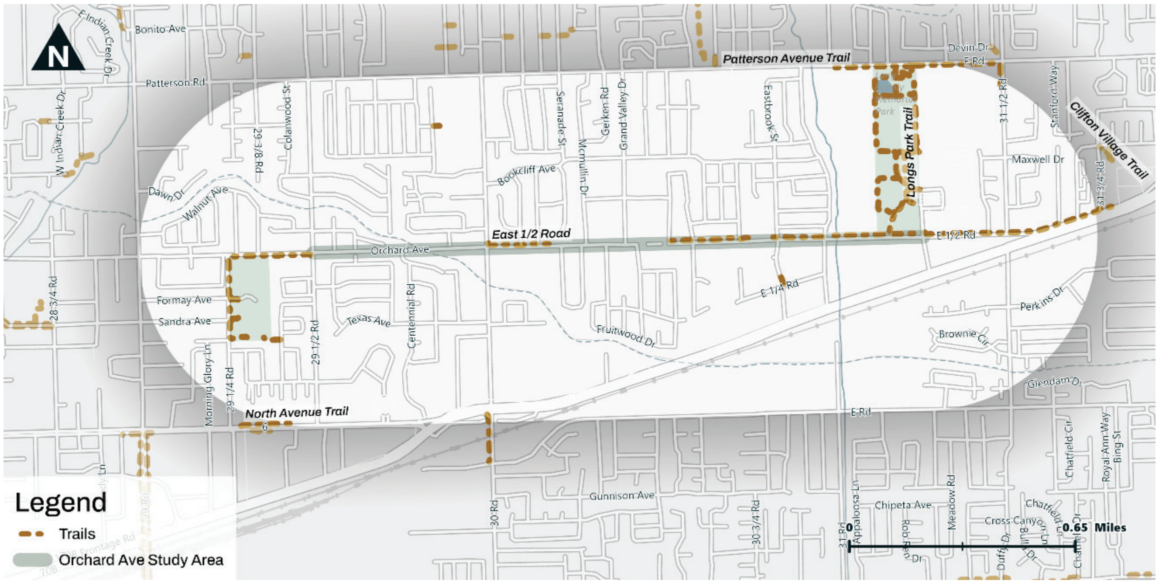


Figure 27: Existing paved trails in the study area

There are several existing and proposed active transportation corridors, with locations shown in **Figure 24**. In addition, there are planned bicycle improvements, as shown in **Figure 25**, including striped bike lanes and shared paths.

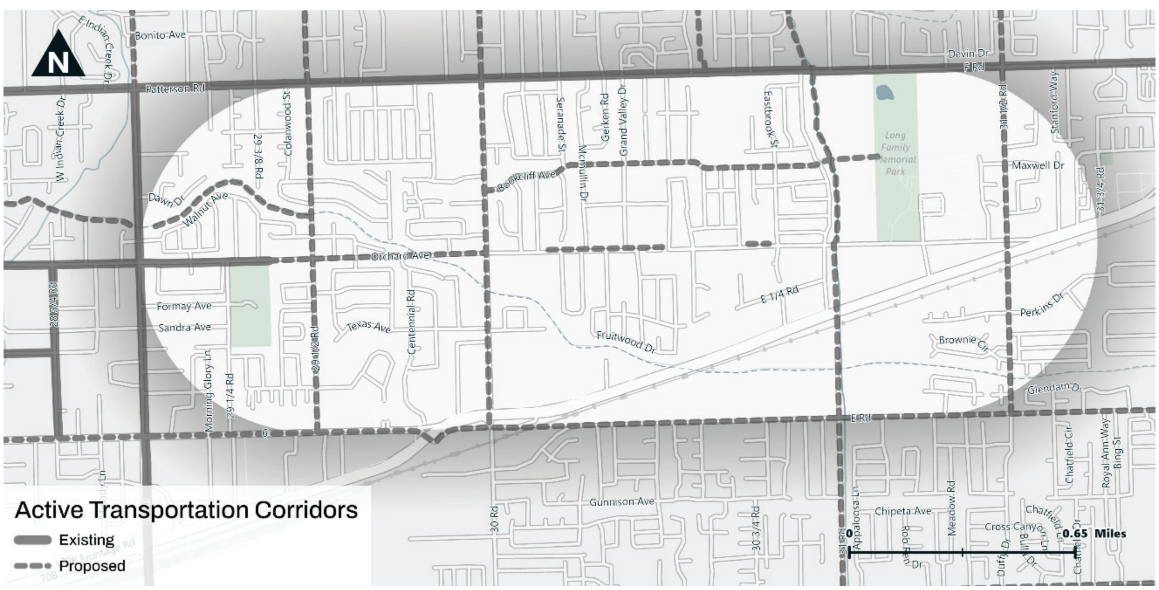


Figure 28: Existing and proposed Active Transportation Corridors

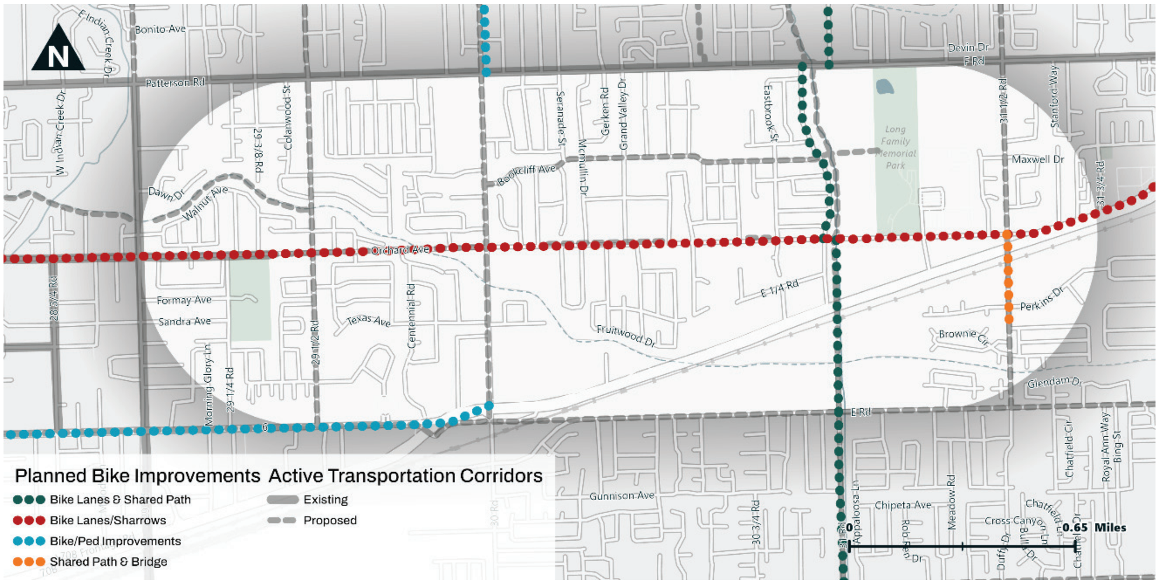


Figure 29: Planned Bike Improvements

Section 3 – Public Outreach

Public Outreach & Engagement

COLLINS ENGINEERS INC.

FEHR PEERS

DESIGNWORKSHOP

Introduction

As part of the Orchard Avenue Corridor Study, the project team engaged with the general public and targeted stakeholders at specific key project milestones. This chapter outlines the general approach and methods used for engagement throughout the study.

Goals and Target Audiences

The overarching goal of the public engagement process is to strive for a broad range of meaningful public participation in the planning process. Members of the public should feel ownership over the process and be informed about the findings of the study.

The target audiences of the public engagement were the following groups:

- Residents along Orchard Avenue and the surrounding community
- School administrators and/or school district representatives
- Elected officials, and others

Figure 30: Public open house at the park

Given the overall project schedule, envisioned as producing 30% design plans by the end of 2022, public involvement was geared towards acquiring feedback from the public and key stakeholders as efficiently as possible.

Public Engagement

For this planning and design effort, the project team sought public input through four major outlets, outlined in the table below

Table 7. Summary of Public Engagement Efforts

TYPE	FREQUENCY DURING THE PROJECT & LOCATION	PURPOSE
Concept Development Design Workshop	September 28, 2021; Mesa County Building	A workshop with the County and the Project Team to develop corridor concept alternatives, after which the public was invited to review and comment on concept alternatives
Public Open House	September 28, 2021; Long Family Memorial Park	The project team interacted directly with community members and other stakeholders

		regarding developed concepts, and the general vision for the corridor
A Project Website (www.mesacounty.us/orchard-avenue**)**	Ongoing throughout the project	The website served as a clearinghouse for information associated with the project. The website was updated on an as-needed basis.

Stakeholder Meetings

The project team reached out to key stakeholders as a preliminary outreach. The City of Grand Junction was contacted and met during the design workshop. The critical request of the City was to create a street section similar to the City standard. To meet this request, a buffer zone was added to the original roadway cross section. The project team also contacted Mesa County's Regional Transportation Planning Office and the Grand Valley Regional Transportation Committee. Discussions and resolutions revolved around providing safe active transportation along the corridor and enhancing current transit stops. Additionally, non-used transit stops were relocated to provide greater access to the public. Many of the stops along the corridor are rural, and updates to the stop should include safety and active transportation accessibility. The Church of Jesus Christ of Latter-Day Saints has a ward located at 3076 E ½ Road. The Church indicated that members used the parking fronting the Church. However, this area is also within Mesa County Rights of Way. The final design of the parking site fronting the church will require additional discussions. The Church also indicated a low drainage point along the southwest corner of the frontage parking area. The Grand Valley Irrigation Company (GVIC) was contacted for the area adjacent to the canal crossing at MESA-E.5-29.8. The consensus was that replacing the existing bridge would benefit both the County and GVIC design requirements, and further discussion on the canal is covered in the Canal Hydraulic Report by Applegate. As the project phases move forward, individual key stakeholders should be re-engaged and outreach for additional minor stakeholders should occur at the beginning of each phase.

Concept Development Workshop

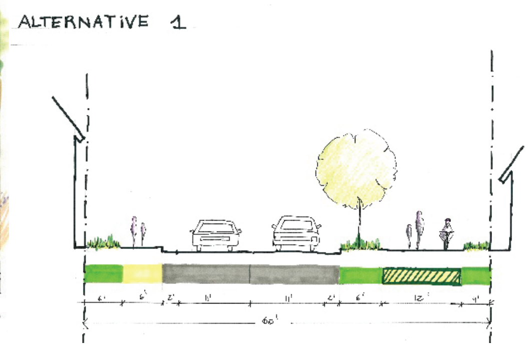
The Orchard Avenue design project aims to transform the corridor from an older, traditional rural/suburban roadway into a true multimodal corridor that better accommodates pedestrians, bicycles, buses, and cars. A key milestone to accomplish this was a workshop where the multi-disciplinary team worked together to develop several concepts. Relying on a comprehensive understanding of existing conditions assembled by

Figure 31: Concept development workshop participants

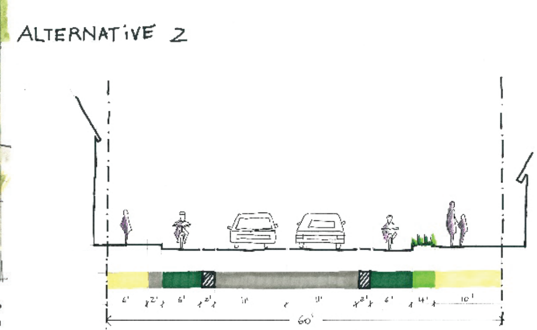
the project team, the study team facilitated a day-long design workshop on September 28, 2021. This workshop focused on developing a series of concept designs that addressed existing challenges to align with project goals.

This workshop began with a corridor "walk-through" that included an overview of the existing corridor conditions. Next, project objectives and an overview of issues and concerns were shown. Afterward, participants were divided into groups to brainstorm concepts, including but not limited to intersections types and layout, roadway cross-sections (including horizontal concepts), active transportation treatments, transit accommodations, landscaping including median treatments, lighting, and other elements as identified by the team. The goal was to have a variety of concepts sketched directly onto the scroll plots and/or tracing paper. The concepts were used "as is" for the public to see a variety of ideas generated by our team. As outlined in the alternative concepts below.

Alternative 1



Alternative 2



Public Open House

After the workshop, the project team hosted an open house at Long Family Memorial Park to gather input on challenges and opportunities along Orchard Avenue from the general public. It was also an opportunity to gather input from the public on concepts developed by the consultant team and County staff during the Concept Development Workshop held earlier that day.

Members of the public were asked to identify issues they experienced on Orchard Avenue, between 29 ½ Road and Warrior Way, and what opportunities for improvement they would like to see. Nearly 50 members of the community turned out to learn more about the project, share their ideas, and have their questions answered by the project team. The event was also covered by KKCO 11, details of which are available here: https://www.nbc11news.com/2021/09/29/mesa-co-revamp-sections-orchard-ave-corridor/

Figure 32: Public Open House participants and staff, At right, the map with comments

Due to public health ordinances associated with the ongoing COVID-19 pandemic, the open house was held outside in a pavilion at Long Family Memorial Park. The open house consisted of a series of presentation boards staffed by project team members to solicit input from the public on concepts. In addition, a long, scale-accurate map was laid out on the table, and participants were invited to provide feedback on the problems, issues, needs, and opportunities associated with the corridor. The full boards and feedback are in this report's **Project Website**.

All the information gathered from the public open house was incorporated into the final design for the corridor.

Key takeaways included:

- Safety
  - People wanted to feel safe using the corridor, which could be addressed by separating different kinds of user groups (separated bike and pedestrian paths)
  - People wanted more speed control devices and traffic calming measures put in place to improve the safety along the corridor, such as:
    - Lowering the speed limit,
    - Adding speed limit signs, or
    - Adding streetlights near cross streets
  - People wanted visual obstructions removed, such as power poles in the field of view when turning on to Orchard Avenue
  - Streetlights along the road near cross-streets
- Traffic and Congestion mitigation
  - A stoplight, roundabout, or other traffic control measure at 31 Road
  - Center turn lanes
  - On-street parking
  - School drop-off zones for pick-up/drop-off and turn around
  - Places for bus stops off the main road, so traffic doesn't queue up behind them
- Active Transportation
  - More crosswalks at Orchard and McMullen, East Valley Drive and Orchard, and from Walmart to Long's Park, among other places
  - Completed sidewalk on both sides of the street
  - Improved bike facilities
- Maintenance and Operations
  - Overall repair and maintenance of the road and sidewalk
  - Drainage and ditch maintenance
  - People did not want to see Orchard Avenue widened or their property taken

Project Website

The project website, www.mesacounty.us/orchard-avenue, was set up by Mesa County as a clearinghouse for relevant data, analysis results, maps, study progress, and announcements. It was updated on an as-need basis. The website included a comment form for the public to submit comments. The website received comments from the public, which were responded to.

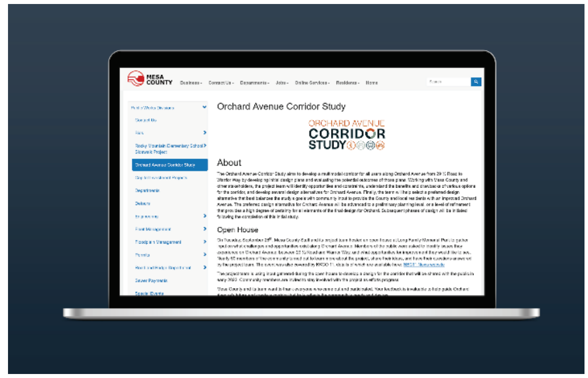


Figure 33: The study website

In addition to a project website, Mesa County used social media to increase total engagement reach. Materials were published on existing City, County, and other relevant stakeholder social media accounts. For overall transparency and to keep the messaging clear, no new project-focused social media accounts were created for this purpose.

Records and responses to questions posed by the public through either the project website or social media are held by the Mesa County Public Information Office.

Section 4 – Roadway

Civil Roadway Discussion

Design Criteria

- Minimum grade = 0.5% per MC Design Standards
- Design Speed is 10 MPH above posted – posted varies from 30 to 35, use 45 MPH as design speed
  - Vertical Curve
    - Crest – K=61
    - Sag – K=79

Drainage Discussion

- Proposed roadway and storm sewer improvements are intended to separate localized stormwater from adjacent irrigation infrastructure. Further improvements to separate regional storm sewers from existing irrigation canals are outside of the scope of this project. Existing storm sewer and irrigation infrastructure comments are based on the City of Grand Junction GIS Utilities Map and field utility-locates.
- From 29 ½ Road to the Grand Valley Canal crossing, Orchard Ave is very flat, with a general slope to the west. The existing roadway has curb and gutter on the north side with curb inlets accepting water to the existing storm sewer which flows west across 29 ½ Road. The existing south side of the road drains overland into the existing irrigation ditch, which survey indicates flows west to an unknown termination point prior to 29 ½ Road. Note - this irrigation ditch (in the GVIC District) does not appear on the City of Grand Junction GIS.

  - The proposed design in this area includes adding an attached walk to the south side of Orchard Road, both to improve pedestrian access on the south side of the road and to control storm runoff from entering the irrigation ditch. Additional curb inlets are proposed on the south side of the roadway crown adjacent to the existing inlets. In this flat area, proposed roadway design shall meet the Mesa County minimum slope of 0.5%, with high points introduced between the existing storm drains to promote positive surface drainage.

Figure 34-Orchard Surface Drainage

- Grand Valley Canal Crossing
    - Preliminary GVIC structure hydraulics indicate that a rise in the bridge deck may be required. This will affect the residential access point directly to the Northeast of the canal. The existing paved cul-de-sac is below the current roadway grade, and currently drains west overland to the canal. An increase in the roadway grade will compound this situation. In the final design phase this area will require enhanced topography and drainage design (approximately 8 lots), while access improvements and ROW adjustments may be required.
- Approximately 250 feet east of the canal there is a relative low spot with curb inlets on either side of the road. These inlets capture storm runoff on Orchard Avenue from the 30 Road intersection as well as surface drainage from Sycamore Avenue. Currently this storm sewer connects to a concrete irrigation structure on the south side of the road, which is then piped and flows south to the canal. To avoid adding storm runoff directly to the irrigation system, this drainage should be captured in a new storm sewer running east to the existing storm sewer in 30 Road. There is existing sanitary and water in this section of the road, and as such utility relocation in this area may be required to maintain proper clearances between storm, water and sanitary. In the final design phase this area will require enhanced topography and drainage design for the neighborhood draining to Sycamore Street, as well as evaluation of the storm sewer capacity in 30 Road.

- Per the Grand Junction GIS, this storm sewer system terminates at a manhole at the intersection of 30 Road and Rood Avenue. The final terminus of this storm line is unknown.

- From 30 Road east to Peachwood Drive, there is a slope at approximately 0.5% from east to west. Existing stormwater in this area drains from the roadway into open irrigation ditches on both sides of the road. The irrigation ditch on the north side collects water from an irrigation ditch running through the neighborhood south from Bookcliff Avenue as well as storm runoff from Serenade Court. This irrigation line crosses Orchard Road between Peachwood and Eastmoor Drives and is shown terminating in that location per the City GIS. Drainage from the proposed roadway in this section should be collected within the roadway prism and directed to the existing inlets at the 30 Road intersection for collection in the storm sewer system.

Figure 35: Stormwater drains along Orchard Avenue

- From the irrigation access at Teco Street west to McMullin Drive stormwater from Orchard Avenue surface drains into adjacent properties. Proposed roadway will capture stormwater in this area and surface drain to 30 Road.

There are two curb inlets at the intersection of McMullin Drive and Orchard Avenue that the GIS does not provide an outfall location. In final design phase enhanced topography and drainage design should be pursued in this area.

- From McMullin Drive to Shoshone Street the existing road grade is approximately 0.5% from east to west. Storm runoff in this area currently sheet flows off the road to the adjacent properties. The proposed roadway design will capture storm runoff in the roadway prism and surface flow to the west.

- There is existing storm sewer infrastructure on the north side of Orchard at the intersections of both Shoshone Street and East Valley Drive, with the extension of storm sewer leaving the Right of Way to the south between the two roads. GIS mapping indicates this storm sewer passes south along the property line of two lots and into Fruitwood Drive, ultimately terminating in the canal.
- Orchard Road continues to climb east at 0.5% from East Valley Drive to Sub Valley Street adjacent to the existing frontage road. The storm sewer begins to drain west to east in this area, terminating in Lewis Wash.
- Existing storm sewer in front of the LDS Church property shall be utilized and improved as needed for the revision to the road in this area. Localized high and low points shall be added to provide a minimum of 0.5% roadway centerline slope to the existing high point at 31 Road.
- County provided GIS documents indicate that the existing storm sewer on the north side of Orchard Road connects to the Lewis Wash.
- Existing roadway grades east of Lewis Wash slope slightly to the east. Stormwater from Lewis Wash to the project improvement limits to the east will be collected by existing/proposed storm sewer and piped west to Lewis Wash.

Roadway Discussion

For the suggested roadway design the objective is to make the corridor more inviting to pedestrians and bicyclists by using right-of-way (ROW) sections that utilize a multimodal design. This would allow for safer and more accommodating travel along the corridor for those using the walking paths, bicycle paths and lanes and public transportation. Because the ROW width at certain areas varies, there are multiple roadway sections that change in width to accommodate this, but all sections have an option for multimodal use. The following is a description of the roadway and is to be read in conjunction with the concept plans.

From 2+50 – 5+00:

The roadway starting from 29 1/2 Road and heading east should use a typical section that utilizes a multimodal design that includes two 11-foot driving lanes, two 4-foot bicycle lanes on either side, a 10-foot walking path on the north and 5-foot walking path on the south. Storm drain inlets should be added to contribute to the new drainage system.

From 5+00 – 7+50:

The bus stop location on the south side should remain and be enhanced to make them more obvious and inviting. A new bus stop on the north side should be added. There should be a new crosswalk with curb ramps added to this location to make the bus stops more accessible and safer navigating between them.

From 10+00 – 12+50:

The street section should start to transition into a narrower width to prepare for going over the Grand Valley Canal Bridge. This section should have two 11-foot driving lanes, a bidirectional multimodal 12-foot concrete path to the north and a 5-foot walking path to the south.

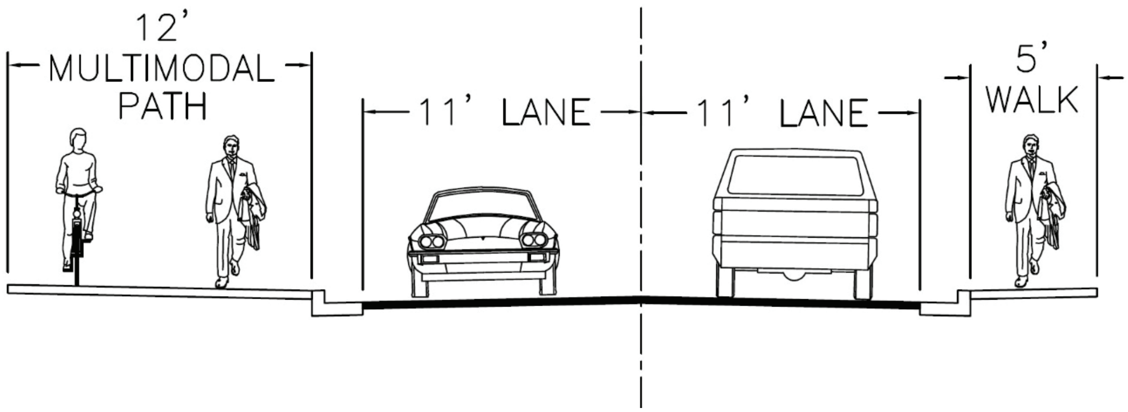


Figure 36 - Typical Narrow Section

From 12+50 – 15+00:

The roadway section should finish the taper down to the narrower bridge section. The intersection of Hall Avenue should be reconstructed to have directional curb ramps that cross Hall Avenue with an added curb ramp on the north for crossing Orchard Avenue facilitating the bus stops to the east.

From 15+00 – 17+50:

New bus stops should be created on the east side of Hall Avenue. Concrete bus pads in the roadway should be evaluated for the prevention of degrading of the roadway due to the buses making stops.

From 17+50 – 20+00:

The Grand Valley Canal Bridge should be improved per the pending design selection for the bridge improvement. Based on the selection, the roadway should be improved to accommodate the proposed roadway section

From 20+00 – 22+50:

Existing Bus stop should be enhanced to make it more obvious and inviting along with a concrete bus pad should be evaluated for the prevention of degrading of the roadway due to the buses making stops.

From 22+50 – 25+00:

On the south side of the roadway, a bus stop should be added along with a concrete bus turn out.

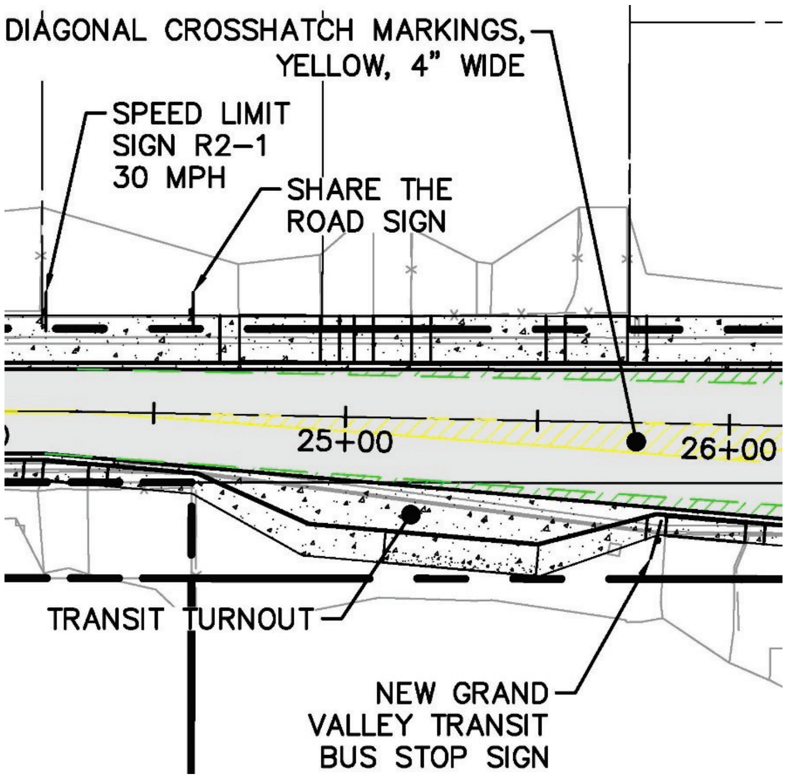


Figure 37 - Transit Turnout

From 25+00 – 32+50:

The roadway section should taper from the typical section into three lane section leading into 30 Road. Heading East into the 30 Road intersection the lanes should be as follows: Right Lane – through straight, middle lane – left turn only, left lane – through straight for opposing traffic. Heading East after 30 Road the lanes should be as follows: Right Lane – through straight, middle – left turn only for opposing traffic, right lane – through straight for opposing traffic. The roadway section tapers from the 30 Road three lane section down to a typical two-lane section. Section includes two 11-foot drive lanes, two 4-foot bicycle paths on either side, a 10-foot concrete path with a 6-foot landscaping buffer and a 5-foot concrete path on the south side.

From 32+50 – 35+00:

Mountainview Drive intersection should be reconstructed with directional curb ramps crossing Mountainview Drive.

From 35+00 – 37+50:

The roadway section should narrow to accommodate the change in ROW width. Section should include two 11-foot drive lanes, two 4-foot bicycle paths on either side, a 10-foot concrete path on the north side and 5-foot concrete path on the south side. Peachwood Drive intersection should be reconstructed with directional curb ramps crossing Peachwood Drive.

From 37+50 – 40+00:

Teco Street intersection should be reconstructed with new directional curb ramps crossing Teco Street.

From 40+00 – 42+50:

The existing bus stops should be enhanced to make them more obvious and inviting. Concrete bus pads should be evaluated for the prevention of degrading of the roadway due to the buses making stops.

From 42+50 – 45+00:

Dodge Street (south)/McMullen Drive (north) intersections should be reconstructed with directional curb ramps crossing said streets along with a crossing over Orchard Avenue to facilitate the adjacent bus stops to the west.

From 45+00 – 47+50:

Shanne Street intersection should be reconstructed with directional curb ramps crossing Shanne Street.

From 47+50 – 50+00:

Grand Valley Drive (north) intersection should be reconstructed with new directional curb ramps crossing Grand Valley Drive. Existing Bus stops should be enhanced to make them more obvious and inviting. Concrete bus pads should be evaluated for the prevention of degrading of the roadway due to the buses making stops. Curb ramps should be added for a street crossing across Orchard Avenue to facilitate safer navigating between bus stops.

From 50+00 – 52+50:

Grand Valley Drive (south) intersection should be reconstructed with directional curb ramps crossing Grand Valley Drive.

From 52+50 – 55+00:

Roadway section should transition from narrower section into wider section due to overall ROW widening. This section should have two 11-foot drive lanes, two 4-foot bicycle paths on either side, a 10-foot concrete path with a 6-foot landscaping buffer on the north and a 5-foot path on the south.

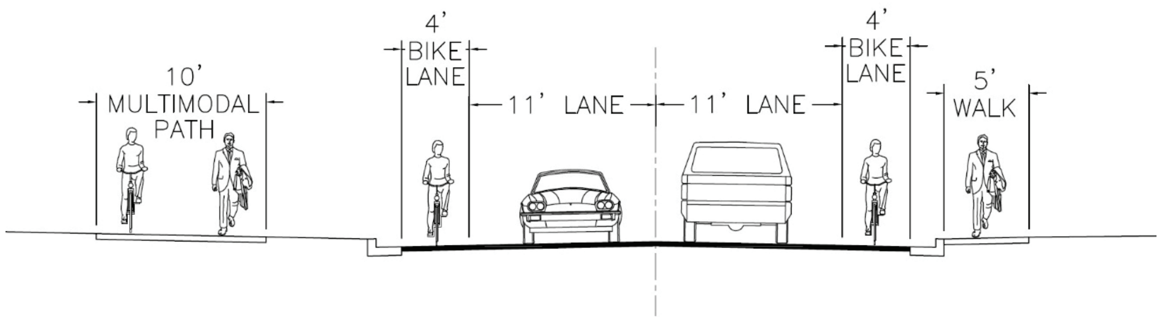


Figure 38 - Typical Section with Bike Lane

From 55+00 – 57+50:

Shoshone Street intersection should be reconstructed with directional curb ramps across Shoshone Street.

From 57+50 – 60+00:

East Valley Drive should be reconstructed with direction curb ramps across East Valley Drive along with adding a crosswalk across Orchard Avenue.

From 60+00 – 62+50:

New underground storm drainage system should start and continue to the east to facilitate roadway drainage and eliminate issues with rainwater ponding in historically problematic areas.

From 62+50 – 65+00:

West and east bound bus stops should be enhanced to be more obvious and inviting. Concrete bus pads should be evaluated for the prevention of degrading of the roadway due to the buses making stops.

From 65+00 – 67+50:

Sun Valley Street intersection should be reconstructed with directional curb ramps going across Sun Valley Street.

From 70+00 – 72+50:

West bound bus stop should be enhanced to be more obvious and inviting. Concrete bus pads should be evaluated for the prevention of degrading of the roadway due to the buses making stops. Hoover Court/Eastbrook Street should be reconstructed with directional curb ramps across Hoover Court/Eastbrook Avenue along with adding a crosswalk across Orchard Avenue to facilitate the adjacent bus stops.

From 72+50 – 75+00:

The east bound bus stop should be enhanced.

From 77+50 – 80+00:

31 Road should be completely reconstructed with new curb ramps for crossing 31 Road along Orchard Avenue and adding a cross walk over Orchard Avenue.

From 80+00 – 82+50:

Suggested roadway should maintain over the newly recommended Lewis Wash Bridge.

From 82+50 – 85+00:

Storm infrastructure should be added to contribute to overall corridor drainage.

From 85+00 – 87+50:

The roadway section should transition from the suggested typical section into the existing improved section. The new storm sewer system should end due to an already existing underground storm sewer system.

From 87+50 – 90+00:

Roadway section should enhance the existing condition by adding a 5-foot walkway to the south where there is currently no path, increasing the size of the path on the north from 8-foot to 10-foot and striping in two 4-foot bicycle paths on either side.

Intersection Discussion

The corridor terminates at the western end at the east leg of the intersection of 29 1/2 Road and Orchard (E 1/2) Road. All legs of the intersection are noted as outside the City of Grand Junction limits. The anticipated design for this intersection is to keep the lane alignments as close to existing as possible. By maintaining the current horizontal configuration and alignments, future intersection enhancements can be designed or modified to fit the requirements. Anticipated improvements to the east leg of the intersection include only minor vertical adjustments and the addition of a multimodal path to the north and a sidewalk to the south. Right of Way along the east leg is listed at 70 feet, which should allow for a sufficient increase in intersection lanes. Curb returns comprise a short radius at the north and south of the east leg, and future enhancements to the intersection may require additional ROW.

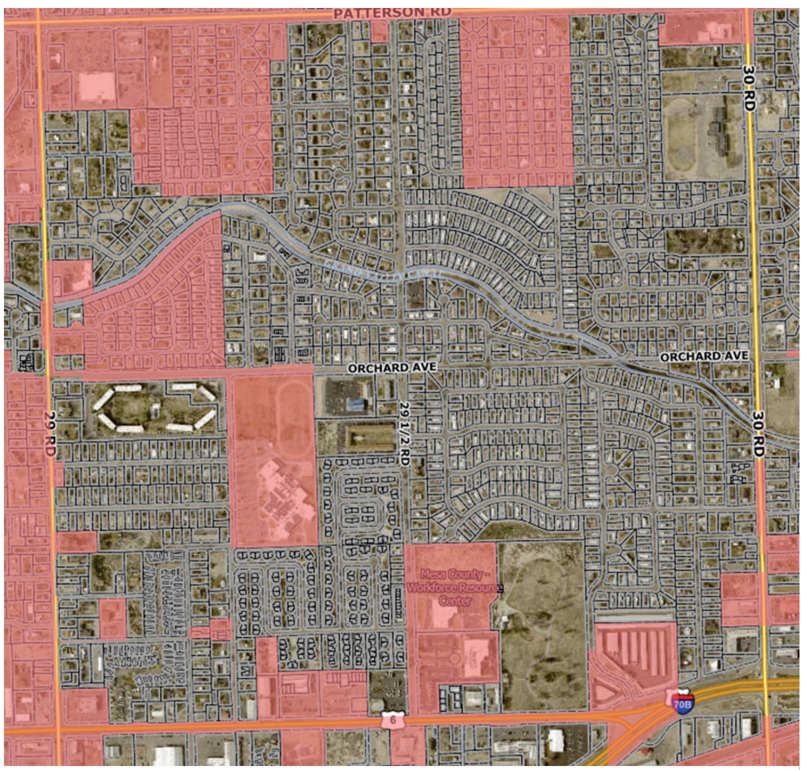


Figure 39 - City Limits : Source City of Grand Junction

At the intersection of 30 Road and Orchard Avenue, attempts were made to remove the right turn conflict in both the north and southbound directions. The right turn movement with a bicycle lane provides a conflict point. Additionally, tractor trailers or other vehicles with trailers often have trailer wheel paths that turn inside the truck or tractor. The far-right turn storage places the cyclist in a precarious location. However, analysis of the intersection with a dedicated right and through left movement resulted in a level of service E in the 2045 year.

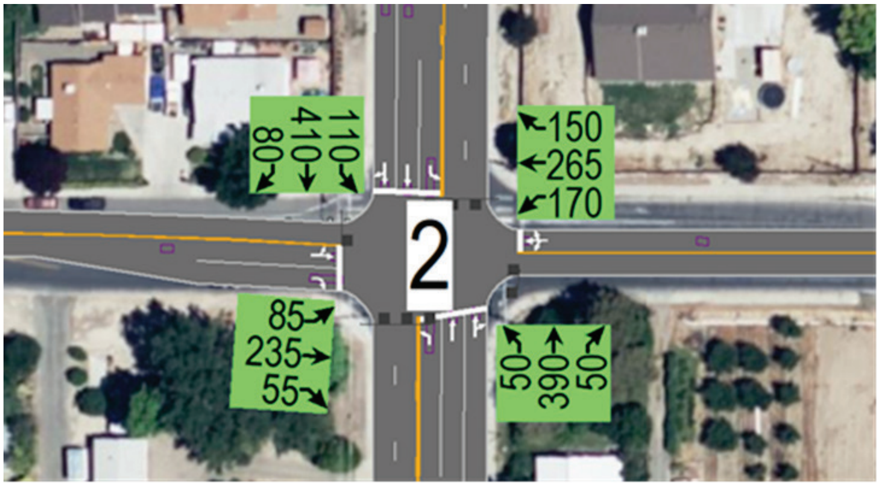


Figure 40 - 30 Road Intersection Through-Left LOS E 2045

As such, the 30 Road Intersection with Orchard Avenue should be configured in the east to west direction with through-right in both east bound and west bound with a dedicated and a protected left turn. The configuration, as shown on the plans, provides a left-turn storage queue that meets the requirements of the 2045 year. Additional skip bicycle lane markings are included to assist the cyclist in crossing the intersection and providing additional awareness for motor vehicle operators. Bicycle "storage" squares may be utilized ahead of the stop bar for added awareness.

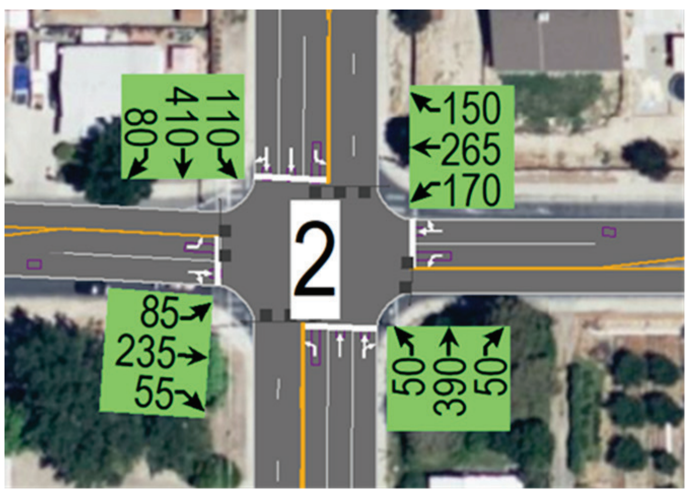


Figure 41 - 30 Road Intersection Through - Right

Of the three major intersections along the corridor study, 31 Road and Orchard avenue represent the only intersection with a level of service F. Additionally, the 85th percentile vehicular speed to the west of this intersection has the highest along the corridor. The current intersection configuration contains a southbound movement that degrades to a level of service F with the AM peak traffic. The intersection, however, returns to a level of service B during PM peak traffic. Both crash severity and frequency are higher in the area surrounding the intersection, and as such, this intersection may pose the most significant safety risk for active transportation.

A round-a-bout was overlayed into the intersection to reduce vehicular speeds and collisions and increase active transportation and safety. The design key parameter was to place the round-a-bout so as not to take rights-of-way. While the round-a-bout fits into the current rights-of-way, the movement from eastbound to southbound contains a substandard curve radius. It may not provide sufficient stopping sight distance for the multimodal crossing. A round-a-bout with larger radii could be properly installed if the taking of properties on the southeast and southwest side were allowed. Additionally, the north leg of the round-a-bout extends well into the subdivision to the north and may adversely affect the connection of Pinyon Place to 31 Road.

Another solution to the 31 Road intersection, as shown on the concept plans, is to align the north and south legs for better visibility. Install traffic calming technics to the intersection's east and west legs. Slowing east to west traffic may allow for natural breaks in traffic that would allow the southbound peak AM traffic movement.

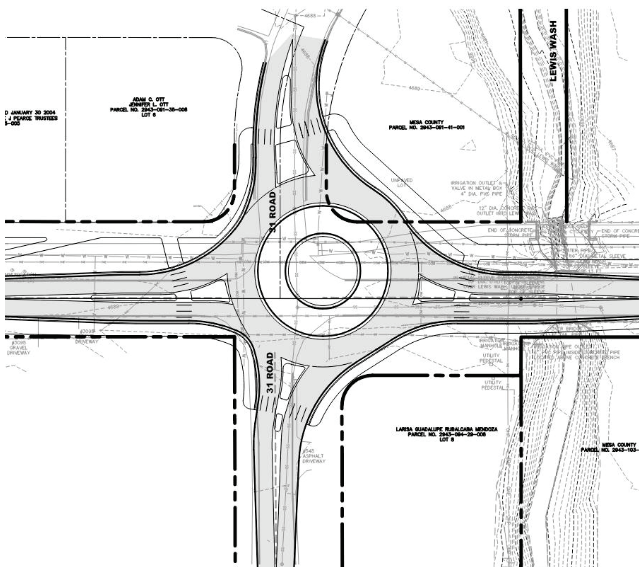


Figure 42 - 31 Road Round-a-Bout

Section 5 – Structures

Structural Bridge Discussion

COLLINS ENGINEERS INC.

Structure Selection Report MESA-E.5-29.8

Project Description

The Orchard Avenue Corridor Study aims to develop a safe and beneficial multimodal corridor for all users along E ½ Road (Orchard Avenue) from 29 ½ Road to Warrior Way. Working with Mesa County, the local community, and other stakeholders, the project team has identified opportunities and constraints, analyzed the benefits and drawbacks of various options for the corridor, and developed several design alternatives. Finally, the team helped select a preferred design alternative that best balances the study's goals with stakeholder input to provide the County and local residents with an improved corridor. The preferred design alternative for E ½ Road has been advanced to a preliminary planning level, or a level of refinement that provides a high degree of certainty for all elements of the final design for Orchard. Subsequent phases of design will be initiated following the completion of this initial study.

This corridor study includes alternatives for two existing bridges along the corridor, one which crosses the Grand Valley Irrigation Canal, and one which crosses Lewis Wash. The following discussion details the structure selection process for the bridge crossing at the Grand Valley Irrigation Canal, Structure MESA-E.5-29.8. The existing roadway bridge is a reinforced concrete box culvert constructed in 1995 and currently is not restricted to any traffic. Though this bridge is structurally sufficient, a replacement structure would be required to accommodate the preferred section along this segment of the multimodal corridor and to improve the channel profile along the canal.

Purpose of the Report

This report is intended to develop guidelines that should be addressed in the subsequent phases of design and make recommendations based on the available information. This report is based on the results of the preliminary level investigation of the existing conditions of the subject structure, including information obtained in the survey, geotechnical investigation, hydrology and hydraulics, existing utilities, and environmental investigations. The study identifies possible structure alternatives based on the site and its potential design constraints.

Structure Selection Process

The following criteria for comparing and evaluating the structural alternatives is discussed below and should need to be considered during design-build processes:

- Hydraulic Opening Requirements
- Roadway Alignments
- Right-of-Way Impacts
- Constructability
- Construction Costs
- Maintenance Requirements
- Durability Considerations
- Multimodal transit suitability
- Traffic Control Requirement

The recommendations of this report are based on the overall consideration of all these elements as appropriate to this site and bridge. In addition to these considerations, all local and federal highway, bridge, and pedestrian design codes and specifications will be adhered to during all stages of design.

Structure Recommendations

Based on the subsequent discussion, the recommended proposed structure is a single span precast, prestressed AASHTO Slab Beam bridge. It consists of Type SIII-36 and SIII-48 sections utilizing the preferred 46-foot roadway cross-section. The width of proposed construction must accommodate a 12-foot multi-use path, 1.5-foot bridge rails, standard 2-foot curb and gutters, 11-foot west and eastbound travel lanes, and a 5-foot sidewalk. The proposed span length is 52 feet. Wingwalls would be required on four corners to retain the roadway fill and accommodate the Grand Valley Irrigation Canal.

The contractor may select a different structure type based on their investigation, meeting the criteria described in this report.

Site Description and Design Features

Existing Structure

The existing MESA-E.5-29.8 structure is a two-cell cast-in-place concrete box culvert with openings measuring 14 feet wide by 5 feet high. It was built in 1995 at Mile Post 29.8, approximately 0.2 miles west of 30 Road Intersection. The structure is skewed 60 degrees. The existing culvert has four concrete wingwalls, one at each corner, varying from 23 feet to 46.2 feet long. Table 8 below summarizes bridge information:

Table 8: Bridge MESA-E.5-29.8 Summary Information

NBI Reporting ID	MESA-E.5-29.8
Year Built	1995
Construction Type	Two-cell Concrete Box Culvert, (2) 14'-0"x 5'-0"
Condition Rating	Good
Load Restricted	No
Bridge Length	58'-8"
Bridge Width	39'-9"
Number of Spans	2
Feature Intersected	Grand Valley Irrigation Canal
ADT	467
Percent Commercial Traffic	7.0%

(Source: 02/06/2020 Structure Inspection and Inventory Report)

The Grand Valley Irrigation Canal flows from southeast to northwest and crosses County Road E ½ at a 60-degree skew.

The replacement of MESA-E.5-29.8 is warranted due to the current structure's inability to carry the multimodal traffic investigated in the Orchard Avenue Corridor Study as well as the preference from the results of the Canal Hydraulic Study Report to remove the middle pier and design the canal invert at this crossing to be "straight-graded." The replacement of the bridge would bring a consistent roadway cross section to the corridor and a desirable upgrade to the canal crossing below.

Vicinity Map

Figure 31 below shows the vicinity of E ½ Road between 29 ½ Road and 30 Road. The existing bridge structure at GVIC is located to the west of 30 Road intersection.

Imagery ©2021 Google, Imagery ©2021 Maxar Technologies, USDA Farm Service Agency, Map data ©2021 100 ft

Figure 43: Vicinity Map of E 1/2 Road between 29 1/2 Road and 30 Road.

MESA-E.5-29.8 is located to the west of 30 Road intersection at Grand Valley Irrigation Canal (Image courtesy of Google)

Right of Way Impact

The existing right of way (ROW) adjacent to Grand Valley Irrigation Canal is approximately 80 feet across on the west side of the bridge, and approximately 65 feet across on the east side. Any alternative selected by a design-build team shall not make any additional impact on the existing right of way beyond that which is planned for roadway improvements between 29 ½ Road to 30 Road. No permanent ROW acquisitions are planned on either side of County Road E ½. Temporary construction easements may be required for drainage erosion control.

Traffic Detour

Traffic may be detoured to the north via County Road F (Patterson Road), or to the south via State Highway 6 (North Ave). However, access must be maintained to Hall Ave on the west side of the bridge, the Canal Access roads on both sides of the canal, and the residences directly adjacent to both ends of the bridge. Figure 32 and Figure 33 below shows detour alternatives during the replacement of the bridge.

