COLORADO
Department of Transportation

CDOT Project NO. FBR R200-266
CDOT Subaccount No. 23558

STRUCTURE ALTERNATIVES EVALUATION REPORT

Region 2 Bridge Bundle Design Build Grant Project
Preliminary Design and Procurement Support Services

Structure M-22-U

(Region 2 – US 350 MP 69.817)

Prepared for:	Colorado Department of Transportation Region 2 5615 Wills Blvd. Pueblo, CO 81008
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Stanley Consultants

Stanley Consultants Project No. 29715
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1. EXECUTIVE SUMMARY

1.1. PROJECT DESCRIPTION

The CDOT Region 2 Bridge Bundle Design Build Project consists of the replacement of seventeen (17) rural bridges on essential highway corridors in southeastern and central Colorado. The key corridors (US 350, US 24, CO 239 and CO 9) provide rural mobility, intra- and interstate commerce, movement of agricultural products and supplies, and access to tourist destinations. The 2 other bridges are Additionally Requested Elements (AREs) in the design build project. There is a total of nineteen (19) structures bundled under this project.

This design build project is partially funded by the USDOT FHWA Competitive Highway Bridge Program grant and funds from the Colorado Bridge Enterprise (14 structures, project number 23558). The 5 additional structures are funded solely by Colorado Bridge Enterprise (project number 23559). These projects are combined to form one design-build project.

The nineteen bridges identified to be included in the 'Region 2 Bridge Bundle' were selected based on similarities in the bridge conditions, risk factors, site characteristics, and probable replacement type, with the goal of achieving economy of scale. Seventeen of the bridges being replaced are at least 80 years old. Five of the bridges are Load Restricted limiting trucking routes through major sections of the US 24 and US 350 corridors. The bundle is comprised of nine timber bridges, four concrete box culverts, one corrugated metal pipe (CMP), four concrete I-beam bridges, and one I-beam bridge with corrugated metal deck.

1.2. PURPOSE OF THE REPORT

This report presents the findings of the preliminary level multidisciplinary investigation of the existing conditions of the given structure. The objective of this report is not to select a new structure type but to develop guidelines that will be addressed in the Design-Build documents and make recommendations based on the available information. All the information obtained in the survey, geotechnical investigation, hydrology and hydraulics, existing utilities, and environmental investigation is discussed in this report. The study evaluates feasible structure alternatives for the site and identifies all known constraints.

1.3. STRUCTURE SELECTION PROCESS

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

- Hydraulic Opening Requirements
- Roadway alignments
- ROW Impacts
- Constructability
- Construction costs
- Maintenance
- Durability
- Traffic Control

The recommendations of the report are based on the overall consideration of all these elements as appropriate to this site and bridge.

1.4. STRUCTURE RECOMMENDATIONS

Based on the subsequent discussion, the recommended proposed overpass structure is a 16 ft x 10 ft reinforced concrete box culvert. The proposed length of the box will be 79.0 ft to accommodate two 12.0 ft lanes of traffic with 6.0 ft shoulders. Northeast and southwest wingwalls will be required parallel to US 350 to retain the roadway section, reduce impacts to the Otero Irrigation Ditch, and stay within the right of way.

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

2. SITE DESCRIPTION AND DESIGN FEATURES

2.1. EXISTING STRUCTURE

The existing structure is a single span concrete deck, steel I beam girder bridge built in 1935 to span the Otero Canal. The bridge is on a 45-degree skew with a span length of 39.5 ft and a total structure length of 44.0 ft. The width of the existing bridge is 30.0 ft curb to curb and 33.5 ft out to out of deck. The existing vertical clearance is approximately 11.0 ft max.

The existing bridge has 7 lines of W27x91 steel girders. The reinforced concrete deck is 8.5 in deep and overlaid with 5.0 in of asphalt. The bridge railing is a 9” tall concrete curb with a 2.0 ft decorative concrete railing. Steel diaphragms are C15x33.9 channels placed at third points of the span and at supports.

The abutments are mass cast-in-place concrete wall abutments with wingwalls. Only the top 3 feet of the abutments and wingwalls are reinforced. Abutments are 44 ft 5 ½ in wide and 18.0 ft high. Thickness of the abutment wall varies from 2 ft 3 in to 9.0 ft at the base. The concrete reinforced wingwalls at both abutments are 10.0 ft and 20.0 ft long. The thickness of the wingwalls varies from 1.0 ft to 7.0 ft at the base.

The structure is located on US 350, southwest of La Junta, at milepost 69.817. Table 1 summarizes bridge information.

National Bridge Structure Number	M-22-U
Year Built	1935
Construction Type	Concrete on I-Beam
Condition Rating	Poor
Load Restricted	No
Bridge Length	44.0 feet
Bridge Width	33.5 feet
Number of spans	1
Water Crossing	Otero Irrigation Canal
AADT	580
Percent Commercial Traffic	7%

Table 1 - Bridge M-22-U Summary Information

Picture 1 - Bridge M-22-U

The replacement of Bridge M-22-U is warranted due to the age and deteriorating conditions. Cracking has been found on the wing walls and abutments. There is visible corrosion on most of the girders and diaphragms. The underside of the deck has cracking and efflorescence throughout. The deck overhangs have severe cracking, spalls with exposed reinforcing, active leakage, rust staining, efflorescence, and loose coarse aggregate the full length of the bridge. Photos below show some of the existing bridge deterioration.

Picture 2 - Pier, Overhang, Deck, Girders

Picture 3 – Corrosion, cracking, efflorescence

2.2. RIGHT OF WAY IMPACT

The existing right of way (ROW) is located approximately 50.0 ft on each side from the centerline of the existing road. 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 US 350. Temporary construction easements may be required for detour or drainage erosion control.

The Otero Irrigation Canal runs southwest to northeast along US 350.

2.3. TRAFFIC DETOUR

As stated by the CDOT grant application, the roadway shall not be closed for construction. Two other alternatives were investigated:

1. Phasing the construction to keep one lane open. To meet all typical CDOT roadway phased construction criteria, this alternative will require overbuilding the proposed bridge on either side. The width of the proposed structure is contingent upon the girder type and width and will wary for the alternatives described below.
2. Building a two-lane shoofly on one side of the existing bridge with a temporary pipe placed for drainage. A shoofly would have temporary impacts to the irrigation canal.

Alternative 1 (phased construction with one lane open) was identified as a preferred traffic alternative for this structure. The Otero Canal is considered a historic landmark; therefore, a shoofly is not preferred due to the impacts of the canal. More information on traffic detour options can be found in the Traffic Design Memorandum for this structure.

2.4. UTILITIES

Stanley subcontracted with Lamb-Star Engineering to provide utility location services in the vicinity of the structure. Based on their investigation, the existing utilities near this structure consist of an overhead and underground CenturyLink telephone line. Both lines run parallel to the existing ROW line on the east side of the bridge approximately 43 ft from the centerline of US 350. They are located just inside of the ROW.

2.5. GEOTECHNICAL SUMMARY

Stanley subcontracted with Yeh and Associates, Inc. to perform the geotechnical investigation of all bridges in this project. The Full Preliminary Geotechnical Study is provided in Appendix D.

Two bridge borings, M-22-U-B-1 and M-22-U-B-2, were drilled near the existing bridge abutments, and two pavement borings, M-22-U-P-1 and M-22-U-P-2, were drilled along the existing pavement approximately 250 feet from the bridge on either end. The approximate boring locations are shown on the engineering geology sheet in Appendix A of the Geotechnical Study. The legend and boring logs are included in Appendix B of the Study, while the laboratory test results are provided in Appendix C of the Study and are shown on the boring logs.

The bridge borings encountered lean clays with sand and gravel and clayey gravel soils overlying limestone bedrock. Table 2 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 feet. The groundwater depths and elevations are based on observations during drilling.

Boring ID	Location[1] (Northing, Easting)	Ground Surface Elevation at Time of Drilling[1] (feet)	Approx. Depth to Top of Competent Bedrock[1] (feet)	Approx. Elevation to Top of Competent Bedrock[1] (feet)	Approx. Groundwater Depth[1, 2] (feet)	Approx. Groundwater Elevation [1, 2] (feet)
M-22-U-B-1	475060.335, 551591.579	4232.0	18.0	4214.0	Not Encountered	Not Encountered
M-22-U-B-2	475012.354, 551541.265	4232.0	16.5	4215.5	Not Encountered	Not Encountered

Table 2 - Summary of Bedrock and Groundwater Conditions

Based on the recommendations of the Geotechnical Study, either spread footing, driven H-pile, or drilled shaft foundations are suitable for support of the structures.

2.6. HYDRAULICS SUMMARY

Bridge M-22-U crosses the Otero Irrigation Canal that flows southwest to northeast.
The drainage flows are regulated by the Otero Ditch Company. Otero Ditch has a decreed flowrate of 123 cfs, which was used as the design flow rate. A HEC-RAS model was developed at this location, which indicated that an 8 ft x 8 ft CBC would be adequate. In order to provide the canal company with a culvert size that is similar to the existing opening, a 16 ft x 10 ft box culvert is proposed. A one-span 40.0 ft long bridge alternative was also evaluated and shown to have an adequate opening to carry the design flows.

The channel was not identified as having a high potential for debris production. Therefore, if a bridge is selected for the proposed conveyance structure, 2 feet of freeboard would typically be required. The proposed bridge alternative meets this freeboard requirement.

A Preliminary Hydraulic Report has been completed and can provide more information about the existing and proposed hydraulics conditions.

2.7. ENVIRONMENTAL CONCERNS

Based on the field investigations performed by Stanley Consultants' Environmental team, no wetlands were present; however, there is a potential to impact up to 1,310 linear feet of USACOE jurisdictional tributaries (the Otero Canal). There were no impacts to any federally listed species identified; however, there is a potential to impact one species listed by the CPW and may need coordination prior to construction

2.8. ROADWAY FEATURES

2.8.1. Cross Section

Existing US 350 is a 2-lane roadway with two-way traffic. Both lanes are 11.0 ft wide with approximately 3.0 ft shoulders and 1.0 ft curb offsets within the limits of the structure.

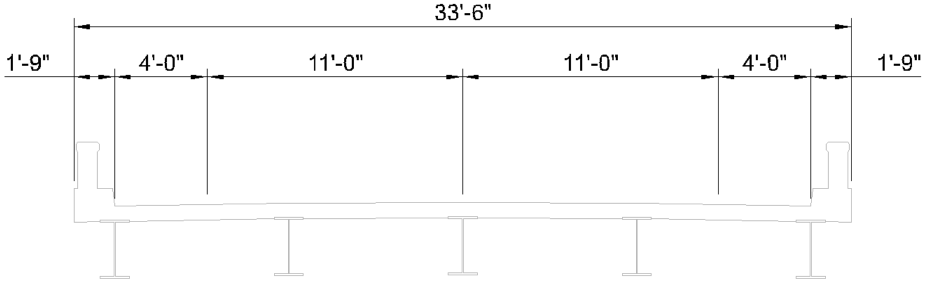

Figure 1 - Existing Section

The proposed roadway section width is based on the traffic volumes and the requirements of the current CDOT Roadway Design Guide. Lane width is expected to be 12.0 ft in each direction with 6.0 ft shoulders, and 2.0 ft curb offset. The AADT for this section of the road is 580 veh/day, and the design speed is 75 mph. Total required roadway width over proposed structure is 40.0 ft. Additional roadway width is needed for phased construction and is discussed in Section 4.7 Construction Phasing.

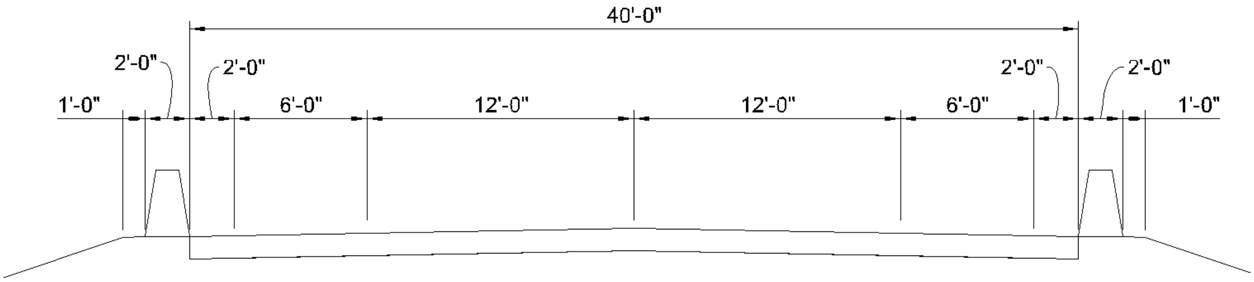

Figure 2 - Proposed Roadway Section

2.8.2. Vertical Alignment

The proposed vertical profile of US 350 must be set as close to the existing as allowed by the results of the hydrology study to avoid any ROW acquisitions and to limit impacts to the existing roadway section beyond the length of the structure.

The proposed bridge profile is on a constant tangent with a slope of -0.02% matching the existing grade. The profile grade is less than 0.5% min recommended by FHWA for bridge decks. Refer to section 4.3 for more information.

2.8.3. Horizontal Alignment

The horizontal alignment of the existing bridge has a 45-degree skew. The bridge is on a continuous horizontal tangent. It is understood that the proposed structure will be constructed in the same location as the existing with no change to the horizontal alignment of the road and skew.

3. STRUCTURAL DESIGN CRITERIA

3.1. DESIGN SPECIFICATIONS

- AASHTO LRFD Bridge Design Specifications, 9th Edition
- CDOT LRFD Bridge Design Manual
- CDOT Bridge Rating Manual
- CDOT Bridge Detail Manual

3.2. CONSTRUCTION SPECIFICATIONS

Colorado Department of Transportation Standard Specifications for Road and Bridge Construction, 2019

3.3. LOADING

Live Loads: HL-93 Design Truck or Tandem, Design Lane Load, Colorado Permit Vehicle

Bridge Barrier: Colorado current standard Bridge Rail (Bridge Rail Type 9)

Future Wearing Surface: 36.67 lbs per square foot (3 in minimum)

Utilities: per plan details if required at final design

Collision Load: the substructure will not require collision loading design. In cases where Bridge Rail is attached to the structure, the effects of vehicular collision on the barrier must be considered in accordance with AASHTO.

Earthquake Load: The structure is located within Seismic Zone 1 and must meet the AASHTO connection and detailing requirements.

Stream Forces and Scour Effects: stream force effects must be evaluated during final design when applicable. Possible cases include stream forces on the substructure and superstructure in addition to buoyancy from overtopping. Evaluation from scour will be performed per the CDOT Bridge Design Manual and AASHTO.

4. STRUCTURE SELECTION

4.1. SELECTION CRITERIA

The goal of this report is to identify which structural alternatives best meet the project requirements. The following criteria were established as a basis for evaluating the suitability of each structure type: hydraulic opening, constructability, construction cost, maintenance & durability, ROW and roadway impacts. The discussion below expands on these factors as it pertains to each alternative. The Summary of Structure Alternatives Evaluation Table can be found at the end of Section 4.

4.2. REHABILITATION ALTERNATIVES

Rehabilitation of M-22-U will not be performed due to the age and type of the bridge. Constructed in 1935, this structure was in service for over 80 years and is showing signs of deterioration and aging that are inconsistent with practical and cost-effective rehabilitation.

4.3. STRUCTURE LAYOUT ALTERNATIVES

Layout of the proposed structure is controlled by the width of the proposed roadway section, stream geometry, hydraulic opening requirements, phased construction considerations and the position of the existing bridge substructure.

The proposed hydraulic report would allow for a small box culvert but based on discussions with the Irrigation Canal owner and CDOT historical team, we proposed to provide a box culvert or bridge alternative that closely represents the existing opening. It will also provide adequate freeboard based on hydraulic elevations provided in the hydrology report. Refer to the CDOT Bridge Design Manual and the CDOT Drainage Manual for additional clearance requirement information.

The horizontal alignment of the proposed structure will have a similar 45-degree skew to follow the irrigation canal.

The FHWA Design of Bridge Deck Drainage, Hydraulic Engineering publications referred to by the CDOT Bridge Design manual states that if the proposed vertical grade is less than 0.5%, the designer must specify a gutter grade that will run the water to the inlet boxed from high points between the boxes. As stated in Section 2.8.2, the proposed vertical roadway grade is approximately -0.02%, matching the existing roadway profile. If bridge structure is selected, design team will need to address drainage issues during the final design.

Any bridge structure selected for final construction must satisfy the live load deflection requirement for the selected girder types specified in the AASHTO LRFD Bridge Design Manual.

4.4. SUPERSTRUCTURE ALTERNATIVES

4.4.1. Concrete Box Culvert Alternative

Concrete box culverts are a cost-effective solution in both short and long-term due to ease of construction and maintenance. The benefit of this structure type is that the culverts can be cast -in-place (CIP) or precast off-site and transported to the site for placement to streamline the construction process. In addition, CBC sizes can be selected from CDOT M&S Standards that cover a wide array of single-cell and multi-cell culvert sizes.

For M-22-U, hydraulically, a single cell 8 ft x 8 ft box culvert would be required to carry the flow. However, due to constraints mentioned previously, a 16 ft x10 ft box culvert was selected to provide a similar opening to the existing. The box is estimated to have a total height of 11 ft 10 in, with an average fill height of 3 ft 6 in. The box can be constructed as CIP or precast. At the end of the box culvert will be concrete headwalls and wingwalls. The proposed CBC is 79.0 ft long to accommodate the proposed roadway section width, making the headwall 1 ft 6 in.

4.4.2. Concrete Girder Bridge Alternatives

Selected materials and structure components must exhibit high durability to provide longevity of the bridge. A precast prestressed concrete girder bridge requires minimum maintenance and have been shown to be highly durable under Colorado's harsh conditions. For this project, viable concrete alternatives include precast prestressed box girders or Colorado bulb tee (CBT) shapes. There are a couple different approaches that can be taken in construction of the proposed structure:

- Proposed girder sizes for alternative 1 were selected based on the Table 5B-1 and Figures 5B-1, 5B-2, 5B-4 in the CDOT Bridge Design Manual. Based on this information, (4) BX 18x48 girder sections spaced at 12' were chosen as a cost-effective precast concrete solution for the required 40.0 ft span. Deck depth for the concrete box girder alternative can be limited to 8.0 in.
- Proposed girder sizes for alternative 2 were selected based on the Table 5B-1 and Figures 5B-1, 5B-2, 5B-4 in the CDOT Bridge Design Manual. Based on this information, (5) BX 18x48 girder sections spaced at 9' were chosen as a cost-effective precast concrete solution for the required 59.0 ft span. Deck depth for the concrete box girder alternative can be limited to 8.0 in.

4.4.3. Steel Girder Bridge Alternatives

At this location, concrete box culvert and concrete girder bridge alternatives have been evaluated. Since steel girders are not usually cost effective for short spans, we have not evaluated a steel girder option at this location. Steel girders also require more frequent future maintenance and are not a preferred alternative.

4.4.4. Span Configurations

Total length of the existing structure is 44.0 ft. The existing substructure is supported by a 9.0 ft wide spread-footing placed directly on the bedrock layer. There are a couple different approaches that can be taken in construction of the proposed structure:

- Concrete Bridge Alternative 1 consists of removing the existing abutment and re-build the proposed abutments in the same location. The removal of the existing substructure can be expensive but would allow for the shortest span. Proposed span for this alternative is 40.0 ft.

- Concrete Bridge Alternative 2 consists of leaving the existing spread footing in place and building new abutments behind existing. Drilling through the existing reinforced concrete is generally not recommended. For this alternative, it was assumed that proposed abutment foundation would be installed far enough from the existing to avoid the spread footing. Proposed span for this alternative is 59.0 ft.

Both alternatives will be explored in the discussion below.

4.5. SUBSTRUCTURE ALTERNATIVES

Feasible substructure types considered in this study are integral abutments supported on H-piles or drilled shafts, or wall type abutments supported on spread footings.

Wall type abutment alternative will be used for 40.0 ft span option, where a lot of required excavation will be done during existing abutment removal process. Tall wall width is assumed to be 2.5 ft wide based on Figure 11-6 in the CDOT Bridge Design Manual. Footing is assumed to be 2.0 ft deep and 11.5 ft wide based on the preliminary bearing capacity calculations. Required wingwall lengths are 20.0 ft & 56 ft 4 in at both the north and south abutments based on the roadway tow of slope model. Wingwalls for this alternative will be connected to tall wall abutments and bearings on a 2.0 ft deep, 11.5 ft wide spread-footing foundation.

Integral abutment alternative with a maximum allowed depth of 6.0 ft will be used for the 59.0 ft span option (see Figure 11-1 in CDOT Bridge Design Manual). Abutment cap will be supported by (7) 24.0 in diameter drilled shafts. Due to the shallow foundation, drilled shafts were selected for this substructure due to the concerns that H-piles would not be able to get sufficient embedment into the hard bedrock layer to provide adequate lateral resistance due to the large skew. Note that portion of the existing substructure can be left in place if this alternative is selected. It is assumed that by providing deeper abutment cap and channel grading, it will be possible to avoid building MSE retaining wall in front of the integral abutment. Wingwalls for this alternative will consist of ether integral wingwall attached to the abutment cap (up to 20.0 ft max), or a combination of 10.0 ft integral wingwall with an independent wingwall to achieve the required design length.

4.6. ACCELERATED BRIDGE CONSTRUCTION (ABC)

CDOT has developed an Accelerated Bridge Construction (ABC) decision making process. The intent of this process is to apply some form of ABC on most projects. Design-build team is encouraged to use these recourses to evaluate cost efficiency of implementing ABC design.

4.7. CONSTRUCTION PHASING

As discussed in Section 2.3, building a shoofly at this location will have temporary impacts to the historic canal and might not be cost effective. Phased construction is feasible and recommended.

Based on the CDOT Roadway requirements, a minimum required roadway configuration for each phase of the construction must consist of 11.0 ft lane, 2.0 ft shoulder on each side, 2.0 ft wide temporary concrete barrier, 1.0 ft min. work zone buffer with pinned barrier and 2.0 ft min. work zone buffer with non-pinned barrier. To accommodate these requirements, bridge deck section will require some amount of overbuild (compared to the approaching roadway section). The Figures below show the required phasing configuration for the superstructure alternatives. More information on phased construction can be found in the Traffic Design Memorandum for this structure.

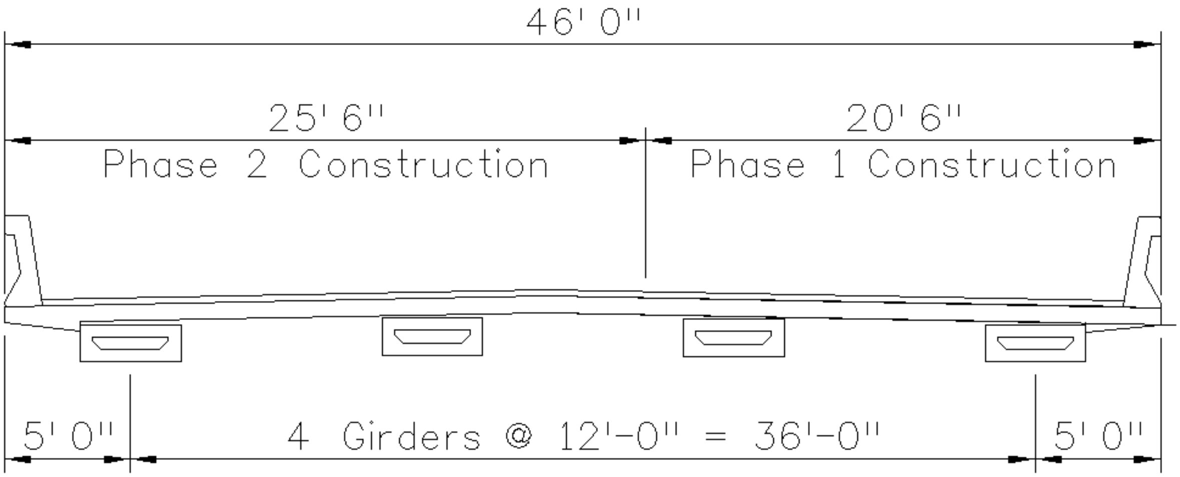

Figure 3 - Phased Construction Bridge Alternative 1

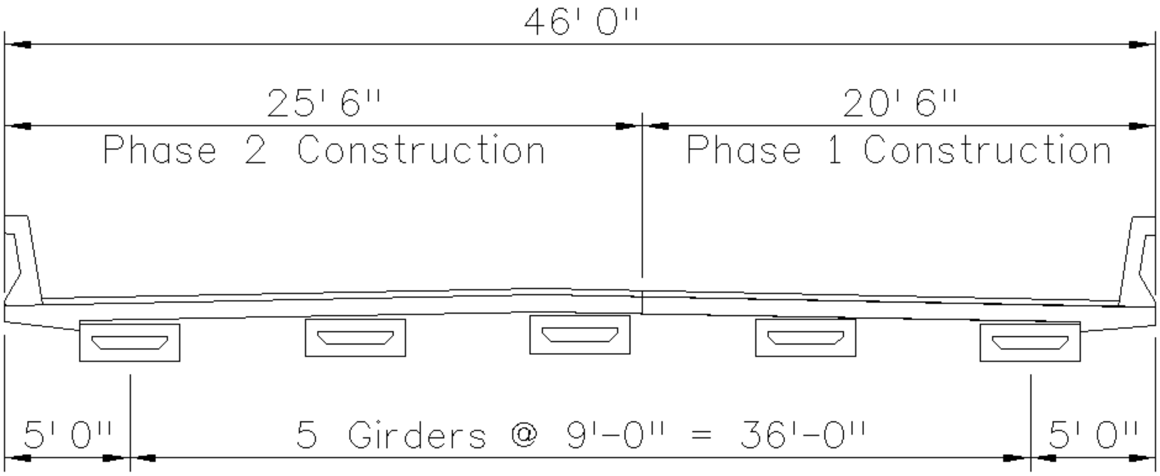

Figure 4 - Phased Construction Bridge Alternative 2

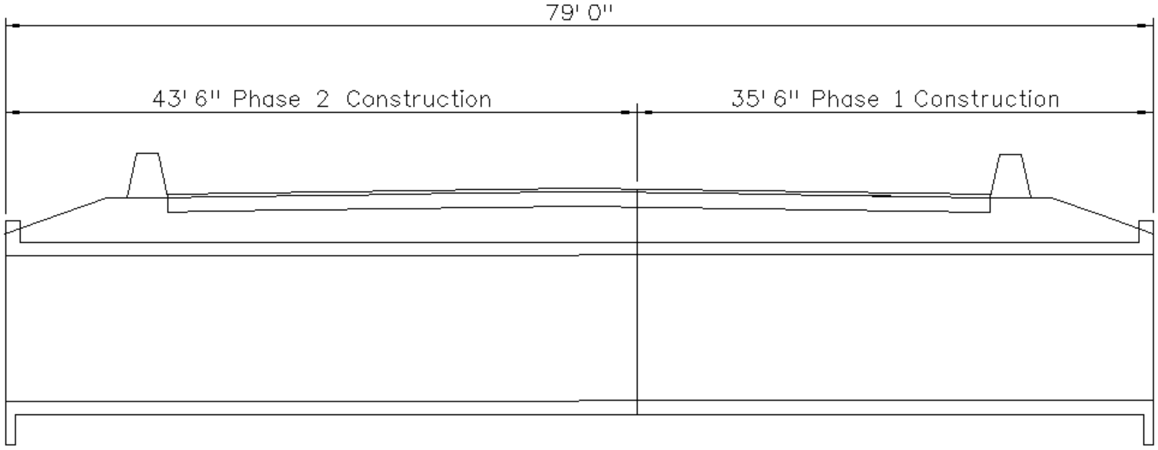

Figure 5 - Phased Construction CBC Alternative

4.8. CONSTRUCTABILITY

The location of this bridge contains very hard rock at 16.5 ft below ground at the south abutment and 18.0 ft below grade at the north abutment.