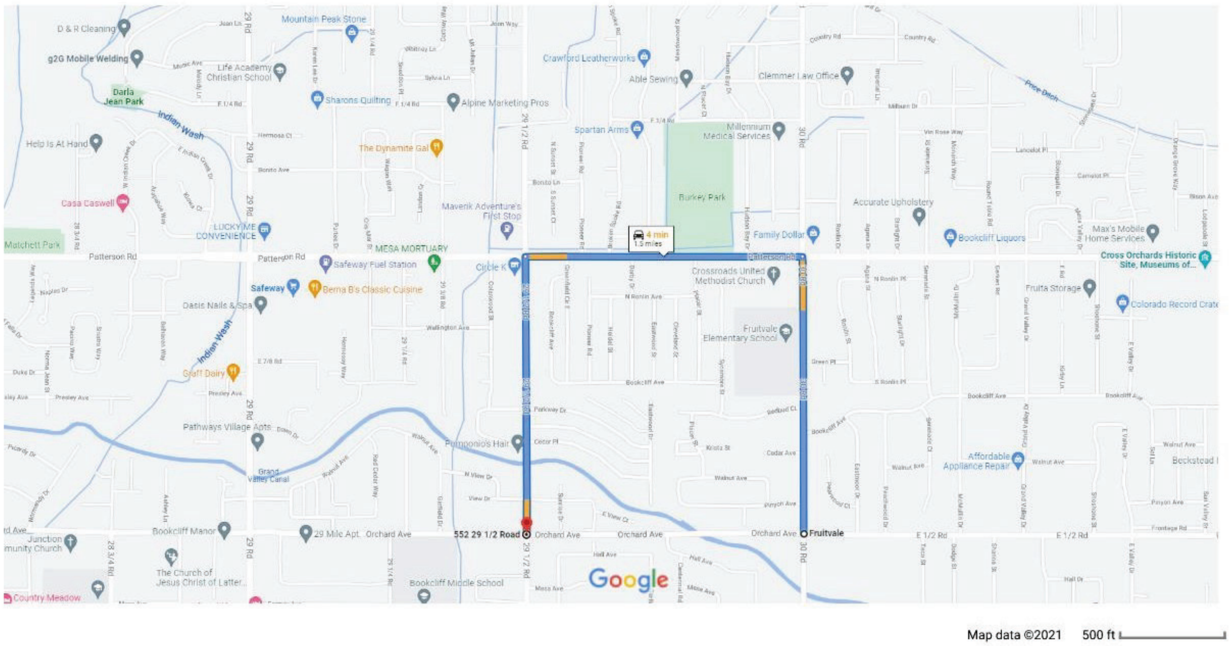


Figure 44: Detour Alternative 1 MESA-E.5-29.8 (Image courtesy of Google)

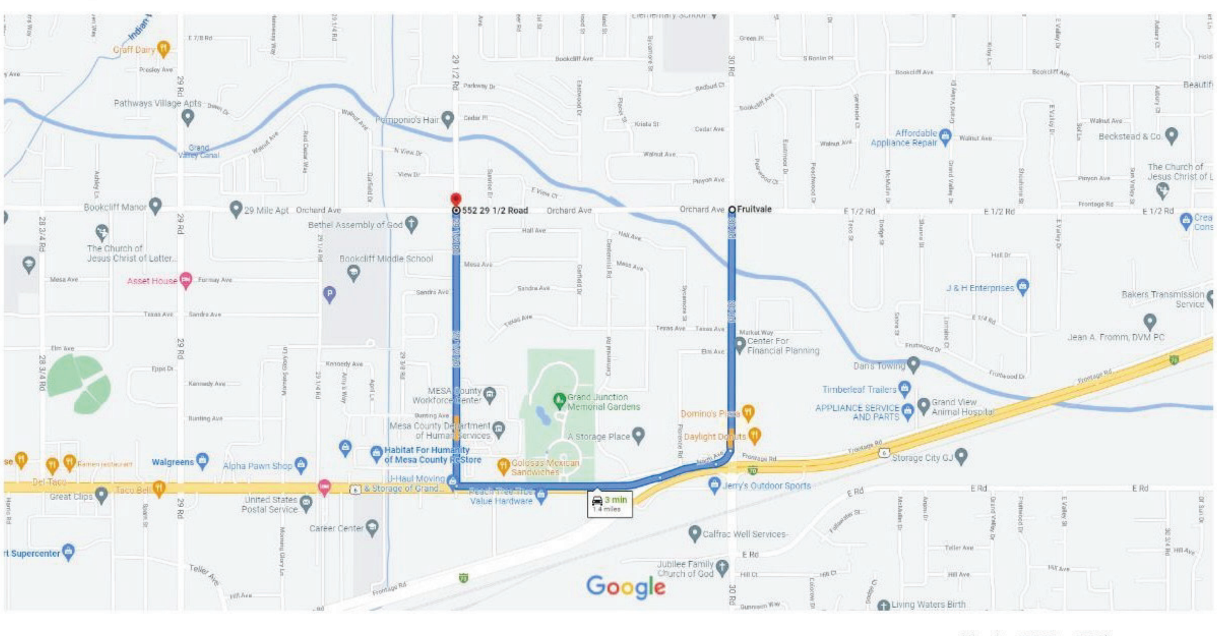


Figure 45: Detour Alternative 2 MESA-E.5-29.8 (Image courtesy of Google)

Utilities

Collins Engineers has partnered with Kaart Group LLC to provide utility location services in the locality of the structure.

Within the vicinity of existing structure MESA-E.5-29.8, there is a 4-inch diameter underground PVC irrigation pipe near the northeast corner of the bridge; two irrigation manholes on the south side of the bridge; and a water main, sanitary sewer, and communications lines on the east side of the bridge, with a communication pedestal near the southeast corner of the bridge. There are no overhead utilities in the vicinity of the bridge.

These utilities shall be preserved in their current alignment after construction. Due to roadway widening, this may require re-alignment of the irrigation pipe; however, the other utilities are far enough away from the bridge that impacts to construction should be minimal. Based on Kaart Surveying's investigation, there are no other existing utilities in the vicinity of the structure.

Geotechnical Summary

Collins Engineers has partnered with Yeh and Associates, Inc. to perform the geotechnical investigation of all aspects of this project. Please refer to the full Geotechnical Investigation Report for more details.

Three bridge borings, B-14, B-15, and B-16 were drilled by Yeh near the existing structure. Results of the bridge boring analyses encountered gravel and clay fill in the first 7-feet, lean clay down to 52-feet below grade, sand and gravel to 70-feet below grade, with shale bedrock starting at 70-feet below grade. Table 9 below provides a summary of the bedrock and groundwater conditions for the bridge borings. The surface elevations, approximate bedrock depths/elevations, and approximate groundwater depths/elevations are presented to the nearest 0.5 ft. The groundwater depths and elevations are based on observations during drilling.

Table 9: Summary of Geotechnical and Groundwater Conditions

Boring ID	Location (Northing, Easting)	Ground Surface Elevation at Time of Drilling (feet)	Approx. Depth to Top of Competent Bedrock (feet)	Approx. Elevation of Top of Competent Bedrock (feet)	Approx. Ground-water Depth (feet)	Approx. Ground-water Elevation (feet)
B-14	42112.1, 109538.7	4,668.6	70.0	4598.6	15.0	4,653.6
B-15	42060.35, 109529.69	4,668.7	Unknown*	Unknown*	6.0	4,662.7
B-16	42123.23, 109403.74	4,667.4	Unknown*	Unknown*	9.0	4,658.4

*Drilling ceased for bad weather and lightning before encountering bedrock
Dated 12/16/2021)

If a replacement bridge structure is selected (Alternative 1), the recommended substructure foundation types for this site include H-piles driven to the dense sand and gravel layer approximately 50 feet below grade. Shallow foundations are not currently foreseen to be viable or economical for the dead and live loads anticipated. It is recommended that wingwalls be supported by piles or of cantilevered design due to the possibility of differential settlement.

If the existing bridge reconstruction alternative is selected (Alternative 2), additional structural capacity would likely need to be added to the existing structure walls. However, additional geotechnical analysis is needed to determine if this is a viable alternative at that time.

If a pedestrian bridge is added adjacent to the existing structure (Alternative 3), additional Geotechnical analysis would be needed to determine if this is a viable alternative at that time.

Hydraulics Summary

Collins Engineers has partnered with Applegate Group, Inc. to perform the hydraulic and hydrologic investigations at Grand Valley Irrigation Canal. Please refer to the full Hydraulic and Hydrologic Investigation Report for more information.

Bridge MESA-E.5-29.8 crosses the Upper Mainline portion of the Grand Valley Irrigation Canal. The canal in this reach is lined with shotcrete that has a trapezoidal section with an average bottom width of 40 feet, depth of approximately 6-feet, and side slopes of 1.5:1. The invert of the existing structure is higher than the area immediately upstream, causing water to pond when the canal is drained every year. Decreed water rights total a flow rate of 640 cubic feet per second (cfs). The freeboard of the existing structure is less than 4-inches at an estimated flow rate of 555 cfs.

A HEC-RAS model was developed at this location which included a design flow rate of 585 cfs, removal of the center pier, and removal of the hydraulic jump near the upstream side of the bridge.

The proposed model indicates that a 24-foot hydraulic opening, without changing the water surface elevation would carry the design flow and maintain the interests of the canal owner.

Environmental and Cultural Resource Concerns

Collins Engineers has partnered with ERO Resources Corp. to perform environmental and cultural resources investigations of all aspects of this project. Please refer to the full Cultural Resources Report for more information.

Based on field investigation performed by ERO, the following historical resources area in the vicinity of the existing bridge.

- Historical Linear (Grand Valley Irrigation Canal)
- Newly Documented Linear (Segment of E ½ Road/Orchard Avenue)
- Newly Recorded Historical Residence (Historical Architecture at 2991 Orchard Avenue)

ERO recommends a determination of "no historic properties affected" pursuant to 36 Code of Federal Regulations 800.4 of the National Historic Preservation Act.

Roadway Design Features

Cross Section

Existing County Road E ½ is a 2-lane roadway with two-way traffic in the vicinity of Bridge MESA-E.5-29.8. The width and typical cross-section transitions from west to east across the existing bridge.

To the west of the bridge, from north to south, the existing cross section consists of an approximately 5-foot wide sidewalk, 12-foot wide west-bound traffic lane, 12-foot wide east-bound traffic lane, and an approximately 4-foot wide asphalt and gravel shoulder.

The typical section across the bridge, starts near Hall Ave and continues approximately to the private residences directly adjacent to the east side of the bridge. From north to south, the cross section consists of a 15-inch wide combination bridge and pedestrian rail, 4.25-foot wide sidewalk, a 9.25-foot wide transition lane which serves the private residences and Canal access roads directly adjacent to the bridge, 12-foot wide west-bound traffic lane, 12-foot wide east-bound traffic lane, and a 12-inch wide combination bridge and pedestrian rail.

To the east of the bridge, from north to south, the existing cross section consists of an approximately 5-foot wide sidewalk, 8-foot wide shoulder, 12-foot wide west-bound traffic lane, 12-foot wide east-bound traffic lane, and an approximately 1-foot wide concrete curb return

Figures 34-36 below illustrate the existing typical sections across Bridge MESA-E.5-29.8:

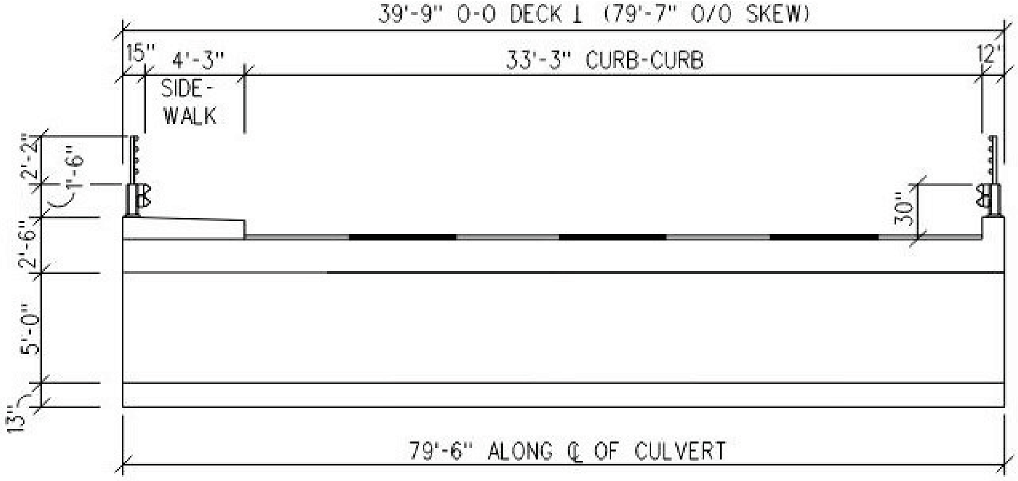


Figure 46: Existing typical section of County Road E 1/2 west of Bridge MESA-E.5-29.8

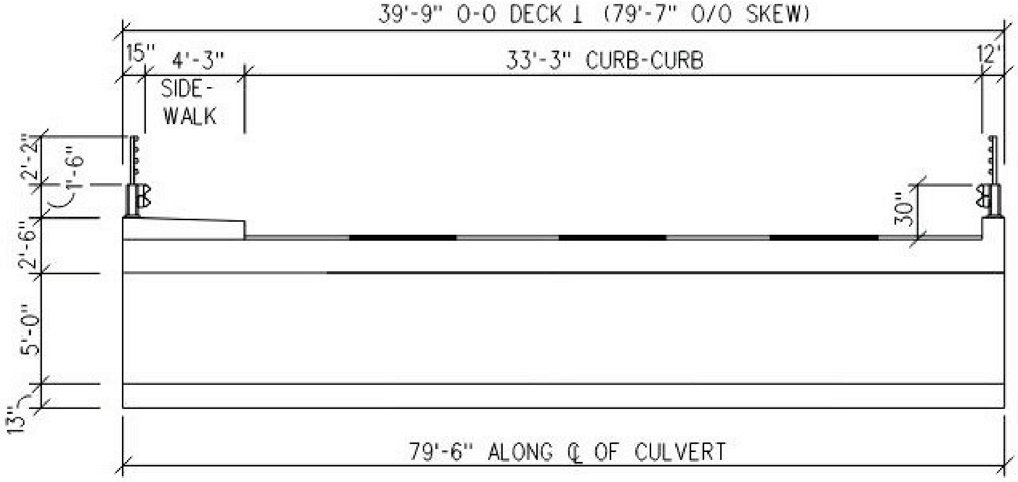


Figure 47: Existing typical section of County Road E 1/2 across Bridge MESA-E.5-29.8

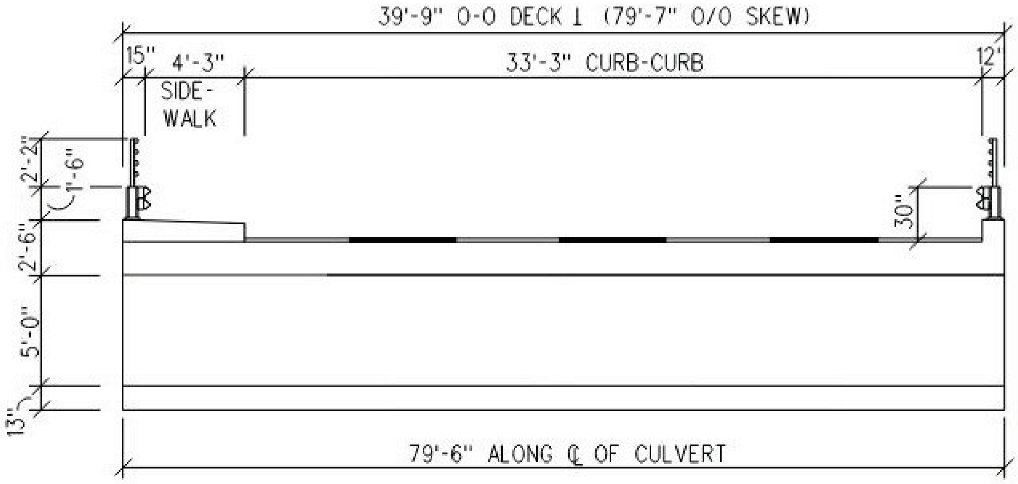


Figure 48: Existing typical section of County Road E 1/2 east of Bridge MESA-E.5-29.8

There is currently one proposed roadway section width proposed for this section of the corridor, which is based on the requirements of the current CDOT Roadway Design Guide.

For the proposed roadway section, vehicular traffic lane width is expected to be 11-feet in each direction with a 12-foot-wide path on the north side, a 5-foot-wide sidewalk to the south, and the Colorado current standard Bridge Rail on each side. Total required out to out width over proposed structure is 46-feet. Figure 37 below illustrates the proposed typical section across Bridge MESA-E.5-29.8.

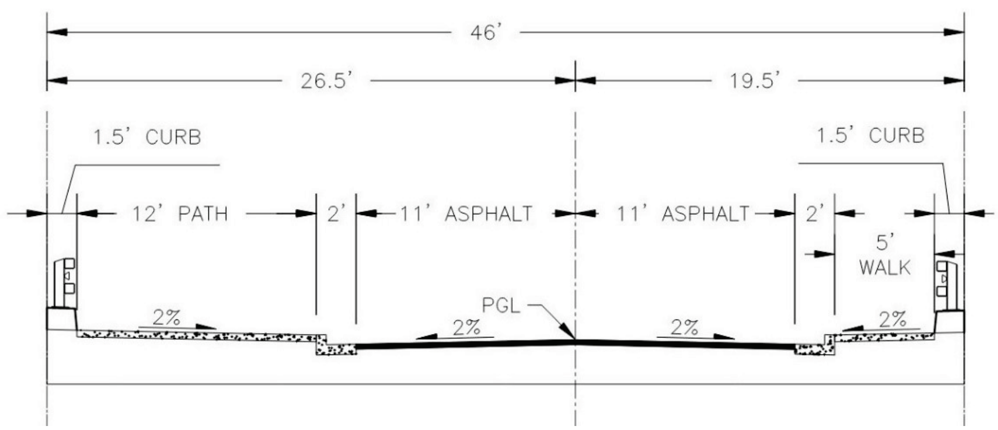


Figure 49: Proposed typical section Bridge MESA-E.5-29.8

Vertical Alignment

The proposed vertical profile of County Road E ½ (Orchard Avenue) must be set as close to the existing profile as allowed by the results of the hydrology study to avoid any ROW acquisitions.

Based on the chosen alternative, the vertical profile may change slightly. If Alternative 1 is chosen, the proposed structure would require the roadway elevation to be raised up to 8-inches higher than the current conditions. If Alternative 2 is chosen, the elevation may only require the elevation to be raised by a few inches. Alternative 3 will not require any changes in vertical alignment.

Horizontal Alignment

The horizontal alignment of the existing bridge is skewed 60-degrees. The bridge is on a continuous horizontal tangent. The proposed structure center line will be offset to the south of the existing centerline by a few feet. The bridge skew is not recommended to be changed.

Structural Design Criteria

Design Specifications

- AASHTO LRFD Bridge Design Specifications, 9th Edition
- Mesa County Design Standards
- CDOT LRFD Bridge Design Manual
- CDOT Bridge Detail Manual
- AASHTO Guide for the Development of Bicycle Facilities, 4th Edition

Construction Specifications

- Special Project Specifications
- Mesa County Standard Specifications
- Mesa County Standard Special Project Specifications
- CDOT Standard Specifications for Road and Bridge Construction, 2021
- CDOT Standard Special Provisions
- AASHTO LRFD Bridge Construction Specifications, 4th Edition

Loading

All loads shall be evaluated in accordance with the Design Specifications listed above. Site- and project-specific provisions in the categories are brought to the designers' attention; however, this list should not be considered exhaustive, and the designer shall use his/her engineering judgement.

Live Load

The replacement bridge shall be designed to carry HL-93 loading and Colorado Permit Vehicle loads in accordance with the Design Specifications listed above.

Dead Load

The following dead loads will be necessary in the design of the proposed structure, analyzed and applied in accordance with the Design Specifications listed above.

- Bridge rails (42-inches high minimum)
- Reinforced concrete paths
- Reinforced concrete roadway curbs
- Buffer zones (area between pedestrian paths and traffic)
- Design wearing surface
- Future wearing surface = 36.67 psf (3" minimum)

Collision Load

There is no vehicular traffic or vessels under the structure, so the substructure will not require investigation of Collision Loads. In the alternatives where the bridge rail is connected to the structure, Vehicular Collision Loads on the barrier shall be investigated in accordance with the Design Specifications listed above.

Earthquake Load

The structure is located within Seismic Zone 1. Earthquake Loads, and connection and detailing design shall be performed in accordance with the Design Specifications listed above.

Stream Forces and Scour Effects

Water Load and Stream Pressure from Grand Valley Irrigation Canal shall be evaluated in accordance with the Design Specifications listed above.

Deck Drainage

Since the bridge crosses a canal, additional runoff, apart from what is currently entering the canal, may not be discharged into the canal. Existing drainage patterns should be matched in the proposed structure design.

Aesthetic Requirements

The current structure is not visually imposing. A similar low profile should be preserved.

Possible Future Widenings

The existing right of way in the vicinity of the bridge varies from 80-feet across on the west side of the bridge, to approximately 65 feet across on the east side. The proposed cross-section width is 46 feet and plans to accommodate all modes of traffic. With no excessive right of way acquisitions planned on either side of County Road E ½, it is unlikely that the proposed bridge would be widened in the future.

Software to be Used by Designer

Bridge design software must be sufficient for the design of the structure, as determined by a reviewer who must hold a PE license in the State of Colorado.

Software to be Used by Independent Design Checker

Either the same software as used for bridge design, or a different sufficient software may be used by the Independent Design Checker, who must hold a PE license in the State of Colorado.

Structure Selection

Three feasible superstructure alternatives have been identified for their potential to adequate carry the multimodal corridor and provide the required hydraulic opening for the canal. The following sections detail the structure selection process.

Selection Criteria

This report is intended to identify which superstructure alternatives are most capable and cost-effective for meeting the project requirements. Each structure was evaluated based on the following criteria:

- Cost
- Weight
- Speed of construction
- Ease of construction access
- Complexity
- Span length
- Superstructure depth
- Maintenance requirements
- Material staging requirements
- Aesthetics
- Substructure complexity

All structure alternatives were initially chosen based on their ability to provide the required corridor width and hydraulic opening.

Rehabilitation Alternatives

The current structure is in good condition and does not require rehabilitation. However, it is recommended for replacement to meet the new Orchard Avenue corridor requirements. Adding a separate pedestrian bridge adjacent to the existing structure to accommodate pedestrian and bicycle traffic (Alternative 3) would preserve the current structure. This solution does not meet the project requirements, however, because there is still inadequate room for shoulder bike lanes on the current structure.

Inspection Summary

The existing structure is in good condition with an NBI Culvert rating of seven. The Inspection Report notes the following defects: light efflorescence near the inlet and outlet of both cells, random moderate width cracks in the wearing surface, minor corrosion on the bridge and pedestrian rails, and minor to moderate spalls and delamination in the wingwalls and concrete curbs. None of these defects require the immediate replacement or rehabilitation of the structure. The replacement of Bridge MESA-E.5-29.8 is recommended for corridor requirements.

Load Test Requirements

Load testing is not required for the current structure due to its good condition.

Structure Layout Alternatives

Layout of the proposed structure alternatives is subject to the requirements of the corridor width, hydraulic opening, canal geometry, utilities, and construction considerations.

Vertical Clearances

The Grand Valley Irrigation Canal crossing requires a minimum of 1-foot of freeboard from the water surface elevation to the lowest point on the superstructure at the design flow to safely pass debris. The freeboard of the existing structure is less than 4-inches at an estimated flow rate of 555 cfs. The designer shall take these considerations into account in the final design. Refer to the CDOT Bridge Design Manual and CDOT Drainage Manual for additional clearance requirements.

Horizontal Clearances

The bridge must not interfere with the intersection of E ½ Road and Hall Road, and access must be maintained to the canal access roads currently present at all four corners of the bridge, and to the private residences along Orchard Ave. Since the roadway is not expected to be realigned in this area, all other horizontal clearances are expected to be met.

Skew

The proposed alignment must maintain the 60-degree skew to maintain the alignment of the Grand Valley Irrigation Canal.

Span Configurations

The total length of all proposed Superstructure Alternatives was determined based on site and construction requirements. The required span length can be met with one or two spans, depending on superstructure type. However, since the existing freeboard is so small, it is beneficial to use a 2-span configuration to minimize the depth of the superstructure. Since the water surface elevation shall not be changed at the design flow rate, the deeper the required superstructure, the more the vertical alignment would be required to be raised in the vicinity of the bridge.

Deflection

The proposed structure alternatives must meet the live load deflection requirements for its superstructure type in the AASHTO LRFD Bridge Design Manual.

Superstructure Alternatives

The following superstructure alternatives were selected as the most capable of meeting the requirements of the Orchard Avenue Corridor Study.

Alternative 1 – Precast Prestressed Concrete Slab Beams

This alternative consists of reconstructing all elements of the structure and replacing it with precast prestressed concrete slab beams and cast-in-place abutments and pier walls. Prestressed slab beams can span the required distance with a low structural depth. This is important to retain the required freeboard while minimizing the impact of raising the vertical alignment of the road in the vicinity of the structure. Precast elements allow for quick and simple construction because the slab beams would be constructed offsite and could be quickly placed with a crane. AASHTO has specifications for standard slab beam sections that can be used to easily design members capable of meeting the structural requirements.

The proposed configuration would consist of a single span approximately 52-feet from CL Support to CL Support, with a hydraulic opening of 25-feet. The bridge would carry the proposed corridor option shown in Figure 37. This option accommodates requests from GVIC to raise the freeboard to 1-foot, as well as flatten out the canal invert to be "straight-graded." Additionally, a full reconstruction of the bridge would allow a seamless integration of the proposed corridor cross section in this area. The centerline of the proposed structure roadway would be pushed to the south of the existing structure by a few feet.

Because the proposed structure would be wider than the existing structure, the existing culvert walls and wingwalls cannot be used for the new structure. Therefore, this Alternative would require a new substructure. See the Geotechnical Summary section of this report for more information.

Though this alternative is the costliest option, it offers the most solutions to the bridge constraints and corridor challenges.

Alternative 2 – Reconstruct Existing Structure

This alternative would require selective demolition of the top slab on the existing structure, with replacement using the same type of AASHTO precast prestressed concrete slab beams as in Alternative 1. The difference is that the existing culvert walls and wingwalls would remain in place, and the culvert walls would be retrofitted to meet the bearing requirements of the slab beams. The replacement of the top slab would serve multiple purposes. It would allow for the improved corridor section to cross the bridge, and it would increase the freeboard between the canal's high-water level and the low chord to 1-foot. Any amount of reconstruction of this bridge should, at a minimum, increase the freeboard to 1-foot.

The proposed configuration would consist of 2-spans of approximately 25.5-feet. However, since the existing culvert walls would be retrofitted, and the existing wingwalls would remain in place, the proposed corridor section may have to be adjusted slightly to accommodate the constrained existing width of the bridge. This proposed configuration would provide the required freeboard at the design flow rate. The centerline of the proposed structure roadway would be in the same location as the existing structure.

Alternative 3 – Adjacent Pedestrian Bridge

This alternative would retain the existing structure in its entirety and add a second structure on its north side to accommodate additional pedestrian and bicycle traffic. The pedestrian bridge could be a prefabricated structure or designed to be constructed on-site.

The proposed configuration would consist of 2-spans of approximately 25.5 feet, so it would require three new substructure units on the north side of the existing structure.

This proposed configuration would provide the required freeboard at the design flow rate for the new structure but would leave the inadequate freeboard of the existing structure unchanged. Furthermore, this alternative does not meet the objectives of the Orchard Ave Corridor Study since it does not provide for one, continuous multimodal corridor in the vicinity of this structure. Therefore, this alternative is not recommended as feasible.

Substructure Alternatives

The substructure for this bridge depends on analysis from the Geotechnical Engineer. Superstructure Alternative 1 would require driven H-Piles. Superstructure Alternative 2 would require further analysis to analyze the change in loads on the existing concrete box culvert walls.

Superstructure Alternative 3 would require no change to the existing substructure but would require further analysis of the loads from a pedestrian bridge to determine a substructure type.

Abutment Alternatives

Seat or semi-integral abutments are preferred for Superstructure Alternatives 1 and 3 because they provide for simple and rapid placement of the precast/prefabricated superstructure elements.

Pier Alternatives

The main difference between Alternatives 1 and 2, besides retaining some existing portions of the structure, is the removal of the center pier in Alternative 1. Per the recommendations given in the Canal Hydraulic Study Report, the most desirable option for a new bridge would be to remove the center pier in order to allow a more consistent hydraulic opening and it would allow the opportunity to readjust the canal invert to be straight-graded. If removing the pier is the most desirable option, deeper AASHTO box beam sections would need to be chosen in order to span over a much longer length. This deeper section would require the roadway profile to be raised up at least 8-inches.

Use of Lightweight or High-Performance Concrete

It is not anticipated that lightweight concrete would be required for any Superstructure Alternative. The use of high-performance concrete or ultra-high-performance concrete could be considered if the increased cost is justifiable. This could help increase the achievable span lengths under Superstructure Alternative 1 and/or decrease the overall required depth of the superstructure under Superstructure Alternatives 1 and 2. In turn, this could help meet the minimum freeboard requirements of the canal and prevent the need to raise the vertical alignment in the vicinity of the bridge.

Wall Alternatives

Superstructure Alternatives 1 and 3 would require new wingwalls to retain the fill around the channels at the upstream and downstream sides. Wingwalls would be designed according to the CDOT M-Standards. The wingwall configuration for Superstructure Alternative 1 would be similar to the existing wingwall layout in terms of length and skew but would need to support more backfill behind the wall if the vertical alignment is raised.

Constructability

All Superstructure Alternatives use precast and/or prefabricated elements, which greatly increase ease of construction. However, Superstructure Alternatives 1 and 3 would require new abutments and piers, requiring cast-in-place concrete to be poured within the current right of way, which would require careful coordination to perform the work efficiently and on schedule.

Superstructure Alternative 2 would require the most extensive planning out of the three alternatives since the existing structure would require partial or complete demolition of the top and/or bottom slab. The substructure would then likely require alterations to the existing foundations (subject to the forthcoming recommendations of the Geotechnical Engineer), walls and piers (to widen the roadway and meet the bearing requirements of the precast slab beams), and wingwalls.

Construction Phasing

Superstructure Alternatives 1 and 2 could be constructed in two phases, allowing one lane of traffic to remain open during construction. If two phases are not desirable, this would require closing of E ½ Road, and a detour plan developed. Careful coordination with stakeholders like the homeowners along Orchard Ave, the owner of Grand Valley Irrigation Canal, and Central High School, shall be maintained to minimize the impact of this detour. Closing the road is especially difficult at this location due to the proximity of the private residence's driveways, canal access roads, and Hall Ave.

If phasing is desired, CDOT Roadway requirements specify a minimum 11-foot lane, with 2-foot-wide shoulders, 2-foot-wide temporary concrete barriers, and a work zone buffer during construction. The work zone buffer may be 1-foot wide if a pinned barrier is used, or 2-feet wide if a non-pinned barrier is used. More information on phased construction can be found in the Traffic Design Memorandum for this structure.

All Superstructure Alternatives using two phases would require shoring of the existing structure and/or adjacent fill slopes.

Use of Existing Bridge in Phasing

The existing structure may be used during phasing under Superstructure Alternatives 1 and 2. Since the existing structure would not be affected under Superstructure Alternative 3, this section is not applicable to that Alternative.

Accelerated Bridge Construction (ABC) Design

CDOT has developed an ABC decision making process to encourage some form of ABC on most projects. Engineers and contractors on the design team for this bridge are encouraged to use this process to evaluate feasibility of using ABC for this structure.

Maintenance and Durability

The required service life for this structure is 100-years. This would be easily met if CDOT specifications and accepted current design and construction practices are followed. The structure would be durable and require minimal maintenance.

Corrosive Resistance

It is important to eliminate the effects of corrosion on the rebar of concrete structures. This can be accomplished using epoxy coated rebar and other waterproofing measures at the discretion of the Design Engineer

Summary of Structure Type Evaluation Table

The following tables show the cost and ability to meet the structural requirements for each Superstructure Alternative.

Construction Cost

It is important to identify the most cost-effective structure type for this project. Preliminary construction cost estimates have been prepared for the superstructure alternatives and are summarized in the table below. See Appendix A2 for detailed cost estimating calculations, including Lifecycle Cost Analyses.

Table 10: Construction Costs Summary

Alternative	Construction Cost	Deck Area (square feet)	Cost per Square Foot	Cost Rating
1 – Precast Prestressed Concrete Slab Beams	$673,342	1,173	$574	1.9
2 – Reconstruct Existing Structure	$275,571	1,173	$235	1.0
3 – Adjacent Pedestrian Bridge	$232,870	960	$242	1.0

Conclusions and Recommendations

Superstructure Alternative 1, the precast prestressed concrete slab beams option meets all criteria with the best cost-effectiveness and constructability requirements. The design engineer and contractor may select a different structure type, provided all requirements above are met. See Appendix A1 for the selected General Layout and Typical Section.

Table 11: Evaluation of Each Superstructure Alternative

Criteria	Alternative 1	Alternative 2	Alternative 3
Hydraulic Opening/Canal Geometry	Satisfies the requirements	Satisfies the requirements	Does not satisfy all requirements
Constructability	May close road and provide detour, or phase construction	May close road and provide detour, or phase construction	No detours or shoring required
Cost Rating	1.9	1.0	1.0
Maintenance Requirements	Routine maintenance required	Routine maintenance required	Routine maintenance required

Structure Selection Report-MESA-E.5-31.01

Executive Summary

Project Description

The Orchard Avenue Corridor Study aims to develop a safe and beneficial multimodal corridor for all users along E ½ Road (Orchard Avenue) from 29½ Road to Warrior Way. Working with Mesa County, the local community, and other stakeholders, the project team has identified opportunities and constraints, analyzed the benefits and drawbacks of various options for the corridor, and developed several design alternatives. Finally, the team helped select a preferred design alternative that best balances the study's goals with stakeholder input to provide the County and local residents with an improved corridor. The preferred design alternative for E ½ Road has been advanced to a preliminary planning level, or a level of refinement that provides a high degree of certainty for all elements of the final design for Orchard. Subsequent phases of design will be initiated following the completion of this initial study.

This corridor study includes alternatives for two existing bridges along the corridor, one which crosses the Grand Valley Irrigation Canal and one which crosses Lewis Wash. The following report details the structure selection process for the bridge crossing at Lewis Wash, currently comprised of two structures: Structure MM-E.5-31.01, the 2-lane roadway bridge, and Structure MM-E.5-31 serving the pedestrian path located approximately 22-feet to the north of the roadway bridge. The existing roadway bridge is a reinforced concrete box culvert constructed in 1950 and currently is not restricted to any traffic. The existing pedestrian bridge is a single span timber bridge constructed in 1998 and currently is not given a sufficiency rating. Though each bridge is structurally sufficient, a replacement structure will be required to accommodate the preferred section along this segment of the multimodal corridor.

Purpose of the Report

This report is intended to develop guidelines that will be addressed in the subsequent phases of design and make recommendations based on the available information. This report is based on the results of the preliminary level investigation of the existing conditions of the subject structures, including information obtained in the survey, geotechnical investigation, hydrology and hydraulics, existing utilities, and environmental investigation. The study identifies possible structure alternatives based on the site and its potential design constraints.

Structure Selection Process

The following criteria for comparing and evaluating the structural alternatives will need to be considered during design-build processes:

- Hydraulic Opening Requirements
- Roadway Alignments
- Right-of-Way Impacts
- Constructability
- Construction Costs
- Maintenance Requirements
- Durability Considerations
- Multimodal transit suitability
- Traffic Control Requirement

The recommendations of this report are based on the overall consideration of all these elements as appropriate to this site and bridge. In addition to these considerations, all local and federal highway, bridge, and pedestrian design codes and specifications will be adhered to during all stages of design.

Structure Recommendations

Based on the subsequent discussion, the recommended proposed structure is a 2-Cell Precast Concrete Box Culvert. The geometry of the selected structure consists of (2) – 14-foot W x 12-foot H cells utilizing the preferred 55-foot roadway cross-section. The width of proposed construction must accommodate a 10-foot multi-use path, 6-foot buffer, standard 2-foot curb and gutters, 4-foot west and eastbound bike lanes, 11-foot west and eastbound travel lanes, and a 5-foot sidewalk. The proposed length will be 30 feet. Wingwalls will be required on four corners to retain the roadway fill and accommodate Lewis Wash.

The designer may select a different structure type based on their investigation, meeting the criteria described in this report.

Site Description and Design Features

Existing Structures

The existing structures located at the Lewis Wash crossing at E ½ Road consist of the roadway structure MM-E.5-31.01 and the pedestrian structure MM-E.5-31 serving the path located approximately 22 feet to the north of the roadway bridge.

The existing roadway structure is a single-cell 12’-2” x 12’-8”, concrete box culvert built in 1950 at Mile Post 31.01, directly east of 31 Road intersection. The structure is not skewed. The existing culvert has four concrete wingwalls, one at each corner. Table 12 below summarizes the bridge information:

Table 12: Bridge MM-E.5-31.01 Summary Information

NBI Reporting ID	MM-E.5-31.01
Year Built	1950
Construction Type	Single-cell Concrete Box Culvert, 12’-2”x12’-8”
Condition Rating	Satisfactory
Load Restricted	No
Bridge Length	12’-2”
Bridge Width	32’-4”
Number of Spans	1
Feature Intersected	Lewis Wash
ADT	4400
Percent Commercial Traffic	N/A

The existing pedestrian bridge structure is a single span timber deck, timber beam bridge built in 1998 at Mile Post 31.0, directly east of 31 Road intersection. The pedestrian bridge is located just upstream of Lewis Wash to the roadway structure. The timber bridge superstructure is set on concrete abutments and wingwalls set straight back on either side of Lewis Wash, and the structure is not skewed. Table 13 below summarizes the bridge information:

Table 13: Bridge MM-E.5-31 Summary Information

NBI Reporting ID	MM-E.5-31
Year Built	1998
Construction Type	Timber Superstructure, Concrete Substructure
Condition Rating	Good
Load Restricted	No
Bridge Length	36'-6"
Bridge Width	8'-2"
Number of Spans	1
Feature Intersected	Lewis Wash
ADT	N/A
Percent Commercial Traffic	N/A

Lewis Wash flows from north to south and crosses County Road E½ at a 0° skew.

The replacement of both bridges is warranted due to the current structure's inability to carry the multimodal traffic investigated in the Orchard Avenue Corridor Study. The replacement of both bridges with a single bridge will bring a consistent roadway cross section to the corridor.

Vicinity Map

Figure 38 below shows the vicinity of E ½ Road between 31 Road intersection and Longs Memorial Park. The existing bridge structures at Lewis Wash are located to the east of 31 Road intersection.

Figure 50: Vicinity Map of E 1/2 Road between 31 Road intersection

Right of Way Impact

The existing right of way (ROW) is approximately 75 feet across at Lewis Wash. Any alternative selected by a design-build team shall not make an impact on the existing right of way. No permanent ROW acquisitions are planned on either side of County Road E½ near this bridge location. Temporary construction easements may be required for drainage erosion control.

Traffic Detour

Traffic may be detoured to the north via Patterson Road (County Road F), or to the south via State Highway 6. However, access must be maintained to 31 Road on the west side of the bridge, Long Family Memorial Park, Central High School, and the residences directly adjacent to the west end of the bridge as shown in Figure 39 below.

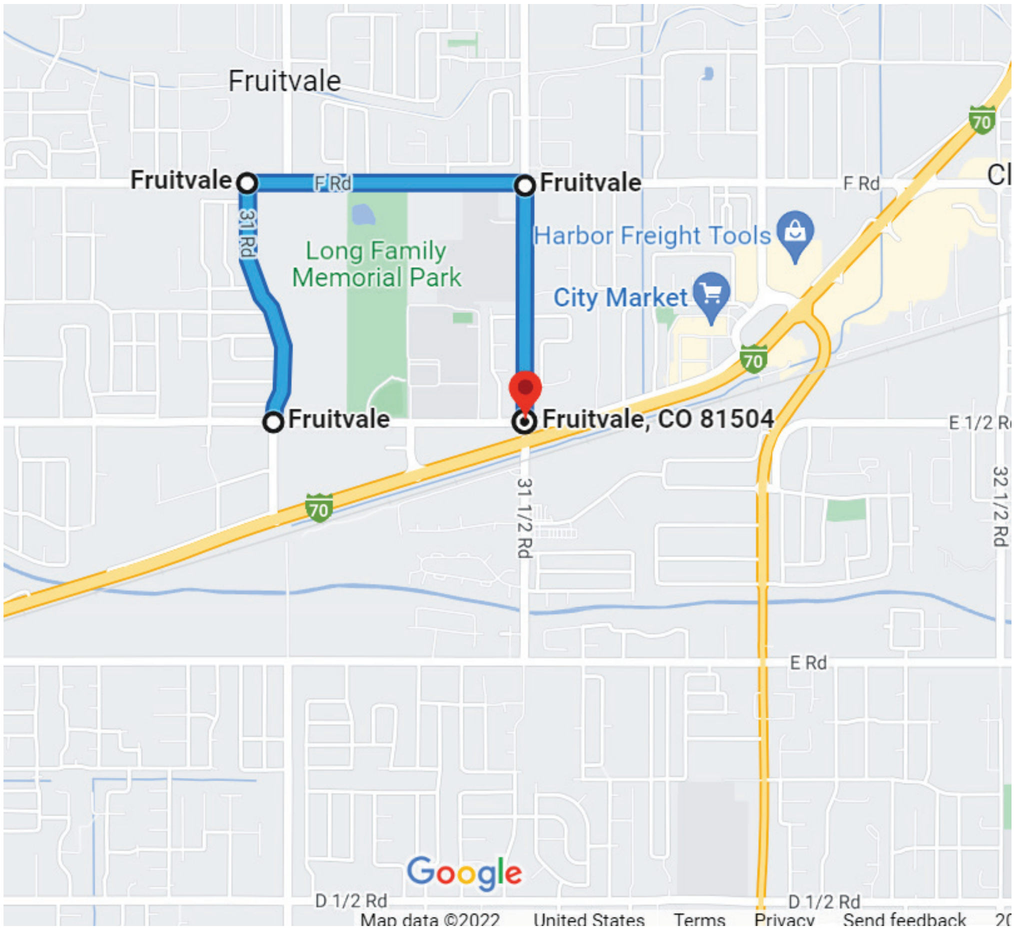


Figure 51: Detour AlternativeMESA-E.5-31.01

(Image courtesy of Google)

Utilities

Collins Engineers has partnered with Kaart Group LLC to provide utility location services in the vicinity of the structure.

Within the vicinity of existing structure MM-E.5-31, there is a 8-in. diameter concrete utility line with its pipe termination at the high water line elevation on the north end of the structure. There are a few other utilities located to the north of the structure that terminate at Lewis Wash, but they do not appear to affect the future demolition of the pedestrian structure or the construction of the replacement bridge.

Within the vicinity of existing structure MM-E.5-31.01, there is an overhead electric line located along the north ROW line of the roadway bridge, running parallel to the existing road. Additionally, there is one 16-inch diameter water pipe, one 12-inch diameter communications pipe, and one 10-inch diameter utility pipe running through the north wingwalls of the existing roadway structure, parallel to the roadway. There is also a 4-inch utility line attached to the south edge of the bridge deck. These utilities will need to be preserved in their current alignment after construction. Due to roadway widening, this may require them passing through the walls of the culvert. Based on Kaart Surveying's investigation, there are no other existing utilities in the vicinity of the structure.

Geotechnical Summary

Collins Engineers has partnered with Yeh and Associates, Inc. to perform the geotechnical investigation of all aspects of this project. Please refer to the full Geotechnical Investigation Report for more information.

Two bridge borings, B-2 and B-13 were drilled by Yeh near the existing structure. Results of the bridge boring analyses encountered sand fill in the first 2 feet, clay down to 57 feet below grade, and sand to 71 feet below grade, with shale bedrock starting at 71 feet below grade. Table 14 below provides a summary of the groundwater and bedrock conditions for the bridge borings. The surface elevations, approximate bedrock depths/elevations, and approximate groundwater depths/elevations are presented to the nearest 0.5 feet. The groundwater depths and elevations are based on observations during drilling.

Table 14: Summary of Geotechnical and Groundwater Conditions

Boring ID	Location (Northing, Easting)	Ground Surface Elevation at Time of Drilling (feet)	Approx. Depth to Top of Competent Bedrock (feet)	Approx. Elevation of Top of Competent Bedrock (feet)	Approx. Ground-water Depth (feet)	Approx. Ground-water Elevation (feet)
B-2	42128.6, 115800.7	4,688.1	Unknown*	Unknown*	16.0	4,673.1
B-13	42081.6, 116002.7	4,687.7	71.0	4,616.7	25.0	4,662.7

*Drilling ceased for bad weather and lightning before encountering bedrock

(Source: Preliminary Geotechnical Report, dated 12/16/2021)

If a CBC structure is selected, the structure will be founded on shallow mat foundations. If a bridge structure is selected, the recommended substructure foundation types for this site include drilled shafts or driven H-piles. Recommended foundation types for wingwalls on the bridge and CBC structures are shallow strip foundations. If a pedestrian bridge structure is selected, the recommended substructure foundation types for this site include drilled shafts and driven H-piles.

Design and construction for the shallow foundation system should take into consideration the scour potential at the proposed site. The bottom of the shallow foundation should be a minimum of 36 inches below the exterior ground surface for frost protection and should be founded on a minimum of 2 feet of CDOT Class 1 Structure Backfill, placed in accordance with the recommendations in the Geotechnical Investigation.

Hydraulics Summary

Collins Engineers has partnered with Wohnrade Civil Engineers, Inc. to perform the hydraulic and hydrologic investigations at Lewis Wash. Please refer to the full Hydraulic and Hydrologic Investigation Report for more information.

Bridge MM-E.5-31.01 crosses Lewis Wash. The Federal Emergency Management Agency (FEMA) has designated the project site as a FEMA Zone A. The design flow rate is 1,920 cfs. A HEC-RAS model was developed at this location. The proposed model indicates that a two-cell 14-foot x 12-foot CBC would carry the design flow with ample freeboard at the 100-year floodplain elevation. Another option investigated was a precast prestressed concrete slab. A precast prestressed concrete box girder bridge alternative was evaluated and was also shown to have an adequate opening to carry the design flows.

Environmental & Cultural Resource Concerns

Collins Engineers has partnered with ERO Resources Corp. to perform environmental and cultural resources investigations of all aspects of this project. Please refer to the full Cultural Resources Report for more information. The only mention of Lewis Wash in the report is under Historical Linear-Segment of E ½ Road / Orchard Ave. ERO recommends a determination of “no historic properties affected” pursuant to 36 Code of Federal Regulations 800.4 of the National Historic Preservation Act.

Roadway Design Features

Cross Section

Existing County Road E½ is a 2-lane roadway with two-way traffic in the vicinity of Bridge MM-E.5-31.01. The width and typical cross-section stays consistent across the existing bridge.

From north to south, the existing cross section of the bridge consists of a standard guard rail, approximately 3-foot gravel and asphalt shoulder, 12-foot westbound traffic lane, 12-foot eastbound traffic lane, 3-foot asphalt and gravel shoulder, and a standard guard rail, totaling to 32 foot-4 inches wide cross section (see Figures 41 & 42).

Figure 52: MM-E.5-31.01 Looking East

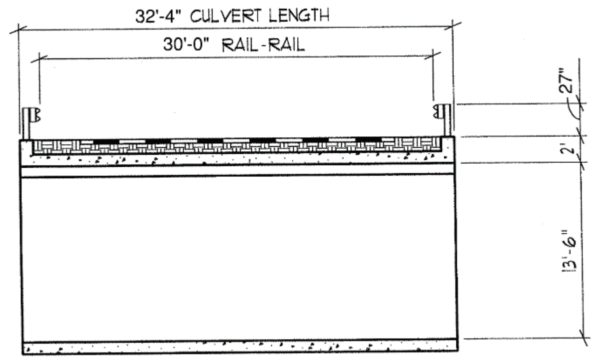


Figure 53: MM-E.5-31.01 Cross Section Sketch

The typical section across the bridge, starts near 31 Road and continues approximately to the private land directly adjacent to the east side of the bridge. 12-foot lanes with unpaved shoulders are consistent across the current bridge and at both approaches. The existing pedestrian bridge MM-E.5-31 is a timber superstructure bridge intended only for non-vehicular traffic. The concrete path leading up to the bridge on either side is 7’-4” wide, and the bridge itself accomodates a 8’-2” opening (see Figures 42 & 43).

Figure 54: MM-E.5-31.01 Cross-Section Looking East

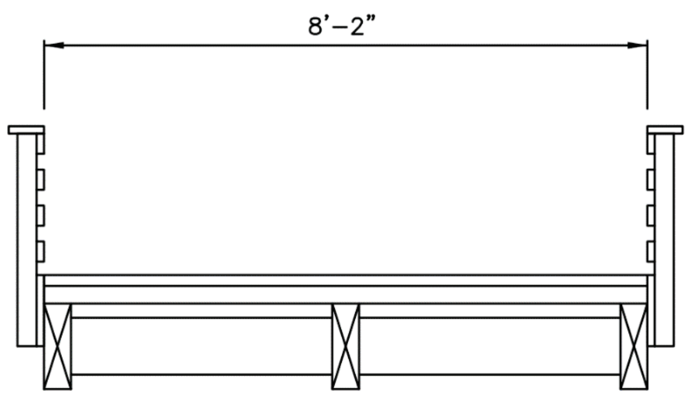


Figure 55: MM-E.5-31.01 Cross Section Sketch

The proposed roadway section width is based on the on the typical preliminary roadway cross section agreed upon for this section of the corridor and the requirements of the current CDOT Roadway Design Guide. Vehicular traffic lane width is expected to be 11-feet in each direction with 4-foot wide lanes for bicycle traffic, a 10-foot multimodal path at the north end with a 6-foot buffer, a 5-foot sidewak to the south, and standard 2-foot curb and gutters on each side. Total required roadway width over proposed structure is 56-feet. Figure 44 below illustrates the proposed typical section across Bridge MM-E.5-31.01:

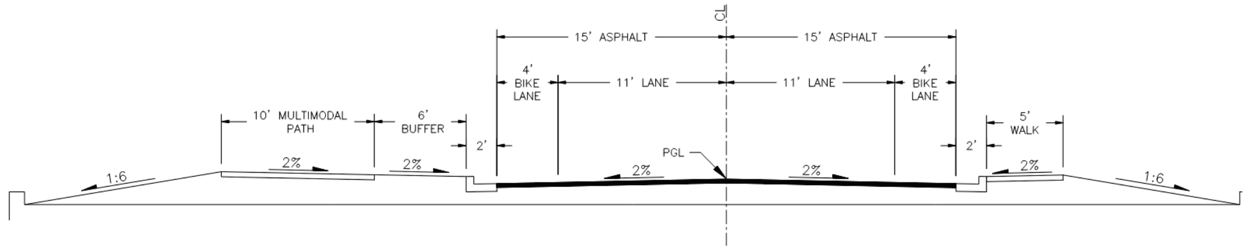


Figure 56: Proposed typical section of Orchard Ave in the vicinity of Bridge MM-E.5-31.01

The proposed vertical profile of Orchard Ave must be set as close to the existing profile as allowed by the results of the hydrology study to avoid any ROW acquisitions.