Some amount of rock excavation is expected for tall wall on spread footing abutment alternative to remove a layer of the deteriorated bedrock, and any bedrock damaged during existing structure removal. For this structure, the proposed spread footing elevation was set about 1.0 ft below the existing footing.

Preliminary Geotechnical Study Report notes that bedrock may be very hard at various elevations. If drilled shaft option is chosen as final foundation alternative, the contractor should mobilize equipment of sufficient size and operating condition to achieve the required design bedrock penetration.

4.9. MAINTENANCE AND DURABILITY

Typical CDOT specified materials and construction methods must be used for the construction of the proposed structure. Following accepted current practice in designing and constructing the structure will provide a durable bridge to meet the required 100-year service life with minimal required maintenance.

Based on discussions with CDOT maintenance, the minimum box culvert height was set at 4 feet. Maintenance has a remote-controlled skid equipment that can clean up a box culvert of this size.

Concrete structures have less maintenance than steel structures and are preferred.

4.10. CORROSIVE RESISTANCE

Epoxy coated reinforcing must be used for all reinforced concrete elements. A waterproofing membrane and stone matrix asphalt will be used on top of the concrete deck or CBC to prevent water and salt intrusion.

4.11. CONSTRUCTION COST

Construction costs are one of the most important factors in the structure type selections. Preliminary construction cost estimates are prepared for all selected structure alternatives to be compared as discussed previously. High level construction cost for each structure type is summarized in the table below. Detailed calculations of the cost can be found in Appendix C of this report. Individual item costs were obtained from the recent CDOT Cost Data Books. 30% contingency multiplier was used in the cost calculations.

Summary of the alternatives:

Concrete Bridge Alternative 1 – 40.0ft span length, 46.0 ft superstructure width, (4) BX 18x48 girders at 12.0 ft spacing, 8.0 in reinforced deck, tall wall abutment on spread footing, integral wingwalls on footings.

Concrete Bridge Alternative 2 – 59.0 ft span length, 46.0 ft superstructure width, (5) BX 18x48 girders spaced at 9.0 ft, 8.0 in reinforced deck, integral abutments on (7) 24.0 in drilled shafts spaced at 10 ft 10 in.

Alternative	**Construction Cost (30% Contingency)**	**Area**	**Cost per sf**	**Cost Rating**
CBC Alternative	$ 606,884.00	1396 sf	$ 435	2.6
Concrete Bridge Alternative 1	$ 1,550,674.00	1840 sf	$ 843	1.0
Concrete Bridge Alternative 2	$ 915,139.00	2714 sf	$ 337	1.7

Table 3 - Construction Cost Summary

4.12. CONCLUSIONS AND RECOMMENDATIONS

Table below provides a summary or feasible alternatives evaluation based on the established selection criteria

Criteria	**RCP**	**CBC**	**Concrete Bridge Alt 1**	**Concrete Bridge Alt 2**
Hydraulic Opening	Does not satisfy requirements	Satisfies the requirements	Satisfies the requirements	Satisfies the requirements
Constructability	n/a	No expected constructability issues. Can be precast to streamline construction.	Removal of the existing structure might present some difficulty due to the size of the existing structure	Drilling into the existing hard bedrock to the min 3D depth or enough achieve longitudinal capacity may present some difficulty
Construction Cost Rating	n/a	2.6	1.0	1.7
Maintenance & Durability	n/a	Low maintenance.	Concrete girders require minimal maintenance.	Concrete girders require minimal maintenance.
ROW and Roadway Impacts	n/a	No ROW impacts	No ROW impacts	No ROW impacts.

Table 4 - Summary of Structure Alternatives Evaluation

Based on the criteria discussed above, the CBC alternative is recommended to replace existing structure M-22-U. The contractor may select a different structure type based on their investigations, meeting the criteria described in this report. See Appendix A for the selected General Layout and Typical Section.

APPENDIX A

General Layout and Typical Section

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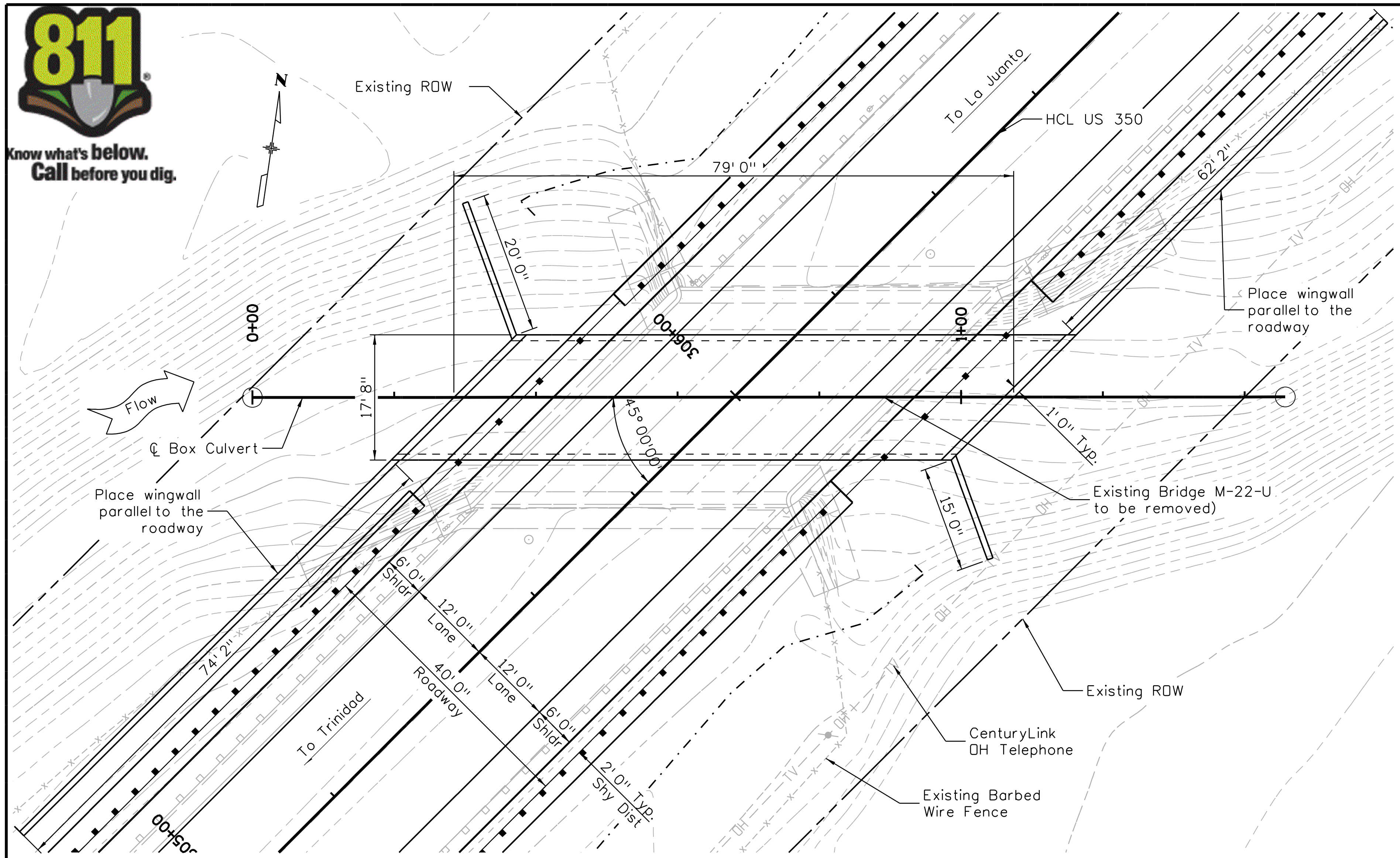
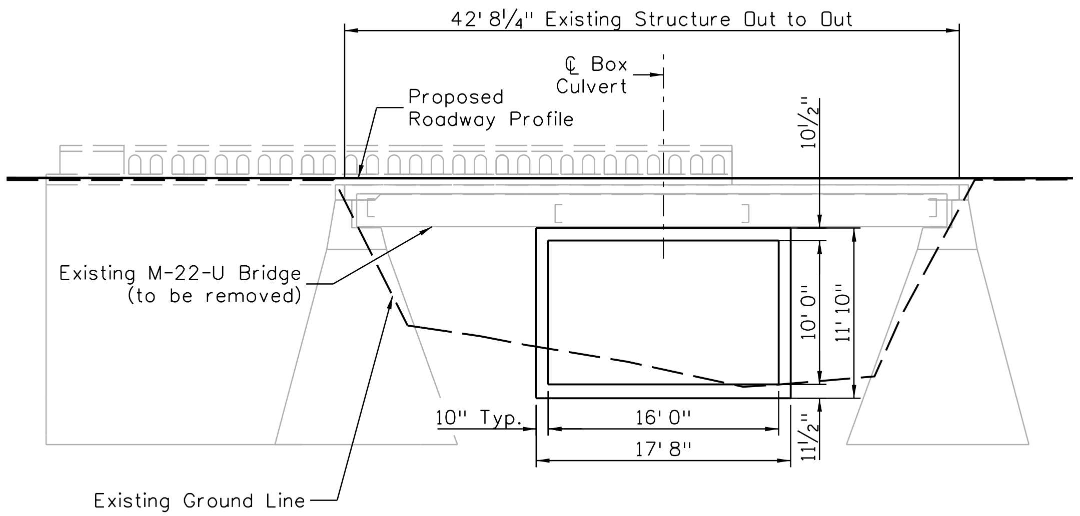
811
Know what's below.
Call before you dig.



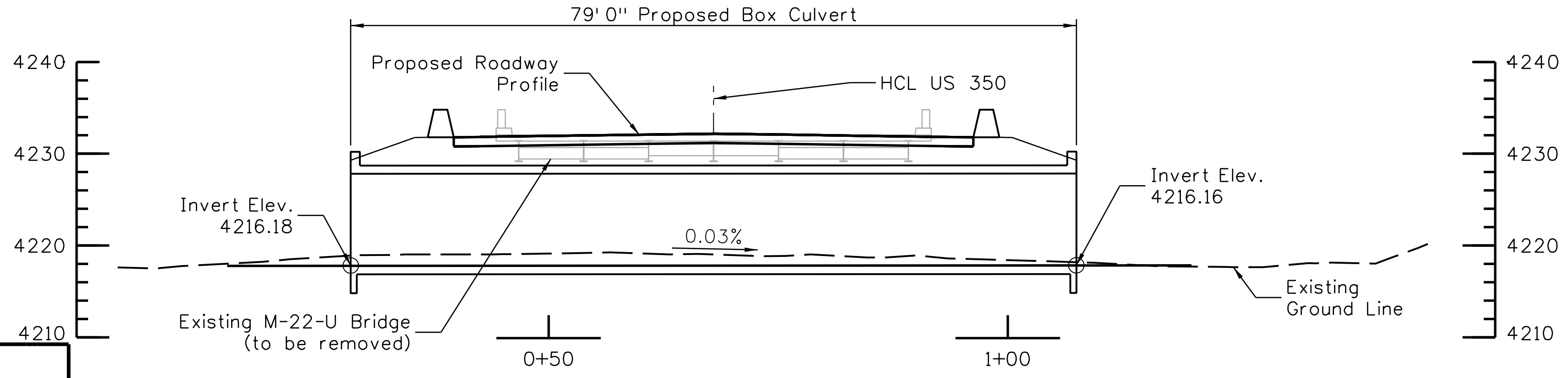


SECTION

(Taken Normal to ℄ Box Culvert)

Notes:

1. Dimensions are based on recent survey and existing as-built drawings.



PROFILE

(Taken Along ℄ Box Culvert)

Print Date: 2/1/2021
File Name: General Layout M-22-U_SH350 MP 69.82.dgn
Horiz. Scale:
Vert. Scale: As Noted

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Centennial, CO 80112
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Sheet Revisions

Date:	Comments	Init.

Colorado Department of Transportation
5615 Wills Blvd
Pueblo, CO 81008
Phone: 719-546-5753
FAX: 719-546-5402
Region 2
JLS

As Constructed
No Revisions:
Revised:
Void:

REGION 2 BRIDGE BUNDLE
US 350 OVER OTERO CANAL
GENERAL LAYOUT AND TYP. SECTION

Designer: I. PUSHKAROVA
Detailer: I. PUSHKAROVA
Sheet Subset: ROADWAY
Structure No. M-22-U
M.P. US 350 69.817
Subset Sheets: 1 of 1

Project No./Code

Sheet Number

APPENDIX B

Structure Selection Report Checklist

Structure Selection Report QA Checklist

This checklist is to serve as a general guideline for structure selection process. It is to be filled out by the project Engineer of Record or designee to indicate all items that are to be discussed in the Structure Selection Report. This checklist is to be included as an appendix to the Structure Selection Report and must be signed by Staff Bridge Unit Leader or designee prior to submittal of FIR documents to the Region.