Based on the chosen alternative, the vertical profile may change slightly. If Alternative 1 is chosen, the vertical alignment will remain as close to the original alignment as possible. Vertical alignment is not anticipated to be a controlling factor of design for this structure.

Horizontal Alignment

The horizontal alignment of the existing bridge is not skewed. The bridge is on a continuous horizontal tangent. The proposed structure will be constructed in the same location as the existing structure with no change to the horizontal alignment or skew of the road.

Structural Design Criteria

Design Specifications

- AASHTO LRFD Bridge Design Specifications, 9th Edition
- Mesa County Design Standards
- CDOT LRFD Bridge Design Manual
- CDOT Bridge Detail Manual
- AASHTO Guide for the Development of Bicycle Facilities, 4th Edition

Construction Specifications

- Special Project Specifications
- Mesa County Standard Specifications
- Mesa County Standard Special Project Specifications
- CDOT Standard Specifications for Road and Bridge Construction, 2021
- CDOT Standard Special Provisions
- AASHTO LRFD Bridge Construction Specifications, 4th Edition

Loading

All loads will be evaluated in accordance with the Design Specifications listed above. Site- and project-specific provisions in the categories are brought to the designer's attention; however, this list should not be considered exhaustive, and the designer shall use his/her engineering judgement.

Live Load

The replacement bridge will be designed to carry HL-93 loading and Colorado Permit Vehicle loads in accordance with the Design Specifications listed above.

Dead Load

Future wearing surface = 36.67 psf (3" minimum)

Existing conduit pipes will be carried by the future structure.

Collision Load

There is no vehicular traffic or vessels under the structure, so the substructure will not require investigation of Collision Loads. In the alternatives where the bridge rail is connected to the structure, Vehicular Collision Loads on the barrier will be investigated in accordance with the Design Specifications listed above.

Earthquake Load

The structure is located within Seismic Zone 1. Earthquake Loads, and connection and detailing design will be performed in accordance with the Design Specifications listed above.

Stream Forces and Scour Effects

Water Load and Stream Pressure from Lewis Wash will be evaluated in accordance with the Design Specifications listed above.

Deck Drainage

The bridge structure cannot drain into Lewis Wash. A drainage system will be required, otherwise alignment with the existing vertical profile is sufficient for proper drainage away from the bridge.

Aesthetic Requirements

The current structure is not visually imposing. A similar low profile should be preserved.

Possible Future Widenings

The existing right of way in the vicinity of the bridge varies from 100-feet across on the west side of the bridge, to approximately 75 feet across on the east side. The proposed cross-section width is 55 feet and plans to accommodate all modes of traffic. With no right of way acquisitions planned on either side of County Road E ½, it is unlikely that the proposed bridge would be widened in the future.

Software to be used by Designer

Bridge design software must be sufficient for the design of the structure, as determined by a reviewer who must hold a PE license in the State of Colorado.

Software to be used by Independent Design Checker

Either the same software as used for bridge design, or a different sufficient software may be used by the Independent Design Checker, who must hold a PE license in the State of Colorado.

Structure Selection

Three feasible superstructure alternatives have been identified for their potential to adequately carry the multimodal corridor and provide the required hydraulic opening for Lewis Wash. The following details the structure selection process.

Selection Criteria

This report is intended to identify which structural alternatives are most capable and cost effective for meeting the project requirements. Each structure was evaluated based on the following: cost, weight, speed of construction, complexity, span length, structural depth, maintenance, falsework fabrication time, access, staging, aesthetics, and substructure complexity. All structure alternatives were initially chosen based on their ability to provide the required corridor width and hydraulic opening.

Rehabilitation Alternatives

The current structure is in satisfactory condition and does not require rehabilitation. However, it is recommended for replacement in order to meet the new Orchard Avenue corridor requirements.

Inspection Summary

The existing roadway structure is in Good Condition with an NBI Culvert rating of 6. The Inspection Report notes the following defects: light scaling with efflorescence on walls; areas of honeycombing with exposed rebar on the walls and ceiling; vertical cracks, some of which are seeping water on the walls; spalls, cracks, deterioration and abrasion on the wingwalls; and water staining and honeycombing on the headwalls. None of these defects require the immediate replacement or rehabilitation of the structure. The replacement of the Lewis Wash Bridge is recommended for corridor requirements.

There is also a pedestrian bridge adjacent to the structure. It is in Good Condition with an NBI Superstructure rating of 7. The Inspection Report notes the following defects: Wear and rutting of running planks, locations exhibiting up to 30% rotting of the deck, cracking and checking of running planks and the deck, checking on exterior girders, and cracking and weathering of the bridge rails.

Load Test Requirements

Load testing is not required for the current structure due to its Satisfactory Condition.

Structure Layout Alternatives

Layout of the proposed structure alternatives is subject to the requirements of corridor width, hydraulic opening, stream geometry, utilities, and construction considerations.

Vertical Clearances

The Lewis Wash crossing requires a minimum 1-foot freeboard above water surface elevation. As noted above, the existing 100-year floodplain is not expected to overtop the roadway in its current condition, nor its proposed configuration. If overhead utilities are relocated below the roadway elevation, all potential vertical clearances are expected to be met. The designer will need to take these considerations into account in final design. Refer to CDOT Bridge Design Manual and CDOT Drainage Manual for additional clearance requirements.

Horizontal Clearances

The bridge must not interfere with the intersection of E ½ Road and 31 Road and maintain proper stopping sight distances leading up to the bridge. Since the roadway is not expected to be realigned in this area, all horizontal clearances are expected to be met.

Skew

The proposed alignment is not skewed.

Span Configurations

The required span length can be met with one or two spans, depending on superstructure type.

Deflection

The proposed structure alternatives must meet the live load deflection requirements for its superstructure type in the AASHTO LRFD Bridge Design Manual.

Superstructure Alternatives

The following three superstructure alternatives were selected as the most capable of meeting the requirements of the Orchard Avenue Corridor Study. All alternatives consider the proposed 55-foot typical cross section shown previously in Figure 44.

Alternative 1 – Precast Concrete Box Culvert

Concrete box culverts are a cost-effective solution for smaller span structures. They can be easily and quickly constructed and are proven to be long-lasting. Using a precast culvert simplifies the construction process since culvert segments are manufactured offsite and are quickly placed at the construction site. The CDOT M & S Standards contain a wide range of culvert sizes that can be used in single and multi-cell configurations to fit the requirements of the Lewis Wash bridge.

The selected configuration for the Lewis Wash CBC Superstructure Alternative is a 14-foot x 12-foot two-cell box. This can carry the design flow and preserves the required freeboard during a 100-year storm event. The centerline of the proposed structure roadway will be placed in line with the current structure. This structure has a minimum design cover of approximately 18 inches.

Because the proposed structure will be wider than the current structure, existing headwalls and wingwalls cannot be used for the new structure. These retaining walls will need to be placed to accommodate phased construction. Wingwalls will be designed to the CDOT M-601-20 standard.

This alternative will require a riprap apron on the downstream side of the structure.

Alternative 2 – Precast Prestressed Concrete Box Girder

Prestressed box girders are capable of spanning the required distance with a low structural depth. This is important to retain the required freeboard without having to raise the road. Precasting allows for quick and simple construction because box girders will be constructed offsite and can quickly be placed with a crane. CDOT has standard box girder dimensions than can be utilized to easily design girders capable of meeting the structural requirements.

The selected configuration for Lewis Wash will consist of a span of approximately 30 feet and of the required corridor width. This will carry the design flow and preserve the required freeboard. The centerline of the proposed structure roadway will be placed in line with the current structure.

This Superstructure Alternative will require a new substructure to support it. Substructure design will be determined based on geotechnical analysis of the site.

Alternative 3 – Precast Prestressed Concrete Slab

Concrete slabs are a simple and durable structure type that has a long lifespan and is capable of spanning Lewis Wash. However, providing a single span prestressed concrete slab increases the depth of the deck enough that it would increase the proposed vertical alignment. Since there is opportunity to keep the vertical alignment as-is with other alternatives, this option is not preferred. Benefits of precasting allow for quick and simple construction because box girders will be constructed offsite and can quickly be placed with a crane.

The selected configuration for Lewis Wash will consist of a span of approximately 30 feet and of the required corridor width. This will carry the design flow and preserve the required freeboard. The centerline of the proposed structure roadway will be placed in line with the current structure.

This Superstructure Alternative will require a new substructure to support it. Substructure design will be determined based on geotechnical analysis of the site.

Span Configurations

The total length of all proposed Superstructure Alternatives was determined based on site and construction requirements. Alternatives 2 and 3 are single span bridges, so they will be 28 feet in span length. Alternative 1 is a two-cell culvert with a total structure length of 30 feet. All alternatives will preserve a total channel width of 28 feet.

Substructure Alternatives

The substructure for this bridge depends on analysis from the Geotechnical Engineer. Superstructure Alternatives 1 and 2 will require strip footings at least 2 feet beneath the wingwalls while Superstructure Alternative 3 will require vertical abutments to preserve the correct channel width while minimizing span length.

Abutment Alternatives

Seat or semi-integral abutments are preferred for Superstructure Alternatives 2 and 3 because they offer simple and fast placing of the precast superstructure elements.

Pier Alternatives

No superstructure alternatives require the usage of a pier.

Use of Lightweight Concrete

It is not anticipated that lightweight concrete will be required for any Superstructure Alternative.

Wall Alternatives

Superstructure Alternative 1 requires wingwalls to retain the fill around the channels at the inlet and outlet ends. Wingwalls will be designed to the CDOT M-601-20 standard.

Constructability

All three Superstructure Alternatives use precast elements which greatly increase ease of construction. Alternatives 2 and 3 require a more complex construction process than Alternative 1 because they require the construction of abutments, which will require pouring concrete in the current ROW.

Construction Phasing

Superstructure Alternative 1 can be constructed in two phases, allowing one lane of traffic to remain open during construction. Superstructure Alternatives 2 and 3 require their substructures to be constructed in the ROW of E ½ Road. This will require closing of the road and a detour. Careful coordination with stakeholders as well as Central High School will be required to minimize impact of this detour.

CDOT Roadway requirements specify a minimum 11-foot lane, with 2-foot wide shoulders, 2-foot wide temporary concrete barriers, and a work zone buffer during construction. The work zone buffer may by 1-foot wide if a pinned barrier is used or 2-foot wide if a non-pinned barrier is used. Due to the presence of future bike lines, this can be accomplished for all Superstructure Alternatives with no overbuild. More information on phased construction can be found in the Traffic Design Memorandum for this structure. All Superstructure Alternatives construction phasing will require shoring.

Use of Existing Bridge in Phasing

This is available for Superstructure Alternative 1 but is not possible for Superstructure Alternatives 2 and 3.

Accelerated Bridge Construction (ABC) Design

CDOT has developed an ABC decision making process to encourage some form of ABC on most projects. Engineers and contractors on the design team for this bridge are encouraged to use this process to evaluate feasibility of using ABC for this structure.

Maintenance and Durability

The required service life for this structure is 100 years. This will be easily met if CDOT specifications and accepted current design and construction practices are followed. The structure will be durable and require minimal maintenance. Superstructure Alternative 1 will require routine cleaning.

Corrosive Resistance

It is important to eliminate the effects of corrosion on the rebar of concrete structures. This can be accomplished using epoxy coated rebar and other waterproofing measures at the discretion of the Design Engineer.

Summary of Structure Type Evaluation Table

The following tables show the cost and ability to meet the structural requirements for each Superstructure Alternative.

Construction Cost

It is important to identify the most cost-effective structure type for this project. Preliminary construction cost estimates have been prepared for the Superstructure Alternatives and are summarized in the table below. See Appendix B2 for detailed cost estimating calculations.

Table 15: Construction Costs Summary

Alternative	Construction Cost	Area	Cost per SF	Cost Rating
Precast Concrete Box Culvert	$341,086	2280	$150	1.0
Precast Prestressed Concrete Box Girder	$318,008	1568	$203	1.1
Precast Prestressed Concrete Slab	$257,338	1568	$164	1.1

Conclusions and Recommendations

The table below summarizes the evaluation of each Superstructure Alternative.

Table 16: Evaluation of Each Superstructure Alternative.

Criteria	Precast CBC	Precast Prestress Box Girder	Precast Prestressed Concrete Slab
Hydraulic Opening/Stream Geometry	Satisfies the requirements	Satisfies the requirements	Satisfies the requirements
Constructability	Precast culvert construction does not require detours. Shoring is required	Detours and shoring required for construction	Detours and shoring required for construction
Cost Rating	1.0	1.1	1.0
Maintenance	Routine cleaning required	Minimal maintenance besides scour protection of abutments	Minimal maintenance besides scour protection of abutments

The precast CBC option meets all criteria with the lowest cost and best constructability. The design engineer and contractor may select a different structure type as long as all requirements are met. See Appendix B1 for the selected General Layout and Typical Section.

Section 6 – Utility

COLLINS ENGINEERS INC.

Utility Discussion

The following utilities were identified based on the Utility Notification Center of Colorado Listed Member Utility Companies along the corridor starting at 29-1/2 Road and extending to Warrior Way. List of members is based on a search 200 feet each side of the approximate centerline of Orchard Avenue (E-1/2 Rd).

Company	Service	Contact
Charter Communications/Spectrum	Cable and Internet	1 (888) 369-2408
Clifton Water District	Potable water line and domestic supply east of 30 Road	(970) 434-7328
Grand Valley Drainage District	Drainage District 3	(970) 242-4343
Highland Park Lateral Ditch Co.	Irrigation Lateral water supplier	(970) 243-3025
Palisade Irrigation District	Irrigation water supplier	(970) 464-4700
CenturyLink	Phone and Fiber, communications	(970) 316-6913
Ute Water District	Potable water line and domestic supply west of 30 Road	(970) 242-7491
City of Grand Junction	Sewer and Storm Sewer	(970) 244-1579
Excel	Power and Gas Supply	(800) 895-4999
Unite Fiber Optic	Private Fiber Optic Network	1 (800)-255-5244

Additional subsurface utilities may include local homeowner's association irrigation systems, unrecorded tailwater infrastructure and other dry utilities that are not part of Colorado's 811 Notification System.

The subsurface utilities shown on the schematic plans were located based on information provided by the companies, located and "painted" and surveyed for horizontal location based on a vertical projection of the utility onto the roadway surface. Vertical location was not established and should be undertaken as part of the following design efforts.

Overhead electric and other communication lines exist throughout the corridor. Where in conflict with the multimodal path or other corridor enhancements, the existing overhead utility poles should be relocated, preferably underground. A total of 34 utility poles should be relocated between Mountain View Drive (Eastmoor Drive) and Sun Valley Street. 1 utility pole between Lewis Wash and Park Entrance should be relocated. Additional poles and other obstructions at private roadway intercepts should be either relocated or moved underground to increase safety of the traveling public by increasing roadway visibility.

Clifton Water District provides water service east of the 30 Road intersection with Orchard Avenue and Ute Water District provides water service west of the above boundary. Based on drainage requirements, there exists minor conflicts with the water lines and the crossing drain lines. Rather than relocate the waterlines, it is advisable that the placement of new inlets along Orchard Avenue be placed to remove the conflict. This may require a design exception to the distance between inlets.

The City of Grand Junction controls the sewer and storm sewer along the corridor. The City's storm sewer is discussed in further detail in the drainage section. The City's sewer should take precedent over other utilities and future improvements. Sewer manholes and other appurtenances should be raised to the new roadway elevation. Where manholes or other elements are in conflict with detached walks or other active transportation enhancements, the sewer element should be incorporated into the design.

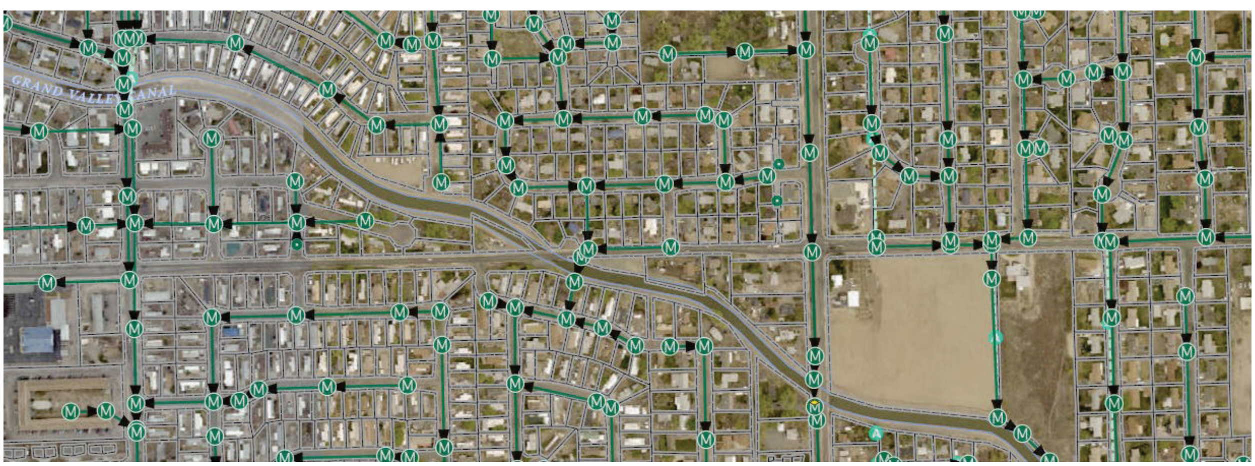


Figure 57: Sewer Infrastructure Orchard West

Figure 58: Sewer Infrastructure Orchard East

Along the eastern third of the corridor Unite Fiber Optic has a utility line. The line crosses starts to the east of Lewis Wash and runs westward until the intersection of 31 Road. The fiber optic line turns south ward and travels southwest to approximately 3070 I-70 B. The line is assumed to be near surface but location and depth verified for both the Lewis Wash structure and the intersection of 31 Road.

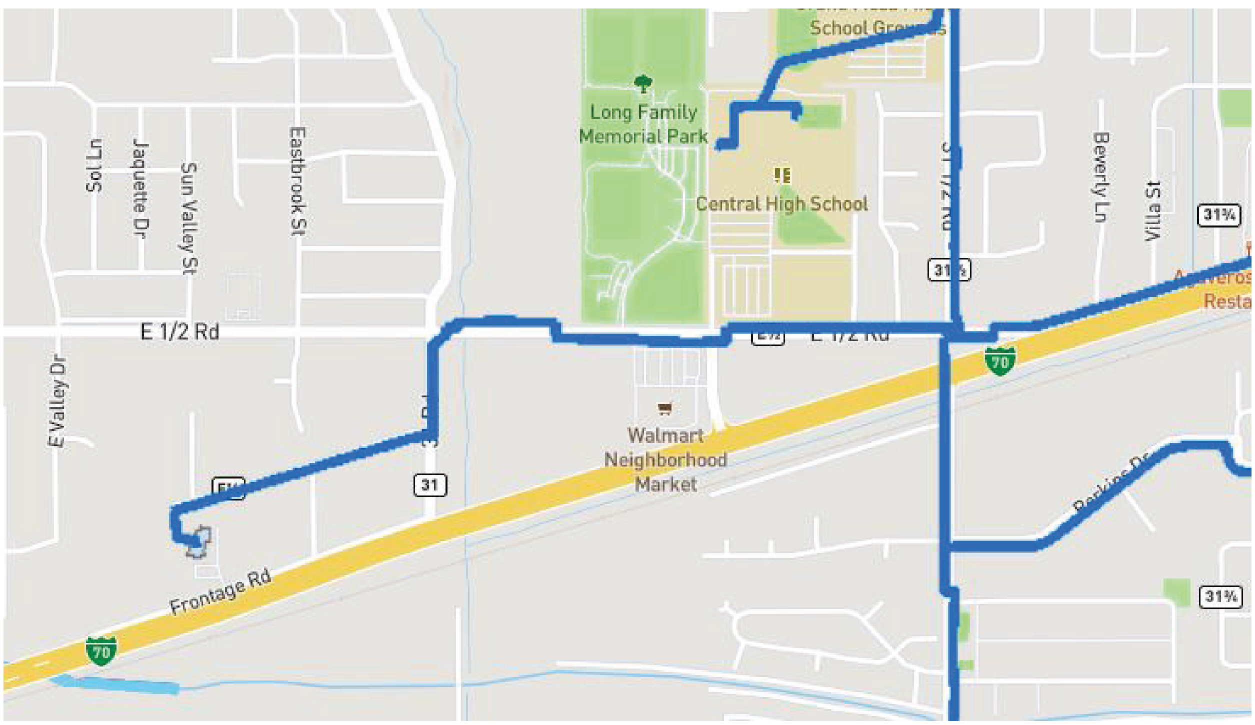


Figure 59: Unite Fiber Optic Line

Where power and gas conflict with the drainage improvements or corridor enhancements the utilities should be relocated. These should be near surface utilities and relocation should have minimal impacts. Additionally, several local and private irrigation lines and other undocumented private elements may exist within the current roadway. While all reasonable efforts should be undertaken to locate and remediate these private elements, it is advised that as a measure of caution, a separate cost line item be established for relocation of unknown utilities.

Section 7 – Rights of Way

Survey and Row Discussion

ROW

The overall guiding principal was to limit the impacts to the public. Per the discussions and open houses one of the resounding comments was to not take property from the public. However, two sections of the corridor should require ROW takes, based on the developed typical section, public safety and enhancing active transportation.

The first section of Orchard Avenue that would require the purchase of ROW would be along the northern side of Orchard Avenue between Sycamore Avenue and 30 Road, or approximately from Station 21+00 to Station 27+30. It is estimated that approximately eight different parcels would require purchase of approximately three feet of their frontage. Total estimated purchase would be 1,954 sq-ft.

The second section would be at the east terminus of the project along the southern end. The need for the ROW take in this area is to create an entrance and crossing that conforms to ADA standards and provides active transportation movement. It should be noted that based on input from the public, ROW to the west of this property may not be purchased without hardship. It is recommended that improvements to the corridor in this area avoid purchasing property from the owners to the west.

Discrepancies between the different forms of ROW existing throughout the corridor and where possible prescriptive rights or other rights should be converted to deeded ROW.

ROW Take #	Parcel #	Lot #	Area (SF)
1	2943-081-13-003	3	15.05
2	2943-081-13-001	1	222.16
3	2943-081-12-005	5	252.24
4	2943-081-12-006	6	289.78
5	2943-081-12-007	7	268.05

6	2943-081-12-008	8	301.64
7	2943-081-42-002	2	295.89
8	2943-081-42-001	1	307.57
9	2943-103-00-134		483.65
10	2943-103-00-136		239.31

Section 8 – Environmental

ERO

ERO Resources Corporation

Environmental and Cultural Report

Environmental Discussion

Abstract

Collins Engineers, Inc., on behalf of Mesa County, contracted ERO Resources Corporation (ERO) to conduct a cultural resource survey for the Orchard Avenue Corridor Study. Mesa County is developing design alternatives to improve the Orchard Avenue transportation corridor. The cultural resource survey was conducted in compliance with Section 106 (54 United States Code (U.S.C.) § 306108) of the National Historic Preservation Act (NHPA, 1966, as amended; 54 U.S.C. § 300101 et seq.).

Within or overlapping the APE are three historical resources: one new segment of a previously documented historical linear (5ME4680.80), one new segment of a newly documented linear (5ME23793.1), and one newly recorded historical residence (5ME23794). Both linear segments are recommended non-supporting of the eligibility of the entire resource and 5ME23794 is recommended not eligible for listing in the NRHP. ERO only documented those resources that will be directly impacted by the proposed project activities. Should additional ROW acquisition be required with property parcels with historic structures, those structures will require documentation and NRHP evaluation as well. Based on current project design as of December 2021, ERO recommends a determination of "no historic properties affected" pursuant to 36 Code of Federal Regulations 800.4 of the National Historic Preservation Act.

Project Description

Collins Engineers, Inc., on behalf of Mesa County, contracted ERO Resources Corporation (ERO) to conduct a cultural resource survey for the Orchard Avenue Corridor Study. Mesa County is developing design alternatives to improve the Orchard Avenue transportation corridor. The primary goal of the Orchard Avenue Corridor Study is to make Orchard Avenue a more comfortable place for those traveling by any mode: walking, bicycling, riding transit, or driving. The project extends from 29 ½ Road at its western terminus to Warrior Way on the east. The cultural resource survey was conducted in compliance with Section 106 (54 United States Code (U.S.C.) § 306108) of the National Historic Preservation Act (NHPA, 1966, as amended; 54 U.S.C. § 300101 et seq.).

Location

The proposed project area occurs along approximately 1.8 miles of Orchard Avenue from Warrior Way west to 29 ½ Road in Grand Junction, Colorado. The project area is in Section 8, 9, and 10 Township 1 South, Range 1 East of the Ute Meridian in Mesa County, Colorado (Figure 48). The elevation of the project area is approximately 4,670 feet above sea level, and the project area is shown on the U.S. Geological Survey (USGS) Grand Junction and Clifton, CO quadrangles. Kathy Croll, ERO Senior Cultural Resource Specialist, conducted a reconnaissance survey of the project area on July 23, 2021.

Natural Environment

The project area is located within the Colorado River Valley; the river is about 2 miles to the south and the Book Cliffs area about 6 miles to the north. The majority of the project area is bordered by residential development to the north and south of Orchard Road. Agricultural land occurs sporadically along Orchard Avenue and Commercial Development occurs at the eastern end of the project area. The Grand Valley Canal flows under Orchard Avenue west of 30 Road and generally flows from the southeast to northwest through the project area. Lewis Wash flows under Orchard Avenue east of 31 Road and flows from the north to south in the project area. The ground visibility ranges from 50 to 100 percent. The surface geology consists of Pinedale and Bull Lake age gravels and alluviums (Tweto 1979).

According to the Web Soil Survey, soil types in the project area include Sagers silty clay loam, 0 to 2 percent slopes; Sagers-Urban land complex, 0 to 2 percent slopes, and Oxyaquic Torrifluvents, 0 to 2 percent slopes (Natural Resources Conservation Service 2021).

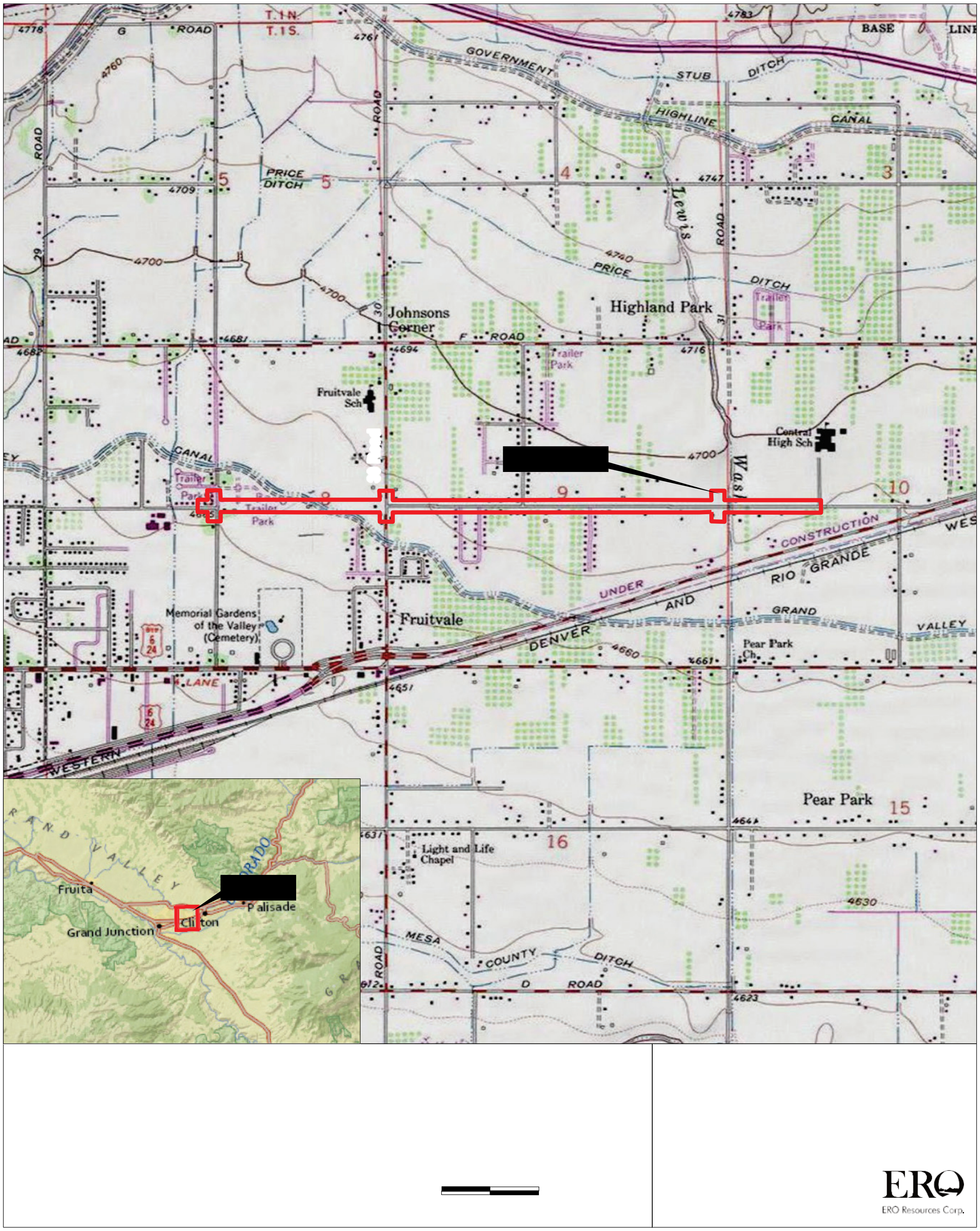


Figure 60: Orchard Avenue Project Location

Figure 61: Project Area overview at Grand Valley Canal

Cultural Overview

An intensive cultural overview is unnecessary, given the size of the project area and the lack of precontact resources. Refer to the Colorado Prehistory: A Context for the Northern Colorado River Basin (Reed and Metcalf 1999) for a complete overview.

Historical settlement of western Colorado occurred during the early 1800s with the arrival of government survey expeditions as well as fur trappers and traders. The Colorado Territory was established in 1861. With the relocation of the Ute Indians to reservations in 1881, settlers built towns and established mineral mines and lumber mills. Land was cleared for crop cultivation, and cattle ranchers moved into the area; railroads were eventually built to move goods in and out of the region. Sheep and cattle herding became predominant in the area in the early 1900s. Grand Junction was incorporated in 1882 and was named the county seat of Mesa County in 1883. By the early 1900s, Grand Junction had evolved into a small city (Museum of Western Colorado 2021).

Colorado's semiarid climate made the development of irrigation––ditches and canals across the state to collect melt water and carry it to agricultural areas and reservoirs––necessary for the settlement of the area. Agricultural irrigation began in the state in the 1860s with the development of small mutual and individual or pioneer ditches. These ditches tend to irrigate low -lying areas in the floodplains and bottomlands by drawing water off existing sources like creeks, rivers, and streams. These early irrigation systems required little engineering or technology (King 1984). Pioneer ditches were often expanded into, or were replaced by, mutual ditches, which are used by multiple entities and are controlled by a ditch company. These ditches soon expanded, and irrigation enterprises developed to construct large systems that could carry more water and serve a larger area.

By the late 1800s, the development of irrigation ditches in Colorado was viewed as an investment opportunity. Large sums of money were spent constructing irrigation systems to reach more remote areas of land in the hopes of creating a profit by selling water rights. Colorado's water laws, which protect the water rights of earlier users, made many of these ditches less successful than originally planned by limiting the quantity of water available to them (Holleran 2005).

Construction of the first irrigation project in the Grand Valley began in 1882 with the Pioneer Ditch, or Mesa County Ditch, and the Pacific Slope Ditch (Museum of Western Colorado 2021; Simonds 1994). The Grand River Ditch (now the Grand Valley Canal), begun in 1881 and finished in 1884, was the largest comprehensive system in the valley and joined the Pacific Slope Ditch, Mesa County Ditch, and Independent Ranchman's Ditch in 1886 (Holleran 2005; Simonds 1994). Construction of the Grand Valley Project occurred during the early 1900s. The Grand Valley Project begins at the Grand Valley Diversion Dam, just east of Palisade, and diverts water to the Government Highline Canal. The Government Highline Canal is 55 miles long and provides water to the Orchard Mesa Canal system as well as to one power plant (the Grand Valley Power Plant), 160 miles of laterals, 100 miles of drains, and two pumping stations.

File and Literature Review

ERO conducted a file and literature review for the project using the OAHP Compass online database on July 10, 2021 and the Mesa County assessor records on July 15, 2021. ERO included a 0.25-mile buffer on the APE to include considerations for indirect effects and the regional context. One previous inventory has been conducted within 0.25 mile of the survey area. The Central Mesa County And Collbran, De Beque, Fruita, And Palisade: Historic Structure Inventory (ME.LG.R6) conducted in 1981 resulted in documentation of the 14 of the previously recorded historic resources adjacent to or overlapping the APE (Table 17). One previously recorded segment of the Grand Valley Canal also overlaps the APE.

Table 17. Previously documented sites within 0.25 mile of the APE.

Site No.	Site Type	Eligibility (Year)	Impacted by Project
5ME.1884	Historic Habitation 544 Sycamore	No assessment ("Lacks integrity" (1981))	Outside of APE: No impact; Not redocumented
5ME.2696	Historic Habitation 547 30 Road	Field Eligible	Outside of APE: No impact; Not redocumented
5ME.2697	Historic Habitation 547 ½ 30 Road	Field Eligible	Outside of APE: No impact; Not redocumented
5ME.2700	Historic Habitation 3054 E ½ Road	No assessment ("Lacks Integrity" (1981))	Adjacent to APE: no ROW acquired: No impact; Not redocumented
5ME.2705	Historic Habitation 3001 E ½ Road	No assessment ("Lacks Integrity" (1981))	Adjacent to APE: no ROW acquired: No impact; Not redocumented
5ME.2712	Historic Habitation 3037 E ½ Road	Field Not Eligible – No longer extant	Adjacent to APE: no ROW acquired: No impact; Not redocumented
5ME.2713	Historic Habitation 3049 E ½ Road	No assessment ("Lacks Integrity" (1981))	Adjacent to APE: no ROW acquired: No impact; Not redocumented
5ME.2714	Historic Habitation 3053 E ½ Road	No assessment ("Lacks Integrity" (1981))	Adjacent to APE: no ROW acquired: No impact; Not redocumented
5ME.2715	Historic Habitation 3095 E ½ Road	No assessment ("Lacks Integrity" (1981))	Adjacent to APE: no ROW acquired: No impact; Not redocumented

5ME.2719	Historic Habitation 3071 E ½ Road	No assessment ("Lacks Integrity" (1981))	Adjacent to APE: no ROW acquired: No impact; Not redocumented
5ME.2721	Historic Habitation 3079 E ½ Road	No assessment ("Lacks Integrity" (1981))	Adjacent to APE: no ROW acquired: No impact; Not redocumented
5ME.2722	Historic Habitation 3057 E ½ Road	No assessment ("Lacks Integrity" (1981))	Adjacent to APE: no ROW acquired: No impact; Not redocumented
5ME.2736	Historic Habitation 3109 E ½ Road	No assessment ("Lacks Integrity" (1981))	Adjacent to APE: no ROW acquired: No impact; Not redocumented
5ME.2737	Historic Habitation 3103 E ½ Road	No assessment ("Lacks Integrity" (1981))	Adjacent to APE: no ROW acquired: No impact; Not redocumented
5Me.4680.1	Grand Valley Canal segment	Officially Eligible (2000)	Crosses APE: Segment documented and assessed below

In addition to the OAHP file search, ERO reviewed the Mesa County Assessor records to determine if historical buildings or structures may have been present in the APE. Thirty-two structures along E ½ Road were built over 50 years ago; ten of these have been previously documented and are listed above. Twenty-three structures will meet the 50-year age criteria in the next 5 years (Appendix E2 Maps: Figures A2-A4).

Table 18: Parcels with historic structures along the APE.

Site No.	Address	Year Built	Impacted by Project
5ME2713	3049 E ½ RD	1900	Adjacent to APE: no ROW acquired: No impact; Not Redocumented
5ME2721	3079 E ½ RD	1905	Adjacent to APE: no ROW acquired: No impact; Not Redocumented
5ME2714	3053 E ½ RD	1905	Adjacent to APE: no ROW acquired: No impact; Not Redocumented
5ME2736	3109 E ½ RD	1908	Adjacent to APE: no ROW acquired: No impact; Not Redocumented
5ME2737	3103 E ½ RD	1908	Adjacent to APE: no ROW acquired: No impact; Not Redocumented
	3070 E ½ RD	1909	Adjacent to APE: no ROW acquired: No impact; Not Redocumented
5ME2700	3054 E ½ RD	1909	Adjacent to APE: no ROW acquired: No impact; No site documentation
5ME 2722	3057 E ½ RD	1910	Adjacent to APE: no ROW acquired: No impact; Not Redocumented
5ME2715	3095 E ½ RD	1910	Adjacent to APE: no ROW acquired: No impact; Not Redocumented
5ME2719	3071 E ½ RD	1925	Adjacent to APE: no ROW acquired: No impact; Not Redocumented
5ME2705	3001 E ½ RD	1929	Adjacent to APE: no ROW acquired: No impact; Not Redocumented

3041 E ½ RD	1934	Adjacent to APE: no ROW acquired: No impact; No site documentation
550 SERENADE CT	1937	Adjacent to APE: no ROW acquired: No impact; No site documentation
3087 E ½ RD	1940	Adjacent to APE: no ROW acquired: No impact; No site documentation
3015 E ½ RD	1942	Adjacent to APE: no ROW acquired: No impact; No site documentation
549 30 RD	1946	Adjacent to APE: no ROW acquired: No impact; No site documentation
3030 E ½ RD	1947	Adjacent to APE: no ROW acquired: No impact; No site documentation
3063 E ½ RD	1948	Adjacent to APE: no ROW acquired: No impact; No site documentation
3117 E ½ RD	1948	Adjacent to APE: no ROW acquired: No impact; No site documentation
3033 E ½ RD	1950	Adjacent to APE: no ROW acquired: No impact; No site documentation
3026 E ½ RD	1954	Adjacent to APE: no ROW acquired: No impact; No site documentation
3040 E ½ RD	1955	Adjacent to APE: no ROW acquired: No impact; No site documentation
2991 ORCHARD AVE	1956	ROW and/or structure may be acquired by the City; Structure documented and assessed below

3065 E ½ RD	1956	Adjacent to APE: no ROW acquired: No impact; No site documentation
3034 E ½ RD	1956	Adjacent to APE: no ROW acquired: No impact; No site documentation
3085 E ½ RD	1956	Adjacent to APE: no ROW acquired: No impact; No site documentation
551 GRAND VALLEY DR	1960	Adjacent to APE: no ROW acquired: No impact; No site documentation
3035 E ½ RD	1963	Adjacent to APE: no ROW acquired: No impact; No site documentation
3061 E ½ RD	1965	Adjacent to APE: no ROW acquired: No impact; No site documentation
3029 E ½ RD	1965	Adjacent to APE: no ROW acquired: No impact; No site documentation
3046 E ½ RD	1972	Adjacent to APE: no ROW acquired: No impact; No site documentation
3019 E ½ RD	1972	Adjacent to APE: no ROW acquired: No impact; No site documentation
3073 E ½ RD	1973	Adjacent to APE: no ROW acquired: No impact; No site documentation
552 29 ½ RD	1974	Adjacent to APE: no ROW acquired: No impact; No site documentation
549 DODGE ST	1974	Adjacent to APE: no ROW acquired: No impact; No site documentation

3044 E ½ RD	1975	Adjacent to APE: no ROW acquired: No impact; No site documentation
548 TECO ST	1975	Adjacent to APE: no ROW acquired: No impact; No site documentation
548 31 RD	1975	Adjacent to APE: no ROW acquired: No impact; No site documentation
547 29 ½ RD	1976	Adjacent to APE: no ROW acquired: No impact; No site documentation
552 EAST VIEW DR	1976	Adjacent to APE: no ROW acquired: No impact; No site documentation
551 PEACHWOOD DR	1976	Adjacent to APE: no ROW acquired: No impact; No site documentation
552 EASTMOOR DR	1976	Adjacent to APE: no ROW acquired: No impact; No site documentation
551 EASTMOOR DR	1976	Adjacent to APE: no ROW acquired: No impact; No site documentation
552 SYCAMORE AVE	1977	Adjacent to APE: no ROW acquired: No impact; No site documentation
2992 ORCHARD AVE	1977	Adjacent to APE: no ROW acquired: No impact; No site documentation
2994 ORCHARD AVE	1977	Adjacent to APE: no ROW acquired: No impact; No site documentation
2996 ORCHARD AVE	1977	Adjacent to APE: no ROW acquired: No impact; No site documentation

551 SYCAMORE AVE	1977	Adjacent to APE: no ROW acquired: No impact; No site documentation
2986 ORCHARD AVE	1977	Adjacent to APE: no ROW acquired: No impact; No site documentation
2984 ORCHARD AVE	1977	Adjacent to APE: no ROW acquired: No impact; No site documentation
2982 ORCHARD AVE	1977	Adjacent to APE: no ROW acquired: No impact; No site documentation
2980 ORCHARD AVE	1977	Adjacent to APE: no ROW acquired: No impact; No site documentation
2978 ORCHARD AVE	1977	Adjacent to APE: no ROW acquired: No impact; No site documentation
553 ½ PEARWOOD CT	1977	Adjacent to APE: no ROW acquired: No impact; No site documentation
552 PEACHWOOD DR	1977	Adjacent to APE: no ROW acquired: No impact; No site documentation

Survey Results

ERO documented three historical resources (5ME4680.80, 5ME23793.1, and 5ME23794). Site 5ME4680.80 is a segment of the Grand Valley Canal that is recommended non-supporting of the overall eligibility of the resources. 5ME23793.1 is a segment of E ½ Road recommended non-supporting of the overall eligibility of the resource. 5ME23794 is a historic habitation that is recommended not eligible for the NRHP. ERO only documented those resources that will be directly impacted by the proposed project activities. Should additional ROW acquisition be required with property parcels with historic structures, those structures will require documentation as well.

Resource Descriptions

5ME4680.80

Type: Historical Linear-Segment of Grand Valley Canal

Description: The Grand Valley Canal is located in the Colorado River Valley. It leaves the Colorado River just south of Palisade and flows west/northwest through the north side of Grand Junction and eventually drains into Big Salt Wash north of Fruita. Segment 80 is a small (about 500 linear feet) section of 5ME4680.1 located along Orchard Avenue between 29 ½ and 30 Roads on the east side of Grand Junction. The vegetation consists of bunch grasses. The elevation is 4,670 feet (1,423 m) asl.

The segment of the ditch is approximately 500 feet long and approximately 50 feet wide. The segment is a concrete lined ditch, is in excellent condition, and is still in use. The Orchard Avenue bridge was built in 1995 (National Bridge Inventory Database 2015) and was lined in 2014-2015. Two canal features were located within the current APE. One headgate was observed on the south side of Orchard Avenue and is not historic. Two-track access roads parallel the canal on both sides.

Construction of the Grand Valley Canal was completed in 1884. It was the largest and most comprehensive system in the valley at the time. Two years after its completion, three other large ditches in the valley – the Pacific Slope, Independent Ranchman's, and Mesa County Ditches – were joined with the Grand Valley Canal. This system allowed for 45,000 irrigatable acres of land and played an extremely important role in cultivation of the Colorado River Valley (Simonds 1994).

Eligibility: The entire Grand Valley Canal is officially eligible for the NRHP under Criterion A due to its association with significant historical events and the early development of irrigation in the Grand Valley Canal. The canal is not associated with important historical persons (Criterion B) nor is it distinctive of a type, period, or method of construction (Criterion C). The canal does not have potential information important to the history of the region (Criterion D). Segment 80 is recommended as non-supporting to the eligibility of the resource due to loss of integrity.

The segment retains the integrity of location and association as it is an active irrigation ditch in its original location. Integrity of design, materials, and workmanship have been impacted by lining of the ditch. Setting and feeling have been compromised by modern residential development.

Management Recommendations: No further work. The proposed project activities consist of replacing the current bridge with a new wider bridge in the same general alignment.

5ME23793.1

Type: Historical Linear-Segment of E ½ Road/Orchard Avenue

Description: 5ME23793.1 is a segment of E ½ Road/Orchard Avenue which starts just west of 29 ½ Road and continues due east to its intersection with Warrior Way. The area has extensive residential development and the vegetation consists of primarily of grasses and other domesticated landscaping species, fruit trees, and riparian species in association with small wetlands in irrigation/roadside ditches along the road. Ground visibility is 75 to 100 percent. The elevation is 4,670 feet (1,423 meters) asl. Houses and mobile homes with some small pockets of remaining farmland line both sides of the road.

Segment 1 is a paved two-lane road with wide shoulders and is approximately 9,800 feet long with varying width from 35 to 60 feet (shoulder to shoulder). The majority of the segment has a right-of way width of about 60 feet. There are two bridges within this segment: one is a concrete culvert built in 1995 that carries the road over the Grand Valley Canal (5ME4680.80) (MESA-E.5-29.8). The other bridge carries E ½ Road/Orchard Avenue over Lewis Wash on the western portion of the segment; this bridge is also a concrete culvert with poured concrete wing walls and construction date is unknown. The entire alignment of E ½ Road/Orchard Avenue extends from I-70 Business on the eastern terminus to just west of North 1st Street on the western terminus.

The portion of the segment to the east of 30 Road was built prior to 1937; the portion to the west of 30 Road is labelled as Orchard Avenue and does not appear to be an official road until after 1966 based on Mesa County historic aerials (Mesa County GIS/IT Department 2021). A 1936 State Highway map shows the part of this road west of 30 Road, but not the eastern portion of the road (Colorado State Highway Department 1936). Prior to 1954 the area north and south of E ½ Road/Orchard Avenue were agricultural with many fruit tree farms visible on historic aerials (Mesa County GIS/IT Department 2021). By the 1977's, mobile home parks had been developed north of Orchard Avenue and had been platted to the south of Orchard Avenue between the Grand Valley Canal and 29 ½ Road. The area west of the Grand Valley Canal along Orchard Avenue/E1/2 Road remained relatively undeveloped until the late 1970s and appears to be similar to today's parcel division by the late 1980s (Mesa County GIS/IT Department 2021).

Eligibility: ERO recommends the road eligible for listing on the NRHP as it is potentially associated with early fruit farming in the Grand Valley that resulted from the construction of the Grand Valley Canal (Criterion A). It does not appear to be associated with significant person(s) such as pioneers or engineers (Criterion B) nor does the road embody distinctive characteristics such as engineering or design qualities (Criterion C). The extant road will not provide additional information important to history (Criterion D). Segment 1 is recommended as non-supporting to the eligibility of the resource due to loss of integrity.

The segment retains the integrity of location and association as it is a transportation corridor in its original location. Integrity of design, materials, and workmanship have been impacted by modern improvements and widening of the road. Setting and feeling have been compromised by modern residential development.

Management Recommendations: No further work upon concurrence of the non-supporting recommendation.

5ME23794

Type: Historical Architectural

Description: Site 5ME23781 is a historical residence located at 2991 Orchard Avenue between the Grand Valley Canal and 30 Road. The vegetation consists of cottonwood with a sparse, weedy understory supporting cheatgrass, prickly lettuce, and other weedy annuals; the soil is a tan sandy loam. The elevation of the site is 4,670 ft asl (1,423 m asl).

The site consists of a wood frame stucco residential structure measuring 1,436 square feet and constructed in 1956 (Mesa County GIS/IT Department 2021). The house is ranch style with a gable roof and sits on a 0.36-acre lot. A fireplace was added in 1991 and a stucco garage was added in 1998. Wood vigas and a small wooden covered porch are visible on the eastern façade of the structure. The garage is located on the southern elevation and the fireplace and added chimney are located on the northern elevation. ERO did not have permission to access the home; all documentation and information was obtained from the Mesa County Assessor records and observations taken from the street.

The house has been in use from 1956 to the present and predates the development of the adjacent portion of Orchard Avenue. This likely explains why the structure is so close to the road; the northern elevation is 13 feet south of the edge of the road. This structure is closer to the street than any of the other residences along this portion of Orchard Avenue.

Eligibility: ERO recommends the site not eligible for listing in the NRHP under any criteria. The site does not appear to be significant to important historical events in the Grand Valley (Criterion A), nor is it associated with important persons (Criterion B). The building is not distinctive of a type, period, or method of construction (Criterion C). In addition, the building does not offer information important to the history of the region (Criterion D).

The aspect of location is intact. Integrity of materials, workmanship, design, feeling, and association are not present due to the additions to the structure that are not consistent with the original construction. The urban development surrounding the project area has further compromised the feeling and association of the site.

Management Recommendations: The project activities potentially include acquisition of the entire parcel. Upon concurrence with the not eligible recommendation, no further work is necessary.

Summary and Management Recommendations

Within or overlapping the APE are three historical resources: one new segment of a previously documented historical linear (5ME4680.80), one new segment of a newly documented linear (5ME23793.1), and one newly recorded historical residence (5ME23794). Both linear segments are recommended non-supporting of the eligibility of the entire resource and 5ME23794 (21-175-KC02) is recommended not eligible for listing in the NRHP. ERO only documented those resources that will be directly impacted by the proposed project activities. Should additional ROW acquisition be required with property parcels with historic structures, those structures will require documentation and NRHP evaluation as well. Based on current project design as of December 2021, ERO recommends a determination of “no historic properties affected” pursuant to 36 Code of Federal Regulations 800.4 of the National Historic Preservation Act.

Section 9 – Geotechnical

Geotechnical Subsurface Investigation

Yeh and Associates, Inc.

Geotechnical • Geological • Construction Services

Purpose and Scope of Study

This preliminary report presents the results of the Yeh and Associates, Inc. (Yeh) geotechnical engineering study for the Orchard Avenue Corridor Study in Mesa County, Colorado from 29 ½ Road approximately 1.75 miles east to Warrior Way, to evaluate the feasibility of potential improvements that will include road widening and pavement design, intersection improvements with new traffic signals, and two (2) replacement structures where Orchard Avenue crosses the Grand Valley Canal and Lewis Wash. Available project information, including cut and fill depths, structure types and dimensions, loading and bearing grades is considered preliminary. The project location map is found in Figure 50 below.

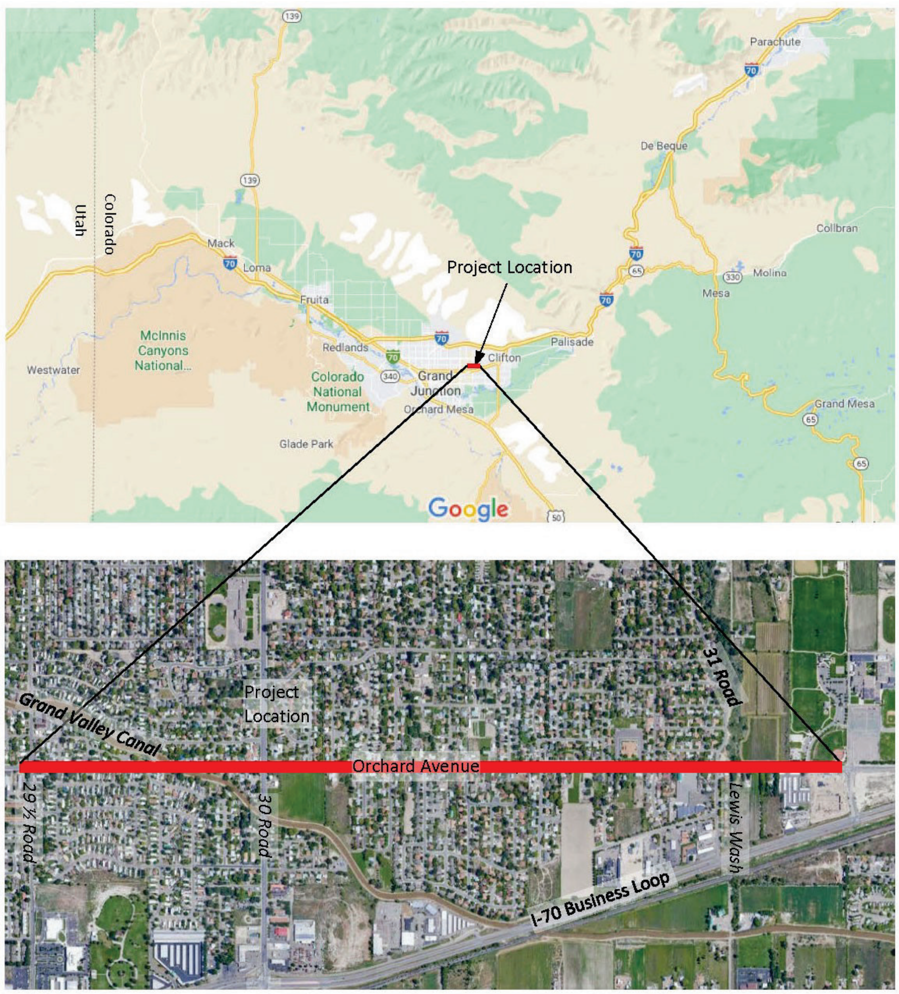


Figure 62: Project Location Map

Our authorized scope of services consisted of the following:

- Drill 10 borings along Orchard Avenue for roadway recommendations.
- Drill 2 borings along Orchard Avenue for Colorado Department of Transportation (CDOT) standard plan traffic signal foundations at the intersection of Orchard Avenue and 30 Road. One of the 10 roadway borings located at the intersection of Orchard Avenue and 29 ½ Road was deepened for possible traffic signal installation.
- Drill 4 borings for design of bridge structure foundations.
- Retrieve soil samples for laboratory testing and to record standard penetration blow counts.
- Laboratory testing of select samples, including classification, corrosivity and R-value, to characterize the soil properties.
- Preliminary engineering analyses for both shallow and deep foundations, and pavements.
- Geotechnical report including the following:
    - Summary of field and laboratory data.
    - Results of geotechnical engineering analyses.
    - Recommendations for structure foundations, pavement and general site work.

This report has been prepared in general accordance with the Request for Qualifications (RFQ) dated May 27, 2021, provided by client. Yeh and Associates, Inc. was authorized to perform this scope of work via a subconsultant agreement with Collins Engineers, Inc. dated July 8, 2021.

Recommendations in this report are based on information collected during our preliminary field investigation. Yeh and Associates, Inc. has completed an evaluation of the surface and subsurface conditions and provided preliminary geotechnical recommendations for proposed pavements and structures. The recommendations herein are based on available information pertaining to the proposed construction provided to us at the time of this report, the results of our subsurface exploration, and site reconnaissance performed as part of the investigation.

These recommendations should be updated as additional information becomes available.

Proposed Construction

The proposed improvements along Orchard Avenue includes approximately 1.75 miles of roadway asphalt-concrete pavement with possible road widening to three lanes between 29 ½ Road and Warrior Way. The roadway section for Orchard Avenue currently includes sidewalks on the north side of the street and on all corners of intersections. We understand multi modal improvements will likely be included in construction and that new traffic signal poles will be installed at the intersection of Orchard Avenue with 30 Road. Improvements at the intersection of Orchard Avenue and 31 Road are anticipated to consist of a shift of the south leg of 31 Road to align with the north leg.

Orchard Avenue crosses the Grand Valley Canal, as shown in Figure 51, and Lewis Wash, as shown in Figure 52. We understand the new structure (Mesa County Structure 29.8) may consist of a single or two-span precast, prestressed concrete slab bridge with either a 46-foot or 56-foot wide roadway section. The existing Lewis Wash concrete box culvert structure will be replaced with a two-cell box culvert (Mesa County Structure 31.01). Detailed plans for structure replacements, detailed structural loads, changes in grade and embankment heights are unknown at the time of this report.

Figure 63: Grand Valley Canal Box culvert at Orchard Avenue, looking west-northwest

Figure 64: Lewis Wash culvert at Orchard Avenue, looking northwest

Site Conditions and Geological Setting

Site Conditions

The project site includes the right-of-way for Orchard Avenue, also known as E ½ Road, between 29 ½ Road and Warrior Way in the Clifton area of Mesa County, Colorado. Orchard Avenue is an east west, paved, two-lane road with turn lanes at major intersections, a 4-foot- wide unpaved shoulder on the south side of the road, and an 8-foot-wide paved shoulder on the north side of the road from just west of McMullen Drive east for approximately 1,800 feet to Shoshone Street.

From 29 ½ Road, the project area extends east to Warrior Way through residential and commercial areas on both sides of the road with one agricultural area near the northeast end of the project. Central High School is located at Warrior Way at the east end of the project area.

The roadway crosses the Grand Valley Canal and Lewis Wash within the project site. Based on information from the National Bridge Inventory Data (2018), the Grand Valley Canal is carried under the roadway by a two-cell concrete box culvert in good condition. The existing cast-in- place (CIP) concrete box culvert structure, constructed in 1995, has a length of approximately 59 feet along the roadway centerline and an outside width of about 40 feet perpendicular to the roadway. As shown in Figure 51, we observed that the water level in the canal was near the top of the box culvert structure at the time of our field investigation. Orchard Avenue spans Lewis Wash via a single span cast-in-place concrete box culvert, constructed in 1950, that is approximately 12 feet wide, 13.5 feet tall and 49 feet long.

The canal and the wash were carrying water at the time of our investigation. During a later visit in early November to obtain water level readings, the Grand Valley Canal was not running and had approximately six inches of stagnant water in the channel. The Colorado River is approximately two miles south of the project area. Vegetation in the project area included landscaped and cultivated areas with native grasses, shrubs, and trees near the canal and wash. The site can be considered topographically flat, except for the Grand Valley Canal crossing and Lewis Wash.

Geological Setting

The project site is in the Grand Valley of the Colorado River approximately three miles southwest of the Book Cliffs of Garfield Mesa and approximately seven miles from the northeast edge of the Colorado National Monument on the Uncompahgre Plateau. Based on the geologic maps of the Clifton quadrangle, Mesa County, Colorado (Carrara, 2001) and The Grand Junction quadrangle (Scott, 2002), the site is located on alluvium and colluvium, which is a mix of alluvium, sheetwash, and debris flow deposits of clay, silt and sand with scattered gravel and boulders. The surficial units overly the Cretaceous age Mancos Shale bedrock that is dipping, or tilted, gently to the northeast. Additional surficial deposits include artificial fill for existing roadway construction. The project area geology map is presented in Appendix C1.

The surficial deposits in the project area may contain expansive clays derived from the Mancos Shale, which may cause stability problems for roads and buildings. Additionally, there is a possibility that evaporite mineral and salt deposits, including sulfates such as gypsum, associated with the Mancos Shale may be present in the soils that underlie the project site. As per the Colorado Geological Survey website for corrosive soils, these minerals may be corrosive to buried metal and concrete. Geohazards noted in the area include, but are not limited to, collapse from hydrocompaction, gullying, piping, expansive soils and bedrock, and flash flood.

Irrigation canals are found in the project area. According to the Mesa County GIS website map viewer and the Federal Emergency Management Agency (FEMA), Flood Zones A and AE are mapped along Lewis Wash and extend for approximately 1,500 feet east to Warrior Way and encompass the right-of-way of Orchard Avenue and north and south along 31 Road in the project area. The remainder of the site is mapped as an area of minimal flooding.

Subsurface Exploration and Conditions

Field Exploration

Yeh subcontracted drilling services from Colorado Drilling and Sampling of Montrose, Colorado for 12 borings drilled on August 2, 2021, and from HRL Compliance Solutions, Inc. of Grand Junction, Colorado for 4 borings drilled during the period August 31-September 3, 2021, along Orchard Avenue between 29 ½ Road and Warrior Way. Borings were located by Yeh based on correspondence with client in accordance with Mesa County Design Standards (2020) boring spacing requirements for pavement design. Boring locations are shown on the Boring Location Maps provided in Appendix C2. Twelve test borings were advanced to depths of 6 to 50 feet below surface grade by Colorado Drilling with a Simco 2800 truck mounted drill rig using solid stem auger. An additional four test borings were advanced to depths of 56.5 to 71.5 feet by HRL Compliance with a Diedrich D-90, track mounted, drill rig using 6-inch hollow stem auger drilling methods.

Borings were advanced to appropriate depths where a Modified California sampler with a 2-inch interior diameter (ID) and 2.5 inch outside diameter (OD), or a standard split spoon sampler with a 1⅜-inch ID and 2-inch OD were used to record blow counts and obtain samples. In addition, thin-walled, Shelby tube sampling was performed at select intervals within the deeper structure borings. Samples were collected in general accordance with ASTM D1586 for SPT, and ASTM D3550 for Modified California. The sampler was seated at the bottom of the boring, then advanced by a 140-pound hydraulic automatic, or "auto," hammer falling a distance of 30 inches. The number of blows required to drive the sampler two 6-inch intervals or a fraction thereof, constitutes the N-value. The N-value, when properly evaluated, is an index of the consistency or relative density of the material tested. Pocket penetrometer readings were performed on cohesive Modified California and Shelby tube samples. Bulk samples from auger cuttings were also obtained at select locations. Samples obtained during the field explorations were examined by the project personnel and representative samples were submitted for laboratory testing to evaluate classifications and engineering characteristics of materials encountered. Upon completion of drilling, the test borings were backfilled with native cuttings.

Test borings in the existing roadway were capped with cold patch asphalt. Test boring logs and legend are presented in Appendix C.

Laboratory Testing

Samples retrieved during the field exploration were returned to the laboratory for review by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) and American Association of State Highway and Transportation Officials (AASHTO). An applicable program of laboratory testing was developed to evaluate engineering properties of the subsurface materials. Additional testing may be performed when final design is provided to Yeh.

Laboratory soil testing included the following:

- Description and Identification of Soils (Unified Soil Classification System)
- Natural Moisture-Density
- Atterberg Limits
- One Dimensional Swell-Collapse
- Unconsolidated-Undrained Triaxial Compression
- One Dimensional Incremental Consolidation
- Specific Gravity
- R-Value
- Water Soluble Sulfate Content
- Water Soluble Chloride Content
- Resistivity
- pH

Laboratory tests were performed in general accordance with the applicable local or other accepted standards. Results of the laboratory tests are shown on the boring logs and are presented in the Laboratory Test Results found in Appendix C4 and C7.

Subsurface Conditions

Paved areas drilled had 4.0 to 9.5 inches of asphalt over 4.0 to 14.0 inches of road base as shown in Table 19 below. In general, subsurface conditions along Orchard Avenue below pavement or adjacent to roadway consisted of up to 11 feet of fill clay, silt, sand and/or gravel over native clay with scattered gravel lenses to the depths explored and as deep as 57 feet. Sand and gravel were encountered in borings B-12, B-13, B-14, B-15, and B-16 between depths of 18 to 57 feet. Shale bedrock was encountered in borings B-13 and B-14 at depths of 71 and 70 feet, respectively. Boring locations were surveyed by Kaart Surveying of Grand Junction, Colorado. Detailed boring logs are provided in Appendix C7.

Table 19. Elevation and Asphalt, Base and Fill Thicknesses at Boring Locations

Boring Number	Ground Surface Elevation of Boring (feet)	Asphalt Pavement Thickness (inches)	Aggregate Road Base Thickness (inches)	Estimated Fill Thickness (inches) (*feet)	Boring Location on Orchard Avenue
B-1	4686.7	4.0	4.0	33.5	560 ft east of Lewis Wash
B-2	4688.1	5.0	7.0	none	106 ft east of Lewis Wash
B-3	4690.1	7.0	5.0	54.0	1100 ft west of 31 Rd
B-4	4686.5	8.0	4.0	30.0	2700 ft west of 31 Rd
B-5	4682.5	6.5	5.5	6.0	1960 ft east of 30 Rd
B-6	4676.6	9.5	20.5	30.0	1040 ft east of 30 Rd
B-7	4674.8	9.0	9.0	48.0	530 ft east of 30 Rd
B-8	4672.1	4.0	14.0	78.0	SE corner intersection 30 Rd
B-9	4671.5	6.0	12.0	30.0	NW corner intersection 30 Rd
B-10	4669.9	7.0	23.0	30.0	120 ft east of GV Canal
B-11	4662.6	7.0	23.0	none	630 ft east of 29 ½ Rd
B-12	4661.6	7.5	28.5	none	SE corner intersection 29 ½ Rd
B-13	4687.7	n/a	n/a	*11 feet	NE corner Lewis Wash culvert
B-14	4668.6	n/a	n/a	*7 feet	NE corner Grand Valley Canal
B-15	4668.7	n/a	n/a	*8 feet	SW corner Grand Valley Canal
B-16	4667.4	n/a	n/a	*7 feet	NW corner Grand Valley Canal

Fill Sand and Gravel Road Base

Five fill sand with gravel road base samples had 9 to 31 percent fines (material passing the No. 200 sieve). Atterberg limits testing indicated liquid limits of no value to 19 percent and plasticity indices of non-plastic to 4 percent. The road base samples classified as SC-SM, SP-SM, and SM based on the Unified Soil Classification System (USCS) and as A-1-a (0), A-1-b (0), and

A-2-4 (0) based on the American Association of State Highway and Transportation Officials (AASHTO).

Fill Clay and Silt

Four samples of fill clay and silt had 57 to 81 percent fines, liquid limits of no value to 25 percent and plasticity indices of non-plastic to 10 percent. One fill clay sample was tested for swell consolidation (ASTM D4546) and exhibited collapse of 0.1 percent when wetted under an applied pressure of 500 pounds per square foot (psf). The fill clay and silt samples classified as ML, CL, and CL-ML (USCS) and as A-4 with group indices of 0, 1, and 6 (AASHTO).

Fill Gravel

One sample of fill gravel had 23 percent fines.

Native Clay and Silt

Thirty-eight native clay samples and one silt sample had 58 to 98 percent fines, liquid limits of 20 to 34 percent, and plasticity indices of 4 to 19 percent. Eleven of the native clay samples from depths of 2 to 9 feet were tested for swell/consolidation (ASTM D4546). Four of these samples exhibited no movement when wetted under an applied pressure of 500 psf. Another clay sample exhibited swell of 0.5 percent when wetted under an applied pressure of 500 psf. The remaining six samples exhibited collapse of 0.1 percent, 0.1 to 2.8 percent and 0.1 to 0.3 percent when wetted under applied pressures of 300 psf, 500 psf, and 1,000 psf, respectively. One of the clay samples taken at a depth of approximately 20 feet measured 2.747 for specific gravity. Nine of the clay samples were tested for unconsolidated-undrained triaxial compression and one sample was tested for one dimensional consolidation and these test results can be found in Appendix D. Hveem (R-value) testing performed on two of the clay samples taken at depths of 3 to 6 feet resulted in values of 8 and 9 at exudation pressures of 300 pounds per square inch (psi). The native clay samples classified as CL and CL-ML (USCS) and as A-4 with group indices of 0, 3, 5, and 7, and A-6 with group indices of 5, 7 through 13, 16 and 17 (AASHTO).

Native Sand and Gravel

Five native sand and gravel samples had 10 to 14 percent fines, liquid limits of no value and plasticity indices of non-plastic. The sand and gravel samples classified as SM, SP-SM, GM, and GP-GM (USCS) and as A-1-b (0) and A-1-a (0) (AASHTO).

Groundwater

Groundwater was encountered in borings B-2, B-8, B-9, B-12, B-13, B-14, B-15, and B-16 at depths of 16.0 feet, 20.0 feet, 18.0 feet, 4.0 feet, 25.0 feet, 15.0 feet, 6.0 feet, and 9.0 feet, respectively, below grade during drilling. These observations represent groundwater conditions at the borehole location at the time of our exploration

and should not be extrapolated to other times or at other locations. A piezometer was installed in boring B-15 (Grand Valley Canal location) to a depth of 20 feet below ground surface. Subsequent groundwater levels measured in B-15 were 9.5 feet and 14.1 feet on September 7, 2021 and November 3, 2021, respectively. The Grand Valley Canal was running nearly bankfull at time of drilling, September 7, 2021 and was nearly empty with an estimated six inches of stagnant water on November 3, 2021.

Groundwater conditions often fluctuate and may be influenced by seasonal precipitation, road maintenance practices, development, canal operations, or other factors. The magnitude of groundwater variations will be largely dependent upon fluctuations in local irrigation practices, snowmelt, duration and intensity of precipitation and the surface and subsurface drainage characteristics of the surrounding area. We recommend water level monitoring be performed through spring of 2022.

Seismicity

The seismic site classifications for the Orchard Avenue Corridor Study area (latitude 39.0845 degrees, longitude -108.5003 degrees) are displayed below in accordance with Table 3.10.3.1-1 of the 2017 AASHTO Guide Specifications for LRFD Bridge Design. The Peak Ground Acceleration (PGA), and the short- and long-period response spectral acceleration coefficients (S_S and S_1 respectively) for the reference site were obtained using the USGS Design Maps tool for an event with a 7% Probability of Exceedance (PE) in 75 years and a Site Class B (reference site). An event with the above probability of exceedance has a return period of about 1,000 years. Since the project site classification (Class E) is different from the reference site (Class B), site specific value adjustments are necessary. The seismic design parameters for a Site Class B reference site and Site Class E are shown in Tables 20-1 and 20-2 below. The site class was based on the conditions encountered in our shallow exploratory soil borings and our knowledge of the subsurface conditions in the site vicinity. The soil characteristics extending beyond the depth of our borings were assumed for the purposes of providing this site classification.

Table 20-1 Seismic Parameters for Reference Site Class B

Site Class	PGA (0.0 sec)	S_S (0.2 sec)	S_1 (1.0 sec)
B	0.083 g	0.168 g	0.040 g

Table 20-2 Seismic Design Parameters for Site Class E

Site Class	A_S (0.0 sec)	S_{DS} (0.2 sec)	S_{D1} (1.0 sec)
E	0.206 g	0.420 g	0.141 g

Foundation Recommendations

General

Deep foundations will be required to support a new structure spanning the Grand Valley Canal. We understand the new structure may consist of a single or two-span precast, prestressed concrete slab bridge. Preliminary structural loading provided by Collins Engineering, Inc. for the various options under consideration include dead loads between 7.5 and 15.9 kips per foot at each substructure unit. Similarly, HL-93 live load reactions range between about 3.3 and 6.5 kips per foot. Driven H-piles penetrating the dense sand and gravel bearing stratum, at depths on the order of 55 feet below roadway elevation, are recommended to support the structure.

We understand that the existing Lewis Wash box culvert structure will be replaced with a two-cell concrete box culvert (CBC) with wing walls supported on shallow foundations. The CBC will be approximately 30 feet wide and 56 feet long. Each of the culvert openings are planned to be 14 feet wide with top and bottom slabs 12 inches thick and 8-inch thick walls. Preliminary structural loading provided by Collins indicates a dead load of about 780 psf across the bottom slab and a live load of 60 psf. Subgrade soils at this location consist of medium stiff to very stiff clays of moderate strength and compressibility. Foundation preparation measures (i.e., removal of in-situ soils and replacement with aggregate base fill and geogrid reinforcement) below the structure and wing walls will be required to provide a firm base during construction and mitigate differential settlement. In addition, shallow groundwater conditions at this location may require dewatering measures to remove water from temporary excavations prior to fill placement.

New traffic signal poles at the intersections of Orchard Avenue with 29 ½ Road and 30 Road will be supported on drilled shafts designed and constructed in accordance with CDOT Standard Plans. Due to medium stiff cohesive soils and potential high groundwater, we anticipate shafts will require temporary casing or drilling slurry to maintain an open excavation for reinforcing steel and concrete placement.

Detailed plans for structure replacements, changes in grade and detailed structural loading are unknown at the time of this report. The preliminary recommendations presented herein should be confirmed and updated as necessary once design plans are available. All foundation excavations should be observed by a representative of the geotechnical engineer prior to placement of imported fill and concrete to confirm subgrade conditions assumed in design. The

recommendations below are based on the soils encountered in the borings, results of laboratory testing, and AASHTO LRFD (2020) methodology.

Mesa County Structure 29.8 – Grand Valley Canal Crossing

Based on the results of our subsurface investigation, we recommend the proposed bridge abutments be supported on driven steel H-piles bearing in dense sand and gravels. Drilled shafts are not expected to be an economical foundation choice to support the proposed bridge based on the depth of the bearing stratum and anticipated construction difficulties associated with soft clay soils, shallow groundwater, and the need for casing to maintain open excavations for reinforcing steel and concrete placement.

A generalized soil profile with soil properties used in foundation design is presented in Appendix C4. Deep deposits of soft clay soils and shallow groundwater were encountered in the exploratory borings B-14, B-15, and B-16 performed at the proposed bridge site. Piles should penetrate dense sands and gravels below the soft clay stratum. Based on the soil borings, we estimate the top surface of this bearing stratum varies between approximately 47 and 52 feet below existing grade.

Static axial pile capacity analyses were performed using the software *RSPile* by Rocscience in accordance with AASHTO LRFD (2020) to estimate nominal bearing resistance of 10-inch,

12-inch, and 14-inch H-Piles that will carry loads via side and tip resistance. The results of these analyses are presented in Appendix C5. Uplift loads on bridge foundations are not anticipated and therefore, uplift resistance values are not provided herein. The axial capacities presented in Appendix C5 do not account for scour. A hydraulic engineer should be consulted about potential scour and scour protection design considerations.

Due to the very soft soils at the bearing elevation of wing walls, it is recommended that walls also be pile supported or be of cantilever design to preclude excessive differential settlement between the bridge structure and the walls.

Vibration effects due to driven piles penetrating the dense sands and gravels should be anticipated and measures to mitigate vibration levels such as proper hammer choice and a detailed vibration monitoring program should be employed. Use of H-piles, which are considered “non-displacement” piles, will also aid in vibration mitigation. Design and construction recommendations for driven piles are presented below.

Driven Steel H- Pile Foundations

1. Using Load Resistance Factor Design (LRFD) criteria for axial compression design, steel H-piles penetrating dense sands and gravel may be designed in accordance with the nominal bearing resistance curves presented in Appendix C5. The factored

bearing resistance is the product of the nominal bearing resistance and the resistance factor. A resistance factor of 0.65 may be used provided that a minimum number of piles are dynamically monitored according to AASHTO Table 10.5.5.2.3-1. The monitoring shall be conducted using a PDA (Pile Driving Analyzer) per the current version of the CDOT Standard Specifications for Road and Bridge Construction, Section 502 (Piling) and should be used to evaluate the acceptance criteria for piles. Resistance Factors for Driven Piles and the driving criteria is established by signal matching at the beginning-of-restrike (BOR). The maximum factored resistance should be checked against the structural strength limit state for the selected piling size and type.

2. Driven piles should be installed per the CDOT Standard Specifications for Road and Bridge Construction, Section 502 (Piling). The piles should be driven without damage at or below the estimated driven pile tip elevations specified below to develop the required resistance. A range of acceptable manufacturer rated hammer energies should be specified in the Contract per CDOT Section 502.03 (a) (3.) that are based on Wave Equation Analyses. It should be noted that the piles are assumed to be driven to the Estimated Pile Tip Elevation. Driving the piles to elevations significantly higher than the Estimated Pile elevation will likely result in unsatisfactory pile performance. Conversely, piles that are driven to elevations significantly lower than the Estimated Tip Elevation may occur and should be noted and Yeh and Associates, Inc should be contacted. Estimated bearing surface elevations and pile tip elevations are shown in Table 21-1.

Table 21-1 Estimated Bearing Surface and Pile Tip Elevations

Location	Sand/Gravel Approximate Elevation*	Estimated Pile Tip Elevation (feet)*
Grand Valley Canal Crossing	4,621 to 4,615	4,611

* Based on survey data provided by client.

3. Based on the results of our field exploration, laboratory testing and our experience with similar properly constructed driven pile foundations, we estimate individual pile settlement will be less than ½ inch when designed according to the criteria presented in this report.

4. Drag loads on piles are not anticipated where new embankments are replacing existing embankments of approximately the same height. Drag loads should be considered in final design for those piles where grade will be raised above existing ground, resulting in additional loads and settlement of the foundation

soils.

5. The upper 3 feet of pile penetration should be neglected for lateral load resistance calculation. For lateral loading analysis using LPILE program, parameters presented in Table 21-2 may be used. A groundwater depth of 10 feet below existing site grades should be applied in the analyses.

Table 21-2 LPILE Parameters

Soil Type	LPILE Soil Criteria	Effective Unit Weight (pcf)		Friction Angle, (deg.)	Cohesion, c (psf)	Strain Factor, ε_{50}	p-y modulus k_{static} (pci)	
		AGT[1]	BGT[2]				AGT[1]	BGT[2]
Native Clay	Soft Clay (Matlock) (Reese)	125	62.5	-	200 to 850	0.02	-	-
Native Silty Sand with Gravel, Silty Gravel with Sand, Sand, Sand with Silt and Gravel	Sand (Reese)	135	72.5	33	-	-	225	125

Note: [1]Above Groundwater Table
[2]Below Groundwater Table

6. Groups of piles will also require appropriate reductions of the lateral capacities based on "shadowing" and other group effects. The minimum spacing requirements between rows of piles should be five diameters from center to center. For lateral loading, recommended P multipliers should comply with AASHTO LRFD Table 10.7.2.4-1 to account for lateral group effects. Reductions for axial capacities are not necessary for piles driven to dense sands and gravels at three-diameter spacing or greater.

7. Per Section 10.7.5 of AASHTO LRFD (2020), the clay soils through which piles will be installed indicate potential pile deterioration (corrosive conditions) as a result of resistivity being less than 2,000 ohm-cm. It is recommended that sacrificial steel area, or other methods, be used to mitigate corrosivity of the site soils. A qualified corrosion engineer should review this data to determine the appropriate level of corrosion protection.

8. We do not anticipate that predrilling or toe protection will be required to reach the estimated pile tip elevations.

Bridge Approach and Embankment Settlement

The site appears suitable for the proposed construction based on geotechnical conditions encountered in the soil borings. Time dependent consolidation settlement may result from placement of new fill above existing site grades. Detailed information regarding fills for construction are not available at the time of this report, however we anticipate fills on the order of 5-feet are likely at bridge approaches due to structure/road widening. Estimated total settlements are expected to be less than 3-inches. From our analysis, we estimate that 60 to 70 percent of total movement would occur within 45 days after placement of new fill. Approach slabs can be constructed once monitoring confirms the settlement is complete or nearly so (less than 1-inch of settlement remaining).

Subgrade soils will require particular attention during design and construction and density testing of the subgrade is required prior to placing new fill. Approach slabs should be supported on at least 2-feet of free draining, imported structural fill. Structural fill should meet CDOT

Class 1 specifications as presented in Table 10-2 in this report. Structural fill material should be placed in loose horizontal lifts of 8 inches in thickness, moisture conditioned and compacted to a minimum of 95 percent modified Proctor.

Mesa County Structure 31.01 – Lewis Wash Box Culvert

We understand the existing box culvert structure planned for removal at this location is grade supported. Due to clay soils beneath the proposed structure, shallow foundation design for the replacement structure should include the excavation of clay foundation soils immediately below the structure bearing grade and replacement with CDOT Class 6 Aggregate Base Course (ABC) or approved crushed stone materials reinforced with geogrid. The depth of the aggregate section should be 2 feet. This also pertains to associated wing walls. This mitigation measure serves to reduce both total and differential settlements and provides uniform bearing to the structure. Below are additional recommendations for design and construction of shallow foundations at this location.

1. Following demolition of the existing structure, all loose, disturbed, or otherwise unstable soils including fill should be removed. The Class 6 ABC layer should be reinforced with geogrid as detailed below. Considering the potentially high groundwater levels at the site and a wet excavation, AASHTO 57 stone, or equivalent clean crushed aggregate, would be an acceptable alternative to Class 6 ABC. Additionally, the imported aggregate should extend laterally from the edges of foundations a minimum of 2 feet for the CBC and at least half the footing width for wing wall foundations.
2. At the base of the excavation, the imported aggregate section should bear on geogrid over separator fabric with the separator fabric covering the bottom and sides of section to reduce migration of fines into the aggregate material. The fabric should be tucked under the CBC structure a minimum of 3 feet on each side of the culvert. Additional layers of geogrid may be required to produce a stable foundation platform. The separator fabric should conform to CDOT Standard Specifications. The biaxial geogrid should consist of Tensar BX-1200, or approved equivalent.
3. Shallow foundations for CBC and wing wall strip footings with a minimum width of 3 feet constructed as described above may be designed using a nominal (unfactored) bearing resistance of 7.0 ksf. The bearing resistance factor for shallow foundations is 0.50 in accordance with AASHTO LRFD (2017) Table 10.5.5.2.2-1.
4. Wingwall foundations should bear below frost depth, at least 24 inches below nearest adjacent finished grade, or deeper depending on scour requirements.
5. Fill material should be placed in accordance with recommendations in Section 10 of

this report. If AASHTO 57 stone or equivalent is used, vibratory plate compaction with placement and proof roll observation by a representative of Yeh and Associates can be used for acceptance in lieu of nuclear density testing.

6. Backfill against structure foundations should consist of granular material such as CDOT Class 1 Structure Backfill meeting the requirements of Table 10-2 of this report and compacted as discussed in Section 10.
7. An unfactored coefficient of friction of 0.60 may be used for the calculation of sliding resistance when performing an external stability check in accordance with AASHTO (2020) Section 10.6.3.4. The recommended sliding resistance factor is 0.80 for shallow foundations per AASHTO (2020) Table 10.5.5.2.2-1.
8. Global stability of the culvert wing walls should be evaluated by Yeh when more detailed design information becomes available.
9. Total settlement is estimated to be 1 to 2 inches when constructed as discussed above. Differential settlement, as measured along a horizontal distance of 50 feet, is estimated to be ½ to ¾ of the total settlement.
10. Settlement monitoring of survey monuments must be performed following fill placement. Survey monuments should be installed at each end of the CBC structure at a minimum. At a minimum, survey readings should be taken every two weeks, or more frequently if desired. A Yeh geotechnical engineer should review the settlement data with site personnel. Final roadway paving should not start until the monitoring confirms the settlement is complete or nearly so (less than 1 inch of settlement remaining).
11. Design of the CBC structure should incorporate a toe wall or turned-down edges at the ends of the structure to mitigate under seepage and potential soil piping within foundation and fill section materials. It is recommended that the cutoff extend to the base of the imported aggregate layer at a minimum.
12. Contractor should plan for significant dewatering activities at this location and may choose to schedule foundation work during winter months when groundwater tables are expected to be lowest. Groundwater levels in borings B-2 and B-13 during drilling were 16.0 feet and 25.0 feet, respectively. Methods to divert, pump and dispose of this water, including permits, should be finalized *prior* to the initiation of construction.

Drilled Shaft Foundations for Signal Poles

Design Approach

It is our understanding that the existing traffic signal poles on the northwest and northeast corners of the intersection of Orchard Avenue and 30 Road will be relocated and that new traffic signal poles will be supported on drilled shafts, designed in accordance with the CDOT M & S-Standard Plans. The geotechnical recommendations presented herein are based on CDOT S-Standard Plan S-614-40 for typical traffic signal installations. Per the CDOT standard plans, drilled shaft foundations for the signal pole could extend on the order of 15 to 20 feet below the ground surface. Use of the Standard Plans require that the following minimum soil parameters be met:

- Total soil unit weight = 110 pounds per cubic foot (pcf)
- Undrained shear strength = 750 psf (cohesive soils)
- Internal angle of friction = 30 degrees (cohesionless soils)

Based on the results of our field investigation and laboratory testing for borings B-8, B-9, and B-12, the above minimum soil parameters are satisfied at those locations, and a CDOT standard plan drilled shaft foundation may be utilized in design of signal poles for the project.

Drilled Shaft Construction Recommendations

The following recommendations can be used in the construction of drilled shafts. Construction of drilled shafts should be in accordance with AASHTO (2020) and the current version of the CDOT Standard Specifications.

1. Groundwater may be encountered during foundation drilling depending on the time of year and location. At the time of drilling, groundwater was encountered at a depth of 4 feet in boring B-12 (29 ½ Road intersection) and at depths of 18 to 20 feet in borings B-8 and B-9 (30 Road intersection). The presence of groundwater in the exploratory borings indicates casing and/or dewatering equipment may be required and should be anticipated by the contractor.
2. The Contractor shall construct the drilled shafts using means and methods that maintain a stable hole. Slurry or temporary casing may be needed to maintain an open hole during excavation.
3. Wet method (tremie) of concrete placement may be required if more than 3 inches of water is measured at the bottom of the shaft.

4. A representative of the geotechnical engineer should observe drilled shaft installation operations on a full-time basis to confirm design assumptions.

Lateral Earth Pressure

Wing walls should be designed to resist lateral earth pressure. We recommend all retaining/wing walls are backfilled with CDOT Class 1 Structure Backfill as shown in Table 10-2 of this report. Walls can be designed using an equivalent fluid density of 38 pcf for active or 60 pcf for at rest conditions for Class 1 Structure Backfill. This equivalent fluid density assumes a horizontal slope above the wall. This value also assumes that the backfill materials are not saturated. Wall designs should consider the influence of surcharge loading such as traffic, construction equipment and/or sloping backfill. All foundation and retaining structures should be designed for appropriate hydrostatic and surcharge pressures resulting from adjacent roadways, traffic, construction materials and equipment. Hydrostatic (seepage) pressures should not be allowed to develop in the active soil wedge zone. We recommend that the wall designer include appropriate drainage elements that are typically installed near the back and bottom of retaining walls, such as geocomposite strip drains, perforated pipes, filter materials and/or weep holes to control surface and groundwater flows.

Pavement Recommendations

Evaluation of flexible and rigid pavements for the project were performed in accordance with Chapter 8 – *Surfacing Structural Design* of the Mesa County 2020 Design Standards, the CDOT 2020 Pavement Design Manual and AASHTO methodology for pavement design (1993). The sections below discuss details regarding design traffic levels, pavement subgrade strength, design assumptions and inputs, and various flexible and rigid pavement sections for consideration.

Traffic Loading

The traffic loading was determined using an assumed design volume of 6,065 vehicles per day (two-way traffic) obtained from traffic counts shown on the Mesa County GIS Viewer for Transportation. The ADT for design is based on the highest traffic count listed during the years 2016-2020 along Orchard Avenue between 29 ½ Road and Warrior Way. Twenty-year projected volumes were used as an input for the design of hot mix asphalt (HMA) pavement and thirty- year projected volumes were used as an input for the design of Portland cement concrete pavement (PCCP). A growth rate of 2.2 percent was assumed. The resulting traffic Equivalent Single Axle Load (ESAL) values were 880,626 for HMA pavement and 1,995,403 for PCCP. The data and calculations of the traffic loading ESAL values is presented in Appendix C6. Traffic loading and design pavement sections should be updated as necessary to incorporate traffic studies performed specifically for this project, if available.

Subgrade Strength

R-values of 8 and 9 were obtained from representative samples of shallow subgrade soils at the project site along Orchard Avenue between 29 ½ Road and Warrior Way. The tested materials were sampled from combined clay cuttings collected from borings B-7, B-8, B-9, and B-12 at depths of 3 to 6 feet. The R-value of 8 was used to calculate a resilient modulus of 5,440 psi for use in the pavement section design. The modulus value was used as one of the inputs for pavement design and analysis following the AASHTO methodology to determine recommended pavement thickness. Structure layer coefficients used in design are based on the Mesa County Design Standards 2020.

Design Assumptions and Inputs

Table 22-1 presents the input design parameters used for the design of flexible pavement sections. Table 22-2 presents the input design parameters used for the design of rigid pavement sections.

Table 22-1 Flexible Pavement Design Parameters

HMA Design Inputs			
Initial Serviceability	4.5	Overall Deviation	0.49
Terminal Serviceability	2.5	HMA Str. Layer Coefficient	0.44
Reliability Level, %	95	Class 6 Aggregate Base Coefficient	0.12
Structural Numbers			
Pavement		**ESALs**	**Structural Number (SN)**
HMA Traffic Loading		880,626	4.00

The pavement design regional factor of 2.00 was obtained using the Exhibit 22.1 table in the 2020 Mesa Design Standards.

Table 22-2 Rigid Pavement (with dowels) Design Parameters

PCCP Design Inputs			
Initial Serviceability	4.5	Elastic Modulus of PCCP, psi	3,400,000
Terminal Serviceability	2.5	Modulus of PCC Rupture (Flexural Strength, psi)	650
Reliability Level, %	95	Overall Deviation	0.34
Joint Spacing (feet)	15	k-value (psi/in)	100
PCCP Traffic Loading ESALs (Collector)	1,995,403	Load Transfer Coefficient, J	2.8*

* Load transfer devices, 1.25-inch dowels and No. 5 tie bars should be included in the concrete pavement in compliance with CDOT M-Standard M-412.

Pavement Sections

A pavement section is a layered structure designed to disperse dynamic traffic loads to the subgrade. The performance of the pavement structure depends on the traffic loadings and physical properties of the subgrade materials. The recommended pavement design thickness sections are summarized below. Recommended HMA pavement thicknesses are presented in Table 22-3 and Table 22-5, and recommended PCCP thickness are shown in Table 22-4.

HMA pavement design calculations were performed using the PaveXpress website, which is based on the 1993 AASHTO Pavement Design Guide and the Mesa County Design Standards (2020). The PCCP pavement thickness was determined using the design program from the FHWA

1998 Supplement to the 1993 AASHTO Pavement Design Manual. The program outputs for all pavement designs are presented in Appendix C6.

Table 22-3 Recommended HMA and Base Thicknesses (Collector)-No Base Reinforcement

Pavement Type	Required SN	New HMA (inches)	Class 6 Aggregate Base Course (inches)	Calculated SN
HMA Alternate A	4.00	6	10	4.04
HMA Alternate B	4.00	7	8	4.04

Table 22-4 Recommended PCCP and Base Thickness (with dowels*)

Pavement Type	Minimum Aggregate Base Course (inches)	Design Thickness (inches)	Recommended PCCP (inches)
PCCP (Collector) Alternate C	6.0	8.2	8.5

* Load transfer devices, 1.25-inch dowels and No. 5 tie bars should be included in the concrete pavement in compliance with CDOT M-Standard M-412.

HMA Pavement Design with Base Reinforcement

A design using an appropriate geotextile base reinforcement to provide a more economical section is provided and the following thicknesses would apply for HMA and base course with the use of geotextile conforming to Mirafi RS380i below the base course. This geotextile functions as both a separator geotextile preventing contamination of the base with fines from the clay subgrade as well as providing stabilization similar to that provided by a Mirafi or approved equivalent geogrid. Use of this reinforcing geotextile allows use of an increased resilient modulus in the pavement design. Other parameters can be found in Table 22-5.

Table 22-5 Recommended HMA and Base Thicknesses with Mirafi RS 380i Base Reinforcement

Pavement Type	Required SN	New HMA (inches)	Class 6 Aggregate Base Course (inches)	Calculated SN
Alternate D	4.00	4.0	12.5	4.09
Alternate E	4.00	6.0	7.5	4.04

Hot Mix Ashpalt Type

A printout from the LTPPBind program is presented following the pavement designs in Appendix C6. The data from the LTPPBind program, based on local weather data, recommends that performance graded binder PG 64-22 be used in the project area. For the HMA mix we recommend a nominal 0.5 inch mix conforming to CDOT Grading SX(75) containing the above performance graded binder; PG 64-22. A locally produced mix that is approved for use on Mesa County projects in the area can be substituted for the recommended HMA mix.

Aggregates for hot plant mix bituminous pavement should be of uniform quality, and composed of clean, hard, durable particles of crushed stone, gravel, or slag. Excess of fine material should be wasted before crushing.

Pavement Preparation

To prepare the subgrade for the placement of new pavements, we recommend removal of topsoil, vegetation, and existing pavement structures (where present) prior to construction. Based on our borings, existing subgrade includes native and fill soils, which may or may not be compacted. To address possible swell/collapse in areas of new pavement construction, we recommend the top 2-feet of subgrade soils be removed and recompacted in accordance with specifications at or above optimum moisture content. The base of excavations should be scarified, moisture conditioned and recompacted to a minimum depth of 8 inches prior to fill placement. A minimum of 2-feet of removal is sufficient where deeper fill material exists.

Both a reinforced base section and a standard aggregate base section are presented in Tables 8.3, 8.4, and 8.5. The reinforced base section requires a geotextile conforming to Mirafi RS380i on the compacted subgrade prior to the placement of the base course. If the pavement section using the Mirafi RS380i reinforcement is not chosen, the pavement designs require a thicker base section, and we recommend the placement of a separation geotextile conforming to AASHTO M288 Class 1 Grade 1 on the compacted subgrade prior to placement of the ABC to prevent migration of fines into the base material.

Other stabilization recommendations such as a combination of a geogrid and separation geotextile may be considered during construction in areas of unstable subgrade. Any alternate pavement section will require approval of the owner agency. The ABC and HMA or PCCP should be placed in accordance with the project plans to meet the design roadway grades for drainage. Additional recommendations in Section 10 should be followed. Stabilization, either mechanical or chemical, of the existing subgrade may be necessary to achieve a stable paving subgrade. These recommendations can be provided during construction if necessary. Subgrade deterioration in areas of frequent construction traffic should be anticipated and stabilization methods such as additional aggregate base thickness and/or geogrid stabilization may be necessary as noted above.

Corrosivity

The concentrations of water-soluble sulfates were measured in six samples obtained from the exploratory borings taken at depths of 3 to 13.5 feet ranged from 0.007 to 1.450 percent. This concentration of water-soluble sulfates in four of these samples represents a Class 2 degree of sulfate attack on concrete exposed to these soils based on Table 601-2, CDOT (2021). If Portland concrete cement is utilized, we recommend a cement type to resist attack be used at the site for material placed directly on existing in place fill or native soils.

In addition, pH, water soluble chloride, and soil resistivity tests were performed on the same samples to evaluate the potential attack on concrete and buried metal at the site. Test results measured pH values of 7.6 to 8.0, resistivity measurements of 404 to 1639 ohm-centimeters, and the concentration of water-soluble chlorides were 0.0047 to 0.0221 percent. A qualified corrosion engineer should review this data to determine the appropriate level of corrosion protection.

Site Grading and Construction Considerations

The following presents recommendations for site preparation, excavation, subgrade preparation and placement of engineered fills on the project. Site preparation and earthwork operations should be performed in accordance with applicable codes, safety regulations, and other local, state, or federal guidelines. Earthwork on the project should be observed and evaluated by Yeh. The evaluation of earthwork should include observation and testing of engineered fills, subgrade preparation, foundation bearing soils and other geotechnical conditions exposed during the construction of the project. Soil slope cut and fill grading for the proposed improvements, as applicable should follow the procedures of the current version of the CDOT Standard Specifications for Road and Bridge Construction.

Site and Subgrade Preparation

Preparation of the site should begin with stripping and removal of existing structures, topsoil, all organic materials, and any construction debris or unsuitable material. The stripped materials should be removed for offsite disposal in accordance with local laws and regulations or stockpiled for landscaping purposes. All exposed surfaces should be free of mounds and depressions, which could prevent uniform compaction.

Following initial stripping, grading, and required over excavation/undercutting, all exposed areas which will receive fill, support structures, and under new pavements, should be scarified to a minimum depth of 8 inches, moisture conditioned, and compacted according to *Section 10.6 - Compaction Requirements*, of this report. Prior to placement of fill or structural elements, the condition of the exposed subgrade soil should be evaluated by observation of a proof roll. Proof rolling the subgrade aids in identifying soft or disturbed areas. Unsuitable areas identified by the proof rolling operation should be undercut and replaced with imported structural fill. Proof rolling may be accomplished through use of a fully loaded, pneumatic-tire, dump truck or similar equipment providing an equivalent subgrade loading. Proof rolling should be performed under the observation of the geotechnical engineer using multiple passes in both directions to ensure complete coverage and should be in accordance with Section 203 of the current version of the CDOT Standard Specifications.

Following proof roll observations, suitable fill should be placed to the design grade as soon as practical to avoid moisture changes in the underlying soils. All structural fill soils should meet the requirements of *Section 10.5 - Engineered and Structural Fill Requirements*, of this report and be placed and compacted in accordance with the criteria presented in Section 10.6 of this report.

Undercutting and Subgrade Stabilization

Based on the subsurface conditions encountered in the borings, subgrade soils exposed during construction of the proposed structures and pavements will be moisture-sensitive and could become overly soft and unstable at higher moisture levels. If unstable conditions are encountered or develop during construction, stability may be improved by scarifying and drying/wetting the subgrade soils. Clays may require 3 to 6 inches of crushed rock/gravel to provide a stable working surface. The amount of aggregate and type of stabilization required will be a function of the conditions encountered during construction. Over excavation of wet zones and replacement with structural fill or crushed rock may be necessary.