Project Name ______________________________

Project Location ______________________________

Project Number ____________________ Subaccount ____________________

Structure Number(s) ______________________________

Engineer of Record ____________________ Date ____________________

Cover Sheet

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

Executive Summary

- ☐ Project Description
- ☐ Purpose of the Report
- ☐ Structure Selection Process
- ☐ Structure Recommendations

Site Description and Design Features

- ☐ Existing Structures
- ☐ ROW Impact
- ☐ Traffic Detour
- ☐ Utilities
- ☐ Geotechnical Summary
- ☐ Hydraulics Summary
- ☐ Environmental Concerns
- ☐ Roadway Design Features
    - ☐ Cross Section
    - ☐ Vertical Alignment
    - ☐ Horizontal Alignment

Structural Design Criteria

- ☐ Design Specifications
- ☐ Construction Specifications
- ☐ Loading
    - ☐ Collision Load
    - ☐ Earthquake Load
- ☐ Software to be used by the Designer
- ☐ Software to be used by the Independent Design Checker

Structure Selection

- ☐ Selection Criteria
- ☐ Rehabilitation Alternatives
- ☐ Structure Layout Alternatives:
    - ☐ Vertical Clearances
    - ☐ Horizontal Clearances
    - ☐ Deflection
    - ☐ Skew

☐ Superstructure Alternatives:
  ☐ Concrete Girder Alternatives
  ☐ Steel Girder Alternatives
  ☐ Span Configurations

* CBC Alternative
* RCP Alternative

☐ Substructure Alternatives:
  ☐ Abutment Alternatives (GRS, Integral, Semi-integral, etc.)
  ☐ Pier Alternatives
☐ Wall Alternatives
☐ Construction Phasing
☐ Possible Future Widenings
☐ Use of Existing Bridge in Phasing / Partial Configuration
☐ ABC Design
☐ Constructability
☐ Aesthetic Design
☐ Maintenance and Durability
☐ Corrosive Resistance
☐ Load Testing Requirements
☐ Use of Lightweight Concrete
☐ Construction Cost
☐ Life Cycle Cost Analysis

Other

Figures and Appendices

☐ Vicinity Map
☐ Alternative Typical Sections
☐ General Layout of the Selected Structure
☐ Summary of Structure Type Evaluation Table
☐ Summary of Quantities and Cost Estimate Tables
☐ Inspection Report
☐ Hydraulics Investigation Results
☐ Geotechnical Investigation Results

Recommendations

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

List of Variances

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 C

Construction Cost Estimate

Project No.: CDOT #23558 (Stanley #29715) Date: 2/1/2021
Project Name: Region 2 Bridge Bundle Design Build Grant Project
Subject: Quantity Calculations - M-22-U CBC Alternative
Client: CDOT Region 2

CBC Alternative

Contract Item No.	Item Description	Unit	Estimated Unit Cost	TOTAL	
				Approx Quantities	Estimated Total Cost
202-00400	Removal of Bridge	EACH	**$ 90,000.00**	**1**	$ 90,000
206-00000	Structure Excavation	CY	**$ 20.00**	**932**	$ 18,630
206-00100	Structure Backfill (Class 1)	CY	**$ 35.00**	**611**	$ 21,395
206-01750	Shoring	L S	**$ 12,000.00**	**2**	$ 24,000
515-00120	Waterproofing (Membrane)	SY	**$ 22.50**	**188**	$ 4,237
601-04550	Concrete Class G	CY	**$ 900.00**	**251**	$ 226,193
601-40300	Structural Concrete Coating	SY	**$ 14.00**	**233**	$ 3,264
602-00020	Reinforcing Steel (Epoxy Coated)	LB	**$ 1.50**	**52744**	$ 79,115
				Subtotal of accounted construction items =>	$ 466,834
				Contingency Multiplier =>	30%
				Subtotal of construction items =>	**$ 606,884**
				Deck area (SF) =>	1396
				Cost per SF =>	**$ 435**

Project No.: CDOT #23558 (Stanley #29715) Date: 2/1/2021
Project Name: Region 2 Bridge Bundle Design Build Grant Project
Subject: Quantity Calculations - M-22-U Concrete Bridge Alternative
Client: CDOT Region 2

CONCRETE BRIDGE ALTERNATIVE 1 - 40 FT

Contract Item No.	Item Description	Unit	Estimated Unit Cost	TOTAL	
				Approx Quantities	Estimated Total Cost
202-00400	Removal of Bridge	EACH	**$ 90,000.0**	**1**	$ 90,000
206-00000	Structure Excavation	CY	**$ 20.00**	**3856**	$ 77,114
206-00100	Structure Backfill (Class 1)	CY	**$ 35.00**	**3299**	$ 115,454
206-01750	Shoring	L S	**$ 12,000.00**	**2**	$ 24,000
515-00120	Waterproofing (Membrane)	SY	**$ 22.5**	**255**	$ 5,735
601-04550	Concrete Class G	CY	**$ 900.00**	**584**	$ 525,154
601-40300	Structural Concrete Coating	SY	**$ 14.00**	**693**	$ 9,697
602-00000	Reinforcing Steel	LB	**$ 3.72**	**78787**	$ 293,088
606-10900	Bridge Rail Type 9	LF	**$ 152.00**	**87**	$ 13,224
618-01992	Prestressed Concrete Box (Depth Less Than 32 Inches)	SF	**$ 60.00**	**656**	$ 39,360
				Subtotal of accounted construction items =>	$ 1,192,826
				Contingency Multiplier =>	30%
				Subtotal of construction items =>	**$ 1,550,674**
				Deck area (SF) =>	1840
				Cost per SF =>	**$ 843**

Project No.: CDOT #23558 (Stanley #29715) Date: 2/1/2021
Project Name: Region 2 Bridge Bundle Design Build Grant Project
Subject: Quantity Calculations - M-22-U Steel Bridge Alternative
Client: CDOT Region 2

STEEL BRIDGE ALTERNATIVE 2 - 59 FT

Contract Item No.	Item Description	Unit	Estimated Unit Cost	TOTAL	
				Approx Quantities	**Estimated Total Cost**
202-00400	Removal of Bridge	EACH	**$ 90,000.0**	**1**	$ 90,000
206-00000	Structure Excavation	CY	**$ 20.00**	**807**	$ 16,139
206-00100	Structure Backfill (Class 1)	CY	**$ 35.00**	**602**	$ 21,067
206-01750	Shoring	L S	**$ 12,000.00**	**2**	$ 24,000
503-00024	Drilled Shaft (24 Inch)	LF	**$ 400.0**	**280**	$ 112,000
515-00120	Waterproofing (Membrane)	SY	**$ 22.50**	**345**	$ 7,769
601-04550	Concrete Class G	CY	**$ 900.00**	**201**	$ 180,596
601-40300	Structural Concrete Coating	SY	**$ 14.00**	**586**	$ 8,210
602-00000	Reinforcing Steel	LB	**$ 3.72**	**41346**	$ 153,806
606-10900	Bridge Rail Type 9	LF	**$ 152.00**	**121**	$ 18,367
618-01992	Prestressed Concrete Box (Depth Less Than 32 Inches)	SF	**$ 60.00**	**1200**	$ 72,000
	Subtotal of accounted construction items =>				$ 703,953
	Contingency Multiplier =>				30%
	Subtotal of construction items =>				**$ 915,139**
	Deck area (SF) =>				2714
	Cost per SF =>				**$ 337**

APPENDIX D

Geotechnical Report

Yeh and Associates, Inc.
Geotechnical • Geological • Construction Services

2000 Clay Street, Suite 200
Denver, CO 80211
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February 3, 2021

Project No. 220-063

Mr. Ron Gibson, P.E.
Stanley Consultants
8000 South Chester Street, Suite 500
Centennial, Colorado 80112

Subject: **Preliminary Geotechnical Study**
Structure M-22-U
23558/23559 Region 2 Bridge Bundle
CDOT Region 2, Colorado

Dear Mr. Gibson:

This memorandum presents the results of Yeh and Associates, Inc.'s (Yeh) preliminary geotechnical engineering study for the proposed replacement of Structure M-22-U as part of the CDOT Region 2 Bridge Bundle Design-Build Project.

The CDOT Region 2 Bridge Bundle Design-Build Project consists of the replacement of a total of 19 structures bundled together as a single project. These structures are rural bridges on essential highway corridors (US 350, US 24, CO 239, and CO 9) in southeastern and central Colorado. These key corridors provide rural mobility, intra- and interstate commerce, movement of agricultural products and supplies, and access to tourist destinations. The design-build project consists of 17 bridges and two Additionally Requested Elements (ARE) structures.

This design-build project is jointly funded by the USDOT FHWA Competitive Highway Bridge Program grant (14 structures, Project No. 23558) and the Colorado Bridge Enterprise (five structures, Project No. 23559). These projects are combined to form one design-build project. The two ARE structures are part of the five bridges funded by the Colorado Bridge Enterprise.

The 19 bridges identified to be included in the Region 2 Bridge Bundle were selected based on similarities in the bridge conditions, risk factors, site characteristics, and probable replacement type, with the goal of achieving economy of scale. Seventeen of the bridges being replaced are at least 80 years old. Five of the bridges are load-restricted, limiting trucking routes through major sections of the US 24 and US 350 corridors. The bundle includes nine timber bridges, four concrete box culverts, one corrugated metal pipe (CMP), four concrete I-beam bridges, and one I-beam bridge with corrugated metal deck.

1 PROJECT UNDERSTANDING

Bridge M-22-U is part of the Region 2 Bridge Bundle project that will be delivered as a design-build project. Our preliminary geotechnical study was completed to support the 30% design level that will be included in the design build bid package. We understand the existing structure will be replaced with either a concrete box culvert (CBC) or a bridge structure. The new structure will be constructed along the current roadway alignment and existing roadway grade will be maintained. No significant cut or fills are required for construction of the proposed replacement structure.

2 SUBSURFACE CONDITIONS

Two bridge borings, M-22-U-B-1 and M-22-U-B-2, were drilled by Yeh in the vicinity of the existing bridge, and two pavement borings, M-22-U-P-1 and M-22-U-P-2, were drilled along the existing pavement approximately 250 feet from the bridge. The approximate boring locations are shown on the engineering geology sheet in Appendix A. The legend and boring logs are included in Appendix B. Laboratory test results are provided in Appendix C and are shown on the boring logs.

The bridge borings encountered lean clays with sand and gravel and clayey gravel soils overlying limestone bedrock. Table 1 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 feet. The groundwater depths and elevations are based on observations during drilling.

Table 1. Summary of Bedrock and Groundwater Conditions

Boring ID	Location[1] (Northing, Easting)	Ground Surface Elevation at Time of Drilling[1] (feet)	Approx. Depth to Top of Competent Bedrock[1] (feet)	Approx. Elevation to Top of Competent Bedrock[1] (feet)	Approx. Groundwater Depth[1, 2] (feet)	Approx. Groundwater Elevation [1, 2] (feet)
M-22-U-B-1	475060.335, 551591.579	4232.0	18.0	4214.0	Not Encountered	Not Encountered
M-22-U-B-2	475012.354, 551541.265	4232.0	16.5	4215.5	Not Encountered	Not Encountered

Notes:

(1) Surface elevations, approximate bedrock depths/elevations, and approximate groundwater depths/elevations are presented to the nearest 0.5 feet. Location and elevation are provided by project surveyor.

(2) Groundwater depths and elevations are based on observations during drilling.

3 BRIDGE FOUNDATION RECOMMENDATIONS

We understand that the replacement structure will consist of either a new bridge structure or a concrete box culvert structure (CBC). If a bridge structure is selected, then the abutments and piers will be supported on driven H-piles, drilled shafts, or shallow foundations. If a CBC structure is selected, then the structure will be founded on a shallow mat foundation. Wing walls for the bridge and CBC structures will be founded on shallow strip foundations.

Based on the subsurface conditions encountered during our preliminary study, our engineering analysis, and our experience with similar projects, it is our opinion that driven H-pile and drilled shaft foundations are suitable for support of the bridge structure. Shallow foundations are suitable for support of the CBC and wing wall structures and may be suitable for the support of the bridge structure. Recommendations for shallow foundations are presented in Section 3.1, drilled shaft recommendations are presented in Section 3.2, driven H-pile recommendations are provided in Section 3.3, and CBC foundation recommendations are presented in Section 3.4.

The soil and bedrock properties were estimated from penetration resistance, material descriptions, and laboratory data. The design and construction of the foundation elements should comply with all applicable requirements and guidelines listed in AASHTO (2020) and the CDOT Standard Specifications (CDOT 2019).

3.1 Shallow Foundation Recommendations

Based on the depth to bedrock and the anticipated loading requirements, shallow foundations such as reinforced concrete strip footings may be suitable to support the bridge structure. Alternatively, a Geosynthetic Reinforced Soil – Integrated Bridge System (GRS-IBS) may be considered. We recommend the FHWA GRS-IBS Implementation guide (FHWA-HRT -11-026) and Synthesis report (FHWA-HRT-11-027) be followed for the design and construction of the GRS-IBS system. Design and construction for the shallow foundation or GRS-IBS system should take into consideration the scour potential at the proposed bridge site.

We anticipate that the bearing resistance of the shallow foundations will meet the project loading requirements provided that the shallow foundations are founded on competent bedrock. The bottom of GRS-IBS structures should be founded directly on competent bedrock. Existing surficial soils and weathered bedrock should be over-excavated to the top of competent bedrock prior to placement of shallow foundations or GRS-IBS.

Visual inspection of the foundation excavations should be performed by a qualified representative of the Geotechnical Engineer of record to identify the quality of the foundation materials prior to construction of the foundation. Groundwater may be encountered during excavation for the subgrade preparation. Groundwater control systems may be required to prevent seepage migrating into the construction zone by creating groundwater cut-off and/or dewatering systems.

3.2 Drilled Shaft Recommendations

3.2.1 Drilled Shaft Nominal Axial Resistance

The estimated bearing resistance should be developed from the side and tip resistance in the underlying competent bedrock. The resistance from the overburden soil should be neglected. We used unconfined compressive strength (UCS) and Standard Penetration Test (SPT) values to evaluate side and tip resistances in accordance with AASTHO LRFD (2020). The design approach in Abu-Hejleh et al. (2003) provides recommendations for the use of an updated Colorado SPT-based (UCSB) design method. In this design method, the nominal side and tip resistance of a drilled shaft in bedrock is proportional to the driven sampler penetration resistance. This approach was generally used to estimate the axial resistance in the bedrock where UCS test results were unavailable. Based on local practice, the modified California penetration resistance is considered to be equivalent to SPT penetration resistance, i.e. N value, in bedrock.

Table 2 contains the recommended values for the nominal side and tip resistance for drilled shafts founded in the underlying competent bedrock. The upper three feet of competent bedrock penetration shall not be used for drilled shaft resistance due to the likelihood of construction disturbance and possible additional weathering. To account for axial group effects, the minimum spacing requirements between drilled shafts should be three diameters from center-to-center.