If areas are found to be unsuitable for re-work, additional stabilization will be required. If additional stabilization is required, Yeh should be contacted to evaluate the conditions in the field, and a suitable stabilization method can be provided. In addition, any soft and/or wet areas exposed during the excavation may need to be stabilized prior to the placement of new fill to create a stable, firm construction platform. A typical stabilization method may include utilizing crushed rock with the combination of geogrid (e.g., Tensar BX1200 or TX160) to create a stable base. Other stabilization methods may also be appropriate.

Excavation and Trench Construction

Excavations will encounter a variety of soil types including gravel, sand, silt, and clay. It is anticipated that it will be possible to excavate these materials with conventional heavy-duty earth working equipment. The excavation contractor is responsible for determining the means and methods necessary to accomplish earthwork operations.

All excavations must comply with the applicable Local, State, and Federal safety regulations, and particularly with the excavation standards of the Occupational Safety and Health Administration (OSHA). Construction site safety, including excavation safety, is the sole responsibility of the Contractor as part of its overall responsibility for the means, methods, and sequencing of construction operations. Yeh and Associates recommendations for excavation support are provided for the Client's sole use in planning the project, and in no way do they relieve the Contractor of its responsibility to construct, support, and maintain safe slopes. Under no circumstances should the following recommendations be interpreted to mean that Yeh and Associates is assuming responsibility for either construction site safety or the Contractor's activities.

Based on the borings, the overburden silty sand and sandy clay encountered on this site will likely classify as Type C material using OSHA criteria. OSHA requires that unsupported cuts be no steeper than 1.5:1 for Type C soils. In general, we believe that these slope ratios will be temporarily stable under unsaturated conditions. Flattened slopes may be required if excavations extend into the groundwater, or the slopes will be exposed for an extended period of time. Please note that an OSHA-qualified "competent person" must make the actual determination of soil type and allowable sloping in the field.

The soils encountered in the proposed excavations may vary significantly across the site. The preliminary classifications presented above are based solely on the materials encountered in widely spaced exploratory test borings. The contractor should verify that similar conditions exist throughout the proposed area of excavation.

As a safety measure, it is recommended that all vehicles and soil stockpiles be kept a lateral distance equal to at least the depth of the excavation from the crest of the slope. The exposed slope face should be protected against the elements and monitored by the contractor on at least a daily basis.

Dewatering/Shoring

The extent of dewatering necessary to construct foundations will depend on groundwater levels at the time of construction. Groundwater levels may be influenced by irrigation practices in the area and other factors as discussed in *Section 4.4 - Groundwater* of this report.

Excavation/trenching operations may also encounter perched groundwater depending on seasonal moisture levels. Surface and groundwater infiltration may occur during construction, requiring construction dewatering. Utilization of appropriate construction dewatering equipment/systems such as well points, sumps, and trenches, will be the responsibility of the contractor. In addition, trenching into unstable, saturated overburden soils will require temporary shoring, where construction of safe slopes is not feasible. OSHA requirements for excavation in unstable materials should be followed.

Dewatering to a depth of at least 1 foot below the base of excavations is recommended to mitigate the possibility of unstable (pumping) ground during subgrade preparation and placement of fill. For the clay soils encountered in the borings, measures such as pumps and sumps may be sufficient to remove water from excavations. Seams or pockets of granular materials, where encountered, could contribute significantly higher quantities of water to excavations and additional measures may be required to control seepage. The base of excavations should be slightly sloped during construction to promote positive drainage.

Engineered and Structural Fill Requirements

Based on our laboratory test results, the on-site soils may be utilized as on-site engineered fill placed for roadway embankment, provided they are properly moisture conditioned and compacted as per the CDOT Standard Specifications. The on-site soils are moisture sensitive, may be difficult to work with, and will provide poor support for construction vehicles. Approved imported materials meeting requirements of Table 23-1 may be used as soil embankment material.

Table 23-1 Imported Engineered Fill Specifications

Gradation Requirements	
Standard Sieve Size	**Percent Passing**
3 inch	100
No. 200	35 maximum
Plasticity Requirements (Atterberg Limits)	
Liquid Limit	30 maximum
Plasticity Index	15 maximum

CDOT Class 1 Structure Backfill as specified in Table 23-2 is recommended for backfill of the wing walls associated with the proposed bridge over the Grand Valley Canal and the CBC at Lewis Wash.

Table 23-2 Structural Backfill Specifications

Graded Material Size	Percent Passing
2-inch sieve	100
#4 sieve	30 to 100
#50 sieve	10 to 60
#200 sieve	5 to 20
Maximum Liquid Limit of 35 or less Maximum Plasticity Index of 6 or less	

We recommend that a qualified representative of Yeh visit the site during excavation and during placement of the engineered fill to verify the soils exposed in the excavations are consistent with those encountered during our subsurface exploration and that proper foundation subgrade preparation and placement is performed.

All fill placed on this site should be compacted according to the recommendations in *Section*

- *Compaction Requirements*, of this report. It is recommended that a sample of any imported fill material proposed for use on the project be submitted to our office for approval and testing at least three (3) days prior to stockpiling at the site.

Compaction Requirements

Fill materials should be placed in horizontal lift thicknesses that are suitable for the compaction equipment being used but in no case should exceed 8 inches by loose measure. Fill materials should be moisture conditioned and compacted in accordance with the CDOT Standard Specifications as summarized in Table 23-3.

Table 23-3 Compaction Requirements

Fill Location	Material Type	Percent Compaction	Moisture Content
Roadway, Embankment	Engineered Fill A-1, A-2-4, A-2-5, and A-3 soils (on-site or imported soils)	95 minimum (AASHTO T 180)*	± 2 % of optimum
	Engineered Fill Soil types other than those above (on-site or imported soils)	95 minimum (AASHTO T 99)*	± 2 % of optimum
Wing Walls	CDOT Class 1 Structure Backfill	95 minimum (AASHTO T 180)*	± 2 % of optimum
Aggregate Base (ABC) for Roadway or CBC Foundation	Class 6 ABC	95 minimum (AASHTO T 180)	± 2 % of optimum

* Modified by CP 23

Cut and Fill Slopes

Permanent un-retained cut and fill slopes in the project area should not be steeper than 3H:1V (horizontal: vertical). As applicable, embankment placed on existing slopes should be benched in accordance with the CDOT Standard Specifications. Benching of slopes during construction may be required. Benches should be wide enough to accommodate compaction and earth moving equipment and to allow placement of horizontal lifts of fill material.

The risk of slope instability will be increased if seepage is encountered in cuts and fills. Saturation or near saturation of the slopes may result in slope failure, even if the slopes are constructed to the recommended configurations. If seepage is encountered in permanent excavations, an investigation should be conducted to determine if the seepage will adversely affect the stability of the slope. Additional drainage elements such as strip drains, piped outlets, and/or horizontal drains may be necessary to contain the seepage.

Positive surface drainage should be provided around all permanent cuts and fills to direct surface runoff away from the slope faces. Fill slopes, cut slopes, and other stripped areas should be protected from erosion by re-vegetation or other methods of stabilization.

Drainage Considerations

Positive drainage should be provided during construction and maintained throughout the life of the project. Proper design of drainage should include prevention of ponding water on or immediately adjacent to the structures. We recommend the ground surface surrounding structures be sloped to drain away from the structures. Surface features that could retain water in areas adjacent to the structures should be sealed or eliminated. Backfill against any kind of structure and in utility line trenches should be well compacted and free of construction debris to reduce the possibility of moisture infiltration and migration. Concentrated runoff should be avoided in areas susceptible to erosion and slope instability. Slopes and other stripped areas should be protected against erosion by re-vegetation or other methods.

Construction in Cold Weather

Fill placed to raise grade in non-structural areas, structure backfill or other fill should not be placed on frosted or frozen ground, nor should frozen material be placed as fill. Frozen ground should be allowed to thaw or be completely removed prior to placement of fill. Additionally, foundations or other concrete elements should not be constructed on frozen soil. Frozen soil should be completely removed from beneath the concrete elements, or thawed, scarified, and re-compacted. The amount of time passing between excavation or subgrade preparation and placing concrete should be minimized during freezing conditions to prevent the prepared soils from freezing. Blankets, soil cover, or ground heaters may be required to help protect subgrade soils.

Continuation of Services

The geotechnical professional should continue to provide services though the completion of the design, evaluate the subsurface conditions at site through construction, and observe that the work being performed and subsurface conditions encountered are consistent with the recommendations of this report.

Plan Review

Yeh should be provided the opportunity to review the project plans and specifications as the design progresses to evaluate whether the recommendations of this report have been incorporated into the design, and to provide input to preparation of the geotechnical aspects of the specifications.

Construction Observation

A qualified geotechnical professional should observe grading operations during construction on behalf of the owner to have reasonable certainty that fill placement and compaction is being performed according to the recommendations of this report. Field density testing should be performed to help evaluate the compaction and moisture content of the materials being placed. Fill and aggregates delivered to the site should be sampled and tested for conformance with the gradation and quality requirements in the suggested materials specifications of this report and/or contract documents. The frequency and locations of the tests should be at the discretion of the geotechnical professional. The project specifications should include provisions for the contractor to allow for testing and to provide any shoring, ingress-egress, or traffic control needed to safely perform the testing at the locations and depths needed.

Limitations

The findings and recommendations presented in this report are based upon data obtained from borings, field observations, laboratory testing, our understanding of proposed construction, and other sources of information referenced in this report. It is possible that subsurface conditions may vary between or beyond the boring locations explored. The nature and extent of such variations may not become evident until construction. If during construction conditions appear to be different from those described herein, Yeh should be advised and provided the opportunity to observe and evaluate those conditions and provide additional recommendations, as necessary. Yeh should also be contacted if the scope of construction changes from that generally described within this report. The conclusions and recommendations contained in this report shall not be considered valid unless Yeh reviews all proposed construction changes and either verifies or modifies the conclusions of this report in writing.

This report was prepared in substantial accordance with the generally accepted standards of practice for geotechnical engineering as exist in the site area at the time of our investigation. No warranties, expressed or implied, are intended or made.

Section 11 – Canal Hydraulics

Hydraulic Report Canal

Project Description

The Orchard Avenue Corridor Study aims to develop a safe and beneficial multimodal corridor for all users along E ½ Road (Orchard Avenue) from 29 ½ Road to Warrior Way. Working with Mesa County, the local community, and other stakeholders, the project team has identified opportunities and constraints, analyzed the benefits and drawbacks of various options for the corridor, and developed several design alternatives. Finally, the team helped select a preferred design alternative that best balances the study's goals with stakeholder input to provide the County and local residents with an improved corridor. The preferred design alternative for E ½ Road has been advanced to a preliminary planning level, or a level of refinement that provides a high degree of certainty for all elements of the final design for Orchard. Subsequent phases of design will be initiated following the completion of this initial study.

This corridor study includes alternatives for two existing bridges along the corridor, one which crosses the Grand Valley Irrigation Canal, and one which crosses Lewis Wash. The following report by Applegate Group Inc. details the structure selection process for the bridge crossing at the Grand Valley Irrigation Canal, Structure MESA-E.5-29.8 The Existing roadway bridge is a reinforced concrete box culvert constructed in 1995 and currently is not restricted to any traffic. Though this bridge is structurally sufficient, a replacement structure would be required to accommodate the preferred section along this segment of the multimodal corridor and to improve the channel profile along the canal.

Purpose of the Report

This report is intended to develop guidelines that should be addressed in the subsequent phases of design and make recommendations based on the available information. This report is based on the results of the preliminary level investigation of the existing conditions of the subject structure, including information obtained in the survey, geotechnical investigation, hydrology and hydraulics, existing utilities, and environmental investigations. The study identifies possible structure alternatives based on the site and its potential design constraints.

Structure Selection Process

The following criteria for comparing and evaluating the structural alternatives is discussed below and should need to be considered during design-build processes:

- Hydraulic Opening Requirements
- Roadway Alignments
- Right-of-Way Impacts
- Constructability
- Construction Costs
- Maintenance Requirements
- Durability Considerations
- Multimodal Transit suitability
- Traffic Control Requirement

Structure Recommendations

Based on the subsequent discussion, the recommended proposed structure is a single span precast, prestressed AASHTO Slab Beam bridge. It consists of Type SIII-36 and SIII-48 sections utilizing the preferred 46-foot roadway cross-setion. The width of proposed construction must accommodate a 12-foot multi-use path, 1.5-foot bridge rails, standard 2-foot curb and gutters, 11-foot west and eastbound travel lanes, and a 5-foot sidewalk. The proposed length is 52-feet. Wingwalls would be required on four corners to retain the roadway fill and accommodate the Grand Valley Irrigation Canal.

The contractor may select a different structure type based on their investigation, meeting the criteria described in this report.

The Engineers

Applegate Group Inc (Applegate) is a water resource engineering firm focused on raw water solutions for municipalities, ditch companies, irrigators and other entities. Applegate's expertise lies in water planning, water rights engineering, water policy, and development of water infrastructure to assist our clients with a reliable supply of water . Applegate has consulted the Grand Valley Irrigation Company (GVIC) with shotcrete lining and infrastructure projects for their canals since 2008.

As part of Collins Engineers Inc. (Collins) Orchard Avenue Corridor Study Project team, hydraulic modeling expertise of the Grand Valley Canal in the vicinity of Orchard Ave was needed to evaluate alternative options for a new bridge across the canal. Applegate's extensive experience in both modeling hydraulics and working directly with GVIC for over 12 years made them the most qualified candidate for the analysis.

Canal Overview

GVIC is a privately owned, non-profit, mutually funded irrigation company that serves approximately 34,000 irrigated acreages across the Greater Grand Junction Area from Palisade to Loma. Water is diverted from the Colorado River near Palisade with 1882 and 1914 absolute water rights with a decree that totals 640 cubic feet per second (cfs). GVIC owns and operates a system of canals with a total combined length of nearly 100 miles. Their system is comprised of the Upper Mainline Canal, Mainline Canal, Highline Canal, Mesa County Ditch, Independent Ranchman's Ditch, and Kiefer Extension. The canal system is mostly earthen canal, but portions of the system are shotcrete lined or piped. The Upper Mainline canal is the focus of this report which is comprised of mostly earthen canal with some shotcrete lined sections that are up to 45 feet wide and 6 feet deep.

The U.S. Bureau of Reclamation Colorado River Basin Salinity Control Program has been funding projects that reduce salt loading in the Colorado River Basin for decades. The Grand Valley has major irrigation infrastructure with large amounts of salts in the soils, so both government owned/operated and private canals and ditches in the area have obtained funding to line their systems with shotcrete over the last 10-15 years. GVIC in particularly has lined almost 10 miles of canal with shotcrete. The Bureau's specifications require a layer of plastic water barrier underneath the shotcrete as well as watertight interfaces with any other structures such as bridges and turnouts.

Explanation of Terms

For the sake of this report, pertinent terms are defined below:

- **Bridge Span:** The length along the longitudinal axis the bridge between two supports. The span is parallel to direction of vehicle travel.
- **Bridge Width:** The total width of all lanes and shoulders on the bridge. The width is perpendicular to the direction of vehicle travel.
- **Hydraulic Opening:** The total distance between bridge abutments. The opening is perpendicular to the direction of water flow.
- **Hydraulic Height:** The total distance between the canal invert and low chord of the bridge.
- **Hydraulic Width:** The distance along the longitudinal axis of the canal under the bridge. The hydraulic width is parallel to the direction of water flow.
- **Straight grade:** Maintain a consistent slope or grade in the canal invert, achieving a relatively evenly sloped water surface in the canal.

Site Description

Orchard Avenue crosses the Upper Mainline canal between 30 Road and 29 ½ Road. The canal in this reach is lined with shotcrete that has a trapezoidal section with average bottom widths 40-foot, side slopes of 1.5:1 and is generally 6-foot deep. The canal was lined with shotcrete in 2017, tying into but not modifying the bridge under Orchard Ave. The bridge has concrete floors and walls in generally good condition along with a central pier of 1 foot width that runs the entire length of the bridge. The western side of the pier contains stop log slots which can be utilized by GVIC to check up water in the canal. Trash and debris flowing in the canal tend to collect on the pier which is an operational concern for GVIC as demonstrated in Figure 53, below. There is also a headgate turnout just upstream of the bridge on the south side of the canal also highlighted in Figure 53, below.

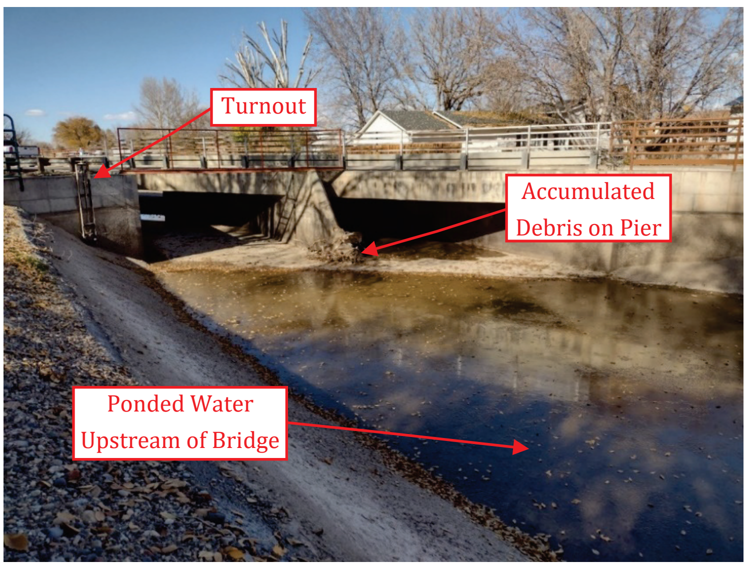


Figure 65: Existing Orchard Avenue Bridge Opening over Canal

The invert of the concrete floor under the bridge is several inches higher than the canal upstream of the bridge. This elevated profile causes water to pond locally just upstream of the bridge after the canal is shut off which is demonstrated in the following figure. The grade of the canal invert rises about five inches over about 100 feet to the bridge, rises another two inches through the bridge, and slopes down at a grade of 0.7% for 100 feet after the bridge. Otherwise, the canal invert profile is graded at 0.02% in this reach.

Perforated pipe set in a gravel envelope underneath the north toe of the canal are within the vicinity of the Orchard Avenue Bridge. These function as an underdrain to prevent floatation of the liner system when the canal is drained. Underdrains in the vicinity of Orchard Avenue Bridge are shown in **Figure 54**, below which was clipped from the As-Built Plans for the project.

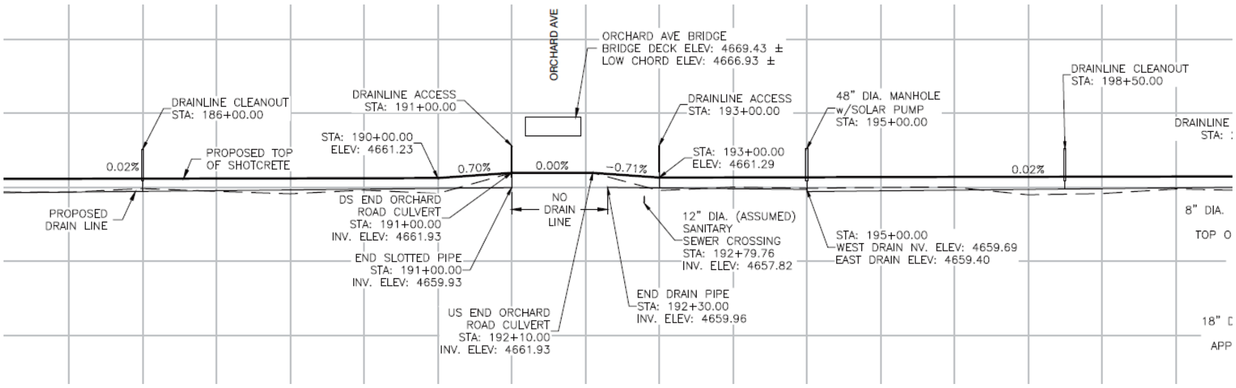


Figure 66: Clip from GVIC Salinity Lining Plan

Set Showing Drain Lines in Vicinity of Orchard Avenue Bridge

Design Criteria and Considerations

On August 10th, 2021, the project team met with representatives from GVIC and Mesa County to discuss design criteria and survey requirements for the Orchard Ave bridge over the Grand Valley Canal. The meeting helped establish what outcomes were essential versus those that were preferred but optional. Design criteria (essential) and considerations (optional) the design of Orchard Avenue as it pertains to impacted GVIC canal infrastructure are summarized below:

Existing Structure

The existing MESA-E.5-29.8 structure is a two-cell cast-in-place concrete box culvert with openings measuring 14-feet wide x 5-feet high. It was built in 1995 at Mile Post 29.8, approximately 0.2-miles west of 30 Road Intersection. The structure is skewed 60-degrees. The existing culvert has four concrete wingwalls, one at each corner, varying from 23 feet to 46.2 feet long. Table 24 below summarizes bridge information:

Table 24: Bridge MESA-E.5-29.8 Summary Information

NBI Reporting ID	MESA-E.5-29.8
Year Built	1995
Construction Type	Two-cell Concrete Box Culvert, (2) 14’-0”x 5’-0”
Condition Rating	Good
Load Restricted	No
Bridge Length	58’-8”
Bridge Width	39’-9”
Number of Spans	2
Feature Intersected	Grand Valley Irrigation Canal
ADT	467
Percent Commercial Traffic	7.0%

The Grand Valley Irrigation Canal flows from southeast to northwest and crosses County Road E ½ at a 60-degree skew.

The replacement of MESA-E.5-29.8 is warranted due to the current structure’s inability to carry the multimodal traffic investigated in the Orchard Avenue Corridor Study as well as the preference from the results of the Canal Hydraulic Study Report to remove the middle pier and design the canal invert at this crossing to be “straight-graded.” The replacement of the bridge would bring a consistent roadway cross section to the corridor and a desirable upgrade to the canal crossing below.

Design Criteria

- Design flow shall be 585 cubic feet per second
- Bridge shall pass design flow with 1 foot of minimum freeboard below low chord of bridge to pass debris. No siphon condition through bridge without maintenance agreement from Mesa County
- Existing water surface elevations in canal shall not be raised
- Existing water surface elevations in canal shall not be lowered to a point that would impact existing users
- Function of turnouts must be maintained; turnouts can be relocated but must tie into existing manhole locations
- Maintain liner seal between canal liner and bridge infrastructure
- Maintain function of canal drain line and cleanouts
- Maintain access for GVIC staff to maintain canal via access roads (i.e. curbs, gates, etc.)
- Bridge shall incorporate guard rails to prevent vehicles, pedestrians, bikers, etc. from crashing into or entering canal

Design Considerations

- Prefer to maintain checking ability but not essential. GVIC can entertain design options that don't incorporate checking ability at Orchard Ave Bridge as is the existing configuration.
- Prefer to eliminate raised canal invert through bridge to provide positive drainage from upstream to downstream end. Existing canal invert through Orchard Ave bridge is raised which prevents canal from completely draining without pumps during seasonal shut off.
- Design alternatives should facilities flow of debris through bridge section. Eliminate pier in canal if possible.
- Design alternative should improve hydraulics through bridge. Approach section should be shaped to provide improved hydraulic efficiency. Exit section should provide smooth transition to canal section.

Data Collection

Flow data and survey points were needed for hydraulic analysis of the Orchard Avenue bridge crossing the Upper Mainline Canal. Accurate representations of existing flow and geometry conditions are necessary to establish existing hydraulic conditions and potential impacts to canal operation from bridge alternative options.

Flow Measuring

Applegate measured the flow of the Upper Mainline Canal at 31 Road on August 11, 2021, according to stream gaging procedures recommended in the USBR's Water Measurement Manual. Ideally, canal flow would be measured directly at the Orchard Avenue Bridge but safety concerns from vehicle traffic and equipment limitations made measurement their unfeasible. The 31 Rd bridge, which is approximately 1.3 miles upstream from the Orchard Avenue Bridge, was selected as a measurement location due to light vehicular traffic and favorable canal flow conditions conducive to measuring flow with stream gaging equipment.

The Area-Velocity stream gaging method was performed which entailed measuring depths and velocities across a canal section perpendicular to the direction of flow. A Marsh-McBirney Flo-MateTM Electromagnetic Flow Meter affixed to a wading rod was utilized to collect velocity and depth measurements across the canal section at the 31 Road Bridge. Two velocity measurements at 20% and 80% of the depth from the water surface were collected at each measurement location and averaged together to determine the mean velocity; this is commonly referred to as the Two-Point Method which is recommended to determine accurate mean velocities for water depths greater than 2 feet. Discharge was computed according to the Mid-Section Method resulting in a flow rate of 569.3 cubic feet per second (cfs) in the canal at the 31 Rd Bridge, see table in Appendix D1 for a tabulation of measurements and discharge calculations.

GVIC provided turnout data for flows taken by water users between 31 Rd and the Orchard Ave bridge, totaling 14.3 cfs (see Appendix D2). The flow rate estimated at the Orchard Ave Bridge on the day of the survey was determined to be 555 cfs.

Canal Survey

KAART surveyed the Orchard Avenue corridor from Central High School to just past 29 ½ Rd in September of 2021. Applegate requested specific data points to be gathered along the canal from 30 Rd, around the Orchard Avenue bridge and down to 29 ½ Rd. Since the canal was operating during the survey, water surface elevations (WSE) were collected through the reach of interest while inverts of the canal were only collected at the bridges where feasible. The top of shotcrete and top of bank elevations were taken at an approximately 200-foot interval along the entire project reach. Multiple shots of the Orchard Ave bridge were taken as well.

It is worth noting the lack of freeboard between the water surface and low chord of the bridge during the time of the survey at an estimated flow of 555 cfs. There was a difference of less than 4 inches between the water surface level just before the bridge and the low chord as shown in **Figure 55**, below. The lack of freeboard is also visible when the canal is shut off as the high-water line is within an inch of the low chord as shown in **Figure 56**, below.

Figure 67: Existing Freeboard

Observed at Orchard Avenue Bridge in September 2021

Figure 68: Existing High Water

Observed at Downstream End of Orchard Avenue Bridge

Hydraulic Evaluation

HEC-RAS is a U.S. Army Corps of Engineers hydraulic modeling software was used to perform flow analysis and computations for this study. Applegate has extensive experience using this powerful tool to model hydraulics of irrigation systems with excellent results often corroborated in the field. Applegate has developed a 1-dimensional HEC-RAS model encompassing a reach of the Upper Mainline Canal from 31 Road to Patterson Road near the St Mary's Medical Center where the canal then splits into the Highline Canal, Independent Ranchman's Ditch, and Mainline Canal. The model was developed to assist with the design of various USBR Salinity Lining Projects and has been further refined to incorporate on-site revisions during construction of these projects ending in 2018. This model was utilized to analyze existing conditions and proposed bridge alternatives for the Orchard Avenue Corridor study.

HEC-RAS Model Calibration

A full as-built survey had not been conducted on the aforementioned canal reach and as such the model was updated and calibrated to represent observed conditions.

The HEC-RAS model for the project reach was first updated based on survey points collected by KAART as described above. Inverts at the bridges for Orchard Ave, 30 Road and 29 ½ Road and the top of shotcrete elevations were adjusted in the model to reflect the survey. The surveyed hydraulic opening and low chord were represented at the Orchard Avenue bridge element in the model. Flows determined by water measurement and turnout data as described above were also incorporated into the model.

For the purposes of this analysis, the model was considered calibrated when modeled WSE matched the surveyed WSE within ±0.1 feet of tolerance. Since the geometry and flow rate were physically measured, factors such as contraction and expansion coefficients through the bridge and the Manning's roughness number (n) of the canal or bridge section were adjusted to calibrate the model. The contraction and expansion coefficients account for the head losses that occur as water travels through the bridge while the Manning's 'n' number accounts for the friction losses that are a function of the canal surface roughness. Typically, smooth concrete has a Manning's 'n' value of 0.014 and shotcrete typical on the GVIC canal has a Manning's n Value of 0.017 which were incorporated into the model. Applegate has corroborated a Manning's 'n' value for shotcrete of 0.017 from calibration efforts on past projects. The coefficients for expansion and contraction were set to 0.3 and 0.1 respectively, which are typical for models of this nature.

The HEC-RAS model was run with updated geometry and flows and the resulting WSEs were compared to the observed WSEs from the survey. The model appeared to accurately represent the surveyed WSE utilizing the model parameters described above. The close match of WSE between the model and the survey are demonstrated in **Figure 57** below.

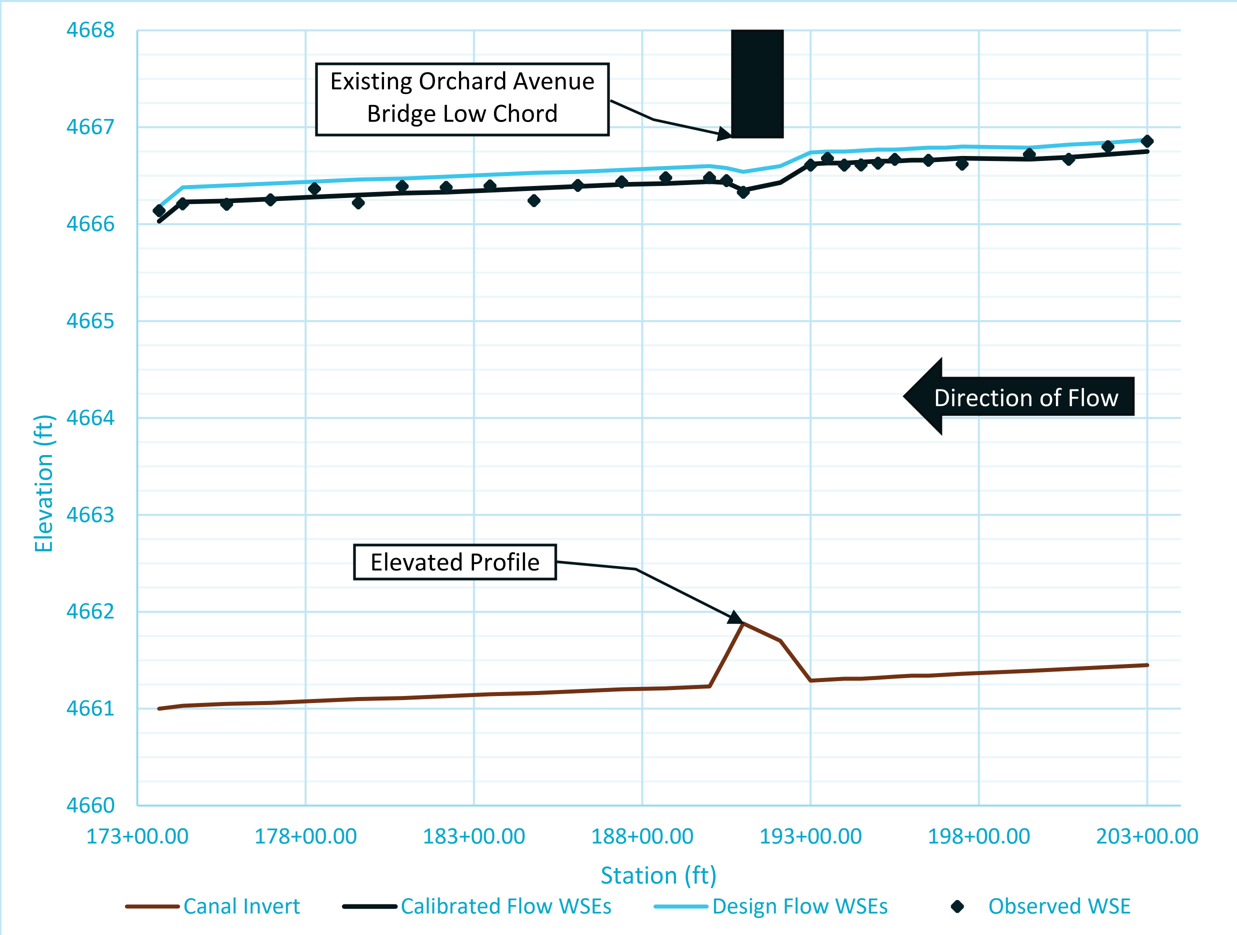


Figure 69: Calibrated Model Results

Existing Conditions Model

The design flows of 585 cfs was applied to the calibrated model to establish existing conditions in the canal and through the Orchard Avenue bridge. **Figure 57** above compares the flow rate measured during calibration to the higher design flow. Essentially, the additional 30cfs in the canal results in a 2-inch increase of WSEs throughout the model. The existing conditions model served as the basis for developing and evaluating bridge design alternatives described in the following section.

Design Alternatives

Critical design criteria for developing bridge alternates at this phase of design included the freeboard requirement and minimizing impacts to existing WSEs. Alternative bridge designs are required to pass the design flow with at least 1 foot of freeboard. This freeboard requirement is typical for open irrigation canals to pass debris through bridges.

Alternative bridge designs developed for this study must also consider impact to WSE in the canal. Lowering existing WSEs decreases hydraulic head available to turnouts within the canal which would impact their operation. Raising WSEs would decrease existing freeboard in the canal thus increasing the risk of the canal being overtopped and flooding residents adjacent to the canal which is unacceptable. Alternative bridge designs were developed to result in no increase of WSEs and minimize lowering of WSEs in the canal for these reasons except locally through the bridge.

GVIC expressed interest in removing the pier and elevated profile section under the bridge during the initial design coordination meeting. These changes to the bridge from the existing configuration would affect the hydraulics and thus the required bridge spans to meet design criteria. Four alternatives were developed and evaluated for the Orchard Avenue bridge which focused on various combinations of keeping and/or removing the elevated profile and pier through the bridge.

Please note that when the canal was lined with shotcrete years ago, the canal was locally graded to the elevated profile about 100-foot upstream and downstream, interrupting the normal 0.02% grade of the canal. If the elevated profile were removed, the canal would have to be straight graded for about 300-foot total and the shotcrete would need to be removed and replaced at a lower elevation for 100-foot both upstream and downstream of the bridge in order to drain properly. This would add considerable costs associated with removing and replacing shotcrete sections to remove the elevated profile that would need to be considered along with bridge costs in choosing an alternative.

Hydraulic openings for alternative designs were adjusted to result in the smallest bridge span while satisfying the critical design criteria described above. Hydraulic widths for all design alternatives were developed to resulted in no change in canal WSEs as generated from the existing conditions model which was the most limiting design criteria. Essentially this equated to maintaining a WSE of 4666.8 ±0.05 feet at the cross section 100-feet upstream of the bridge prior to the approach section for all design alternatives. Once this criteria was met, the low chord was established by applying the 1 foot freeboard requirement to the modeled WSE just upstream of the bridge. These critical design points are demonstrated in the following figure which is clipped directly from the HEC-RAS model.

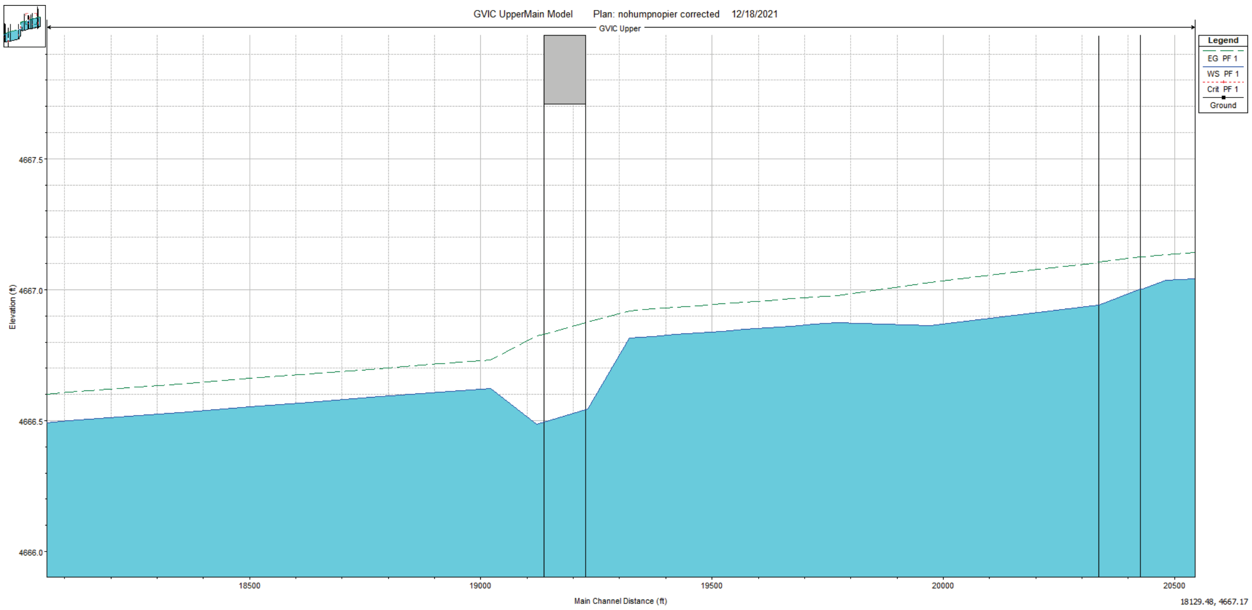


Figure 70: Critical Design Points from HEC-RAS Model

Hydraulic openings for alternative designs were adjusted to result in the smallest bridge span while satisfying the critical design criteria described above. Hydraulic widths for all design alternatives were developed to resulted in no change in canal WSEs as generated from the existing conditions model which was the most limiting design criteria. Essentially this equated to maintaining a WSE of 4666.8 ±0.05 feet at the cross section 100-feet upstream of the bridge prior to the approach section for all design alternatives. Once this criteria was met, the low chord was established by applying the 1 foot freeboard requirement to the modeled WSE just upstream of the bridge. These critical design points are demonstrated in the following figure which is clipped directly from the HEC-RAS model.

Bridge abutments for alternative designs maintained existing flow lines in the canal resulting in an angle of 60.88° between the hydraulic opening and the bridge span. Please note that for every foot that the hydraulic opening shrinks, the span will lessen by about 2 feet when account for that angle. The bridge width for alternative designs was assumed to be 45 feet based on a street section provided by the project team for all design alternatives. Design alternatives also assumed the canal section would gradually transition to the bridge section gradually over 100 linear feet upstream and downstream of the bridge to create hydraulicly efficient approach and exist section.

Alternative designs were developed and evaluated by modifying the HEC-RAS model to represent proposed conditions. The following design alternatives considered for Orchard Avenue bridge are described below:

Alternative 1 – Bridge with Elevation Profile and Pier

This design alternative considers a bridge where the elevated profile and pier are to remain. This is essentially the existing condition, but the low chord of the bridge is raised to achieve 1-foot of freeboard. This results in a hydraulic opening of 29 feet which equates to a bridge span of 59 feet in the direction of vehicle travel. This correlates closely to the existing hydraulic width and bridge span according to the survey.

Alternative 2 – Bridge with Elevated Profile and No Pier

This design alternative retains the elevated profile but assumes no pier in the canal flow area. This results in a hydraulic opening of 26 feet which equates to a bridge span of 53 feet in the direction of vehicle travel.

Alternative 3 – Bridge with Straight Graded Profile and Pier

This design alternative assumes that the elevated profile through the bridge would be removed and "straight graded" through the bridge and the bridge would have a pier in the middle of the hydraulic opening. This would achieve the drainage of water through the bridge. This results in a hydraulic opening of 26 feet which equates to a bridge span of 53 feet in the direction of vehicle travel.

Alternative 4 – Bridge with Straight Graded Profile and No Pier

This alternative also assumes the elevated profile is removed and the canal invert profile is "straight graded" through the bridge. A pier was not included in the canal for this alternative. This results in a hydraulic opening of 24 feet which equates to a bridge span of 49 feet in the direction of vehicle travel.

Results and Discussion

The resulting hydraulic widths, hydraulic heights and bridge spans from each proposed alternative are summarized in the following table:

Table 25. Bridge Design Alternative Summary

Bridge Design Alternative	Low Chord Elevation (ft)	Hydraulic Width (ft)	Bridge Span (ft)	Hydraulic Height (ft)
1.) Elevated Profile with Pier	4667.60	29	59	6
2.) Elevated Profile without Pier	4667.54	26	53	6
3.) Straight Grade Profile with Pier	4667.58	26	53	6.44
4.) Straight Grade Profile without Pier	4667.54	24	49	6.44

Interestingly, the analysis shows that the elevated profile and the pier have the same effect on the required hydraulic width for design alternatives when applied independently. This is evident as the required hydraulic width to meet design criteria for Alternative 2 and 3 are identical at 26 feet resulting in a bridge of 53 feet.

The analysis also shows that design alternatives which include a pier result in slightly higher low chords than alternatives without piers albeit minimally. Maintaining or removing the elevated profile through the bridge also had a very minimal impact on hydraulics and the difference between alternatives appears to be mostly driven by the pier.

Please note that modeled canal flows for all design alternatives are mostly subcritical due to flat grades in the canal, meaning that flow hydraulics are controlled by conditions downstream. Although the proposed bridge openings have some impact, canal hydraulics are mostly controlled by downstream canal geometry and energy losses from other bridges downstream.

A brief sensitivity analysis was performed within the model to explore how varying the hydraulic width could impact upstream WSEs in the canal. The sensitivity analysis indicated that WSEs changed by only hundredth of a foot for every 1-foot that the hydraulic opening is widened. If the bridge abutments were completely eliminated, the furthest the water surface could drop would be WSE 4666.61, or one tenth from the current calibrated water surface, even if the bridge abutments were completely eliminated. This proved true even for design alternatives that maintained the elevated profile through the bridge. This reiterates that the hydraulic dynamics are dominated by conditions downstream and that Increasing the hydraulic width of bridge openings beyond the dimensions of the canal would result in negligible reduction to upstream WSEs in the canal.

Velocities increase and the flow depth reduces as flows contract through the bridge impinges but not a point that creates a hydraulic jump. The hydraulic width would need to be narrowed significantly in order to cause a hydraulic jump through the bridge, which is not recommended.

The design alternative and evaluation above was presented to the project team and initial feedback focused on exploring options to reduce the low chord elevation to facilitate drainage and grading associated with the proposed Orchard Avenue alternate corridor sections. Narrowing the hydraulic width of bridge opening beyond what is shown in Table 25 above could result in lower WSEs through the bridge resulting in a lower bridge deck, but this was not pursued as it would create additional headloss and increase WSEs in the canal upstream of the bridge which is unacceptable. The project team also approached GVIC to explore reducing freeboard requirements but again this was not pursued as the benefit of reducing the freeboard and thus bridge deck did not outweigh the risk of debris clogging the bridge opening causing the canal banks to overtop and flood residents in the adjacent neighborhood.

Conclusion

In conclusion, Applegate used HEC-RAS to calibrate a model of the existing Grand Valley Canal hydraulics utilizing flow measurement data and KAART survey points. The calibrated model was then utilized to analyze canal impacts due to various alternative options for the Orchard Avenue bridge crossing the Upper Mainline Canal. The hydraulic opening and corresponding bridge span for each scenario were presented along with a discussion of the hydraulic evaluation.

Applegate Group recommends pursuing Design Alternative 4 for the Orchard Avenue Bridge design as it results in the lowest low chord elevation and bridge span while addressing GVIC design criteria and operating concerns.

Section 12 – Lewis Wash Hydraulics

Wohnrade Civil Engineers

Preliminary Hydraulic Report Lewis Wash

Introduction

Objective

This study documents the results of a preliminary (30%) hydraulic analysis as part of the ORCHARD AVENUE CORRIDOR STUDY for the replacement of the existing culvert crossing at Lewis Wash and Orchard Avenue in Mesa County, Colorado.

The project includes: the removal of an existing 12'-2" W x 12'-8"H cast-in-place concrete culvert with wingwalls (Photo 1); replacing the box culvert with 2- 14'W x 12'H reinforced concrete box culverts with increased flood capacity, and the widening to Orchard Avenue. The roadway

Photo 1 – Upstream End of Existing Culvert Structure at e 1/2 Road

width at the structure will increase from 24.5' to 30' while keeping the new headwalls and wingwalls set back from the edge of road. A 5-foot-wide attached walk will be located on the south side of Orchard Avenue, and a 12-foot-wide detached multi-use path will be located on the north.

As per criteria contained in the Mesa County/City of Grand Junction Stormwater Management Manual (Reference 1), the proposed culvert has been sized to convey the 100- year peak (1% annual chance) discharge of 1,920 cfs with a minimum of 1-foot of freeboard between the 100-year water surface elevation, and the low chord of the structure. The HEC- RAS computer modeling presented herein also serves to demonstrate "no-rise" in the 100-year flood elevation, as compared to the existing conditions model prepared as part of a 2012 study prepared by Matrix Design Group.

Orchard Avenue is classified as a Rural Collector/Urban Major Collector with an existing 75-foot right-of-way in the vicinity of Lewis Wash. Additional right-of-way dedication is not anticipated at this time.

Mapping and Surveying

CR Surveying of Grand Junction, Colorado, provided field survey information and topographic mapping of the project site, with a contour interval of 1-foot. The survey was performed between September and November 2021 and was referenced to a 3 1/4" Alloy Cap in a monument box at the road intersection of 30 and E 1/2. The elevation is 4672.02 and corresponds with Mesa County Local Coordinate System. The Basis of Bearings is from the West 1/4 of Section 9 and the Center West 1/16 corner of Section 9 this bearing is S89°57'46"E.

Previous Studies

There are five known hydrologic and/or hydraulic studies related to Lewis Wash that precede this report. Previous studies were obtained from Carrie Gudorf at the Mesa County Public Works-Engineering Department on September 1, 2021.

Previous studies include:

1. Drainage Report for Lewis Wash prepared by Boyle Engineering (Reference 1)
2. 2007 Master Plan for Lewis Wash prepared by URS (Reference 2)
3. Floodplain Information Report, Lewis Wash, prepared by Matrix Design Group (Reference 3)
4. Lewis Wash Floodplain Study D ½ Road to E Road, Hydraulic Study Report, prepared by Matrix Design Group (Reference 4)
5. Letter of Map Revision, Lewis Wash, D1/2 Road to E Road, prepared by Matrix Design Group, (Reference 5)

A Letter of Map Revision (LOMR) was obtained by Mesa County on May 30, 2013 (See Exhibit 1). The LOMR included the reach of Lewis Wash from approximately 600-feet downstream of D ½ Road to approximately 30-feet downstream of E Road and reflected the D Road culvert replacement and Lewis Wash channel improvement designs prepared by Matrix Design Group and SGM Engineering. Peak 10, 50, 100, and 500-year discharges used in the 2013 LOMR were taken from the 2008 Floodplain Information Report, which references the 2004 Boyle Engineering hydrology (See Exhibit 3).

Project Location and Description

Project Location

The Lewis Wash and Orchard Avenue culvert crossing is in the Southwest ¼ of the Northwest ¼ of Section 10, Township 1 South, Range 1 East, of the Ute Meridian, Mesa County, Colorado. The culvert crossing is within the city limits of Grand Junction and is approximately 0.25-miles west of Central High School (See Vicinity Map).

The Lewis Wash culvert crossing is in a residential area with adjacent to open space and an undeveloped property to the north. Property immediately adjacent to the crossing is owned by Mesa County.

Project Description

The Orchard Avenue Corridor Study extends from 29 ½ Road on the west to Central High School on the east for a total distance of approximately 1.75-miles. The purpose of the project is to develop a corridor study, which includes 30% design development documents for future multi-modal improvements along the road corridor.

There are no known irrigation ditches in the vicinity of the culvert crossing.

Photo 2 – Orchard Avenue – Looking West at Upstream End of Existing CBC

Existing Culvert

The existing culvert crossing at Lewis Wash and Orchard Avenue is a cast-in-place concrete box culvert with a width of 12’-2” and a height of approximately 12’-8” and conveys flows in Lewis Wash from north to south under Orchard Avenue. The structure has no elements that would give it historic significance. The existing culvert is approximately 33-feet in length with an orientation that is perpendicular to Orchard Avenue. The ultimate receiving water for Lewis Wash is the Colorado River, which is located approximately 1.8 miles to the south.

Lewis Wash is a low-gradient stream with an average channel slope of 1.76%, and a slope of approximately 0.67% through the existing culvert structure. Channel elevations at the upstream and downstream ends of the culvert structure are 4674.83 and 4674.59 respectively. The culvert structure contains concrete headwalls and wingwalls at both the upstream and downstream ends, which are at an angle of roughly 45-degrees to the headwall.

Photo 3 – Lewis Wash

The side slopes along the main channel of Lewis Wash within the study reach vary from approximately 0.8H:1V to 1.4H:1V and the channel is heavily vegetated (See Photo 3).

Two existing storm sewers discharge into Lewis Wash at the upstream end of the existing concrete box culvert. Storm sewers enter from both the east and west, conveying stormwater runoff from adjacent developments. The peak 100-year discharge from these sewers would have been accounted for in the 2004 Boyle Engineering Report (Reference 1).