Table 2. Recommended Drilled Shaft Axial Resistance

Reference Boring	Approximate Top of Competent Bedrock Elevation (feet)	Tip Resistance (ksf)		Side Resistance, (ksf)	
		Nominal	Factored (Φ=0.5)	Nominal	Factored (Φ=0.55)
M-22-U-B-1	4214.0	150	75	15	8.2
M-22-U-B-2	4215.5	150	75	15	8.2

3.2.2 Drilled Shaft Lateral Resistance

The input parameters provided in Table 3 are recommended for use with the computer program LPILE to develop the soil models used to evaluate the drilled shaft response to lateral loading. Table 3 provides the estimated values associated with the soil types encountered in the borings. They can also be used for driven H-piles, which will be described in Section 3.3. The nature and type of loading should be considered carefully. Individual soil layers and their extent can be averaged or distinguished by referring to the boring logs at the locations of the proposed bridge. The soils and/or bedrock materials prone to future disturbance, such as from utility excavations or frost heave, should be neglected in the lateral load analyses to the depth of disturbance, which may require more than but should not be less than three feet.

Recommendations for p-y multiplier values (P_m values) to account for the reduction in lateral capacity due to group effects are provided in Section 10.7.3.12 of AASHTO (2020). The P_m value will depend on the direction of the applied load, center-to-center spacing, and location of the foundation element within the group.

Table 3. LPILE Parameters

Material Type	LPILE Soil Criteria	Effective Unit Weight (pcf)		Friction Angle, (deg.)	Undrained Cohesion, (psf)	Unconfined Compressive Strength (psi)	Strain Factor, ε50	p-y modulus kstatic (pci)	
		AGT[1]	BGT[2]					AGT[1]	BGT[2]
Class 1 Structure Backfill	Sand (Reese)	130	67.5	34	-	-	-	90	60
Clay (Fill)	Stiff Clay w/o Free Water (Reese)	120	57.5	-	600	-	0.01	-	-
Clayey Gravel (Fill)	Sand (Reese)	125	62.5	30	-	-	-	25	20
Limestone Bedrock	Strong Rock (Vuggy Limestone)	130	130	-	-	4,000	0.002	-	-

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

3.2.3 General Drilled Shaft Recommendations

The following recommendations can be used in the design and construction of the drilled shafts.

- Groundwater and potentially caving soils may be encountered during drilling depending on the time of year and location. The Contractor shall construct the drilled shafts using means and methods that maintain a stable hole.

- Bedrock may be very hard at various elevations. The contractor should mobilize equipment of sufficient size and operating condition to achieve the required design bedrock penetration.
- Drilled shaft construction shall not disturb previously installed drilled shafts. The drilled shaft concrete should have sufficient time to cure before construction on a drilled shaft within three shaft diameters (center to center spacing) begins to prevent interaction between shafts during excavation and concrete placement.
- Based on the results of the field investigation and experience with similar properly constructed drilled shaft foundations, it is estimated that foundation settlement will be less than approximately ½ inch when designed according to the criteria presented in this report.
- A representative of the Contractor's engineer should observe drilled shaft installation operations on a full-time basis.

3.3 Driven H-Pile Recommendations

3.3.1 Driven H-Pile Axial Resistance

Steel H-piles driven into bedrock may be designed for a nominal axial resistance equal to 34 kips per square inch (ksi) multiplied by the cross-sectional area of the pile for piles composed of Grade 50 ksi steel for use with LRFD Strength Limit State design. Piles should be driven to refusal into the underlying bedrock as defined in Section 502.05 of CDOT (2019). A wave equation analysis using the Contractor's pile driving equipment is necessary to estimate pile drivability.

Based on the strength of the limestone bedrock encountered during our investigation, it is likely that refusal will be met within the upper 1 to 2 feet of bedrock. Holes may need to be pre-drilled to meet the requirement for pile design tip elevations.

3.3.2 Driven H-Pile Axial Resistance Factors

Assuming a pile driving analyzer (PDA) is used to monitor pile driving per Section 502 of CDOT (2019), a resistance factor of 0.65 may be used per AASHTO (2020) Table 10.5.5.2.3-1. Section 502.05 of CDOT (2019) stipulates that if PDA is used, a minimum of one PDA monitoring per bridge bent be performed to determine the condition of the pile, efficiency of the hammer, static bearing resistance of the pile, and to establish pile driving criteria. Per AASHTO (2020) recommendations, a resistance factor of 0.5 can be used for wave equation analysis only without pile dynamic measurements such as PDA monitoring. Per AASHTO (2020) recommendations, a resistance factor of 0.75 may be used if a successful static load test is conducted per site condition.

3.3.3 Driven H-Pile Lateral Resistance

The information provided previously in Section 3.2.2 may be used to evaluate H-pile lateral resistance.

3.3.4 General Driven H-Pile Recommendations

The following recommendations are for the design and construction of driven H-piles.

1. Based on the results of the field exploration and our experience with similar properly constructed driven pile foundations, it is estimated that settlement will be less than approximately ½ inch when designed according to the criteria presented in this report.

2. A minimum spacing requirement for the piles should be three diameters (equivalent) center to center.

3. Driven piles should be driven with protective cast steel pile points or equivalent to provide better pile tip seating and to prevent potential damage from coarse soil particles, which may be present at the site.

4. A qualified representative of the Contractor's engineer should observe pile-driving activities on a full-time basis. Piles should be observed and checked for crimping, buckling, and alignment. A record should be kept of embedment depths and penetration resistances for each pile.
5. It is estimated that the piles will penetrate approximately 1 to 2 feet into competent bedrock (see Table 1 for the estimated elevation for the top of competent bedrock). The final tip elevations will depend on bedrock conditions encountered during driving.
6. If the pile penetration extends below the estimated pile penetration into bedrock by 10 feet or more, the pile driving operations should be temporarily suspended for dynamic monitoring with PDA. We recommend that the subject pile be allowed to rest overnight or longer before restriking and monitoring the beginning-of-restrike with a PDA. The data collected with the PDA shall then be reduced using the software CAPWAP to determine the final nominal pile resistance. The pile driving criteria may be modified by CDOT's or the Contractor's engineer based on the PDA/CAPWAP results.

3.4 CBC Foundation Recommendations

To assure adequate foundation support and to minimize the potential for differential settlement, we recommend that the exposed subgrade soils should be scarified a minimum of 6 inches, moisture conditioned, and re-compacted in accordance with Section 203.07 of the CDOT Standard Specifications (2019) before the placement of structural elements or structural backfill. If unsuitable or soft materials are encountered after the excavation, the materials may be removed and replaced with CDOT Class 1 Structure Backfill in accordance with Section 203.07 of the CDOT Standard Specifications (2019). Visual inspection of the foundation excavations should be performed by a qualified representative of the Geotechnical Engineer of record to identify the quality of the foundation materials prior to placement of backfill and the CBC. Groundwater may be encountered during excavation for the subgrade preparation. Groundwater control systems may be required to prevent seepage migrating into the construction zone by creating groundwater cut-off and/or dewatering systems.

The recommended nominal bearing resistance using Strength Limit State for the CBC and associated wing walls for both moist and saturated conditions are provided in Table 4. We assume the materials in contact with the bottom of the proposed CBC and wing walls will consist of native clay or clayey gravel, or CDOT Class 1 Structure Backfill placed in accordance with Section 203.07 of the CDOT Standard Specifications (2019). The reduced footing width due to eccentricity can be calculated based on the recommendations in Sections 11.6.3.2 and 11.10.5.4 of AASHTO (2020). A bearing resistance factor of 0.45 may be used for shallow foundations based on the recommendations in Table 10.5.5.2.2-1 of AASHTO (2020).

Table 4. Bearing Resistance for CBC and Wing Walls on Shallow Foundation

Soil Conditions	Nominal Bearing Resistance (ksf) [1, 2]
Moist	2.0 + 1.0 * B'
Saturated	1.0 + 0.5 * B'

[1] B' is the footing width in feet reduced for eccentricity (e). B' = B - 2e, where B is the nominal foundation width.
[2] The calculated nominal bearing resistance is based on a minimum 12 inches of embedment and shall be limited to 10 ksf.

The proposed CBC will be at the location of the existing CBC, and as needed, a portion of the CBC will be in a cut area, therefore it is estimated that the total settlement of the structure will be minimal and will occur during construction. The structure settlement is partially controlled by the weight of the adjacent embankment fill.

Thus, it is recommended that the embankment fill on both sides of the CBC be placed at a relatively uniform elevation.

Resistance to sliding at the bottom of foundations can be calculated based on a coefficient of friction at the interface between the pre-cast concrete and the existing native soils or compacted CDOT Class 1 Structure Backfill. The recommended nominal coefficients of friction and the corresponding resistance factors for Class 1 Structure Backfill and native soils are provided in Table 5.

Table 5. Coefficients of Friction for CBC and Wing Walls on Shallow Foundation

Foundation Soil Type	Coefficient of Friction	Resistance Factor
Class 1 Structure Backfill	0.53	0.9
Native Clay	0.30	0.8

Backfill adjacent to the CBC should be Class 1 Structure Backfill, compacted with moisture density control. Backfill materials shall have a Class 0 for severity of sulfate exposure. Fill should be tested for severity of sulfate exposure prior to acceptance.

The passive pressure against the sides of the foundation is typically ignored; however, passive resistance can be used if long-term protection from disturbance, such as frost heave, future excavations, etc., is assured. Table 6 presents recommendations for the passive soil resistances for the encountered soil conditions. The passive resistance estimates are calculated from Figure 3.11.5.4-1 in AASHTO (2020) where a portion of the slip surface is modeled as a logarithmic spiral, the backslope is horizontal and the passive soil/concrete interface friction angle is equal to 60 percent of the soil's friction angle.

The recommended passive earth pressure resistances are presented in terms of an equivalent fluid unit weight for moist and saturated conditions. The recommended passive earth pressure values assume mobilization of the nominal soil/concrete foundation interface shear strength. A suitable resistance factor should be included in the design to limit the strain, which will occur at the nominal shear strength, particularly in the case of passive resistance. The resultant passive earth force, calculated from the equivalent fluid unit weight, should be applied at a point located 1/3 of the height of the soil (in contact with the foundation) above the base of the foundation, directed upward at an angle of 20 degrees from the horizontal.

Table 6. Passive Soil Resistance for CBC

	Soil Type	Nominal Resistance	Resistance Factor
Passive Soil Resistance	Moist	332 psf/ft	0.50
	Saturated	159 psf/ft	0.50

3.5 Lateral Earth Pressures

External loads used in the analyses of the bridge abutments and wing walls should include earth pressure loads, traffic loads, and any other potential surcharge loads. Typical drainage details consisting of inlets near the abutments, geocomposite strip drains, and perforated pipes shall be included in the design to properly contain and transfer surface and subsurface water without saturating the soil around the abutments.

All abutment and wing wall backfill materials should meet the requirements for CDOT Structure Backfill Class 1 in accordance with CDOT (2019). All backfill adjacent to the abutments and walls shall be placed and compacted in accordance with CDOT (2019). It is recommended that compaction of backfill materials be observed and evaluated by an experienced Contractor's engineer or Contractor's engineer's representative.

A lateral wall movement or rotation of approximately 0.1 to 0.2 percent of the wall height may be required to mobilize active earth pressure for the recommended backfill materials. If the estimated wall movement is less than this amount, an at-rest soil pressure should be used in design. In order to mobilize passive earth pressure, lateral wall movement or rotation of approximately 1.0 to 2.0 percent of the wall height may be required for the recommended backfill materials. It should be carefully considered if this amount of movement can be accepted before passive earth pressure is used in the design.

Earth pressure loading within and along the back of the bridge abutments and wing walls shall be controlled by the structural backfill. We recommend that active, at-rest, and passive lateral earth pressures used for the design of the structures be based on an effective angle of internal friction of 34 degrees, and a unit weight of 135 pounds per cubic foot (pcf) for CDOT Structure Backfill Class 1. The following can be used for design assuming a horizontal backslope:

- Active earth pressure coefficient (k_a) of 0.28
- Passive earth pressure coefficient (k_p) of 3.53
- At-rest earth pressure coefficient (k_0) of 0.44

Lateral earth pressures for a non-horizontal backslope can be estimated using section 3.11 in AASHTO (2020).

3.6 Bridge Scour Parameters

A bulk sample of the creek bed soils/rock below the existing bridge was collected for gradation analysis. The results of the grain size analysis are presented in Appendix C.

4 BRIDGE APPROACH PAVEMENT

Pavement borings were located approximately 250 feet beyond the existing bridge abutments on each side. Prior to drilling, the existing pavement was cored with a 4-inch nominal diameter core barrel. Photos of the pavement core, logs of the subsurface soils/rock, and results of geotechnical and analytical laboratory testing are presented in the appendices. Bulk soil samples were collected from the pavement borings and combined for classification, strength (R-value), and analytical testing. The asphalt pavement thicknesses, aggregate base thicknesses (if present), subgrade soil classifications, and subgrade R-values are presented in Table 7. Analytical test results are presented in Table 8. Preliminary pavement design will be completed by CDOT Staff Materials.

Table 7. Existing Pavement Section and Subgrade Properties

Boring ID	Existing Asphalt Concrete Thickness (in)	Aggregate Base Thickness (in)	Subgrade Soil Classification (AASHTO)[1]	R-Value[1]
M-22-U-P-1	8.0	Not Encountered	A-6 (11)	15
M-22-U-P-2	10.0	Not Encountered		

1. Subgrade Classification and R-value test results based on combined bulk sample from each pavement boring.

5 ANALYTICAL TEST RESULTS

Analytical testing was completed on representative samples of soils encountered in the borings. The test results can be found in Appendix C and are summarized in Table 8. The Analytical results should be used to select the proper concrete type for the project in accordance with CDOT Standard Specifications (2019). A qualified corrosion engineer should review the laboratory data and boring logs to determine the appropriate level of corrosion protection for materials in contact with these soils.