Methods

Historic Property Identification

This cultural resource survey provides compliance under Section 106 of the National Historic Preservation Act (NHPA) and its implementing regulations under 36 Code of Federal Regulations (CFR) Part 800 by undertaking a "reasonable and good faith effort" to identify historic properties (defined as listed in or eligible for listing in the National Register of Historic Places (NRHP)) within the defined area of potential effect (APE). Identification and documentation standards conform to federal land managing agency requirements and secondly to guidelines provided by the State Historic Preservation Officer (SHPO). In doing so, the standards imposed by the Secretary of the Interior for the Identification, Documentation, and Evaluation of Historic Properties are also met. All personnel supervising survey and documentation are listed in applicable federal and state permits and meet or exceed the Secretary of the Interior's Professional Qualification Standards (36 CFR 61).

Historic properties may consist of buildings, structures, objects, or sites and can include districts, landscapes, and traditional cultural properties. The National Park Service has established an age criterion of 50 years for historic property evaluation and to be listed in the NRHP (but see criteria consideration [g] for an exception to the age guideline); in some instances, a federal agency will establish the age criterion at 45 years to account for the duration of the undertaking.

Cultural resources not identified in the Office of Archaeology and Historic Preservation (OAHP) file search and historical records were identified during pedestrian survey. This project used standard pedestrian survey to identify unknown cultural resources within the APE. The APE is defined by the lead federal agency, generally in consultation with the SHPO, and means "the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character of use of historic properties, if any such properties exist" (36 CFR 800.16).

Cultural Resource Documentation

ERO documents cultural resources according to a standardized approach to ensure consistency and accuracy. Sites are digitally documented from multiple perspectives, and all significant tools, diagnostic artifacts, and features are photographed to scale. The site datum is also photographed if physically established and directed by the land managing agency. Individual site maps are produced using a mapping grade (submeter and subcentimeter capable) Trimble GeoXH Explorer global positioning system (GPS) unit. Elements of the site map include all cultural features, diagnostic and point provenence artifacts (designated as field specimens [FS]), artifact concentrations, major vegetation breaks and contour topography, modern features and disturbances, and the site datum (whether physically established or for location purposes).

All required forms are completed digitally in the field using a tablet. Archaeological resources and newly defined segments of linear resources such as ditches and railroads were documented using a Management Data Form (OAHP1400) and appropriate component form (precontact archaeology, historical archaeology, or linear); the boundaries of newly defined linear resource segments are limited to the extent of the resource within the APE. Newly identified historical buildings and structures were documented on an Architectural Inventory Form (OAHP1403). Previously recorded cultural resources identified during the OAHP file search were revisited and reevaluated on OAHP form 1405; if the resource has not been reevaluated within the last 10 years and/or substantial changes have occurred to the property since the previous evaluation, ERO rerecorded and reevaluated the resource by completing new state documentation forms. Location maps (Appendix E1) and OAHP resource documentation forms are included only for agency consultation and reside permanently with the OAHP.

Historic Period Sites

Historic period sites include such purposeful activities as homestead, ranching or agricultural complexes; mining complexes; federal work programs; timber harvesting; and industry, among other site types. Age criteria is established for potential historic sites by referencing general land office (GLO) patents, county assessor records, state water division records, historical maps, and 15′ U.S. Geological Survey (USGS) maps. Historical dumps and artifact scatters without features are evaluated on a case-by-case basis. A single artifact class within a dump, such as sanitary cans, is recorded as an isolated occurrence; conversely, dumps that exhibit diverse artifact classes and date prior to the early part of the 20th century may be documented as archaeological sites, given their information potential.

Linear structures such as water conveyance systems, transmission lines, trails, and roads are documented as sites. An isolated fence line is generally not recorded as a resource unless it demarcates a boundary significant to the history of the area and can be physically linked with a purposeful activity; an isolated fence line may also be documented as a feature of a larger resource. Depending on their cultural context, single or small clusters of mining prospect pits with no associated artifacts are documented as IFs due to general ubiquity and limited information potential.

Criteria for Evaluation

Documented cultural resources are evaluated for their eligibility to be listed in the NRHP. Significance criteria are codified under 36 CFR 60.4, summarized below:

The quality of significance in American history, architecture, archaeology, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and

a) that are associated with events that have made a significant contribution to the broad patterns of our history [Criterion A]; or

b) that are associated with the lives of persons significant in the past [Criterion B]; or

c) that embody the distinctive characteristics of a type, period, or method of construction, or that represents the work of a master, or that possess high artistic value, or that represent a significant or distinguishable entity whose components may lack individual distinction [Criterion C]; or

d) that have yielded, or are likely to yield, information important in prehistory or history [Criterion D].

Cultural resources that do not meet the 50 -year age criterion but that are integral parts of a historic district or carry exceptional importance to the history of the region are considered for eligibility under criteria consideration (g).

Certain kinds of properties are not usually considered for listing in the NRHP: religious properties, moved properties, birthplaces and graves, cemeteries, reconstructed properties, commemorative properties, and properties achieving significance within the past fifty years" (U.S. Department of the Interior, National Park Service 1997). In order for a property to be eligible under a criteria consideration, the property must qualify for one of the four criteria and must possess integrity. Regional contexts and multi- property nominations are used to evaluate significance under Criteria A, B, and C by defining a period of significance in which the cultural resource achieved significance given events important to the interpretation of history.

Regional contexts identified in the Cultural Overview are used to evaluate significance under Criterion D by determining whether a potential property has the potential to answer defined research questions and/or date to a defined period of significance. Historical sites representative of the built environment (i.e., buildings, structures, and engineered features) typically qualify for listing in the NRHP under at least one of the first three criteria (A –C). Archaeological sites typically qualify exclusively under Criterion D, with notable exceptions. An otherwise heavily disturbed site may still retain information potential from intact features (potential chronometric or subsistence data) or discrete areas of the site that retain physical integrity. Archaeological sites with significant sediment deposition remain potentially eligible for listing in the NRHP even without evaluative testing.

Sites evaluated as "needs data" may be eligible under one or more criteria but require further work to determine NRHP eligibility. Cultural resources recommended "needs data" are predominantly archaeological sites (either precontact or historical) suspected of containing buried cultural deposits or historical sites where additional research is necessary to ascertain significance. Sites that are evaluated as not eligible for listing in the NRHP do not meet any of the eligibility criteria and/or have lost physical integrity. Cultural resources are assessed for integrity only if the site meets one or more eligibility criteria. Eroded or otherwise heavily disturbed archaeological sites are typically not considered eligible since the ability to convey significance in the form of intact cultural deposits (i.e., information potential) has been lost through natural or modern disturbance.

For a property to be eligible under one or more criteria, the property must possess physical integrity and retain most if not all aspects of integrity: location, design, setting, materials, workmanship, feeling, and association. Most important of these for any building or structure are the aspects of location, design, and setting. Any property or linear resource that has been relocated/realigned no longer retains integrity of location, perhaps the most important aspect of integrity. The aspect of design is important for demonstrating a building or structure's association with significant historical trends, and is required for a property to qualify under Criterion A or C. Considering most historical properties are still in use, a resource can maintain integrity of design if materials have been maintained in-kind to the design of the original structure or building; for example, in- kind replacement of materials such as wood siding or railroad hardware with modern materials does not diminish integrity of design. However, modern maintenance and upgrades to earthen ditches such as the placement of modern diversion structures and concrete lining does diminish the ditch segment's ability to support eligibility under Criterion A or C. The aspects of feeling and association are intrinsically linked to the aspect of setting; suburban development and modern intrusions on the setting of a potential historic property diminish its ability to convey significance.

ERO uses the following generalized approach to assess integrity under Criterion D. Most archaeological sites are considered to be in their original location unless post-depositional processes, such as erosion, have transported artifacts away from their original context. Artifacts can move both vertically and horizontally in subsurface contexts. The site retains location if no significant post-depositional processes have altered the primary context of the artifacts. The aspect of design is present if the relationship between features or activity loci is apparent and the spatial organization of the site is discernible; design may also be present in highly formalized tools such as projectile points, ceramic vessels, architectural elements, or individual features. Setting refers to the surrounding physical environment of a site, which may be affected by modern development or changes to the natural environment (such as important biotic species) through climate change or modern development. Setting is considered intact if the surrounding environment is similar to the environment during the time of occupation. The aspect of materials is almost always retained due to the nature of the archaeological record and the material culture inherent to archaeological sites: If there were no physical artifacts or features (i.e., materials) present, there would not be a site. Workmanship is retained by the presence of artifacts, architecture, or features emblematic of a particular culture or people, such as a Puebloan kiva or a Clovis projectile point. The aspect of feeling is difficult to ascertain for archaeological sites and is often dependent on Native American perspective. Very few of the physical features present during occupation of a precontact site still exist in the present to convey a property's character. A site that retains association can be linked to a particular cultural -historical period through the presence of diagnostic artifacts or architectural elements or by chronometric means.

Each documented cultural resource described in the Survey Results section, below, is provided a recommendation of NRHP eligibility and evaluated for project effects. Based on this documentation, the lead agency will provide a determination of eligibility for each documented cultural resource based on ERO's recommendation and will provide a determination of project effect on historic properties. The lead agency will then provide SHPO an opportunity to review and provide comment regarding NRHP eligibility and project effects per 36 CFR 800.4 through 800.5. If, during consultation between the lead agency and SHPO, a determination of "adverse effects to historic properties" occurs, further consultation is required to resolve adverse effects.

Design Criteria

Design References

Drainage design criteria specified in the Mesa County/City of Grand Junction Stormwater Management Manual (Reference 6) and the Urban Storm Drainage Criteria Manual, Volumes 1-3 by the Urban Drainage and Flood Control District (Reference 7) have been referenced in the preparation of this study.

Section 1206 of the Mesa County/City of Grand Junction Stormwater Management Manual has been referenced in the design of the proposed culvert using a 100-year peak design discharge of 1,920 cfs, as per the 2004 Boyle Engineering report.

Hydraulics Models

The HEC-RAS computer model, Version 5.0.7, March 2019, created by the Army Corp of Engineers, has been used to develop the 10, 50, 100, and 500-year hydraulic grade lines for both existing and proposed project conditions.

In addition, the computer model GeoHECRAS V 3.0.0.504 (developed by CivilGeo) was used to delineate the 100-year flood boundary for both existing and proposed conditions.

Design Hydrology

Peak Design Discharges

Peak design discharges used for this hydraulic analysis for Lewis Wash are based on the 2012 LOMR model prepared by Matrix Design Group, which references the 2004 Boyle Engineering report.

The design discharges derived from the LOMR model prepared by Matrix Design Group are summarized in Table 26-1 below.

Culvert Designation	10-Year	50-Year	100-Year	500-Year
LEWIS WASH		1126 2899	1510	1920

Table 26-1: Peak Design Discharges at Orchard Avenue (HEC-RAS Bridge Section 32)

Proposed Project Local Drainage Basins

Proposed project local drainage basins have not been delineated as part of this hydraulic analysis. Peak design discharges are not required for the sizing of proposed drainage improvements such as storm inlets and culverts located adjacent to Lewis Wash.

Hydraulic Modeling

HEC-RAS Modeling

The computer model HEC-RAS, Version 5.0.7., March 2019 has been utilized to generate the 10, 50, 100, and 500-year hydraulic profiles for both existing and proposed conditions for the Lewis Wash box culvert. A floodway model was not prepared for this project since the Proposed Project 100-year base flood elevation is contained entirely within the main channel along the study reach.

Wohnrade Civil Engineers, Inc. prepared two hydraulic models to evaluate the 100-year storm event, which include Existing Conditions and Proposed Project models. These models were developed using a recent topographic survey prepared by CR Surveying during the Fall of 2021.

The basis for the Existing Conditions and Proposed Project models is the HEC-RAS model prepared by Matrix Design Group entitled DivStRun22.prj, which was provided by Carrie Gudorf at the Mesa County Public Works-Engineering Department. This model was supplemented with improved field topographic survey provided by CR Surveying.

The HEC-RAS study reach is in the immediate vicinity of the culvert crossing and begins roughly 75-feet downstream of Orchard Avenue and ends roughly 65-feet upstream of Orchard Avenue for a total length of approximately 252-feet. The study reach is relatively short, due to the narrow top width of the 100-year flow, and minimal contraction at the culvert structure.

Cross-section data for the HEC-RAS analysis was generated from field topographic survey provided by CR Surveying. Channel cross sections along the study reach generally range from 113-feet to 2,813-feet in length. The culvert cross-section at the intersection of Orchard Avenue and Lewis Wash is roughly 107-feet, as measured along the roadway centerline.

Manning's roughness coefficients used in the existing and proposed conditions HEC-RAS models were taken from the HEC-RAS model prepared by Matrix Design Group as part of the Letter of Map Revision (LOMR). Roughness coefficients in the vicinity of the culvert crossing at Orchard Avenue vary from 0.050 in the overbanks to 0.075 in the main channel. The high Manning's n value in the main channel can be attributed to several pipe utility crossings (on the upstream side) and large cottonwood trees.

The HEC-RAS study reach is situated along a fairly low-gradient stream with an average channel slope of 1.76%, and a slope of approximately 0.74% through the existing culvert structure.

The computer model CHECKRAS, Version 2.0.1, December 2013 was used to debug the existing and proposed HEC-RAS models and correct any potential errors in the models.

Existing Conditions HEC-RAS Modeling

An Existing Conditions HEC-RAS model was created to model the existing 12-foot-wide concrete box culvert, with a height of approximately 12’-8”, as measured from the low chord of the culvert to the channel flowline. This model was prepared by Wohnrade Civil Engineers, Inc., and is based on topographic survey information collected by CR Surveying during the Fall of 2021.

The existing culvert was analyzed using a subcritical flow regime. The downstream boundary condition set at normal depth at Cross-Section 1, with a slope of 0.002 ft/ft. Cross-Section 1 is located at the confluence with the Colorado River as originally modeled by Matrix Design Group. The culvert modeling approach uses the energy equation to model low flows, and the energy only (standard step) to model high flows. The existing culvert is under inlet control and reveals roadway overtopping during the 100-year event.

The 100-year water surface elevation at the upstream end of the culvert is 4688.55, with an associated flow depth of 13.72-feet, and a top width of 1,669.31-feet (road overtopping). The low chord of the existing culvert is at an elevation of 4687.50, which provides no freeboard. The existing culvert structure lack the capacity to convey the 100-year peak discharge of 1,920 cfs and overtops Orchard Avenue.

Proposed Project HEC-RAS Modeling

The replacement culvert has been designed with a hydraulic capacity to pass the 100-year peak discharge of 1,920 cfs and provides ample freeboard. The proposed culvert is compatible with the surrounding drainage basin and channel cross-section, and existing drainage patterns have been preserved. The proposed culvert also meets the design standards specified in Sections 1203 and 1206 the Mesa County/City of Grand Junction Stormwater Management Manual.

The existing 60-foot-wide road right-of-way will be maintained as part of the proposed project, and no new right-of-way will be dedicated in the vicinity of the Lewis Wash crossing.

The proposed Lewis Wash culvert will include 2- 14’W x 12’H concrete box culverts (CBCs) with a total length of 54-feet. The structure will include 90-degree headwalls and 45- degree wingwalls at the upstream and downstream ends and will be oriented perpendicular to the centerline of Orchard Avenue. Three box culverts were considered but then dismissed to maintain the existing main channel geometry, which is deep and incised.

The proposed culvert was analyzed using a subcritical flow regime. The slope of the channel through the proposed structure is 0.44%, with upstream and downstream channel elevations inside the structure of 4674.83 and 4674.59 respectively.

The culvert modeling approach uses the energy equation to model low flows, and the energy only (standard step) to model high flows.

Flow through the culvert is entirely subcritical for the 100-year profile, and there is no overtopping of the Orchard Avenue roadway. The 100-year water surface elevation at the upstream end of the proposed culvert (Section 32) is 4685.16, with an associated flow depth of 10.33-feet, and a top width of 130.71-feet. The low chord of the proposed culvert is at an elevation of 4686.83, which provides 1.67-feet of freeboard. The proposed culvert structure has ample capacity to convey the 100-year peak discharge of 1,920 cfs.

Table 27.1 Proposed Project HEC-RAS Modeling Summary

Input and Output Data	WCE DATA
Minimum Top of Road Elevation	4686.65
100-year Design Flow (cfs)	1,920
Proposed Conditions HEC-RAS 100-year WSEL*	4685.16
Flowline Elevation at Upstream Side of Culvert	4674.83
Headwater Depth (ft)	10.33
Culvert Height (ft)	12.00
Actual Headwater to Culvert Depth Ratio	0.86
U.S. Freeboard (ft)	1.67
100-year Maximum Allowable Headwater Depth to Culvert (From WCE Existing Conditions HEC-RAS Model)	4688.55

Table 6-1: Culvert ORCHARD AVENUE STUDY - Proposed Project HEC-RAS Output

Note: WSEL is measured at the upstream face of the existing and proposed culverts, and all elevations are based on the NAVD88 Vertical Datum.

Channel Lining and Manning's "n" Calculations

Channel lining calculations have not been performed as part of this 30% Hydraulic Analysis.

The Federal Highway Administration (FHWA) Hydraulic Engineering Circular No. 15 will be referenced at the time of final design to determine whether rock riprap will be necessary through the culvert. Should riprap become necessary, then a Manning's "n" value and permissible shear stress of the proposed rock riprap will be determined. Hydraulic Engineering Circular 23, Design Guideline 8 will also be referenced for the sizing of rock riprap revetment at the abutments, and along both the upstream and downstream wingwalls.

Manning's "n" values from the LOMR model prepared by Matrix Design Group were confirmed by the design engineer as part of a field reconnaissance and were determined to be adequate. Manning's "n" values for the main channel and overbanks along the study reach are 0.075 and 0.050, respectively.

Culvert Scour Calculations

Culvert scour calculations were not prepared as part of this 30% Hydraulic Analysis. A streambed soil sample gathered in September 2021 by Yeh and Associates will be used at a future date when performing the bridge scour analysis.

Project Drainage Improvements

Cross Culverts

Cross culverts under Orchard Avenue will not be required as part of the proposed Orchard Avenue Corridor Project in the vicinity of Lewis Wash. A storm sewer with curb inlets may be required, which would be determined at final design.

Future Road Surface Drainage

Stormwater runoff across the future road section in the vicinity of the Lewis Wash culvert crossing will be minimal, with much of the runoff from the future road being directed to future storm inlets on Orchard Avenue.

Post-Construction BMPs

Erosion Control Plan

A proposed rainfall erosion control plan during construction will consist of temporary erosion control measures. Erosion control measures will be specified on the Interim Condition and Final Condition Stormwater Management Plans prepared by Collins Engineers at the time of final design.

Collins Engineers, Inc. will also prepare a Stormwater Management Plan (SWMP) for this project at the time of final design. A Colorado Discharge Permit System (CDPS), Stormwater Discharge Associated with Construction Activities application will be obtained by the owner from the Colorado Department of Public Health and Environment prior to construction.

Site Stabilization

All areas disturbed by future construction will either be paved or seeded using the seed mix, quantities, and application rates specified on the General Notes sheet of the Stormwater Management Plan prepared by Collins Engineers.

Lewis Wash Conclusions

Compliance with Standards

The proposed improvements have been designed to comply with all applicable drainage criteria, in accordance with the Mesa County/City of Grand Junction Stormwater Management Manual (Reference 6) and the Urban Storm Drainage Criteria Manual, Volumes 1-3 by the Urban Drainage and Flood Control District (Reference 7).

Design Effectiveness

The drainage design presented herein provides a safe and effective means for managing stormwater runoff from the future corridor project without posing a risk to public and private property.

Basis for "No-Rise" in Base Flood Elevation

WCE used the Existing Conditions 100-year water surface elevation (prepared by WCE) as the basis of comparison when determining a "no-rise" condition.

The WCE Existing Conditions HEC-RAS model shows overtopping of Orchard Avenue during the 100-year event, based on a water surface elevation of 4688.55 at the upstream end of the existing culvert.

The WCE Proposed Project 100-year water surface elevation of 4685.16 at the upstream end of the proposed structure, is 3.39-feet lower than the Existing Conditions 100-year water surface elevation, as measured at the upstream end of the proposed structure.

The proposed project is located within a FEMA Zone A regulatory floodplain and meets all applicable Mesa County Floodplain Regulations.

Variances

No variances from the Mesa County Stormwater Management Manual are requested as part of the proposed project.

Permit Applications

A Floodplain Development Permit may be required as part of the future corridor project and will be determined at a later date.

Section 13 – Conclusion

Conclusion

Orchard Avenue (E-1/2 Rd.) Corridor Study outlines roadway corridor improvements to provide transit, multimodal/active transportation, and safety improvements to the section of Orchard Avenue from 29 1/2 Road to Warrior Way. One of the resonating goals of the project outlined by Mesa County, voiced by the public and professionally agreed upon, was to increase safety for active transportation along the corridor. The need to create active mobility for the community and provide planned bicycle connectivity to the region was emphasized through the workshops and public outreach. Public concern emanated from the need to reduce vehicular speeds and improve sight distance. Additionally, the public felt the look of the corridor did not reflect the surrounding properties and needed visual enhancements. The project lies within the urbanized area, and coordination with the City of Grand Junction's TEDs manual prompted the need for a buffer, lighting, and possible landscaping enhancements. GVT discussed the need to streamline some of the bus stops locations and provide concrete loading pads integrated with the sidewalks and multimodal path. Additionally, GVT requested a bus holding area to the southwest of the 30 Road intersection for use by buses ahead of schedule. GVIC requested that the MESA-E.5-29.8 bridge provide enhanced flow and, if possible, removal of the current center pier as the pier is a maintenance concern. The original goals of the project were:

Original Goals	Added Goals
Full multimodal corridor	Slower Vehicular Speeds
Roadway on a diet approach	Reduce Congestion at 31 Road Intersection
Guide vehicular traffic back to the major collectors and I-70B	Provide buffer area for future landscaping and lighting
Provide corridor beautification	Increase canal hydraulics
	Limit right of way takes

The roadway section, as outlined previously, can meet the goals of the project listed above where possible, the buffer can be increased to the City of Grand Junction's requested width. The section also allows for the use of the buffer area for landscaping and lighting. In areas where rights of way are restricted or below the 60-foot width, the two bike lanes will be dropped, and the multimodal path will be widened to twelve feet. A twelve-foot multimodal path allows for bi-directional active transportation.

All attempts were made at the 30 Road intersection to remove the left turn lanes and re-signalize the intersection. Unfortunately, the configuration resulted in a level of service F. To meet the requirements of increasing safety and reducing the right of way takes, the intersection should remain in the current configuration with slight widening for east to west bicycle lanes. The public requested a reduction in congestion and speeds along the 31 Road intersection. Upon review of the traffic data, there is morning traffic congestion. Preliminary design analysis for a round-a-bout indicated that rights of way would have to be acquired to construct a round-a-bout.

To the northeast corner of the 30 Road intersection, the County requested a review of the "roadside waste" area currently used for private used car advertisements, a local unofficial bike park, and a dumping site. Upon review of the area and the understanding that park maintenance funds are limited, it was devised to turn this area into an E-Bicycle and Bicycle training park. Roadway bicycle training parks are used to teach riders the rules of the road and the understanding of traffic signs. The roadway bicycle parks can also be used as a skills course for learners of E-Bicycle and Bicycles. The maintenance for a bicycle park is limited to paint, sealing, and other minor maintenance needs.

Appendices

Appendix

01: A1 – Preliminary Typical Section E.5-29.8

02: A2 –Construction Cost Estimate E.5-29.8

03: A3 – Construction Selection Report Checklist

04: A4 – Inspection Report E.5-29.8

05: B1 – Preliminary Typical Section E.5-31.01

06: B2 – Construction Cost Estimate E.5-31.01

07: B3 – Construction Selection Report Checklist

08: B4 – Inspection Report E.5-31.01

09: C1 – Pavement Design

10: C2 – Boring Locations

11: C3 – Boring Logs and Legend

12: C4 – Foundation Design

13: C5 – Static Axial Capacity Curves

14: C6 – Pavement Design

15: C7 – Summary of Lab Results

15: D1 – Flow Measurements Data and Calculations

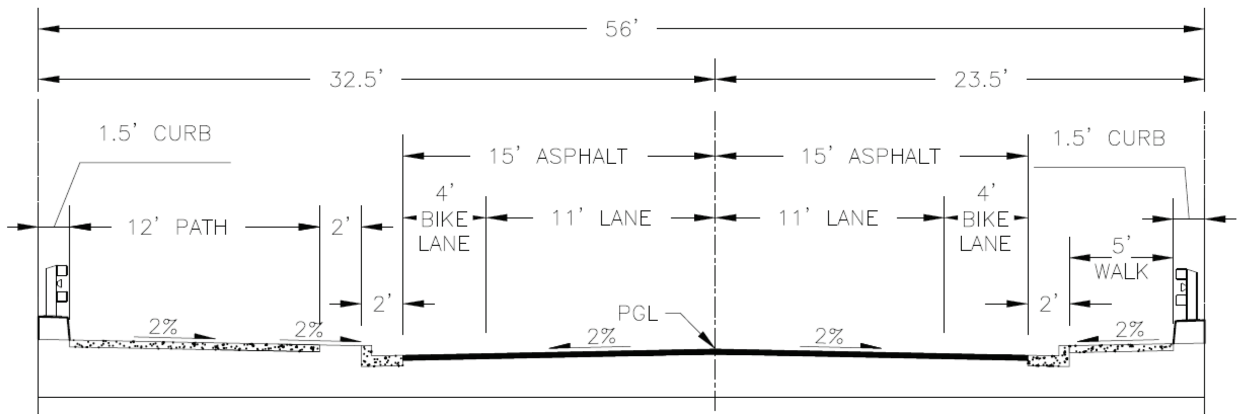
16: D2 – Turnout Flow Data

17: E1 – Cultural Resource Location

18: E2 – Parcel Maps

Appendix A1

Appendix 1: A1 - Preliminary Typical Section



Appendix A2

Appendix 2: A1 Construction Cost Estimate E.5-29.8

Alternative 1 - Precast Prestressed Concrete Slab					
Item	**Item Code**	**Units**	**Quantity**	**Unit Price**	**Total Price**
Class D Concrete (Slabs)	618-06036	SF	1,173	$74.50	$87,389
Class D Concrete (Abuts & Wingwalls)	601-03040	CY	187	$865.03	$161,729
Reinforcement (Abuts & Wingwalls)	602-00020	LB	37,393	$1.77	$66,185
Bridge Rail Type 10M	606-11030	LF	120	$172.62	$20,714
Excavation	206-00000	CY	3,612	$28.42	$102,653
Backfill	206-00100	CY	3,612	$64.97	$234,672
				Total:	**$673,342**

Alternative 2 – Reconstruct Existing Structure					
Item	**Item Code**	**Units**	**Quantity**	**Unit Price**	**Total Price**
Class D Concrete (Slabs)	618-06036	SF	1,173	$74.50	$87,389
Class D Concrete (Culvert)	601-03040	CY	9	$865.03	$7,786
Class D Concrete (Abuts & Wingwalls)	601-03040	CY	25	$865.03	$21,626
Bridge Rail Type 10M	606-11030	LF	120	$172.62	$20,714
Excavation	206-00000	CY	1,200	$28.42	$34,104
Backfill	206-00100	CY	1,600	$64.97	$103,952
				Total:	**$275,571**

Alternative 3 – Pedestrian Bridge					
Item	**Item Code**	**Units**	**Quantity**	**Unit Price**	**Total Price**
Class D Concrete (Abuts & Wingwalls)	601-03040	CY	40	$865.03	$34,601
Excavation	206-00000	CY	72	$28.42	$2,046
Backfill	206-00100	CY	65	$64.97	$4,223
Pedestrian Bridge Prefabbed	N/A	SF	960	$200	$192,000
				Total:	**$232,870**

Appendix A3

Appendix 3: A2 - Structure Selection Report Checklist E.5-29.8

Structure Selection Report QA Checklist

This checklist is to serve as quality assurance of the structure selection process. This checklist must be signed by Staff Bridge Unit Leader or designee prior to submittal of FIR documents to the Region.

Structure Number(s): MESA-E.5-29.8

Cover Sheet

- [x] Name of the Project and Site Address
- [x] Structure(s) Number
- [ ] Property Owner Name and Contact Information
- [ ] Report Preparer Name and Contact Information
- [ ] Seal and Signature of the Designer
- [x] Submittal and Revision Dates as Applicable

Executive Summary

- [x] Project Description
- [x] Structure Recommendations

Site Description and Design Features

- [x] Existing Structures [ ] N/A: ____
- [x] Vicinity Map
- [x] ROW Impact [ ] N/A: ____
- [x] Traffic Detour [ ] N/A: ____
- [x] Utilities [ ] N/A: ____
- [x] Geotechnical Summary
- [x] Hydraulics Summary [ ] N/A: ____
- [x] Environmental Concerns [ ] N/A: ____
- [x] Roadway Design Features
  - [x] Cross Section
  - [x] Vertical Alignment
  - [x] Horizontal Alignment

Structural Design Criteria

- [x] Design Specifications
- [x] Loading [ ] N/A: ____
  - [x] Collision Load
  - [x] Earthquake Load
- [x] Deck Drainage [ ] N/A: ____
- [x] Aesthetic Requirements [ ] N/A: ____
- [x] Possible Future Widenings [ ] N/A: ____

Structure Selection

- [x] Selection Criteria
- [x] Rehabilitation Alternatives [ ] N/A: ____
  - [x] Inspection Summary
  - [x] Load Testing Requirements [ ] N/A: ____

Add figures/sketches to the following sections as needed

- [x] Structure Layout Alternatives
  - [x] Vertical Clearances
  - [x] Horizontal Clearances
  - [x] Skew
  - [x] Span Configurations
- [x] Superstructure Alternatives [ ] N/A: ____
  - [x] Concrete Girder Alternatives
  - [x] Steel Girder Alternatives
  - [x] Deck Drains

- ☑ Substructure Alternatives ☐ N/A: ___
  - ☑ Abutment Alternatives (GRS, Integral, Semi-integral, etc.)
  - ☑ Pier Alternatives
- ☑ Wall Alternatives ☐ N/A: ___
- ☑ Constructability & Construction Phasing
- ☑ ABC Design (include pre-scoping ABC rating results from spreadsheet found on the CDOT website)
- ☑ Maintenance and Durability
- ☑ Corrosive Resistance
- ☑ Summary of Structure Type Evaluation Table
- ☑ Construction Costs (including costs of alternatives)

Other

___

___

Figures and Appendices

- ☑ Alternative Typical Sections (if not provided in the report)
- ☑ General Layout of the Selected Structure
- ☑ Summary of Quantities and Cost Estimate Tables

List of Variances

Requested Variance: ___
Approved? ☐ Yes ☐ No
Requested Variance: ___
Approved? ☐ Yes ☐ No
Requested Variance: ___
Approved? ☐ Yes ☐ No

If you need more space, use an additional sheet(s) of paper.

CDOT Staff Bridge Quality Assurance Sign-off

By signing this checklist Staff Bridge Unit Leader or designee acknowledges approval of the Structure Selection Report findings, recommendations, and all design deviations from the CDOT Structural Standards and design criteria.

Print Name	Signature	Date

Appendix A4

Appendix 4: A4 - Inspection Report E.5-29.8

Routine Inspection
Colorado Department of Transportation
Structure Inspection and Inventory Report (English Units)

Highway Number (ON) 5D:	00000 V
Mile Post (ON) 11:	0.000 mi
Linear Ref. Sys. MP:	0.000 mi

Bridge Key:	MESA-E.5-29.8	Inspection Date:	02/06/2020	Sufficiency Rating:	98.0 ND

NBI Reporting ID:	MESA-E.5-29.8	
Rgn/Sect 2E/2M:	32	
Tran Region 2T:	05	
County Code 3:	077	
077 MESA		
Place Code 4:	00000	
non-city		
Rte.(On/Under) 5A:	1	
Signing Prefix 5B:	4	
Level of Service 5C:	1	
Direction Suffix 5E:	0	
Feature Intersected 6:		
GRAND VALLEY CANAL		
Facility Carried 7:		
COUNTY ROAD E.5		
Alias Str No.8A:		
Prll Str No. 8P:		
N/A		
Location 9:		
.2 MI W OF RD 30		
Max Clr 10:	99.99	
BaseHiway Net12:	0	
IrsinvRout 13A:	0000000000	
IrssubRout No13B:	00	
Latitude 16:	39d 05' 4.52"	
Longitude 17:	108d 30' 0.50"	
Detour Length 19:	1 mi	
Toll Facility 20:	3	
Custodian 21:	02	
Owner 22:	02	
Functional Class 26:	19	
Year Built 27:	1995	
Lanes On 28A:	2	
Lanes Under 28B:	0	
ADT 29:	467	
Year of ADT 30:	2018	
Design Load 31:	0 Unknown	
Apr Rdwy Width 32:	33.00 ft	
Median 33:	0	
Skew 34:	60 °	
Structure Flared 35:	0	
Sfty Rail 36a/b/c/d:	1 0 0 0	
Rail ht36h:	30.0 in	
Hist Signif 37:	5	
Posting status 41:	A	
Service on/un 42A/B:	5	5

Main Mat/Desgn 43A/B:	1	19
Appr Mat/Desgn 44A/B:	0	0
Main Spans Unit 45:	2	
Approach Spans 46:	0	
Horiz Clr 47:	33.30 ft	
Max Span 48:	28.3 ft	
Str Length 49:	58.7 ft	
Curb Wdth L/R 50A/B:	4.3 ft	0.0 ft
Width Curb to Curb 51:	33.30 ft	
Width Out to Out 52:	39.8 ft	
Deck Area:	2336	
Min Clr Ovr Brdg 53:	99.99	
Min Undrclr Ref 54A:	N	
Min Underclr 54B:	0.0 ft	
Min Lat Clrnce Ref R 55A:	N	
Min Lat Undrclr R 55B:	0.0 ft	
Min Lat Undrclr L 56:	0.0 ft	
Deck 58:	N	
Super 59:	N	
Sub 60:	N	
Channel/Protection 61:	7	
Culvert 62:	7	
Oprtng Rtg Method 63:	1 LF Load Factc	
Operating Rating 64:	82.9	
Operating Factor 64:		
Inv Rtng Method 65:	1 LF Load Factc	
Inventory Rating 66:	49.6	
Inventory Factor 66:		
Asph/Fill Thick 66T:	2.0 in	
Str. Evaluation 67:	7	
Deck Geometry 68:	6	
Undrclr Vert/Hor 69:	N	
Posting 70:	5 At/Above Lega	
Waterway Adequacy 71:	8	
Approach Alignment 72:	8	
Type Of Work 75A:	-2	
Work Done By 75B:	!	
Length of Improvment 76:		
Insp Team Indicator 90B:	STANTEC	
Inspector Name 90C:	BOSWORTHK	
Frequency 91:	24 months	
FC Frequency 92A:		
UW Frequency 92B:		
SI Frequency (Pin) 92C:		
FC Inspection Date 93A:		
UW Inspection Date 93B:		
SI Date (Pin) 93C:		

Bridge Cost 94:	$0		
Roadway Cost 95:	$0		
Total Cost 96:	$0		
Year of Cost Estimate 97:	1980		
Brdr Brdg Code/% 98A/B:	-2	0	
Border Bridge Number 99:			
Defense Highway 100:	0		
Parallel Structure 101:	N		
Direction of Traffic 102:	2		
Temporary Structure 103:	_		
Highway Systems 104:	0		
Fed Lands Hiway 105:	0		
Year Reconstructed 106:			
Deck Type 107:	N		
Wearing Surface 108A:	N		
Membrane 108B:	N		
Deck Protection 108C:	N		
Truck ADT 109:	7.00 %		
Trk Net 110:	0		
Pier Protection 111:	!		
NBIS Length 112:	Y		
Scour Critical 113:	8		
Scour Watch 113M:	N		
Future ADT 114:	705		
Year of Future ADT 115:	2038		
CDOT Str Type 120A:	CBC		
CDOT Constr Type 120B:	02		
Inspection Indic 122A:	-		
Inspection Trip 122AA:	Unknown		
Scheduling Status 122B:	_		
Maintenance Patrol 123:	0		
Expansion Dev/Type 124:	O		
Brdg Rail Type/Mod 125A/B:	W	0	
Posting Trucks 129A/B/C:	72.1	110.4	111.4
Str Rating Date 130:	07/24/2018		
Special Equip 133:	Unknown		
Vert Clr N/E 134A/B/C:	X	-1.00	-1.00
Vert Clr S/W 135A/B/C:	X	-1.00	-1.00
Vertical Clr Date:	01/01/1901		
Weight Limit Color 139:	Not Applicable		
Str Billing Type:	IIA		
Userkey 1, Insp System:	OFFSYS		
Userkey 4, Insp Sched:	EVN FEB S_0		
Userkey 5, UW Sched:			
Userkey 6, Pin Sched:			
Inspection Key:	VMCT		

Inspection Type:	Regular NBI
Inspector Name:	BOSWORTHK

LA_SIA	Version 8j - 10/6/2019	Structure ID: MESA-E.5-29.8	Tue 06/02/2020 14:19:51 Page 1 of 4

Routine Inspection
Colorado Department of Transportation
Structure Inspection and Inventory Report (English Units)

Highway Number (ON) 5D: 00000 V
Mile Post (ON) 11: 0.000 mi
Linear Ref. Sys. MP: 0.000 mi

Element Inspection Report

Elm/Env	Description	Unit	Total Qty	% in 1	Qty. St. 1	% in 2	Qty. St. 2	% in 3	Qty. St. 3	% in 4	Qty. St. 4
241/1	**Re Conc Culvert**	**ft**	159	100%	159	0%	0	0%	0	0%	0
		(2) cell poured-in-place concrete box culvert. Bottom slab finish slightly rough. Light efflorescence staining near openings of both cells from spillage over curb.									
510/1	Wearing Surfaces	sq.ft	1955	96%	1880	0%	0	4%	75	0%	0
		Asphalt paving over top slab has 1/4 inch wide random cracks.									
3220/1	*Crack (Wearing Surface)*	*ft*	*23*	*0%*	*0*	*0%*	*0*	*100%*	*23*	*0%*	*0*
		See Element 510 comments.									
330/1	**Metal Bridge Railing**	**ft**	117	0%	0	100%	117	0%	0	0%	0
		Galvanized W-beam rail with double backing tubes on wide flange posts, bolted to top of curb and walk, (4) tube pedestrian rail on top. R1 rust of pedestrian rail at north and spotty Light R1 rust of south top tubes.									
515/1	Steel Protective Coating	sq.ft	117	0%	0	0%	0	0%	0	100%	117
		Galvanized. Failed at rust locations.									
1000/1	Corrosion	ft	117	0%	0	100%	117	0%	0	0%	0
		See Element 330 comments.									
9327/1	**Culvert Wingwalls**	**(EA)**	4	50%	2	25%	1	25%	1	0%	0
		Concrete, extension of end walls, then flared. (4) spalls and (1) delamination below rail posts in southeast up to 4 feet long x 8 inches high x 6 inches deep. Spall and 0.125 inch wide vertical crackint northwest wingwall.									
9338/1	**Conc Curbs/SW**	**(LF)**	117	98%	115	2%	2	0%	0	0%	0
		Concrete curb at south, concrete sidewalk at north. Sidewalks/curbs act as headwalls. Delamination 18 inch L x 8 inch W in northeast corner.									
9501/1	**Channel Cond**	**(EA)**	1	100%	1	0%	0	0%	0	0%	0
		Shotcrete-lined channel. New between 2016 and 2018 inspections.									
9502/1	**ChannProtMatCond**	**(EA)**	1	100%	1	0%	0	0%	0	0%	0
		Shotcrete on banks and channel bottom. New between 2016 and 2018 inspections. Southeast corner apron slab spall.									
9504/1	**BankCond**	**(EA)**	1	100%	1	0%	0	0%	0	0%	0
		Moderate to steep.									
9520/1	**AppRdAlign**	**(EA)**	1	100%	1	0%	0	0%	0	0%	0
		Cracks in approach asphalt up to 0.5 inch wide. 0.125 inch wide diagonal crack in northwest approach sidewalk.									
9530/1	**Approach Guardrail A**	**(EA)**	1	100%	1	0%	0	0%	0	0%	0
		Galvanized W-beam rail on treated timber posts, blocked out, flared with flared end section, at northeast and southwest only. Painted steel tube rail and posts pedestrian rail on northwest and southeast wingwalls. None at southeast and northwest corners.									
9600/1	**Genl Remarks**	**(EA)**	1	100%	1	0%	0	0%	0	0%	0
		Supplemental delineation panel at southwest corner.									

Routine Inspection
Colorado Department of Transportation
Structure Inspection and Inventory Report (English Units)

Highway Number (ON) 5D: 00000 V
Mile Post (ON) 11: 0.000 mi
Linear Ref. Sys. MP: 0.000 mi

Maintenance Activity Summary

MMS Activity	Description	Recommended	Status	Target Year	Priority
156.00	Deck-Seal	2/6/2020	_	2021	Medium

Seal cracks in asphalt on deck.

MMS Activity	Description	Recommended	Status	Target Year	Priority
302.01	Misc-Install Sign	3/18/2008	1	2022	Low

Install Type 3 object markers at southeast, northeast, and northwest corners.

MMS Activity	Description	Recommended	Status	Target Year	Priority
306.05	Approach Railing	3/18/2008	1	2021	High

Install approach rails, transitions, and rail ends to meet current AASHTO/CDOT standards.

MMS Activity	Description	Recommended	Status	Target Year	Priority
358.05	Substructure-Patch spalls	2/18/2014	1	2022	Low

Patch spalls in northwest and southeast wingwalls.

Bridge Notes

BRIDGE OVER IRRIGATION CANAL

Inspection Notes

Date: 2/6/2020
Time: 12:25 PM Temp: 44 degrees Weather: Partly cloudy, calm

Scour Item 113 Documentation

MESA-E.5-29.8 SCOUR Item 113 Screening Memo 2019 06 27.pdf

Routine Inspection
Colorado Department of Transportation
Structure Inspection and Inventory Report (English Units)

Highway Number (ON) 5D: 00000 V
Mile Post (ON) 11: 0.000 mi
Linear Ref. Sys. MP: 0.000 mi

Scope:

☑ NBI ☑ Element ☐ Underwater ☐ Fracture Critical ☐ Other Type: Regular NBI

Team Leader Inspection Check-off:

☐ FCM's
☐ Posting Signs
☐ Essential Repair Verification
☐ Vertical Clearance
☐ Stream Bed Profile

Inspection Team: STANTEC

Inspection Date: 02/06/2020

Inspector: Unknown

Karen Bosworth

Inspector (Team Leader): KAREN BOSWORTH

LA_SIA	Version 8j - 10/6/2019	Structure ID: MESA-E.5-29.8	Tue 06/02/2020 14:19:51 Page 4 of 4

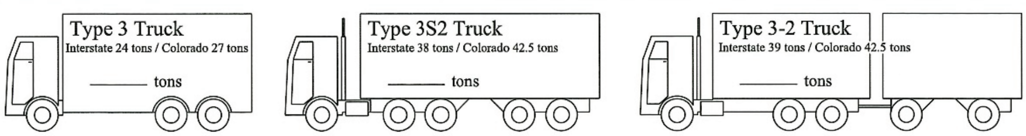
COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

Structure #	MESA-E.5-29.8
State Highway #	E.5 Road
Batch I.D.	
Structure Type	CBC
Parallel Structure #	N/A

Rated using:
Asphalt thickness: 2 in.
☑ Colorado legal loads
☐ Interstate legal loads

Structural Member	Box Culvert				
	Tons				
Inventory	49.6				
Operating	82.9				
Type 3 truck	72.1				
Type 3S2 truck	110.4				
Type 3-2 truck	111.4				
Type SU4 truck (27T)	73.0				
Type SU5 truck (31T)	78.1				
Type SU6 truck (35T)	85.0				
Type SU7 truck (39T)	90.4				
NRL (40T)	92.2				
EV2 (28.75T)	73.1				
EV3 (43T)	74.5				
Permit Truck (96T) Single Lane D.F.					
Modified Tandem (50T) Single Lane D.F.					



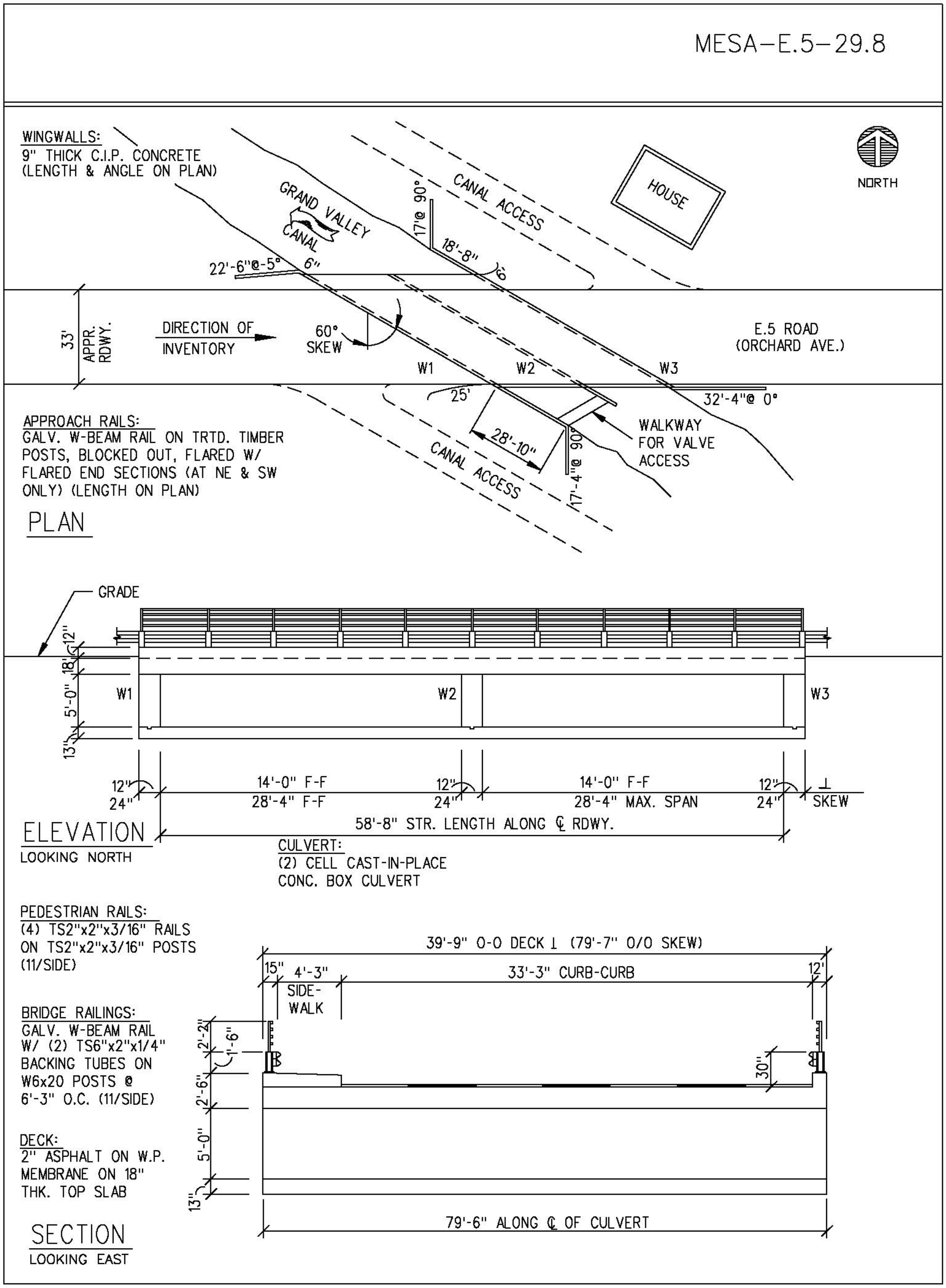
Comments:
(2) cell 14'x5' reinforced concrete box culvert rated for 2" of asphalt. Top slab 18", bottom slab 13", walls 12" f'c = 4.5ksi, fy = 60ksi, Culvert is on 60 degree skew to roadway, reinforcement runs parallel to the roadway

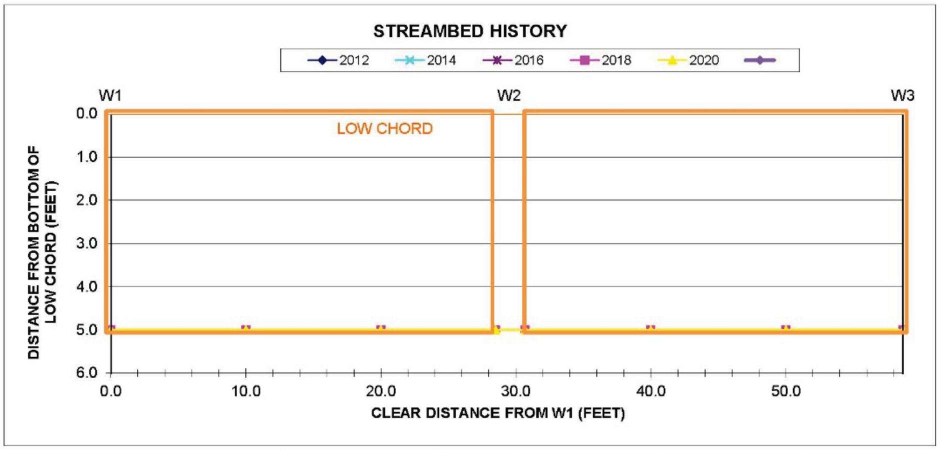
No Posting Recommended

COLORADO LICENSED JOHN BAYLIS BUTT 52613 PROFESSIONAL ENGINEER
2/1/19
SEH

Rated by: (Print name and sign)	Date:	Checked by: (Print name and sign)	Date:
Matthew Henderson, EIT	7/24/2018	John Butt, PE	8/20/2018

CDOT Staff Bridge - LFR 02/2017


MESA-E.5-29.8
WINGWALLS:
9" THICK C.I.P. CONCRETE
(LENGTH & ANGLE ON PLAN)
GRAND VALLEY CANAL
CANAL ACCESS
HOUSE
NORTH
17'@ 90°
18'-8"
22'-6"@-5°
6"
33' APPR. RDWY.
DIRECTION OF INVENTORY
60° SKEW
W1
W2
W3
E.5 ROAD
(ORCHARD AVE.)
25'
32'-4"@ 0°
28'-10"
17'-4"@ 90°
WALKWAY FOR VALVE ACCESS
APPROACH RAILS:
GALV. W-BEAM RAIL ON TRTD. TIMBER POSTS, BLOCKED OUT, FLARED W/ FLARED END SECTIONS (AT NE & SW ONLY) (LENGTH ON PLAN)
PLAN
GRADE
12"
18"
5'-0"
13"
14'-0" F-F
28'-4" F-F
14'-0" F-F
28'-4" MAX. SPAN
12"
24"
⊥ SKEW
58'-8" STR. LENGTH ALONG ℄ RDWY.
ELEVATION
LOOKING NORTH
CULVERT:
(2) CELL CAST-IN-PLACE CONC. BOX CULVERT
PEDESTRIAN RAILS:
(4) TS2"x2"x3/16" RAILS ON TS2"x2"x3/16" POSTS (11/SIDE)
39'-9" O-O DECK ⊥ (79'-7" O/O SKEW)
15"
4'-3"
33'-3" CURB-CURB
12"
SIDE-WALK
BRIDGE RAILINGS:
GALV. W-BEAM RAIL W/ (2) TS6"x2"x1/4" BACKING TUBES ON W6x20 POSTS @ 6'-3" O.C. (11/SIDE)
2'-2"
1'-6"
2'-6"
30"
DECK:
2" ASPHALT ON W.P. MEMBRANE ON 18" THK. TOP SLAB
79'-6" ALONG ℄ OF CULVERT
SECTION
LOOKING EAST



	0.0	10.0	20.0	28.5	30.7	40.0	50.0	58.7	W.L.
2012	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	DRY
2014	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	DRY
2016	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	DRY
2018	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.8
2020	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	DRY

STRUCTURE NUMBER: MESA-E.5-29.8
INSPECTION DATE: 2/6/2020

PERFORMED BY: KEP

Structure Number:	**MESA-E.5-29.8**	Owner:	**Mesa County**
Facility Carried:	**COUNTY ROAD E.5**	Inspection Date:	**2/6/2020**
Feature Intersected:	**GRAND VALLEY CANAL**		

Roadway looking east

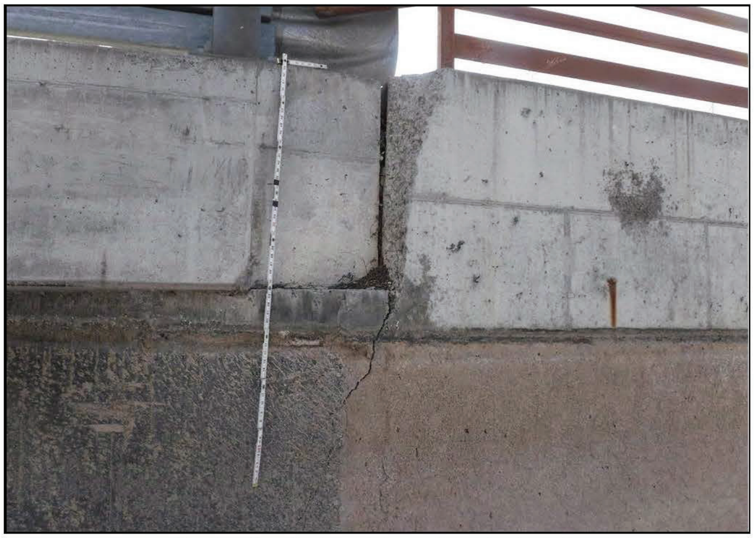
Elevation looking north

Structure Number:	**MESA-E.5-29.8**	Owner:	**Mesa County**
Facility Carried:	**COUNTY ROAD E.5**	Inspection Date:	**2/6/2020**
Feature Intersected:	**GRAND VALLEY CANAL**		

General looking east

Map cracking in asphalt on top slab

Structure Number:	**MESA-E.5-29.8**	Owner:	**Mesa County**
Facility Carried:	COUNTY ROAD E.5	Inspection Date:	**2/6/2020**
Feature Intersected:	GRAND VALLEY CANAL		



Spall and vertical crack in northwest wingwall

Spalls in southeast wingwall at rail posts

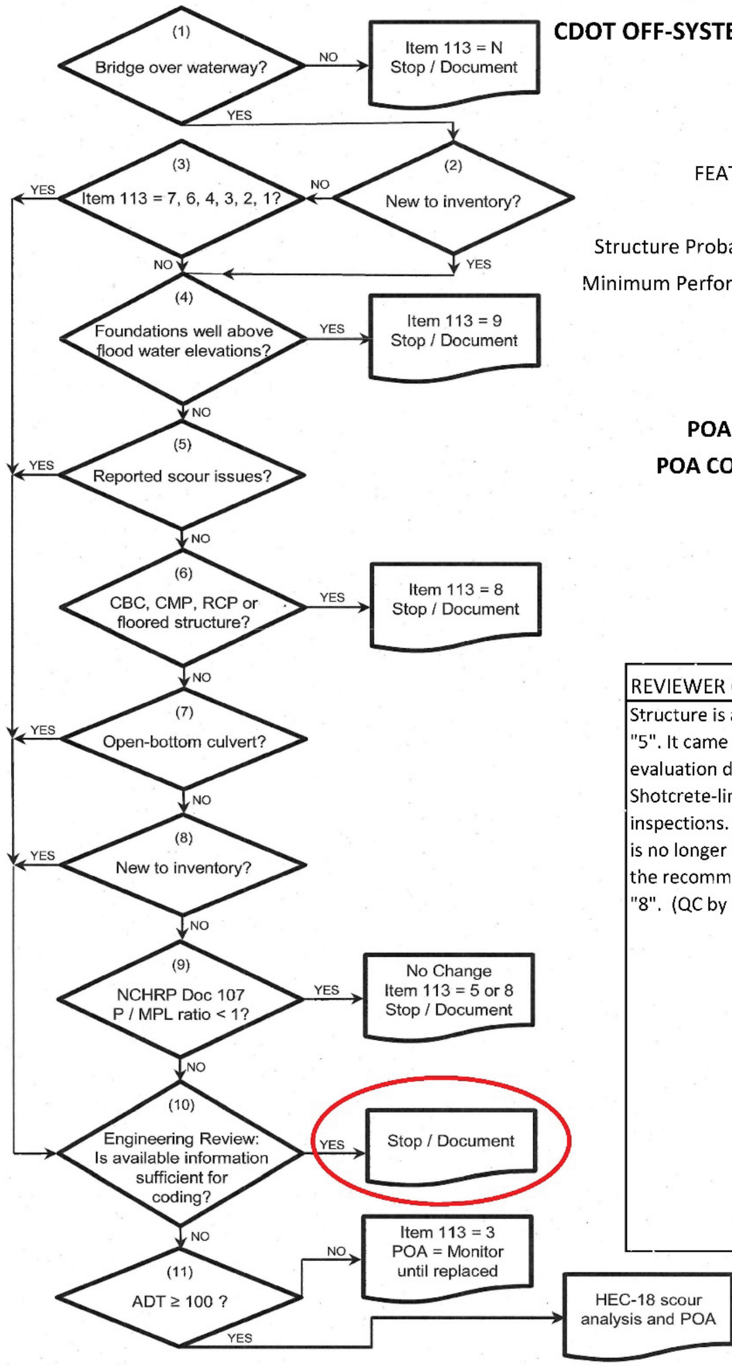
Structure Number:	MESA-E.5-29.8	Owner:	Mesa County
Facility Carried:	COUNTY ROAD E.5	Inspection Date:	2/6/2020
Feature Intersected:	GRAND VALLEY CANAL		

Channel looking upstream

Channel looking downstream

COLORADO
Department of Transportation

CDOT OFF-SYSTEM BRIDGE SCOUR SCREENING CHART



STRUCTURE ID: MESA-E.5-29.8

FACILITY CARRIED: COUNTY ROAD E.5

FEATURE INTERSECTED: GRAND VALLEY CANAL

Structure Probability of Failure (P): n /a

Minimum Performance Level (MPL): n/a

Ratio (P/MPL): n/a

ITEM 113 = 8

POA REQUIRED (Y/N): N

POA COMPLETION DATE: n/a

EVALUATED BY: Salomon Ybarra

ORGANIZATION: Stantec Consulting

DATE: 6/27/2019

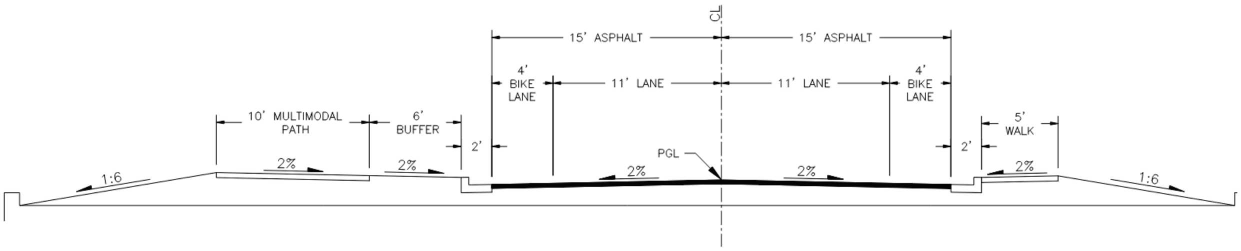
REVIEWER COMMENTS:
Structure is a CBC built in 1995. Item 113 is currently coded "5". It came to individual review because the P/MPL evaluation does not work for culverts. 2014 ADT = 4,514. Shotcrete-lined channel, new between 2016 and 2018 inspections. No scour problems noted. Since the code of "5" is no longer being used for pipe and box culverts in Colorado, the recommendation for this structure is to raise Item 113 to "8". (QC by LML, 7/22/2019)

Save file as: [structure number] SCOUR Item 113 Screening Memo YYYY-MM-DD.pdf

MESA-E.5-29.8 SCOUR Item 113 Screening Memo 2019-06-27.xlsx Last Revised: 12/11/2017

Appendix B1

Appendix 5: B1 - Preliminary Typical Section



Appendix B2

Appendix 6: B2 - Construction Cost Estimate E.5-31.01

Alternative 1 - Precast Concrete Box Culvert					
Item	**Item Code**	**Units**	**Quantity**	**Unit Price**	**Total Price**
Structure Excavation	206-00000	CY	288	$25.00	$7,200
Structure Backfill (Class 1)	206-00100	CY	250	$45.00	$11,250
Geotextile (Drainage) (Class 2)	420-00113	SY	102	$10.00	$1,020
Void Filled Riprap	506-00701	CY	60	$500.00	$30,000
Grouted Riprap Slope and Ditch Paving	507-00351	CY	60	$500.00	$30,000
Concrete Sealer	515-00400	SY	198	$17.00	$3,366
Concrete Class D (Box Culvert)	601-03030	CY	75	$1,000.00	$75,000
Reinforcing Steel (Epoxy Coated)	602-00020	LB	9750	$3.00	$29,250
14x12 Foot Concrete Box Culvert (Precast)	603-71610	LF	76	$2,000.00	$152,000
Fence Wire with Metal Posts	607-01050	LF	80	$25.00	$2,000
				Total:	**$341,086**

Alternative 2 - Prestressed Concrete Box Girder					
Item	**Item Code**	**Units**	**Quantity**	**Unit Price**	**Total Price**
Prestressed Concrete Box Girder	618-01136	SF	1008	$110.93	$111,817
Class B (Abutment & Wingwall) Concrete	601-03040	CY	162	$865.03	$139,943
Reinforcement (Abutment & Wingwall)	602-00000	LB	32356	$1.31	$42,386
Bridge Rail Type 10M	606-11030	LF	56	$172.62	$9,667
Excavation	206-00000	CY	152	$28.42	$4,320
Backfill	206-00100	CY	152	$64.97	$9,875
				Total:	**$318,008**

Alternative 3 - Precast Prestressed Concrete Slab					
Item	**Item Code**	**Units**	**Quantity**	**Unit Price**	**Total Price**
Class D Concrete (Slab)	601-03040	CY	36	$865.03	$31,456
Prestressing Strand	618-00001	LB	3636	$2.00	$7,272.73
Class D Concrete (Abuts & Wingwalls)	601-03040	CY	162	$865.03	$139,943
Reinforcement (Abuts & Wingwalls)	602-00020	LB	32356	$1.77	$57,269
Bridge Rail Type 10M	606-11030	LF	60	$172.62	$10,357
Excavation	206-00000	CY	118	$28.42	$3,360
Backfill	206-00100	CY	118	$64.97	$7,681
				Total:	**$257,338**

Appendix B3

Appendix 7: B3 - Structure Selection Report Checklist E.5-31.01

Structure Selection Report QA Checklist

This checklist is to serve as quality assurance of the structure selection process. This checklist must be signed by Staff Bridge Unit Leader or designee prior to submittal of FIR documents to the Region.

Structure Number(s): MESA-E.5-31.01

Cover Sheet
- [x] Name of the Project and Site Address
- [x] Structure(s) Number
- [ ] Property Owner Name and Contact Information
- [ ] Report Preparer Name and Contact Information
- [ ] Seal and Signature of the Designer
- [x] Submittal and Revision Dates as Applicable

Executive Summary
- [x] Project Description
- [x] Structure Recommendations

Site Description and Design Features
- [x] Existing Structures ☐ N/A: ____
- [x] Vicinity Map
- [x] ROW Impact ☐ N/A: ____
- [x] Traffic Detour ☐ N/A: ____
- [x] Utilities ☐ N/A: ____
- [x] Geotechnical Summary
- [x] Hydraulics Summary ☐ N/A: ____
- [x] Environmental Concerns ☐ N/A: ____
- [x] Roadway Design Features
    - [x] Cross Section
    - [x] Vertical Alignment
    - [x] Horizontal Alignment

Structural Design Criteria
- [x] Design Specifications
- [x] Loading ☐ N/A: ____
    - [x] Collision Load
    - [x] Earthquake Load
- [x] Deck Drainage ☐ N/A: ____
- [x] Aesthetic Requirements ☐ N/A: ____
- [x] Possible Future Widenings ☐ N/A: ____

Structure Selection
- [x] Selection Criteria
- [x] Rehabilitation Alternatives ☐ N/A: ____
    - [x] Inspection Summary
    - [x] Load Testing Requirements ☐ N/A: ____

Add figures/sketches to the following sections as needed
- [x] Structure Layout Alternatives
    - [x] Vertical Clearances
    - [x] Horizontal Clearances
    - [x] Skew
    - [x] Span Configurations
- [x] Superstructure Alternatives ☐ N/A: ____
    - [x] Concrete Girder Alternatives
    - [x] Steel Girder Alternatives
    - [x] Deck Drains

- [x] Substructure Alternatives [ ] N/A:____________________
    - [x] Abutment Alternatives (GRS, Integral, Semi-integral, etc.)
    - [x] Pier Alternatives
- [x] Wall Alternatives [ ] N/A:____________________
- [x] Constructability & Construction Phasing
- [x] ABC Design (include pre-scoping ABC rating results from spreadsheet found on the CDOT website)
- [x] Maintenance and Durability
- [x] Corrosive Resistance
- [x] Summary of Structure Type Evaluation Table
- [x] Construction Costs (including costs of alternatives)

Other

____

____

Figures and Appendices

- [x] Alternative Typical Sections (if not provided in the report)
- [x] General Layout of the Selected Structure
- [x] Summary of Quantities and Cost Estimate Tables

List of Variances

Requested Variance: ____
Approved? [ ] Yes [ ] No
Requested Variance: ____
Approved? [ ] Yes [ ] No
Requested Variance: ____
Approved? [ ] Yes [ ] No
If you need more space, use an additional sheet(s) of paper.

CDOT Staff Bridge Quality Assurance Sign-off

By signing this checklist Staff Bridge Unit Leader or designee acknowledges approval of the Structure Selection Report findings, recommendations, and all design deviations from the CDOT Structural Standards and design criteria.

________________	________________	____________
Print Name	Signature	Date

Appendix B4

Appendix 8: Inspection Report E.5-31.01

Colorado Department of Transportation

Structure Inspection and Inventory Report (English Units)

Bridge Key:	MM-E.5-31	Inspection Date:	9/26/2018	Sufficiency Rating:	NA

NBI Reporting ID:	MM-E.5-31	Main Mat/Desgn 43A/B:	7 2	Bridge Cost 94:	$-
Rgn/Sect 2E/2M:	32	Appr Mat/Desgn 44A/B:	0 00	Roadway Cost 95:	$
Tran Region 2T:	05	Main Spans Unit 45:	1	Total Cost 96:	$
County Code 3:	077	Approach Spans 46:	0	Year of Cost Estimate 97:	
MESA		Horiz Clr 47:	8.1 ft	Brdr Brdg Code/% 98A/B:	
Place Code 4:	00000	Max Span 48:	32.7 ft	Border Bridge Number 99:	
non-city		Str Length 49:	36.5 ft	Defense Highway 100:	0
Rte.(On/Under) 5A:	1	Curb Wdth L/R 50A/B:	0.0 ft 0.0 ft	Parallel Structure 101:	N
Signing Prefix 5B:	4	Width Curb to Curb 51:	8.1 ft	Direction of Traffic 102:	2
Level of Service 5C:	1	Width Out to Out 52:	8.1	Temporary Structure 103:	
Direction Suffix 5E:	0	Deck Area:	290.6 sq. ft	Highway Systems 104:	0
Feature Intersected 6:		Min Clr Ovr Brdg 53:	99.99	Fed Lands Hiway 105:	_
LEWIS WASH		Min Undrclr Ref 54A:	N	Year Reconstructed 106:	
Facility Carried 7:		Min Underclr 54B:	0.0 ft	Deck Type 107:	N
PEDESTRAN WALKWAY		Min Lat Clrnce Ref R 55A:	N	Wearing Surface 108A:	N
Alias Str No.8A:		Min Lat Undrclr R 55B:	0.0 ft	Membrane 108B:	0
		Min Lat Undrclr L 56:	0.0 ft	Deck Protection 108C:	0
Prll Str No. 8P:		Deck 58:	6	Truck ADT 109:	
N/A		Super 59:	7	Trk Net 110:	
Location 9:		Sub 60:	7	Pier Protection 111:	
East of 31 Road		Channel/Protection 61:	7	NBIS Length 112:	N
Max Clr 10:		Culvert 62:	N	Scour Critical 113:	
BaseHiway Net12:	_	Oprtng Rtg Method 63:	5 No rating	Scour Watch 113M:	_
IrsinvRout 13A:	-1	Operating Rating 64:	40.0	Future ADT 114:	
IrssubRout No13B:	-1	Operating Factor 64:		Year of Future ADT 115:	
Latitude 16:	39.084673	Inv Rtng Method 65:	5 No rating	CDOT Str Type 120A:	TTS
Longitude 17:	-108.477844	Inventory Rating 66:	36.0	CDOT Constr Type 120B:	01
Detour Length 19:	1.0 mi	Inventory Factor 66:		Inspection Indic 122A:	_
Toll Facility 20:	3	Asph/Fill Thick 66T:	0 in	Inspection Trip 122AA:	
Custodian 21:	02	Str. Evaluation 67:	3	Scheduling Status 122B:	_
Owner 22:	02	Deck Geometry 68:	2	Maintenance Patrol 123:	-1
Functional Class 26:	19	Undrclr Vert/Hor 69:		Expansion Dev/Type 124:	U
Year Built 27:	1998	Posting 70:	5 At/Above Lega	Brdg Rail Type/Mod 125A/B:	U U
Lanes On 28A:	1	Waterway Adequacy 71:	8	Posting Trucks 129A/B/C:	0.0 0.0 0.0
Lanes Under 28B:	0	Approach Alignment 72:	8	Str Rating Date 130:	10/30/2013
ADT 29:	0	Type Of Work 75A:		Special Equip 133:	Unknown
Year of ADT 30:	2013	Work Done By 75B:	_	Vert Clr N/E 134A/B/C:	_ -1.00 -1.00
Design Load 31:	0	Length of Improvment 76:	0	Vert Clr S/W 135A/B/C:	_ -1.00 -1.00
Apr Rdwy Width 32:	7.3	Insp Team Indicator 90B:	COLLINS	Vertical Clr Date:	
Median 33:		Inspector Name 90C:	SLOPEZ	Weight Limit Color 139:	N, Not Checked
Skew 34:	0,00 °	Frequency 91:	72 months	Str Billing Type:	U
Structure Flared 35:	0	FC Frequency 92A:		Userkey 1, Insp System:	MINORSTR
Sfty Rail 36a/b/c/d:	N N N N	UW Frequency 92B:		Userkey 4, Insp Sched:	
Rail ht36h:	55.00 in	SI Frequency (Pin) 92C:		Userkey 5, UW Sched:	
Hist Signif 37:	5	FC Inspection Date 93A:		Userkey 6, Pin Sched:	
Posting status 41:	A	UW Inspection Date 93B:		Userkey 7, 113 Doc Date:	
Service on/un 42A/B:	3 5	SI Date (Pin) 93C:		Inspection Key:	

Inspection Type:	Regular NBI
Inspector Name:	SLOPEZ

Data Responsibility: Inspection Rating

CDOT_SIA	Version 8e - 6/13/2018	Structure ID:	Page 1 of 2

MESA COUNTY

2018 Mesa County Minor Bridge Inspection

Structure Inspection and Inventory Report: MM-E.5-31

COLLINS ENGINEERS INC

Element Inspection Report | Inspection Date: 9/26/2018

Elm/Env	Description	Unit	Total Qty	% in 1	Qty. St. 1	% in 2	Qty. St. 2	% in 3	Qty. St. 3	% in 4	Qty. St. 4
31/1	Timber Deck	(SF)	296	0%	0	0%	0	0%	0	100%	296
1-3/4-inch x 1/8-inch running planks laid on skew on treated 3-3/4-inch x 10-inch deck. Nail sticking out on running planks. Several locations of rot up to 30% of deck. Wear and rutting on running planks. Water stain at bottom of deck. Up to 60 locations of cracked running planks. A few locations of checking < 1 inch on deck at bottom. There are 2 locations of protruding planks up to 1/2-inch at the north side.											
111/1	Timber Open Girder	(LF)	110	0%	0	100%	110	0%	0	0%	0
(3) 20 1/2-inch x 5-inch glu-lam treated timber girders. Diaphragm at abutments and midspan. Checks > 1/8-inch wide on exterior girders.											
215/1	R/Conc Abutment	(LF)	16	100%	16	0%	0	0%	0	0%	0
Concrete with deadman tie backs. Graffiti on both abutments.											
311/1	Moveable Bearing	(EA)	6	100%	6	0%	0	0%	0	0%	0
Steel sliding plate. Minor debris on bearings areas.											
326/1	Bridge Wingwalls	(EA)	4	100%	4	0%	0	0%	0	0%	0
Concrete U-type wingwalls. Minor erosion at northeast wingwalls and northwest.											
332/1	Timb Bridge Railing	(LF)	73	0%	0	0%	0	0%	0	100%	73
2.5-inch x 7-inch timber rails on 5.5-inch x 5.50-inch timber post. Crack in rail at northwest. Weathered and rot on top rails. Checks > 1 inch and several locations of posts and rails have shakes on rails. Full length splits at top.											
9501/1	Channel Cond	(EA)	1	100%	1	0%	0	0%	0	0%	0
Sand and silt in channel. Well vegetated channel											
9502/1	ChannProtMatCond	(EA)	1	100%	1	0%	0	0%	0	0%	0
Retaining wall at southeast and southwest bank. RCP pipe at bottom of retaining wall. Void under retaining wall and adjacent sidewalk at southwest wit 14-inch undermining.											
9504/1	BankCond	(EA)	1	100%	1	0%	0	0%	0	0%	0
Steep slope. Trees and shrubs on and above banks.											

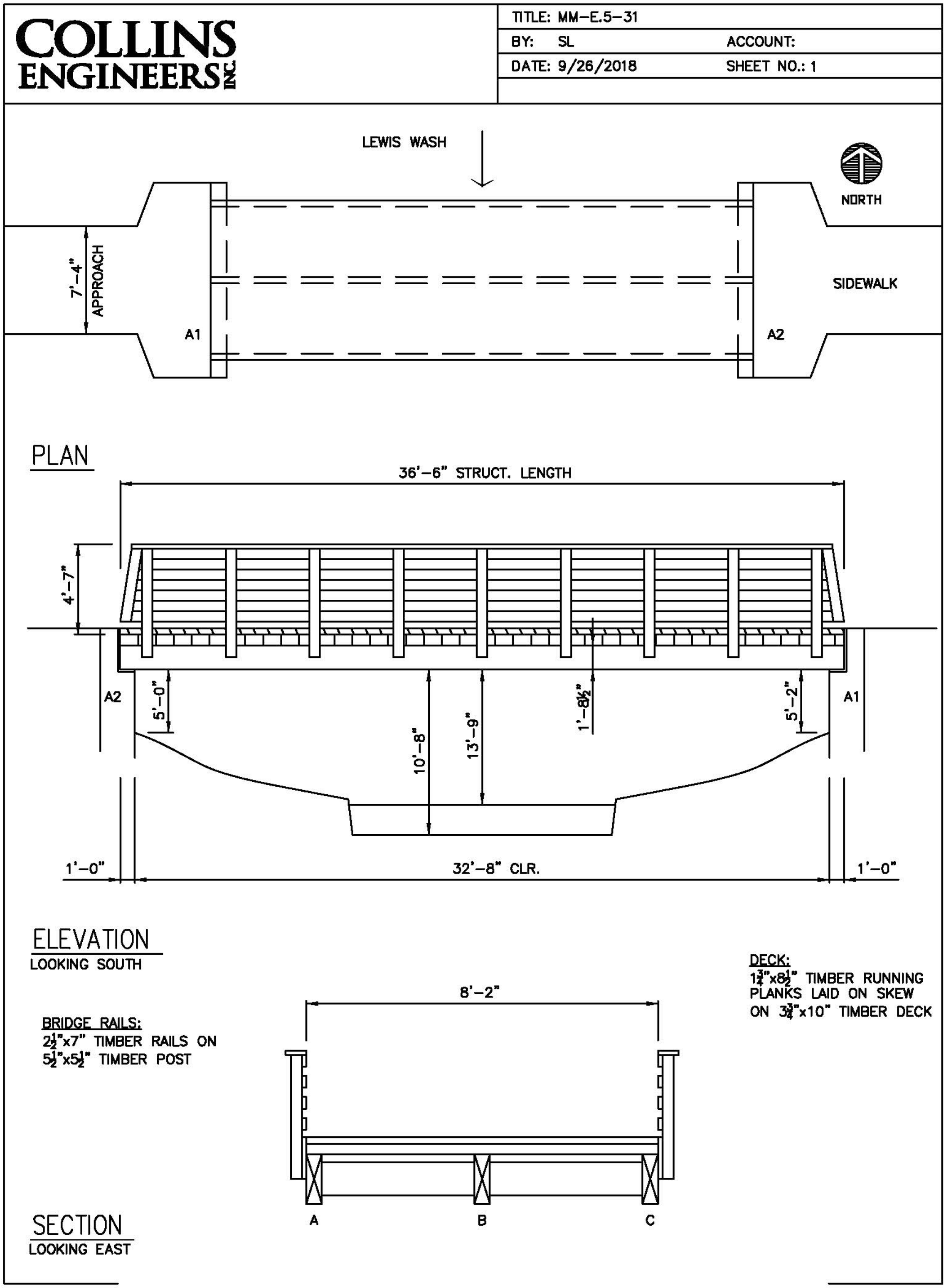
Maintenance Activity Summary	Recommended	Status	Target Year	Est Cost ($)
Railing	10/30/2013	0	2018	5000
Replace weathered and rotted top rails.				
Br Dk Rpr	09/26/2018	0	2018	15000
Replace deck.				
Pr Maint	10/30/2016	0	2018	200
Fill void under west approach sidewalk.				

Bridge Notes

Structure MM-E.5-31.01 is just downstream.

Inspection Notes

Inspector (Team Leader): SAMUEL LOPEZ


COLLINS ENGINEERS INC.
TITLE: MM-E.5-31
BY: SL
ACCOUNT:
DATE: 9/26/2018
SHEET NO.: 1
LEWIS WASH
NORTH
7'-4"
APPROACH
A1
A2
SIDEWALK
PLAN
36'-6" STRUCT. LENGTH
4'-7"
A2
5'-0"
10'-8"
13'-9"
1'-8½"
5'-2"
A1
1'-0"
32'-8" CLR.
1'-0"
ELEVATION
LOOKING SOUTH
DECK:
1¾"x8½" TIMBER RUNNING PLANKS LAID ON SKEW ON 3¾"x10" TIMBER DECK
8'-2"
BRIDGE RAILS:
2½"x7" TIMBER RAILS ON 5½"x5½" TIMBER POST
A
B
C
SECTION
LOOKING EAST

2018 Mesa County Minor Bridge Inspection

ID: MM-E.5-31 (Ped)

Street: PEDESTRAN WALKWAY
Feature Crossed: LEWIS WASH

Deck looking east

Deck looking west

COLLINS ENGINEERS

2018 Mesa County Minor Bridge Inspection

ID: MM-E.5-31 (Ped)

Street: PEDESTRAN WALKWAY
Feature Crossed: LEWIS WASH

Elevation looking north

Elevation looking southwest

COLLINS
ENGINEERS

2018 Mesa County Minor Bridge Inspection

ID: MM-E.5-31 (Ped)

Street: PEDESTRAN WALKWAY
Feature Crossed: LEWIS WASH

Channel looking upstream

Channel looking downstream

COLLINS ENGINEERS

2018 Mesa County Minor Bridge Inspection

ID: MM-E.5-31 (Ped)

Street: PEDESTRAN WALKWAY
Feature Crossed: LEWIS WASH

Rotted deck plank

Running plank condition

COLLINS ENGINEERS

2018 Mesa County Minor Bridge Inspection

ID: MM-E.5-31 (Ped)

Street: PEDESTRAN WALKWAY

Feature Crossed: LEWIS WASH

Protruding plank at northside

Weathered and rotting top rail

COLLINS ENGINEERS

2018 Mesa County Minor Bridge Inspection

ID: MM-E.5-31 (Ped)

Street: PEDESTRAN WALKWAY
Feature Crossed: LEWIS WASH

Cracked and weathered rail at northwest corner

Underside view looking east

COLLINS ENGINEERS

2018 Mesa County Minor Bridge Inspection

ID: MM-E.5-31 (Ped)

Street: PEDESTRAN WALKWAY
Feature Crossed: LEWIS WASH

Check greater than 1 inch on girders

Typical bearing condition

2018 Mesa County Minor Bridge Inspection

ID: MM-E.5-31 (Ped)

Street: PEDESTRAN WALKWAY

Feature Crossed: LEWIS WASH

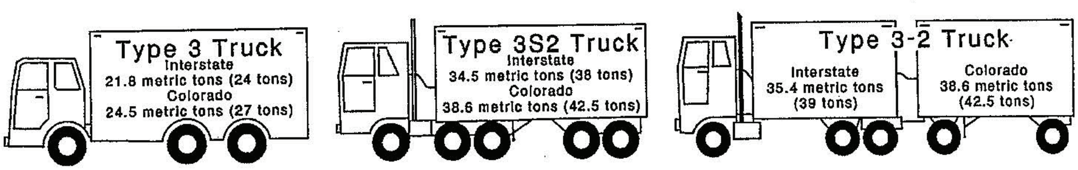
1.5 inch x 1 foot void under southwest sidewalk

COLLINS ENGINEERS

COLORADO DEPARTMENT OF TRANSPORTATION LOAD FACTOR RATING SUMMARY	Structure # MM-E.5-31.01
	Abbr. Str. # MM-E.5-31.01
Rated Using:	Road or Street # County Road E.5
Asphalt Thickness: NA	Batch I.D.
[X] Colorado Legal Loads	Structure Type CBC
[ ] Interstate Legal Loads	Parallel Structure # N/A

Structural Member	CONCRETE BOX CULVERT		DECK		GIRDER			
	Metric Tons	(Tons)	Metric Tons	(Tons)	Metric Tons	(Tons)	Metric Tons	(Tons)
Inventory MS 18 (HS20)	32.6	(36.0)						
Operating MS 18 (HS20)	36.2	(40.0)						

Type 3 Truck				
Type 3S2 Truck				
Type 3-2 Truck				
Permit Truck				



_____ Metric Tons _____ Tons   _____ Metric Tons _____ Tons   _____ Metric Tons _____ Tons

Comments:

Approximately 1'-2" asphalt and embankment fill on concrete box culvert 12'-2" wide by 13'-6" high measured normal to the centerline of the culvert.

The rating is empirical based on the condition of the structure.

BRIDGE REINSPECTED BUT NOT NEED TO BE RERATED
COLLINS ENGINEERS, 2018

NO POSTING REQUIRED

BRIDGE REINSPECTED BUT NOT RERATED BY
ALFRED BENESCH & COMPANY 2013

BRIDGE REINSPECTED BUT NOT
RERATED BY LONCO, INC.

Rated By: Tom Kozojed	Date: 4/13/04	Checked By: Jacob Horvath	Date: 4/13/04

Colorado Department of Transportation

Structure Inspection and Inventory Report (English Units)

Bridge Key: MM-E.5-31.01 | Inspection Date: 9/26/2018 | Sufficiency Rating: 79.2

NBI Reporting ID:	MM-E.5-31.01
Rgn/Sect 2E/2M:	32
Tran Region 2T:	05
County Code 3:	077
MESA	
Place Code 4:	00000
non-city	
Rte.(On/Under) 5A:	1
Signing Prefix 5B:	4
Level of Service 5C:	1
Direction Suffix 5E:	0
Feature Intersected 6:	
LEWIS WASH	
Facility Carried 7:	
COUNTY ROAD E.5	
Alias Str No.8A:	
Prll Str No. 8P:	
N/A	
Location 9:	
3101 E.5 Road	
Max Clr 10:	
BaseHiway Net12:	_
IrsinvRout 13A:	-1
IrssubRout No13B:	-1
Latitude 16:	39.084545
Longitude 17:	-108.477874
Detour Length 19:	2.0 mi
Toll Facility 20:	3
Custodian 21:	02
Owner 22:	02
Functional Class 26:	19
Year Built 27:	1950
Lanes On 28A:	2
Lanes Under 28B:	0
ADT 29:	4400
Year of ADT 30:	2004
Design Load 31:	0
Apr Rdwy Width 32:	24.0
Median 33:	
Skew 34:	0,00 °
Structure Flared 35:	0
Sfty Rail 36a/b/c/d:	N N N N
Rail ht36h:	27.00 in
Hist Signif 37:	5
Posting status 41:	A
Service on/un 42A/B:	1 5

Main Mat/Desgn 43A/B:	1 19
Appr Mat/Desgn 44A/B:	0 00
Main Spans Unit 45:	1
Approach Spans 46:	0
Horiz Clr 47:	30.0 ft
Max Span 48:	12.2 ft
Str Length 49:	12.2 ft
Curb Wdth L/R 50A/B:	0.0 ft 0.0 ft
Width Curb to Curb 51:	0.00 ft
Width Out to Out 52:	32.3
Deck Area:	398.3 sq. ft
Min Clr Ovr Brdg 53:	99.99
Min Undrclr Ref 54A:	N
Min Undercl 54B:	0.0 ft
Min Lat Clrnce Ref R 55A:	N
Min Lat Undrclr R 55B:	0.0 ft
Min Lat Undrclr L 56:	0.0 ft
Deck 58:	N
Super 59:	N
Sub 60:	N
Channel/Protection 61:	6
Culvert 62:	6
Oprtng Rtg Method 63:	5 No rating
Operating Rating 64:	40.0
Operating Factor 64:	
Inv Rtng Method 65:	5 No rating
Inventory Rating 66:	36.0
Inventory Factor 66:	
Asph/Fill Thick 66T:	14 in
Str. Evaluation 67:	6
Deck Geometry 68:	4
Undrclr Vert/Hor 69:	
Posting 70:	5 At/Above Lega
Waterway Adequacy 71:	7
Approach Alignment 72:	8
Type Of Work 75A:	
Work Done By 75B:	_
Length of Improvment 76:	0
Insp Team Indicator 90B:	COLLINS
Inspector Name 90C:	SLOPEZ
Frequency 91:	72 months
FC Frequency 92A:	
UW Frequency 92B:	
SI Frequency (Pin) 92C:	
FC Inspection Date 93A:	
UW Inspection Date 93B:	
SI Date (Pin) 93C:	

Bridge Cost 94:	$-
Roadway Cost 95:	$
Total Cost 96:	$
Year of Cost Estimate 97:	
Brdr Brdg Code/% 98A/B:	
Border Bridge Number 99:	
Defense Highway 100:	0
Parallel Structure 101:	N
Direction of Traffic 102:	2
Temporary Structure 103:	
Highway Systems 104:	0
Fed Lands Hiway 105:	_
Year Reconstructed 106:	
Deck Type 107:	N
Wearing Surface 108A:	N
Membrane 108B:	0
Deck Protection 108C:	0
Truck ADT 109:	
Trk Net 110:	
Pier Protection 111:	
NBIS Length 112:	N
Scour Critical 113:	
Scour Watch 113M:	_
Future ADT 114:	
Year of Future ADT 115:	
CDOT Str Type 120A:	CBC
CDOT Constr Type 120B:	01
Inspection Indic 122A:	_
Inspection Trip 122AA:	
Scheduling Status 122B:	_
Maintenance Patrol 123:	-1
Expansion Dev/Type 124:	U
Brdg Rail Type/Mod 125A/B:	U U
Posting Trucks 129A/B/C:	0.0 0.0 0.0
Str Rating Date 130:	4/13/2004
Special Equip 133:	Unknown
Vert Clr N/E 134A/B/C:	_ -1.00 -1.00
Vert Clr S/W 135A/B/C:	_ -1.00 -1.00
Vertical Clr Date:	
Weight Limit Color 139:	N, Not Checked
Str Billing Type:	U
Userkey 1, Insp System:	MINORSTR
Userkey 4, Insp Sched:	
Userkey 5, UW Sched:	
Userkey 6, Pin Sched:	
Userkey 7, 113 Doc Date:	
Inspection Key:	

Inspection Type: Regular NBI

Inspector Name: SLOPEZ

Data Responsibility: Inspection Rating

CDOT_SIA **Version 8e - 6/13/2018** Structure ID: **Page 1 of 2**

2018 Mesa County Minor Bridge Inspection

MESA COUNTY

COLLINS ENGINEERS INC

Structure Inspection and Inventory Report: MM-E.5-31.01

Element Inspection Report

Inspection Date: 9/26/2018

Elm/Env	Description	Unit	Total Qty	% in 1	Qty. St. 1	% in 2	Qty. St. 2	% in 3	Qty. St. 3	% in 4	Qty. St. 4
241/1	Concrete Culvert	(LF)	33	55%	18	45%	15	0%	0	0%	0
Cast in place concrete box culvert with integral wingwalls and headwalls. Light scaling and/or abrasion with light efflorescence on walls. Ceiling has numerous spots of honeycomb with several locations of exposed reinforcement. (2) locations of cracks with water leaking at west wall. Hairline horizontal cracking on both walls. Honeycombing and exposed rebar on walls.											
327/1	Culvert Wingwalls	(EA)	4	25%	1	75%	3	0%	0	0%	0
Cast in place concrete. Spall up to 3-feet x 2-feet x 6-inch deep at bottom comer of southwest wingwall, 1 to 12 inches deep x 2 feet 6 inches square. Horizontal cracks on wingwall. S1 scaling and abrasion with light efflorescence at all wingwalls. Deterioration at end of southwest wingwall. Spall 2-feet x 1-feet x 6-inch at southeast wall.											
334/1	Metal Rail Coated	(EA)	24	100%	24	0%	0	0%	0	0%	0
Galvanized W-beam rail, blocked out at W-beam, on 6x9 galvanized steel posts fastened to top headwalls.											
335/1	Culvert Headwalls	(EA)	2	100%	2	0%	0	0%	0	0%	0
Cast in place concrete, light water staining on both walls. Honeycombing on edges.											
9501/1	Channel Cond	(EA)	1	100%	1	0%	0	0%	0	0%	0
Gravel and cobbles, good alignment. Debris- Trash at upstream channel, Fallen trees and brush in culvert.											
9504/1	BankCond	(EA)	1	100%	1	0%	0	0%	0	0%	0
Lined with trees, willows and brush, moderate slopes upstream and steep slopes downstream											
9530/1	Approach Guardrail A	(EA)	1	100%	1	0%	0	0%	0	0%	0
Approach rails short at southeast, transitions not doubled. Galvanized W-beam rail on treated timber, blocked out, buffered end sections. Minor damage to southwest approach rail (scape marks). Damaged rail post at northeast comer. (1) Missing and (2) twisted blocking at northeast approach rail.											

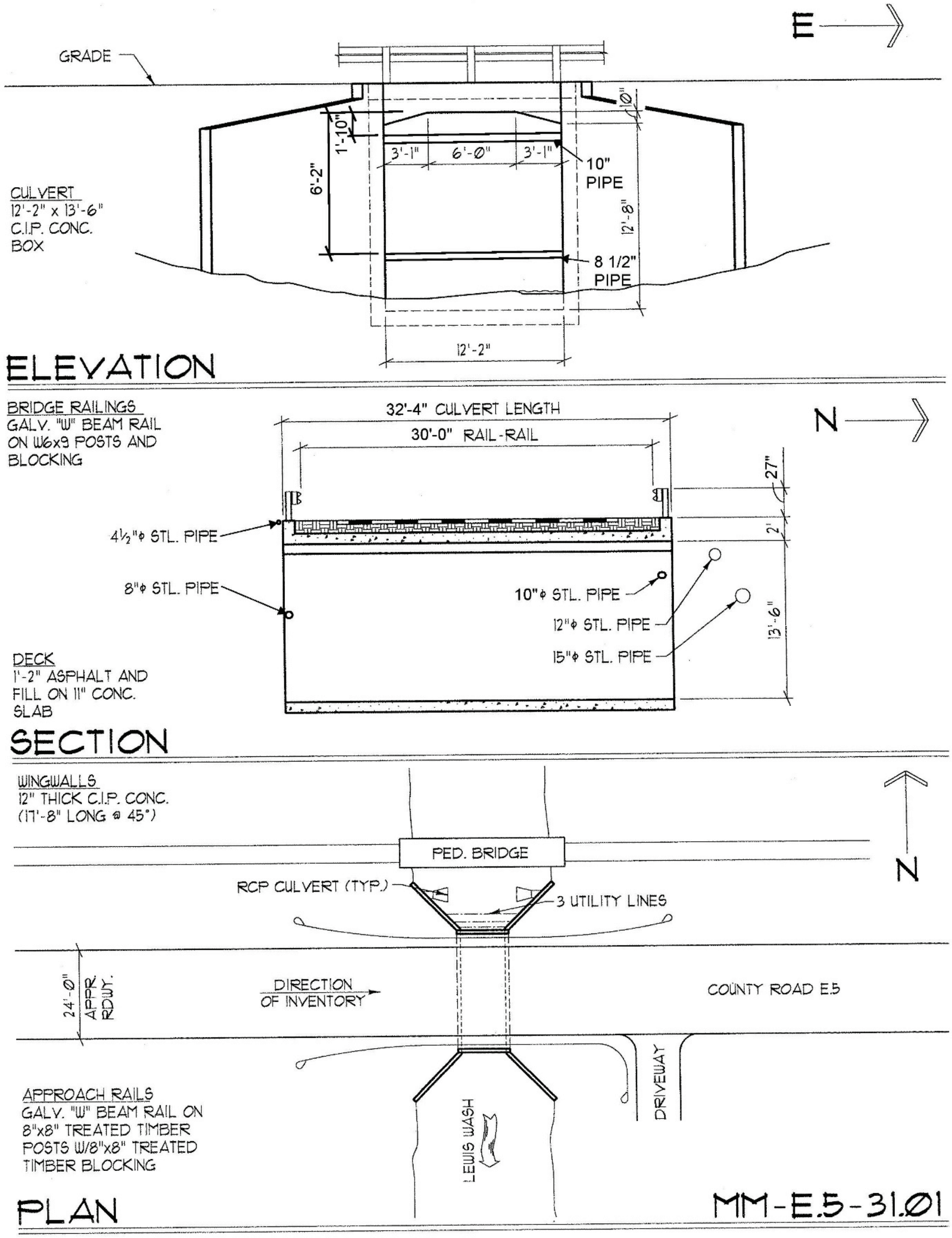
Maintenance Activity Summary	Recommended	Status	Target Year	Est Cost ($)
Railing	11/10/2006	0	2018	35000
Modify bridge rails to meet current AASHTO/CDOT standards.				
Railing	11/10/2006	0	2018	300
Repair damaged W-beam at southwest approach				
Railing	10/30/2013	0	2018	7000
Lengthen approach rail at southeast to meet current AASHTO/CDOT				
Railing	10/30/2013	0	2018	300
Repair/replace broken post at northeast approach rail end.				
Debris	12/17/2009	0	2018	300
Remove debris in channel.				

Bridge Notes

2 feet 6-inch diameter reinforced concrete pipe culvert (RCPC) beyond northwest wingwall and 4 feet diameter RCPC beyond northeast wingwall convey into channel. 8-inch diameter steel utility pipe through walls at north end. 12 inches and 14-inch diameter steel utility pipes through north wingwalls, 8-inch diameter steel utility pipe through south wingwalls. Structure MM-E.5-31 is just upstream.