Table 8. Analytical Test Results

Boring ID	Material	Water Soluble Sulfates, %	Water Soluble Chlorides, %	pH	Resistivity, ohm-cm
M-22-U-P-1/P-2	Lean Clay (Fill)	1.534	0.0026	-	-
M-22-U-B-1	Clayey Sand	0.654	0.0065	7.7	1119

6 SEISMIC CONSIDERATIONS

No active faults are known to exist in the immediate vicinity of the proposed bridge location. Based on the site class definitions provided in Table 3.10.3.1-1 of AASHTO LRFD (2020), the site can be categorized as Site Class E. Also based on the recommendations in Table 3.10.6-1 of AASHTO LRFD (2020), the bridge site can be classified as Seismic Zone 1.

The peak ground acceleration (PGA) and the short- and long- period spectral acceleration coefficients (S_s and S_1, respectively) for Site Class B (reference site class) were determined using the seismic design maps from the USGS website. The seismic design parameters for Site Class E are shown in Table 9.

Table 9. Seismic Design Parameters

PGA (0.0 sec)	S_S (0.2 sec)	S_1 (1.0 sec)
0.040 g	0.089 g	0.030 g
A_s (0.0 sec)	S_{DS} (0.2 sec)	S_{D1} (1.0 sec)
0.099 g	0.222 g	0.103 g

7 LIMITATIONS

Our scope of services was performed, and this report was prepared in accordance with generally accepted principles and practices in this area at the time this report was prepared. We make no other warranty, either express or implied.

The classifications, conclusions, and recommendations submitted in this report are based on the data obtained from published and unpublished maps, reports, and geotechnical analyses. Our conclusions and recommendations are based on our understanding of the project as described in this report and the site conditions as interpreted from the explorations. This data may not necessarily reflect variations in the subsurface conditions and water levels occurring at other locations.

The nature and extent of subsurface variations may not become evident until excavation is performed. Variations in the data may also occur with the passage of time. If during construction, fill, soil, rock, or groundwater conditions appear to be different from those described in this report, this office should be advised immediately so we could review these conditions and reconsider our recommendations. If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed because of natural forces or construction operations at or adjacent to the site, we recommend that this report be reviewed to determine the applicability of the conclusions and recommendations concerning the changed conditions or time lapse. We recommend on-site observation of foundation excavations and foundation subgrade conditions by an experienced geotechnical engineer or engineer's representative.

The scope of services of this study did not include hazardous materials sampling or environmental sampling, investigation, or analyses. In addition, we did not evaluate the site for potential impacts to natural resources, including wetlands, endangered species, or environmentally critical areas.

8 REFERENCES

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Respectfully Submitted,
YEH AND ASSOCIATES, INC.

Prepared by:

Cory S. Wallace, EIT, GIT
Staff Engineer

Reviewed by:

COLORADO LICENSED PROFESSIONAL ENGINEER
JG THOMAS MCCALL
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2-3-2021

JG T. McCall, PE
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Independent Technical Review by:

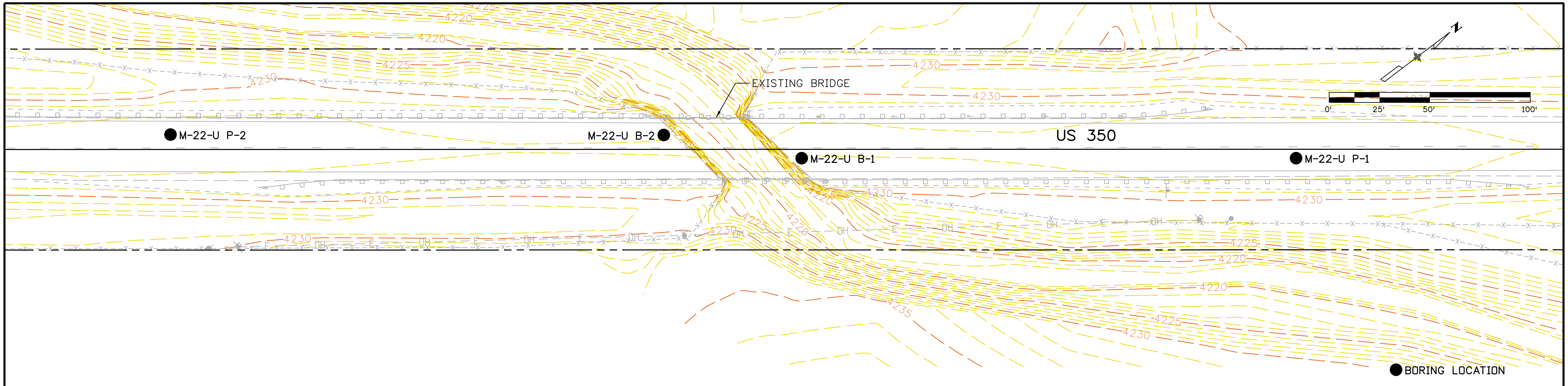
Hsing-Cheng Liu, PE, PhD
Senior Project Manager

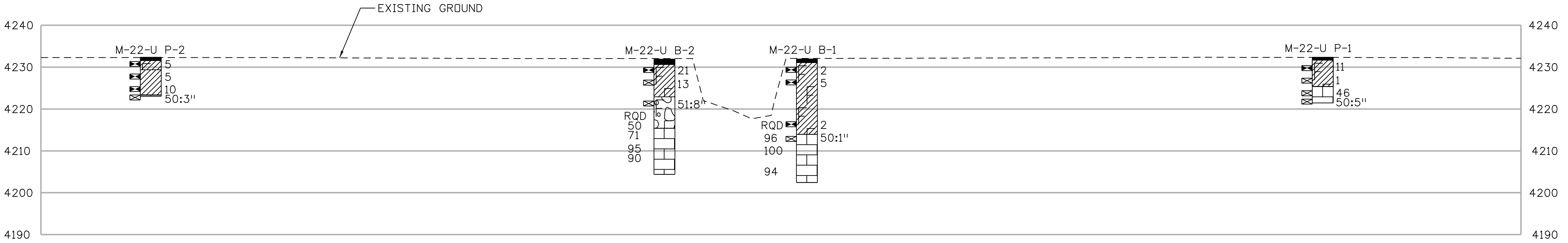
Attachments:
Appendix A
Appendix B
Appendix C

APPENDIX A

ENGINEERING GEOLOGY SHEET

mwalz 4:26:48 PM pw:\\cdot-pw.bentley.com:cdot-pw-01P\Documents\01 Major Projects\R2B2 (REGION 2 BRIDGE BUNDLE)\Legacy Data\23558 - R2B2 (REGION 2 BRIDGE BUNDLE) (GRANT)\Materials_Geotechnical\Drawings\23558GEOT_Engineering Geology M-22-

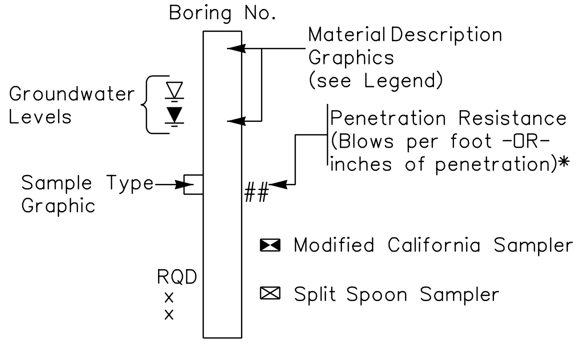




LEGEND

- ■ Asphalt
- ▨ Low Plasticity Sandy Clay
- F Fill
- ▨ USCS Clayey Gravel
- ⊞ Limestone

TYPICAL BOREHOLE LOG



*e.g. A value of 50/3 or 50:3" indicates that 50 blows were applied to the sampler, with a penetration of 3 inches.

Print Date: 11/20/2020
File Name: 23558GEOT_Engineering Geology M-22-U.dgn
Horiz. Scale: 1:50 Vert. Scale: As Noted
Unit Information Unit Leader Initials
Yeh and Associates, Inc.
Geotechnical · Geological · Construction Services

Sheet Revisions

Date:	Comments	Init.

Colorado Department of Transportation
1480 Quail Lake Loop, Suite A
Colorado Springs, CO 80906
Phone: 719-634-2323
FAX: 719-227-3298
Region 2

As Constructed
No Revisions:
Revised:
Void:

R2 BRIDGE BUNDLE
ENGINEERING GEOLOGY

Designer:	JTM	Structure Numbers	M-22-U
Detailer:	MJW		
Sheet Subset:	Geology	Subset Sheets:	1 of 1

Project No./Code
STM R200-262
23558
Sheet Number

APPENDIX B

KEY TO BORING LOGS

BORING LOGS

PAVEMENT CORE PHOTOS

ROCK CORE PHOTOS

Yeh and Associates, Inc.
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Project:	CDOT Region 2 Bridge Bundle
Project Number:	220-063

Legend for Symbols Used on Borehole Logs

Sample Types

- ░ Bulk Sample of auger/odex cuttings
- ◫ Rock core
- ⧓ Modified California Sampler (2.5 inch OD, 2.0 inch ID)
- ☒ Standard Penetration Test (ASTM D1586)

Drilling Methods

- ◫ CORING
- ☐ HOLLOW-STEM AUGER

Lithology Symbols (see Boring Logs for complete descriptions)

- ■ Asphalt
- ○ Cobbles and gravel
- ▨ USCS Fat/High Plasticity Clay
- ▨ USCS Lean/Low Plasticity Clay
- ▨ Fill with Clay as major soil
- ○ Fill with Gravel as major soil
- ▨ USCS Clayey Gravel
- ▥ USCS Silty, Clayey Gravel
- ○ USCS Poorly-graded Gravel
- ▨ USCS Poorly-graded Gravel with Clay
- ▨ Low Plasticity Gravelly Clay
- ▥ USCS Silt
- ▤ USCS Low Plasticity Organic silt or clay
- ▨ High Plasticity Sandy Clay
- ○ Poorly-graded Sandy Gravel
- ▨ Low Plasticity Sandy Clay
- ▨ USCS Clayey Sand
- ▥ USCS Silty Sand
- ░ USCS Poorly-graded Sand
- ▨ USCS Poorly-graded Sand with Clay
- ○ Cobbles and gravel
- ☐ Diorite
- ✓ Gneiss
- + Granite
- ▦ Limestone
- ░ Sandstone
- ▤ Shale
- ≋ Weathered Bedrock

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/Collapse (ASTM D4546)
UCCS	Unconfined Compressive Strength (Soil - ASTM D2166, Rock - ASTM D7012)
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)

Notes

1. Visual classifications are in general accordance with ASTM D2488, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)".
2. "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.
3. 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.
4. "ER" for the hammer is the Reported Calibrated Energy Transfer Ratio for that specific hammer, as provided by the drilling company.

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Project Name: CDOT Region 2 Bridge Bundle

PAGE 1 of 1

Project Number: 220-063

Boring No.: **M-22-U-P-1**

Boring Began: 8/24/2020
Boring Completed: 8/24/2020
Drilling Method(s): Coring /
Hollow-Stem Auger
Driller: Vine Laboratories
Drill Rig: CME 55 Truck
Hammer: Automatic (hydraulic), ER: 80%

Total Depth: 10.9 ft
Ground Elevation: 4232.36
Coordinates: N: 475257.1 E: 551738.8
Location: US 350, northbound outside lane
Logged By: R. Desterhouse
Final By: J. McCall

Weather Notes: Clear, hot
Inclination from Horiz.: Vertical
Night Work: ☐

Groundwater Levels: Not Observed			
Symbol			
Depth	-	-	-
Date	-	-	-

Elevation (feet)	Depth (feet)	Sample Type/Depth	Drilling Method	Soil Samples: Blows per 6 in	Soil Samples: Penetration Resistance	Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Atterberg Limits: Liquid Limit	Atterberg Limits: Plasticity Index	AASHTO & USCS Classifi-cations	Field Notes and Other Lab Tests
							0.0 - 0.7 ft. ASPHALT (8 inches).									
							0.7 - 7.0 ft. Lean CLAY with sand (CL) (Fill), brown, moist, very soft to stiff.									
4230				6-5	11			9.5		6.0	22.8	71.2	32	16	A-6 (9) CL	
	5			2-0-1	1											
4225							**7.0 - 10.9 ft. LIMESTONE**, light gray to light brown, slightly weathered, medium hard to very hard.									
				31-12-34	46											
	10			45-50:5"	50:5"											

Bottom of Hole at 10.9 ft.