Inspection Notes

Inspector (Team Leader): SAMUEL LOPEZ


E
GRADE
CULVERT
12'-2" x 13'-6"
C.I.P. CONC.
BOX
1'-10"
6'-2"
3'-1"
6'-0"
3'-1"
10"
10"
PIPE
12'-8"
8 1/2"
PIPE
12'-2"
ELEVATION
BRIDGE RAILINGS
GALV. "W" BEAM RAIL
ON W6x9 POSTS AND
BLOCKING
32'-4" CULVERT LENGTH
30'-0" RAIL-RAIL
N
27"
2'
4½"φ STL. PIPE
8"φ STL. PIPE
10"φ STL. PIPE
12"φ STL. PIPE
15"φ STL. PIPE
13'-6"
DECK
1'-2" ASPHALT AND
FILL ON 11" CONC.
SLAB
SECTION
WINGWALLS
12" THICK C.I.P. CONC.
(17'-8" LONG @ 45°)
PED. BRIDGE
N
RCP CULVERT (TYP.)
3 UTILITY LINES
24'-0"
APPR.
RDWY.
DIRECTION
OF INVENTORY
COUNTY ROAD E.5
DRIVEWAY
APPROACH RAILS
GALV. "W" BEAM RAIL ON
8"x8" TREATED TIMBER
POSTS W/8"x8" TREATED
TIMBER BLOCKING
LEWIS WASH
PLAN
MM-E.5-31.01

2018 Mesa County Minor Bridge Inspection

ID: MM-E.5-31.01

Street: COUNTY ROAD E.5
Feature Crossed: LEWIS WASH

Deck looking west

Deck looking east

COLLINS ENGINEERS

2018 Mesa County Minor Bridge Inspection

ID: MM-E.5-31.01

Street: COUNTY ROAD E.5
Feature Crossed: LEWIS WASH

Upstream elevation

Downstream elevation

COLLINS ENGINEERS

2018 Mesa County Minor Bridge Inspection

ID: MM-E.5-31.01

Street: COUNTY ROAD E.5
Feature Crossed: LEWIS WASH

Channel looking upstream

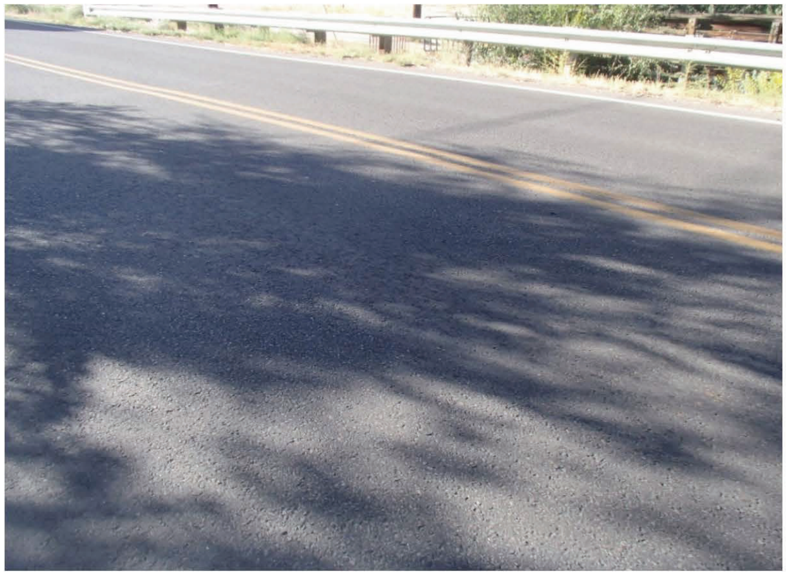
Channel looking downstream

COLLINS
ENGINEERS

2018 Mesa County Minor Bridge Inspection

ID: MM-E.5-31.01

Street: COUNTY ROAD E.5
Feature Crossed: LEWIS WASH



View of deck

Crack with water leaking at southwest corner

COLLINS ENGINEERS

2018 Mesa County Minor Bridge Inspection

ID: MM-E.5-31.01

Street: COUNTY ROAD E.5
Feature Crossed: LEWIS WASH

Twisted blocks on northeast approach rail

Underside view looking south

COLLINS ENGINEERS

2018 Mesa County Minor Bridge Inspection

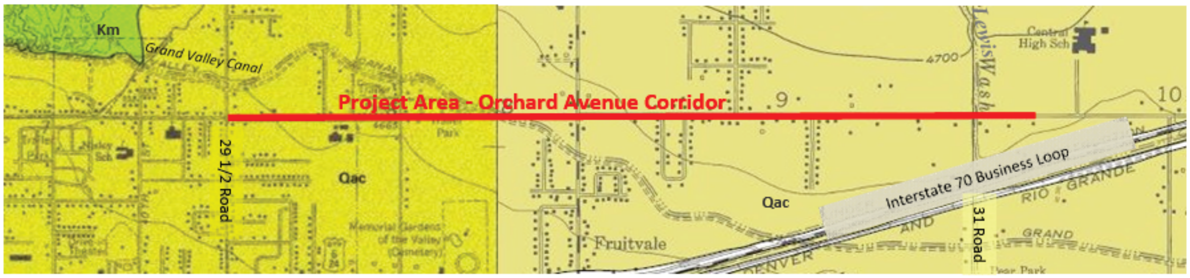
ID: MM-E.5-31.01

Street: COUNTY ROAD E.5
Feature Crossed: LEWIS WASH

Spalling on southeast wingwall

Appendix C1

Appendix 9: C1 - Geology Map



Qac	Km	Qac
Alluvium and colluvium, undivided	Mancos Shale	Alluvium and colluvium, undivided

Base map on left from Geologic map of the Grand Junction quadrangle Mesa County, Colorado by Scott, Carrara, Hood and Murray, 2002

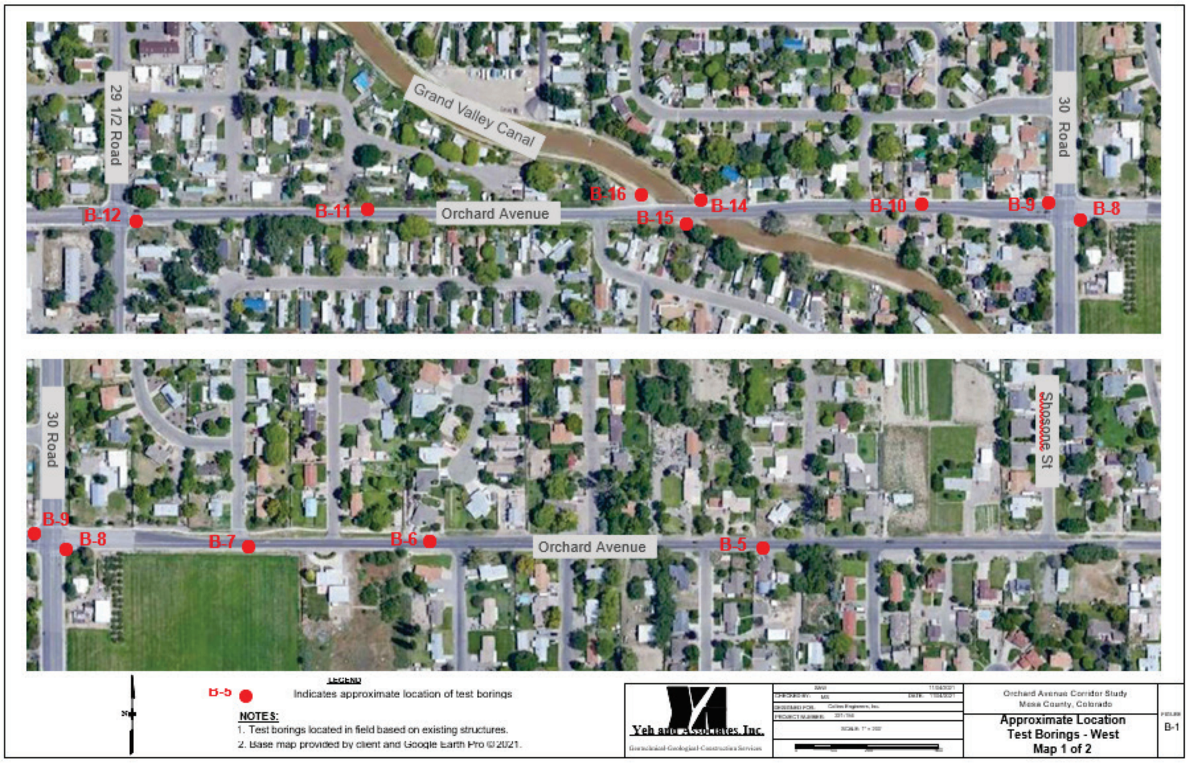
Base map on right from Geologic map of the Clifton quadrangle Mesa County, Colorado by Carrara, 2001

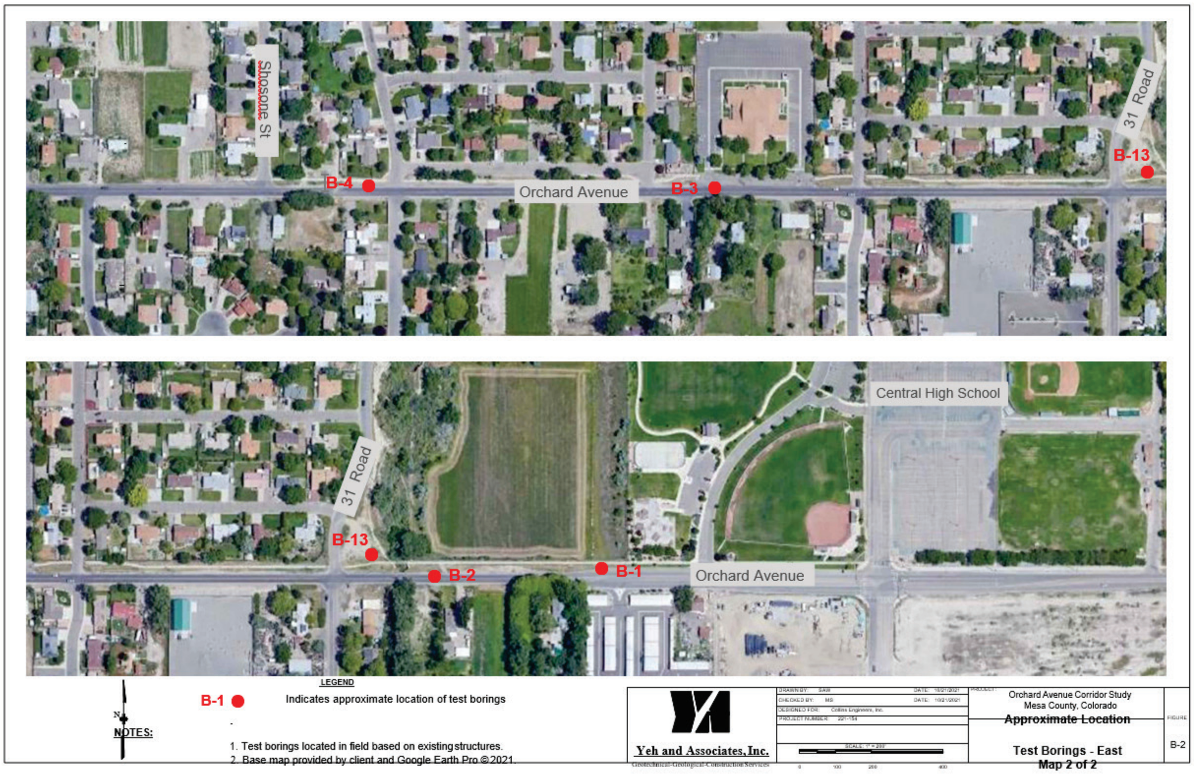
↑ North

Print Date: 10/07/2021 File Name: Orchard Avenue Corridor Study Scale: Not to scale	**Geologic Map - Approximate Project Area Location** **Orchard Avenue** **Mesa County, Colorado**		SHEET NUMBER:
Yeh and Associates, Inc. Geotechnical - Geological - Construction Services	Drawn by: SAW Checked by: SWR	Yeh and Associates Project No. 221-154	**A-1**

Appendix C2

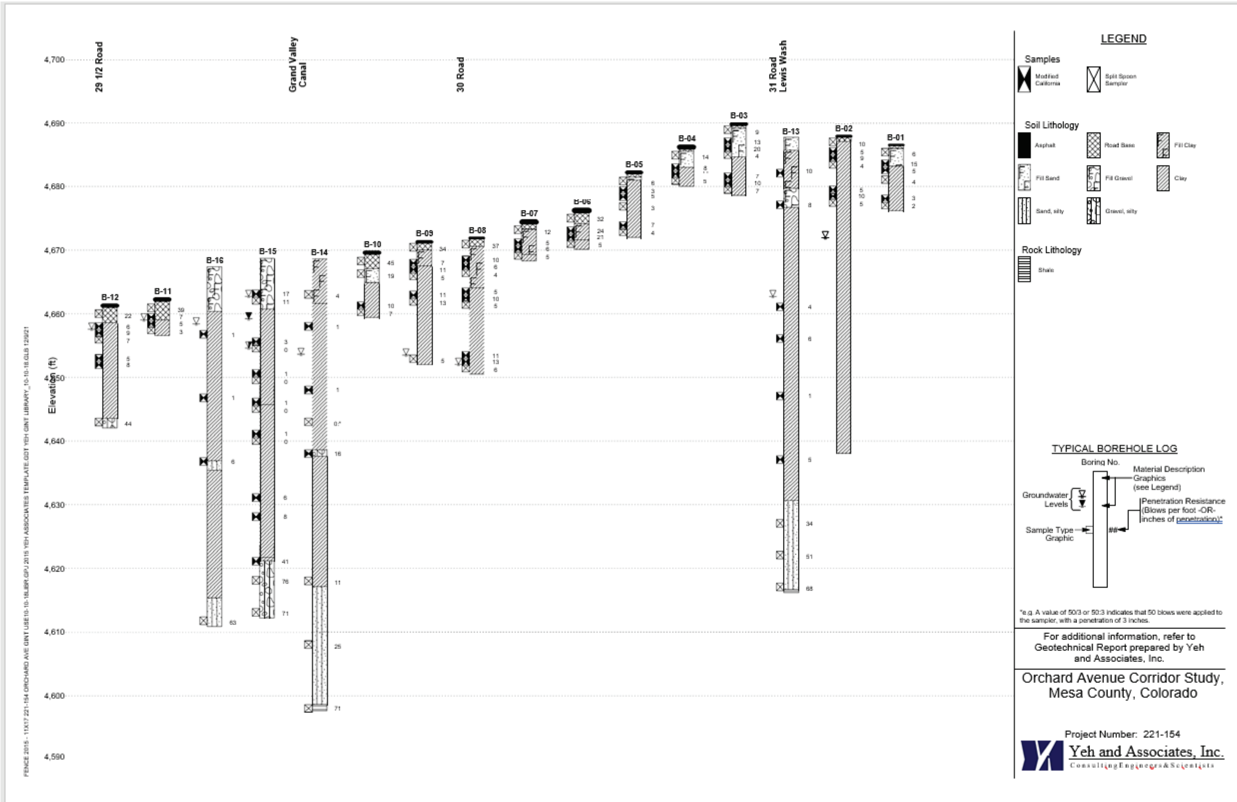
Appendix 10: C2 – Boring Locations




Shosone St
31 Road
B-13
B-4
Orchard Avenue
B-3
Central High School
31 Road
B-13
B-2
B-1
Orchard Avenue
LEGEND
B-1
Indicates approximate location of test borings
N
NOTES:
1. Test borings located in field based on existing structures.
2. Base map provided by client and Google Earth Pro © 2021.
Yeh and Associates, Inc.
Geotechnical-Geological-Construction Services
DRAWN BY: SAW
DATE: 10/21/2021
CHECKED BY: MS
DATE: 10/21/2021
DESIGNED FOR: Collins Engineers, Inc.
PROJECT NUMBER: 221-154
SCALE: 1" = 200'
0
100
200
400
PROJECT:
Orchard Avenue Corridor Study
Mesa County, Colorado
Approximate Location
Test Borings - East
Map 2 of 2
FIGURE
B-2

Appendix C3

Appendix 11: C3 - Boring Logs and Legend



Yeh and Associates, Inc. Consulting Engineers & Scientists	*Project:* Orchard Avenue Corridor Study, Mesa County, Colorado *Project Number:* 221-154

Legend for Symbols Used on Borehole Logs

Sample Types

Auger Cuttings

Modified California Sampler (2.5 inch OD, 2.0 inch ID)

Shelby Tube

Standard Penetration Test (ASTM D1586)

Lithology Symbols (see Boring Logs for complete descriptions)

Asphalt

Road Base

Fill Clay

Fill Sand

Fill Gravel

Clay

Sand, silty

Gravel, silty

Shale

Lab Test Standards

Moisture Content	ASTM D2216
Dry Density	ASTM D7263
Sand/Fines Content	ASTM D421, ASTM C136, ASTM D1140
Atterberg Limits	ASTM D4318
AASHTO Class.	AASHTO M145, ASTM D3282
USCS Class.	ASTM D2487

(Fines = % Passing #200 Sieve
Sand = % Passing #4 Sieve, but not passing #200 Sieve)

Other Lab Test Abbreviations

pH	Soil pH (AASHTO T289-91)
S	Water-Soluble Sulfate Content (AASHTO T290-91, ASTM D4327)
Chl	Water-Soluble Chloride Content (AASHTO T291-91, ASTM D4327)
S/C	Swell/Consolidation (ASTM D4546)
UCCS	Unconfined Compressive Strength (ASTM D2166)
R-Value	Resistance R-Value (ASTM D2844)
DS (C)	Direct Shear cohesion (ASTM D3080)
DS (phi)	Direct Shear friction angle (ASTM D3080)
Re	Electrical Resistivity (AASHTO T288-91)
PtL	Point Load Strength Index (ASTM D5731)
PP	Pocket Penetrometer, tons per sq ft (tfs)

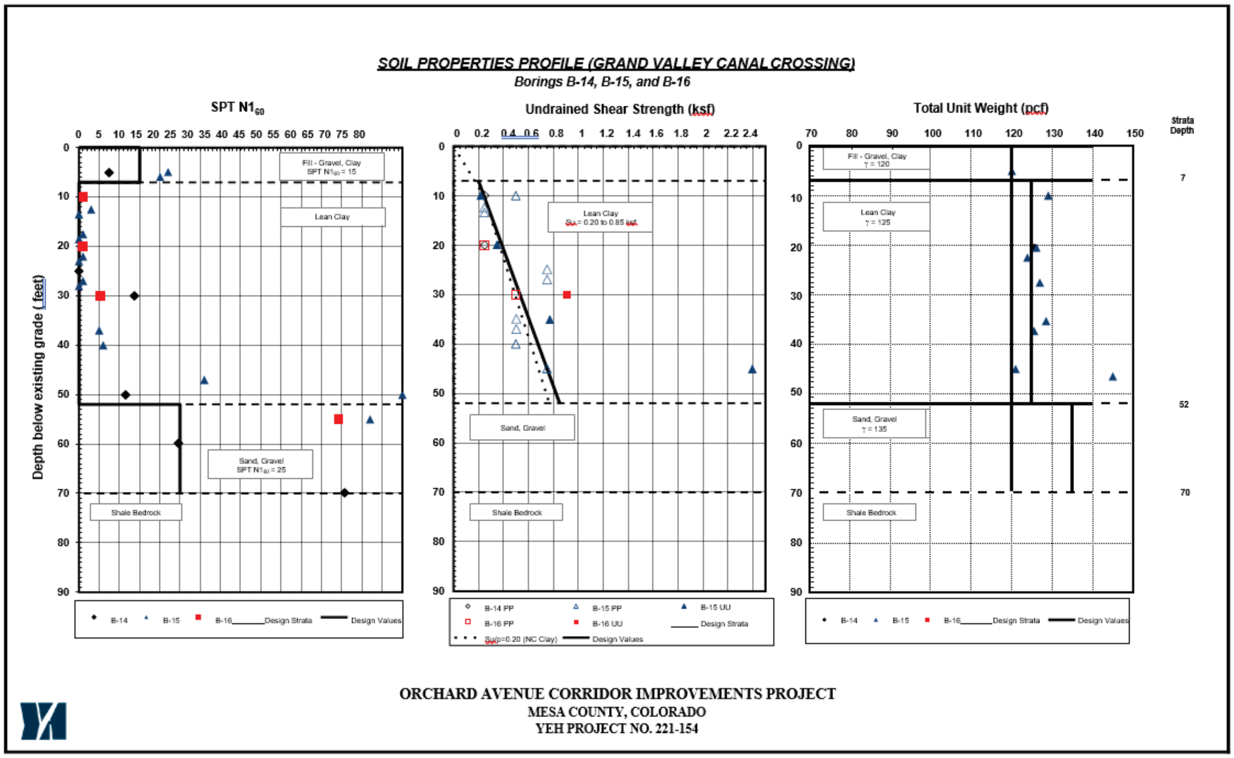
Notes

1. "Penetration Resistance" on the Boring Logs refers to the uncorrected N value for SPT samples only, as per ASTM D1586. For samples obtained with a Modified California (MC) sampler, drive depth is 12 inches, and "Penetration Resistance" refers to the sum of all blows. Where blow counts were > 50 for the 3rd increment (SPT) or 2nd increment (MC), "Penetration Resistance" combines the last and 2nd-to-last blows and lengths; for other increments with > 50 blows, the blows for the last increment are reported.

2. The Modified California sampler used to obtain samples is a 2.5-inch OD, 2.0-inch ID (1.95-inch ID with liners), split-barrel sampler with internal liners, as per ASTM D3550. Sampler is driven with a 140-pound hammer, dropped 30 inches per blow.

Appendix C4

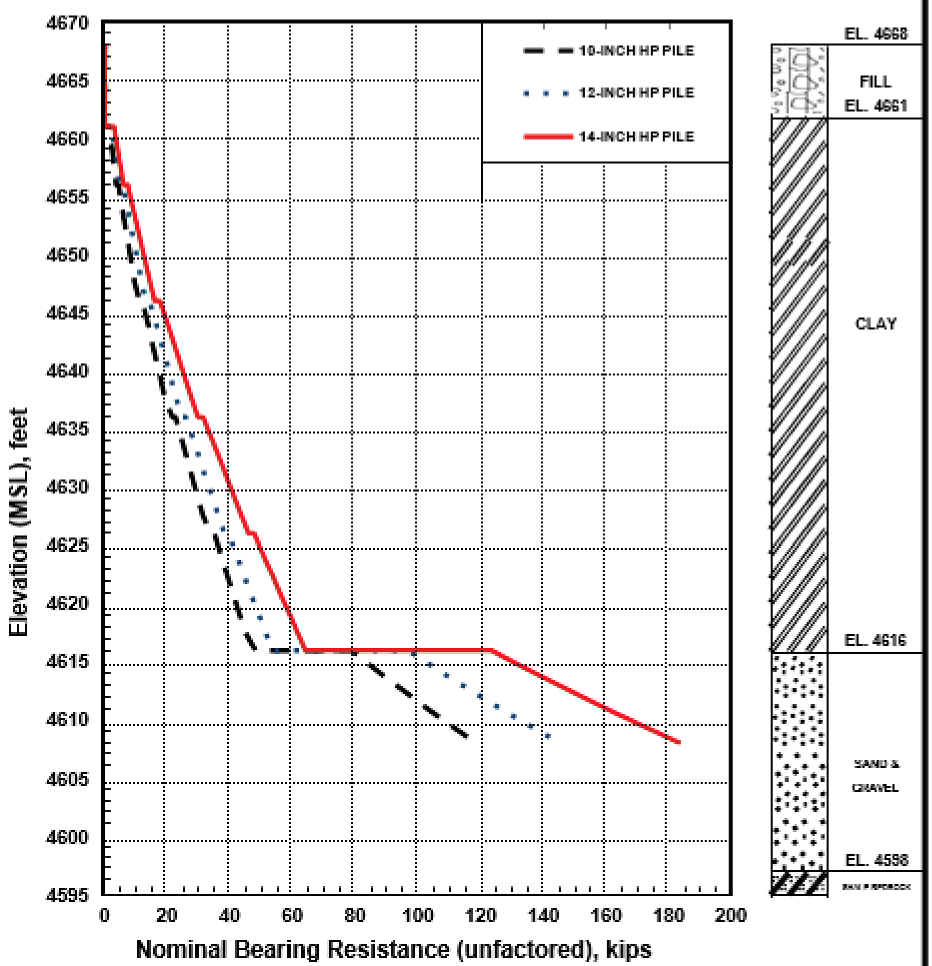
Appendix 12: C4 - Foundation Design



Appendix C5

Appendix 13: C5 - Static Axial Capacity Curves

STATIC AXIAL CAPACITY CURVES
ABUTMENTS 1 AND 2
10-IN., 12-IN., AND 14-IN. H-PILES



Note: Strength Limit Resistance Factor for Compression Loading is 0.65 with PDA/signal matching.

GRAND VALLEY CANAL CROSSING
ORCHARD AVENUE CORRIDOR IMPROVEMENTS PROJECT
YEH REPORT NO. 221-154

FIGURE E.2

Appendix C6

Appendix 14: C6 - Pavement Design

Orchard Avenue Corridor Study **Yeh No. 221-154**

Orchard Avenue Traffic Loading Between 29 1/2 Road and Warrior Way

Daily Traffic Volumes 2016-2020

Mesa County GIS Viewer for Transportation ADT

Average Daily Traffic (ADT)	
2016-2020 ADT	6,065
20-Year Factor	1.55%
2042 ADT	9,372
2052 ADT	11,651
Average ADT flexible with 110% adjustment	8,491
Average ADT rigid with 110% adjustment	9,744

Collector Traffic Mix	
% Passenger	0.95
% Single Axle	0.04
% Truck Traffic	0.01
Lane Factor (per direction)	0.6

Flexible Pavement Factors	
# Lanes	2
Design Life (years)	20
Load Equivalencies	
Passenger Vehicle	0.003
Single Axle	0.249
Truck Traffic	1.087

Rigid Pavement Factors	
# Lanes	2
Design Life (years)	30
Load Equivalencies	
Passenger Vehicle	0.003
Single Axle	0.285
Truck Traffic	1.692

Traffic Loading - Flexible	
EDLA	201
ESAL	1,467,710
Factored Loads	
EDLA	0
ESAL	0

Traffic Loading - Rigid	
EDLA	304
ESAL	3,325,671
Factored Loads	
EDLA	0
ESAL	0

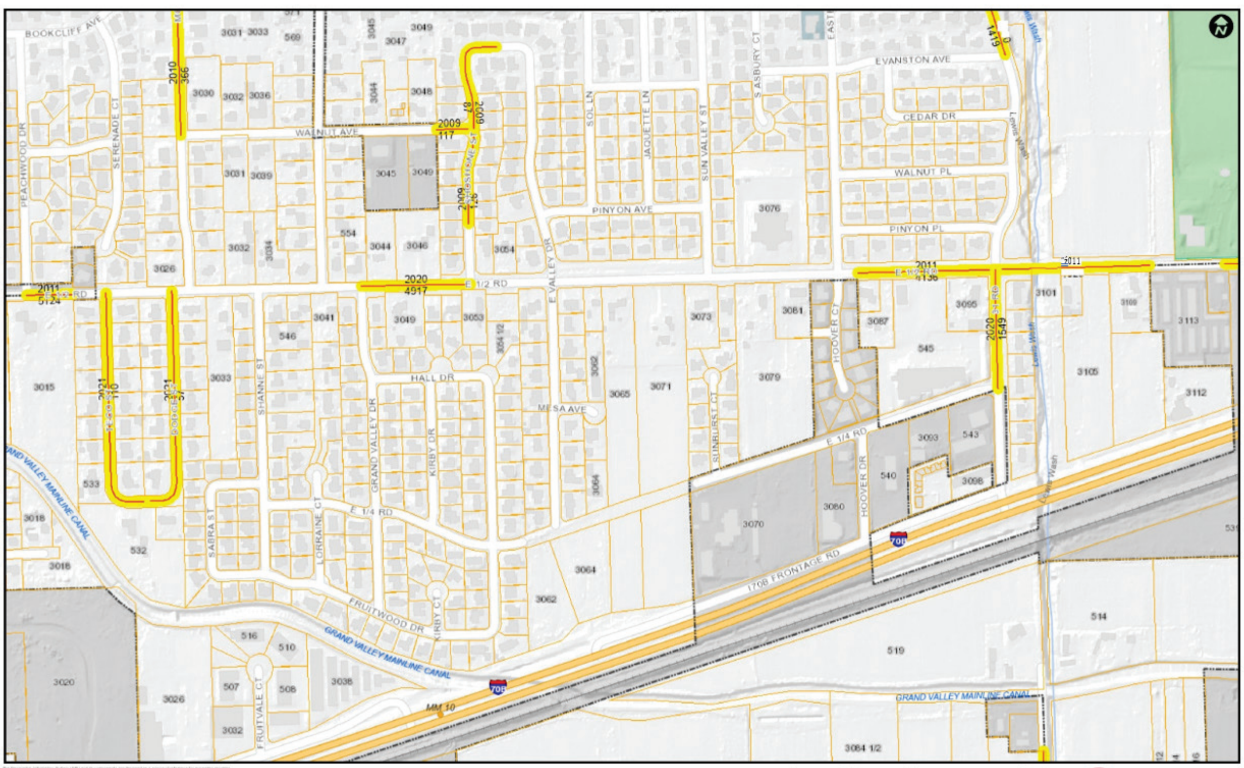
For Flexible Pavement Design, use ESAL = 880,626

For Rigid Pavement Design, use ESAL = 1,995,403

Orchard Ave Traffic Count East

Print Date: November 2, 2021

Mesa County, Colorado
GIS/IT Department



Orchard Ave Traffic Count Middle

Print Date: November 2, 2021

Mesa County, Colorado
GIS/IT Department


PARKWAY DR
REDBUD CT
BOOKCLIFF AVE
SUNSET DR
CEDAR PL
KRISTA ST
CEDAR AVE
WALNUT AVE
PINYON AVE
N VIEW DR
VIEW DR
E VIEW DR
E VIEW CT
GRAND VALLEY MAINLINE CANAL
ORCHARD AVE
HALL AVE
MESA AVE
SANDRA AVE
TEXAS AVE
N PALACE CIR
S PALACE CIR
KENNEDY AVE
BUNTING AVE
ELM AVE
MARKET WAY
ELLENDALE DR
SUNRISE DR
GARFIELD DR
SYCAMORE ST
CENTENNIAL RD
PLACER DR
FLORENCE RD
ESTATE ST
APRIL LN
EASTWOOD ST
PEARWOOD CT
EASTMOOR DR
PEACHWOOD DR
SERENADE CT
SABRA ST
SHANNE ST
FRUITVALE CT
30 RD
2016
5443
2016
4962
2016
6065
2020
4820
2011
5124
2020
4039
2015
5001
2010
4176
2016
4973
2020
4215
2016
4367
2016
4770
2020
4713
2020
3967
2010
6158
2010
366
2021
110
2021
57
Orchard Ave Traffic Count West
Print Date: November 2, 2021
Mesa County, Colorado
GIS/IT Department

Appendix C7

Appendix 15: C7 - Summary of Lab Results

YEH & ASSOCIATES, INC.

Summary of Laboratory Test Results

Project No: 221-154 Project Name: Orchard Avenue Corridor Study, Mesa County, Colorado

Sample Location			Moisture Content (%)	Dry Density (pcf)	Gradation			Atterberg			Water Soluble Sulfate (%)	Water Soluble Chloride (%)	Resistivity (ohm-cm)	pH	Swell (+) / Collapse (-)		One Dimen. Consol.	Specific Gravity at 20 degrees C	UU Triax. Shear Strength-Su (psf)	R-Value	AASHTO	USCS	Material Description
Test Boring	Depth (ft)	Sample Type			Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	LL	PL	PI					(%)	psf							
B-1	3.5	MC	16.1	99	0	14	86	24	16	8					0.0	500					A-4 (5)	CL	CLAY
B-2	2.0	MC	14.0	98	4	17	79	27	18	9					-0.1	300					A-4 (5)	CL	CLAY with sand
	4.0	SPT									1.383	0.0117	661	7.9									CLAY with sand
	9.0	MC	15.2	110	0	24	76	30	17	13					-0.3	1,000					A-6 (8)	CL	CLAY with sand
B-3	0.6	SPT	5.0		33	43	24	NV	NP	NP											A-1-b (0)	SM	FILL SAND, silty with gravel/ROAD BASE
	2.5	MC	10.4	102	9	34	57	NV	NP	NP											A-4 (0)	ML	FILL SILT, sandy
B-4	4.0	MC	16.0	107			95	30	16	14					-0.1	500					A-6 (12)	CL	CLAY
B-5	3.5	MC	17.0	106	0	6	94	28	17	11					0.0	500					A-6 (9)	CL	CLAY
	5.0										1.293	0.0128	620	8.0									CLAY
B-6	1.0	SPT	5.6		34	35	31	19	15	4											A-2-4 (0)	SC-SM	FILL SAND, clayey, silty with gravel/ROAD BASE
	3.0	MC	11.0	119			70								-0.1	500							FILL CLAY, sandy
	5.0	SPT	13.6		0	11	89	27	16	11											A-6 (8)	CL	CLAY
B-7	4.0	MC	16.0	104	3	17	80	29	19	10					-0.1	500					A-4 (7)	CL	FILL CLAY with sand

MC-Indicates Modified California sampler
SPT-Indicates standard split spoon sampler
ST-Shelby tube
Bulk-Auger cuttings
NV-No value
NP-Non-plastic

Page 1 of 4

YEH & ASSOCIATES, INC.

Summary of Laboratory Test Results

Project No: 221-154 Project Name: Orchard Avenue Corridor Study, Mesa County, Colorado

Sample Location			Moisture Content (%)	Dry Density (pcf)	Gradation			Atterberg			Water Soluble Sulfate (%)	Water Soluble Chloride (%)	Resistivity (ohm-cm)	pH	Swell (+) / Collapse (-)		One Dimen. Consol.	Specific Gravity at 20 degrees C	UU Triax. Shear Strength-Su (psf)	R-Value	AASHTO	USCS	Material Description
Test Boring	Depth (ft)	Sample Type			Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	LL	PL	PI					(%)	psf							
Mix B-7, B-8, B-9	3 to 6	BULK	9.0		7	26	67	27	16	11	1.276	0.0102	737	8.0						9	A-6 (5)	CL	Mix FILL and Native CLAY, sandy
B-8	0.5	SPT	2.9		30	45	25	NV	NP	NP											A-1-b (0)	SM	FILL SAND, silty with gravel/ROAD BASE
	3.0	MC	13.6	96	10	22	68	21	16	5											A-4 (1)	CL-ML	FILL CLAY, silty, sandy
	8.0	MC	16.4	99			63	29	17	12					-0.1	1,000					A-6 (5)	CL	CLAY, sandy
	18.0	MC	17.4	102			88	23	19	4											A-4 (2)	ML	SILT
B-9	4.0	MC	9.7	94	2	9	89	27	17	10					-2.8	500					A-4 (7)	CL	CLAY
	4.5	MC	8.2	101	0	4	96	28	17	11					0.5	500					A-6 (9)	CL	CLAY
B-10	1.0 to 2.5	BULK	3.0		32	45	23	NV	NP	NP											A-1-b (0)	SM	FILL SAND, silty with grave/ROAD BASE
B-11	3.5	MC	18.0	102	0	15	85	31	14	17					0.0	500					A-6 (13)	CL	CLAY with sand
B-12	1.0	SPT	1.2		44	47	9	NV	NP	NP											A-1-a (0)	SP-SM	FILL SAND with silt and gravel/ROAD BASE
	3 to 6	BULK	7.9		3	11	86	28	16	12	1.450	0.0221	404	8.0						8	A-6 (9)	CL	CLAY
	4.0	MC	18.6	106	0	3	97	30	18	12					0.0	500					A-6 (11)	CL	CLAY

MC-Indicates Modified California sampler
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YEH & ASSOCIATES, INC.

Summary of Laboratory Test Results

Project No: 221-154 Project Name: Orchard Avenue Corridor Study, Mesa County, Colorado

Sample Location: Test Boring	Depth (ft)	Sample Type	Moisture Content (%)	Dry Density (pcf)	Gradation: Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	Atterberg: LL	PL	PI	Water Soluble Sulfate (%)	Water Soluble Chloride (%)	Resistivity (ohm-cm)	pH	Swell (+) / Collapse (-) (%)	psf	One Dimen. Consol.	Specific Gravity at 20 degrees C	UU Triax. Shear Strength-Su (psf)	R-Value	AASHTO	USCS	Material Description
B-13	10.0	MC									0.034	0.0119	896	7.6									FILL GRAVEL, clayey with sand
	14.5 to 15.0	ST	13.6	98															2500				CLAY
	19 to 21	ST	21.1	107	0	6	94	34	15	19							See Appendix D	2.747			A-6 (17)	CL	CLAY
	24 to 26	ST	22.3	99															660				CLAY
	29 to 31	ST	22.0	103															910				CLAY
	31.0	MC	20.4	102	0	6	94	27	15	12											A-6 (10)	CL	CLAY
	40.0	MC	22.8	106															570				CLAY
	50.0	MC	23.6	103	0	2	98	27	15	12											A-6 (10)	CL	CLAY
	60.0	SPT	13.0		33	57	10	NV	NP	NP											A-1-b (0)	SP-SM	SAND with silt and gravel
B-14	5.0	SPT	24.4		0	19	81	25	15	10											A-4 (6)	CL	FILL CLAY with sand
	10.5	MC	19.9		1	41	58	20	16	4											A-4 (0)	CL-ML	CLAY, silty, sandy
	20.0	MC	21.5	103																			CLAY, silty, sandy
	31.0	SPT	25.3		0	9	91	32	16	16											A-6 (13)	CL	CLAY
	50.0	SPT	22.9		0	18	82	29	14	15											A-6 (10)	CL	CLAY with sand
	60.0	SPT	12.8		41	45	14	NV	NP	NP											A-1-a (0)	SM	SAND, silty with gravel

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YEH & ASSOCIATES, INC.

Summary of Laboratory Test Results

Project No: 221-154 Project Name: Orchard Avenue Corridor Study, Mesa County, Colorado

Sample Location: Test Boring	Depth (ft)	Sample Type	Moisture Content (%)	Dry Density (pcf)	Gradation: Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	Atterberg: LL	PL	PI	Water Soluble Sulfate (%)	Water Soluble Chloride (%)	Resistivity (ohm-cm)	pH	Swell (+) / Collapse (-) (%)	psf	One Dimen. Consol.	Specific Gravity at 20 degrees C	UU Triax. Shear Strength-Su (psf)	R-Value	AASHTO	USCS	Material Description
B-15	5.0	MC	9.7	109	48	29	23																FILL GRAVEL, silty with sand
	10 to 12	ST	23.6	104	0	6	94	25	15	10									220		A-4 (7)	CL	CLAY
	13.5	SPT									0.007	0.0047	1639	7.9									CLAY
	20 to 22	ST	23.2	102															350				CLAY with sand
	22.0	MC	18.7	104	0	27	73	23	15	8											A-4 (3)	CL	CLAY with sand
	27.5	MC	21.6	104	0	3	97	32	15	17											A-6 (16)	CL	CLAY
	35 to 37	ST	23.1	104															770				CLAY
	37.0	MC	22.6	102	0	4	96	30	16	14											A-6 (12)	CL	CLAY
	45 to 47	ST	20.5	100															2400				CLAY
	47.5	MC	6.1	136	57	31	12	NV	NP	NP											A-1-a (0)	GP-GM	GRAVEL with silt and sand
	55.0	SPT	6.5		44	42	14	NV	NP	NP											A-1-b (0)	GM	GRAVEL, silty with sand
B-16	10.0	MC	21.8	102	0	8	92	28	15	13											A-6 (10)	CL	CLAY
	20.5	MC	20.7	99																			CLAY
	30.0	MC	22.3	105	0	7	93	32	14	18									910		A-6 (16)	CL	CLAY
	55.0	SPT	11.8		40	50	10	NV	NP	NP											A-1-b (0)	SP-SM	SAND with silt and gravel

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Appendix D1

Appendix 16: D1 - Flow Measurement Data and Calculations

GVIC Canal: 8/11/2021 @ 11:00AM - 1:00PM						
x (ft)	***Depth (ft)***	***Velocity (fps)***		***Average Velocity (fps)***	***Section Width (ft) *via midsection method***	***Flow (cfs)***
		0.2d	***0.8d***			
0.0	start					
1.0	3.40	4.15	5.46	4.81	2.00	32.67
3.0	3.40	4.34	5.95	5.15	2.00	34.99
5.0	3.50	4.77	6.42	5.60	2.00	39.17
7.0	3.50	4.12	7.15	5.64	2.00	39.45
9.0	3.60	3.84	7.03	5.44	2.00	39.13
11.0	3.70	4.1	6.56	5.33	2.00	39.44
13.0	3.70	3.72	6.39	5.06	2.00	37.41
15.0	3.80	4.11	6.41	5.26	2.00	39.98
17.0	3.70	4.06	6.35	5.21	2.00	38.52
19.0	3.70	4.22	6.55	5.39	2.00	39.85
21.0	3.55	4.59	6.94	5.77	2.00	40.93
23.0	3.50	4.36	6.72	5.54	2.00	38.78
25.0	3.40	4.24	6.28	5.26	2.00	35.77
27.0	3.40	3.14	4.98	4.06	2.00	27.61
29.5	3.30	4.22	5.00	4.61	3.00	45.64
31.0	end					
					Total	**569.3**

Appendix D2

Appendix 17: D2 - Turnout Flow Data Provided by GVIC

HEADGATE #	SHARES ORDERED	CFS RUNNING CONSTANT
31RD.		
UM120	133	1.15 (LATERAL)
UM120-A	3	FT (FIELD TURNOUT/PUMP)
UM121	3	FT
UM123	5	FT
UM125	32	.82
UM128	9	FT
UM130	110	1.80
UM133	12	FT
UM133-B	16	FT
UM135	164	3.04
UM140	10	.40
UM141	66	1.80
UM143-BB	0	0
UM145	0	0
UM147	2	FT
UM148	23	.90
UM150	4	FT
UM154-AA	1	FT
UM158	40	.53
UM160	177	1.34
UM160-A	2	FT
UM165	63	1.20
TOTALS	875 SHARES	12.90 CFS

ORCHARD BRIDGE

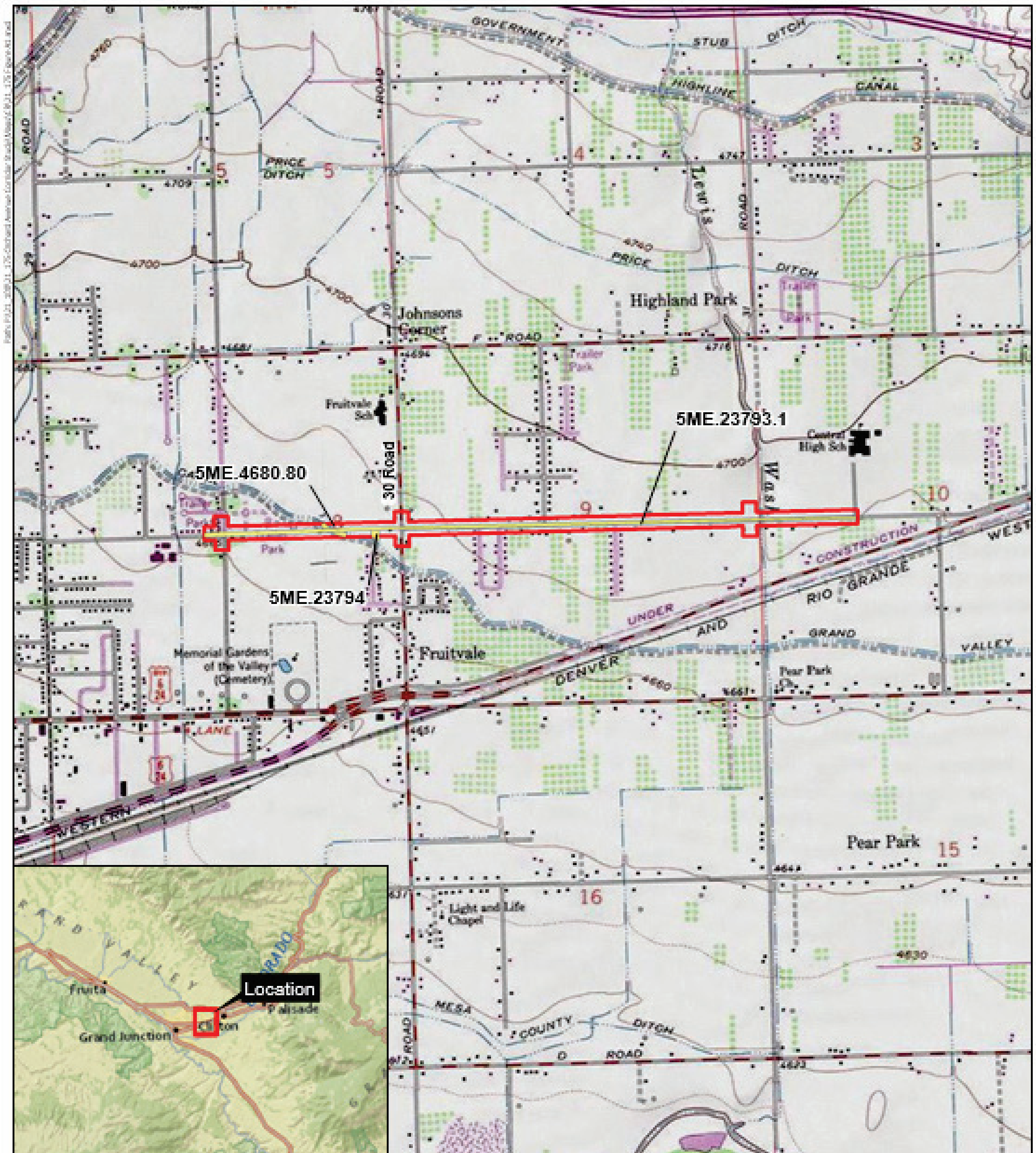
FIELD TURNOUTS MAYBE ADDITIONAL 2.0 CFS

14.90 CFS

08/18/2021
cdg
td

Appendix E1

Appendix 18: E1 - Cultural Resource Location



Orchard Avenue Corridor Study

Sections 8-10, T1S, R1E; Ute Meridian
UTM NAD 83: Zone 12N; 717089mE, 4329160mN
Longitude 108.490138°W, Latitude 39.084570°N
USGS Grand Junction and Clifton, CO Quadrangles
Mesa County, Colorado

0 750 1,500 Feet
1:24,000

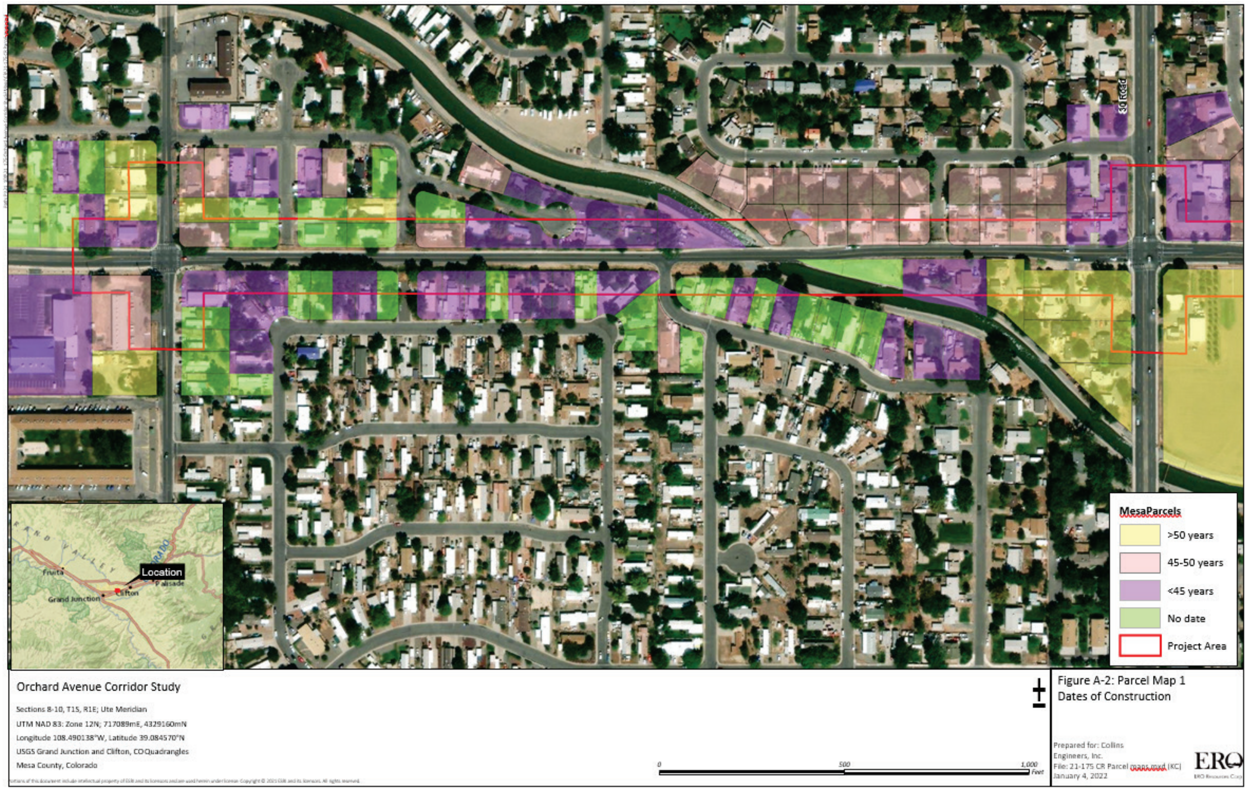
Figure A1
Cultural Resource Location

Prepared for: Collins Engineers, Inc.
File: 21_175 Figure A1.mxd (KC)
January 5, 2022

ERO Resources Corp

Appendix E2

Appendix 19: E2 – Parcel Maps



Orchard Avenue Corridor Study

Sections 8-10, T1S, R1E; Ute Meridian
UTM NAD 83: Zone 12N; 717089mE, 4329160mN
Longitude 108.490138°W, Latitude 39.084570°N
USGS Grand Junction and Clifton, CO Quadrangles
Mesa County, Colorado

0 500 1,000 Feet

Figure A-4: Parcel Map 3
Dates of Construction

Prepared for: Collins Engineers, Inc.
File: 21-175 CR Parcel maps.mxd (KC)
January 4, 2022

ERO Resources Corp