Elevation (feet)
4220
4215
4210

Project Name: CDOT Region 2 Bridge Bundle

PAGE 1 of 1

Project Number: 220-063

Boring No.: **M-22-U-P-2**

Boring Began: 8/27/2020
Boring Completed: 8/27/2020
Drilling Method(s): Coring / Hollow-Stem Auger
Driller: Vine Laboratories
Drill Rig: CME 55/300 Track
Hammer: Automatic (hydraulic), ER: 80%

Total Depth: 9.3 ft
Ground Elevation: 4232.35
Coordinates: N: 474816.2 E: 551394.1
Location: US 350, southbound outside lane
Logged By: C. Wallace
Final By: J. McCall

Weather Notes: Clear, 80s
Inclination from Horiz.: Vertical
Night Work: ☐

Groundwater Levels: Not Observed			
Symbol			
Depth	-	-	-
Date	-	-	-

Elevation (feet)	Depth (feet)	Sample Type/Depth	Drilling Method	Soil Samples Blows per 6 in	Soil Samples Penetration Resistance	Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Atterberg Limits Liquid Limit	Atterberg Limits Plasticity Index	AASHTO & USCS Classifi-cations	Field Notes and Other Lab Tests
							0.0 - 0.8 ft. ASPHALT (10 inches).									
				2-3	5	F F F	**0.8 - 3.0 ft. Lean CLAY with sand (CL) (Fill)**, light brown to gray, moist, medium stiff.									
4230																
							3.0 - 9.0 ft. Lean CLAY with sand (CL), light brown to light gray, moist, stiff, abundant calcite crystals, rock structure apparent (residuum).									
	5			3-2	5			16.5	104.5	0.0	20.1	79.9	36	21	A-6 (15) CL	S/C=0.4%
4225				3-7	10											
				50:3"	50:3"		**9.0 - 9.3 ft. LIMESTONE**, light brown, slightly weathered, very hard.									
							Bottom of Hole at 9.3 ft.									
4220																
4215																
4210																

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Project Name: CDOT Region 2 Bridge Bundle

PAGE 1 of 2

Project Number: 220-063

Boring No.: **M-22-U-B-1**

Boring Began: 8/24/2020
Boring Completed: 8/28/2020
Drilling Method(s): Hollow-Stem Auger / Wireline Coring
Driller: Vine Laboratories
Drill Rig: CME 55 Truck
Hammer: Automatic (hydraulic), ER: 80%

Total Depth: 29.5 ft
Ground Elevation: 4231.95
Coordinates: N: 475060.3 E: 551591.6
Location: US 350, northbound outside lane
Logged By: R. Desterhouse
Final By: J. McCall

Weather Notes: Hot, 100F
Inclination from Horiz.: Vertical
Night Work: ☐

Groundwater Levels: Not Observed			
Symbol			
Depth	-	-	-
Date	-	-	-

Elevation (feet)	Depth (feet)	Rock Recovery (%)	Rock RQD (%)	Soil Samples Blows per 6 in	Soil Samples Penetration Resistance	Material Description	Moisture Content (%)	Dry Density (pcf)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Atterberg Limits Liquid Limit	Atterberg Limits Plasticity Index	AASHTO & USCS Classifi-cations	Field Notes and Other Lab Tests
						0.0 - 0.9 ft. ASPHALT (11 inches).									
4230				1-1	2	**0.9 - 18.0 ft. Lean CLAY with sand (CL) and gravel (Fill)**, light brown to yellowish brown, soft to medium stiff.									
	5			2-3	5		15.0	109.6	22.0	29.5	48.5	34	19	A-6 (5) SC	pH=7.7 S=0.654% Chl=0.0065% Re=1119ohm·cm
4225															
	10														
4220															
	15			1-1	2										
4215															
				50:1"	50:1"	**18.0 - 29.5 ft. LIMESTONE**, white to light gray, very hard, subvertical fractures wtih oxide staining, fresh to slightly weathered with local decomposed zones, fossiliferous, gypsum in fractures.									
	20	97	97												UCCS=5740 psi
4210															
		100	100												

Elevation (feet)	Depth (feet)	Sample Type/Depth	Drilling Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi-cations	Field Notes and Other Lab Tests
				Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance								Liquid Limit	Plasticity Index		
4205				100	94													

Bottom of Hole at 29.5 ft.

4200

4195

4190

4185

4180

Project Name: CDOT Region 2 Bridge Bundle

PAGE *1 of 2*

Project Number: 220-063

Boring No.: **M-22-U-B-2**

Boring Began: 8/27/2020

Boring Completed: 8/27/2020

Drilling Method(s): Hollow-Stem Auger / Wireline Coring

Driller: Vine Laboratories

Drill Rig: CME 55/300 Track

Hammer: Automatic (hydraulic), ER: 80%

Total Depth: 27.5 ft

Ground Elevation: 4231.9

Coordinates: N: 475012.4 E: 551541.3

Location: US 350, southbound outside lane

Logged By: C. Wallace

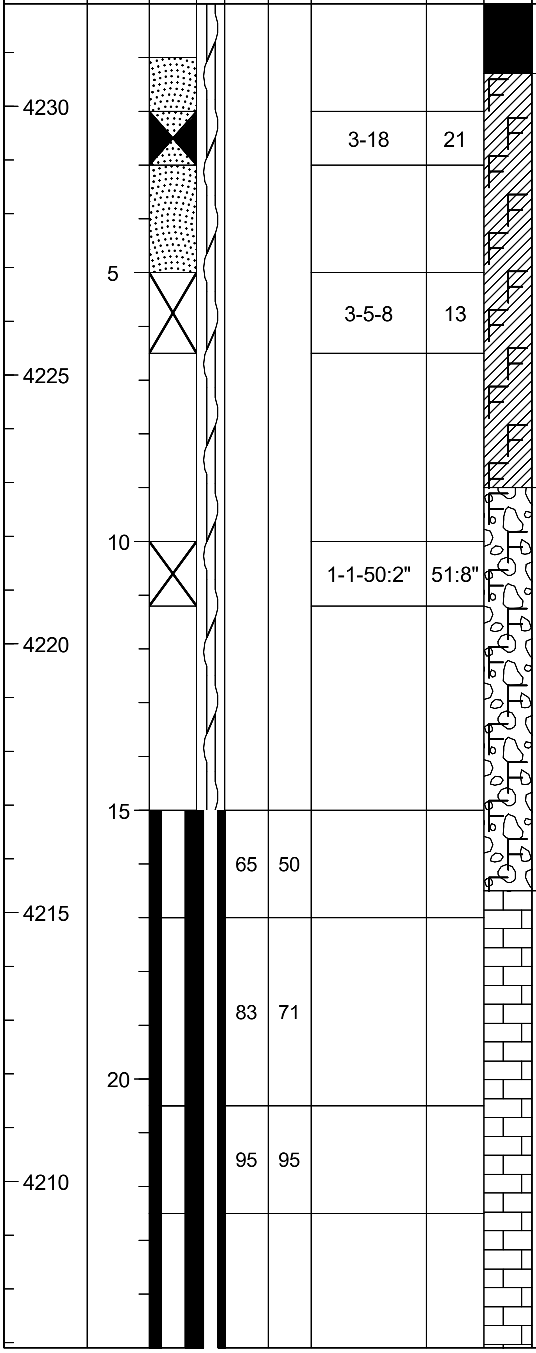
Final By: J. McCall

Weather Notes: Clear, 80s

Inclination from Horiz.: Vertical

Night Work: ☐

Groundwater Levels: Not Observed			
Symbol			
Depth	-	-	-
Date	-	-	-



Elevation (feet)	Depth (feet)	Rock Recovery (%)	Rock RQD (%)	Soil Samples Blows per 6 in	Soil Samples Penetration Resistance	Material Description	Moisture Content (%)	Dry Density (pcf)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Atterberg Limits Liquid Limit	Atterberg Limits Plasticity Index	AASHTO & USCS Classifi-cations	Field Notes and Other Lab Tests
						0.0 - 1.3 ft. ASPHALT (15 inches).									
4230				3-18	21	**1.3 - 9.0 ft. Sandy lean CLAY with gravel (CL) (Fill)**, light brown to gray, moist, very stiff, limestone gravels.									
	5			3-5-8	13										
4225															
	10			1-1-50:2"	51:8"	**9.0 - 16.5 ft. Clayey GRAVEL with sand (GC) (Fill)**, light brown and light gray, moist, very loose, limestone gravels.	3.7		49.0	20.3	30.7				
4220															
	15	65	50												
4215						**16.5 - 27.5 ft. LIMESTONE**, light gray, predominantly decomposed to slightly weathered, very hard, irregularly spaced and oriented fractures, oxide staining, clay infilling.									
		83	71												UCCS=12490 psi
	20														
4210		95	95												

Elevation (feet)	Depth (feet)	Sample Type/Depth	Drilling Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi-cations	Field Notes and Other Lab Tests
				Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance								Liquid Limit	Plasticity Index		
4205				90	90													

Bottom of Hole at 27.5 ft.

4200

4195

4190

4185

4180

Boring:	**B-1**	AC:	**10.5"**
Roadway:	**US 350**	PCC:	**-**
Direction:	**Northbound**	Base:	**-**
Lane:	**Outside**	Notes:	P-1 core crumbled. B-1 core shown.

Boring:	**P-2**	AC:	**10"**
Roadway:	**US 350**	PCC:	**-**
Direction:	**Southbound**	Base:	**-**
Lane:	**Outside**	Notes:	-

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Pavement Core Photographs

FIGURE

B-1

PROJECT NO. 220-063
FIGURE BY: BHL
CHECKED BY: JTM
DATE: 11/16/2020
YEH OFFICE: Colorado Springs

CDOT Region 2 Bridge Bundle
Structure M-22-U

Yeh and Associates, Inc.
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Rock Core Photos
Boring: B-1
Depth: 18' - 26'

PROJECT NO.	220-063	DATE:	11/16/2020
FIGURE BY:	BHL	YEH OFFICE:	Colorado Springs
CHECKED BY:	JTM		

CDOT Region 2 Bridge Bundle
Structure M-22-U

FIGURE

B-2

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Rock Core Photos
Boring: B-1
Depth: 26' - 29'

FIGURE

B-3

PROJECT NO.	220-063	DATE:	11/16/2020
FIGURE BY:	BHL	YEH OFFICE:	Colorado Springs
CHECKED BY:	JTM		

CDOT Region 2 Bridge Bundle
Structure M-22-U

Yeh and Associates, Inc.
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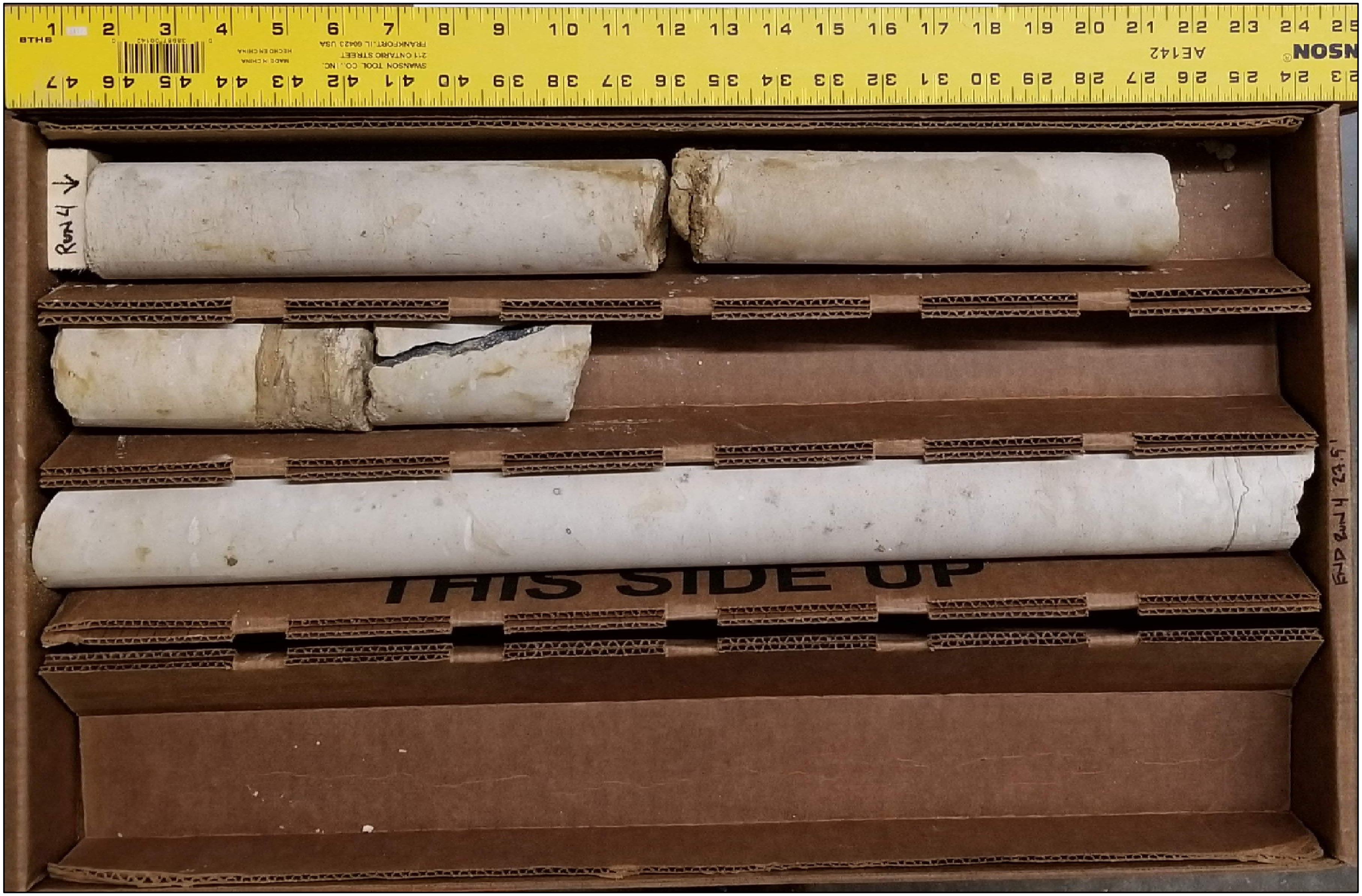
Rock Core Photos
Boring: B-2
Depth: 15' - 22.5'

PROJECT NO. 220-063
FIGURE BY: BHL
CHECKED BY: JTM
DATE: 11/16/2020
YEH OFFICE: Colorado Springs

CDOT Region 2 Bridge Bundle
Structure M-22-U

FIGURE
B-4



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Rock Core Photos
Boring: B-2
Depth: 22.5' - 27.5'

PROJECT NO.	220-063	DATE:	11/16/2020
FIGURE BY:	BHL	YEH OFFICE:	Colorado Springs
CHECKED BY:	JTM		

CDOT Region 2 Bridge Bundle
Structure M-22-U

FIGURE

B-5

APPENDIX C

SUMMARY OF LABORATORY TEST RESULTS

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Colorado Springs Lab

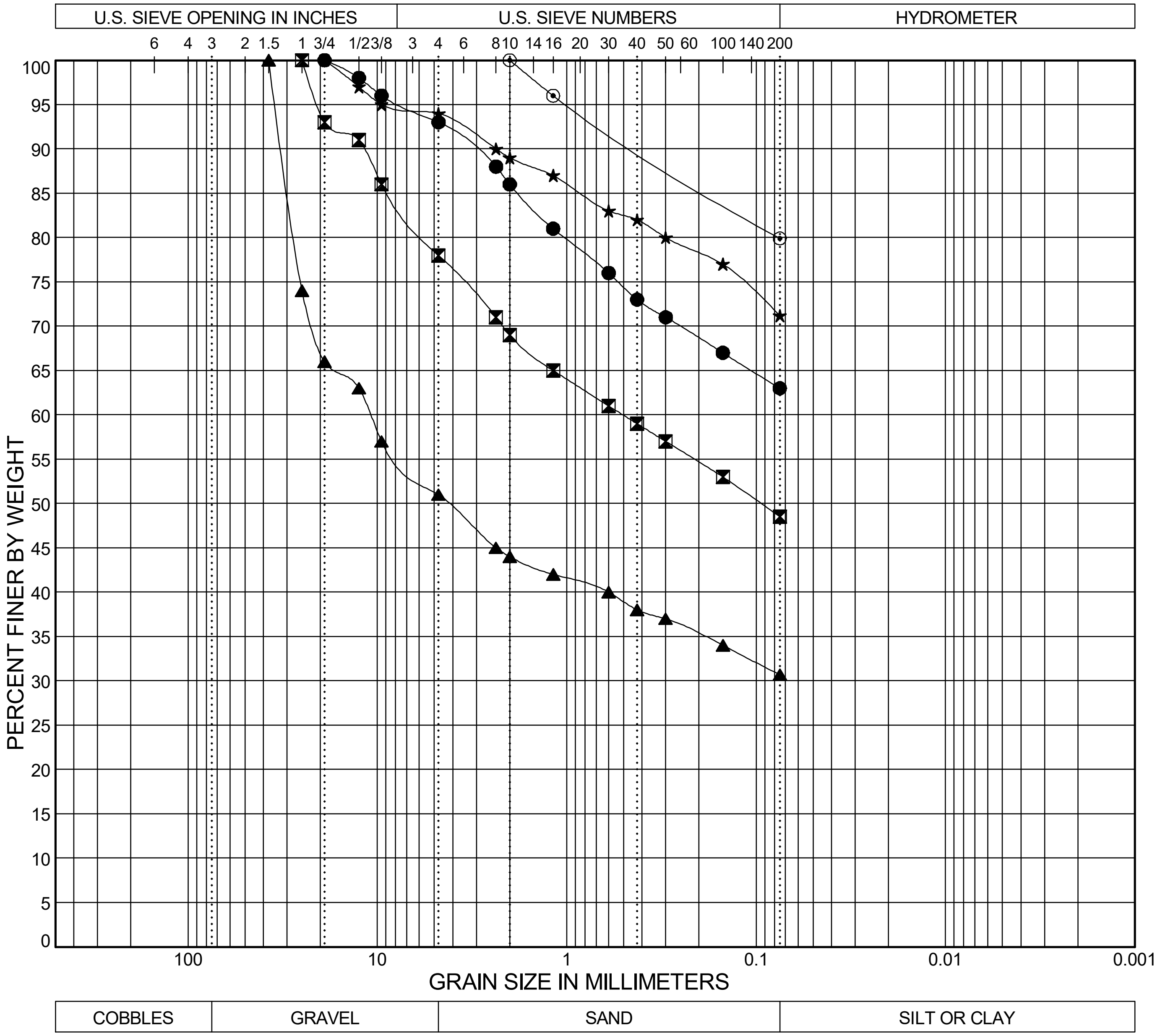
Summary of Laboratory Test Results

Project No: 220-063 Project Name: CDOT Region 2 Bridge Bundle Date: 11-19-2020

Sample Location			Natural Moisture Content (%)	Natural Dry Density (pcf)	Gradation			Atterberg			pH	Water Soluble Sulfate (%)	Water Soluble Chloride (%)	Resistivity (ohm-cm)	Swell (+) / Collapse (-) (% at Load in psf)	Unconf. Comp. Strength (psi)	R-Value	Classification	
Boring No.	Depth (ft)	Sample Type			Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	LL	PL	PI								AASHTO	USCS
M-22-U P-1/P-2	2.5	BULK	13.8		7.0	30.0	63.0	36	14	22		1.534	0.0026				15	A-6 (11)	CL
M-22-U Scour	0	BULK	5.9		31.0	24.3	44.7												
M-22-U-B-1	5.0	MC	15	109.6	22.0	29.5	48.5	34	15	19	7.7	0.654	0.0065	1119				A-6 (5)	SC
M-22-U-B-1	21.0	CORE														5740			
M-22-U-B-2	10.0	SPT	3.7		49.0	20.3	30.7												
M-22-U-B-2	18.0	CORE														12490			
M-22-U-P-1	2.0	BULK	9.5		6.0	22.8	71.2	32	16	16								A-6 (9)	CL
M-22-U-P-2	4.0	MC	16.5	104.5	0.0	20.1	79.9	36	15	21					0.4 @ 200			A-6 (15)	CL

Report By: D. Gruenwald

Checked By: J. McCall



	BOREHOLE	DEPTH (ft)	AASHTO Classification	USCS Classification	LL	PL	PI	%Gravel	%Sand	%Fines	
										%Silt	%Clay
●	**M-22-U P-1/P-2**	**2.5**	**A-6 (11)**	**CL**	**36**	**14**	**22**	**7.0**	**30.0**	**63.0**	
☒	**M-22-U-B-1**	**5.0**	**A-6 (5)**	**SC**	**34**	**15**	**19**	**22.0**	**29.5**	**48.5**	
▲	**M-22-U-B-2**	**10.0**						**49.0**	**20.3**	**30.7**	
★	**M-22-U-P-1**	**2.0**	**A-6 (9)**	**CL**	**32**	**16**	**16**	**6.0**	**22.8**	**71.2**	
⊙	**M-22-U-P-2**	**4.0**	**A-6 (15)**	**CL**	**36**	**15**	**21**	**0.0**	**20.1**	**79.9**	

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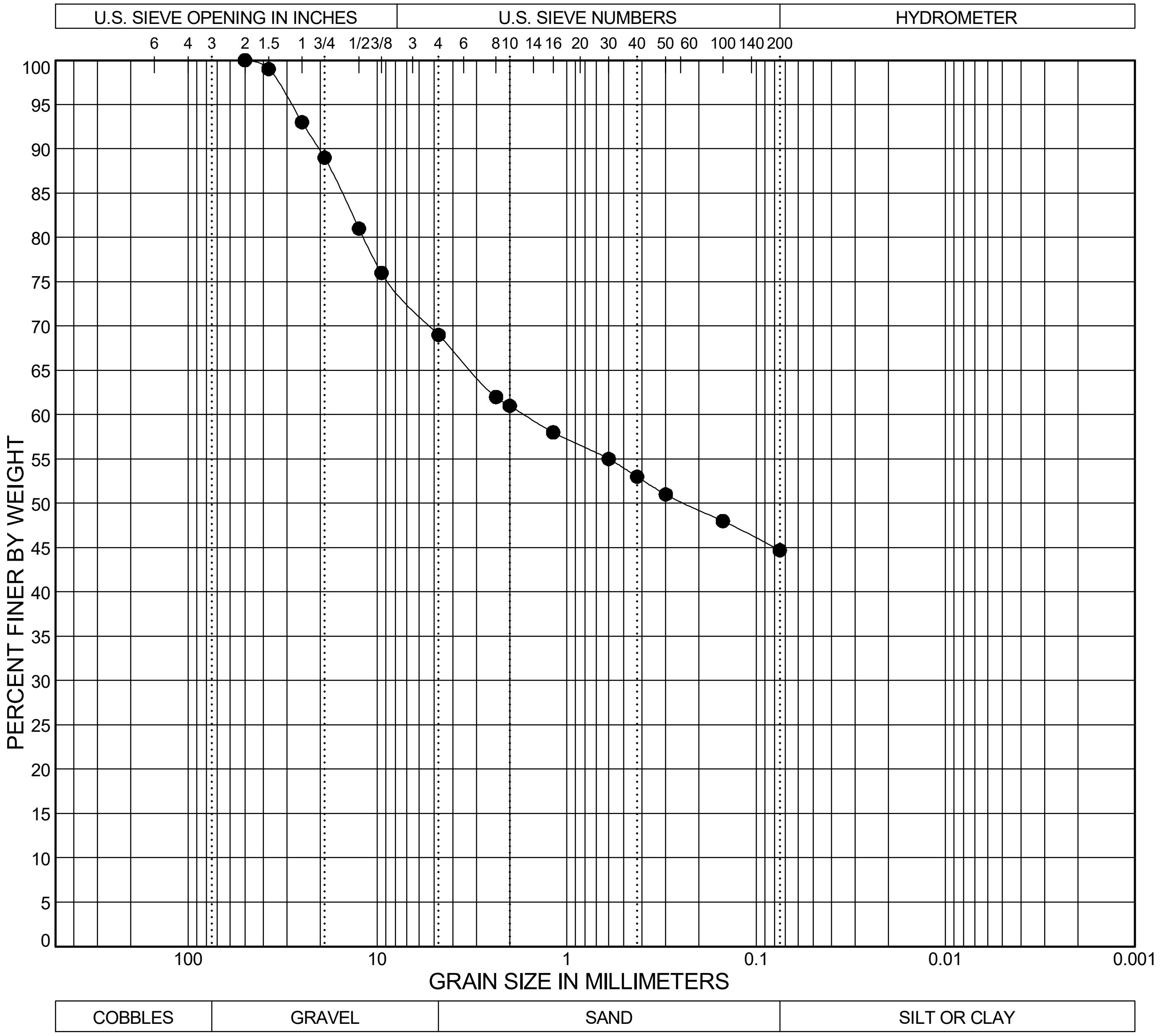
SIEVE ANALYSIS

FIGURE
C- 1

Project No. 220-063 Date: 11-19-2020
Report By: D. Gruenwald Yeh Lab: Colorado Springs
Checked By: J. McCall

CDOT Region 2 Bridge Bundle
Structure M-22-U

03 GRAIN SIZE YEH 220-063 R2 BRIDGE BUNDLE.GPJ 2019 YEH COLORADO TEMPLATE.GDT 2019 YEH COLORADO LIBRARY.GLB 11/19/20



	BOREHOLE	DEPTH (ft)	AASHTO Classification	USCS Classification	LL	PL	PI	%Gravel	%Sand	%Fines	
										%Silt	%Clay
●	**M-22-U Scour**	**0.0**						**31.0**	**24.3**	**44.7**	

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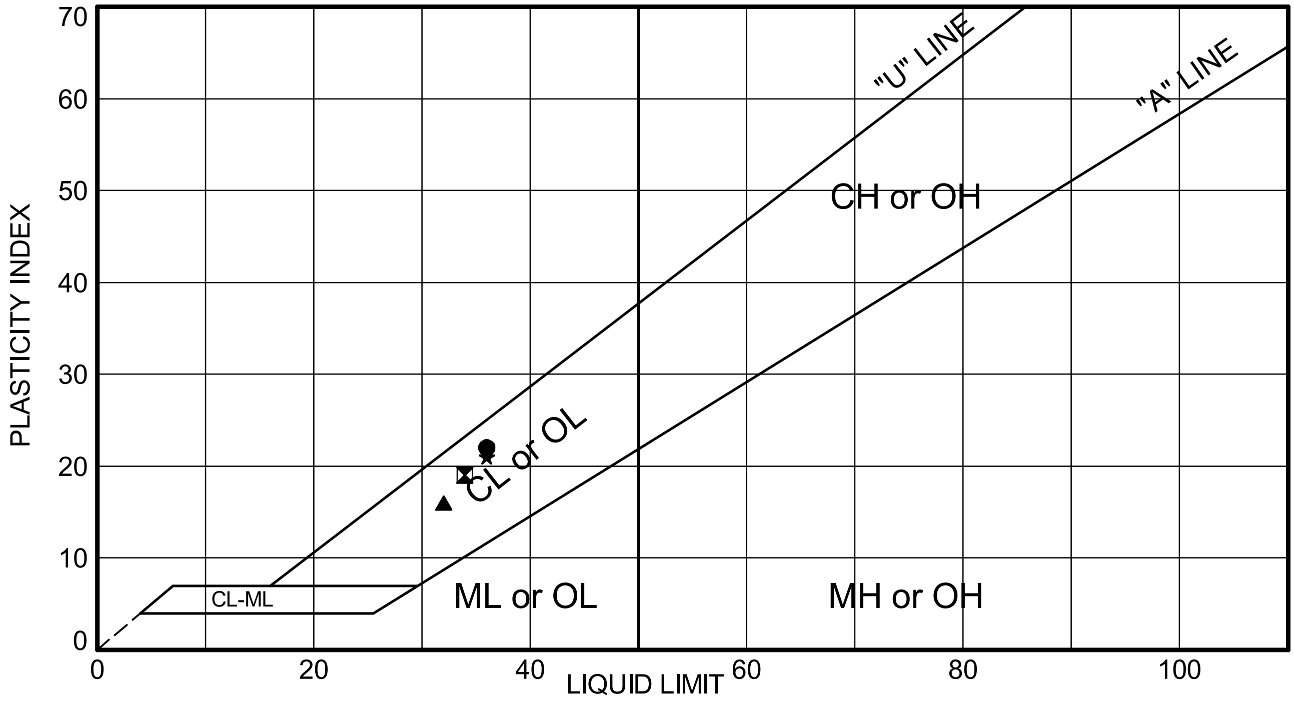
SIEVE ANALYSIS

FIGURE C- 2

Project No.	220-063	Date:	11-19-2020
Report By:	D. Gruenwald	Yeh Lab:	Colorado Springs
Checked By:	J. McCall		

CDOT Region 2 Bridge Bundle
Structure M-22-U



	BOREHOLE	DEPTH (ft)	LL	PL	PI	Passing #200	USCS Sample Description and Symbol	AASHTO Class.
●	**M-22-U P-1/P-2**	**2.5**	**36**	**14**	**22**	**63.0**	**SANDY LEAN CLAY (CL)**	**A-6 (11)**
⧗	**M-22-U-B-1**	**5.0**	**34**	**15**	**19**	**48.5**	**CLAYEY SAND with GRAVEL (SC)**	**A-6 (5)**
▲	**M-22-U-P-1**	**2.0**	**32**	**16**	**16**	**71.2**	**LEAN CLAY with SAND (CL)**	**A-6 (9)**
★	**M-22-U-P-2**	**4.0**	**36**	**15**	**21**	**79.9**	**LEAN CLAY with SAND (CL)**	**A-6 (15)**

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ATTERBERG LIMITS

CDOT Region 2 Bridge Bundle
Structure M-22-U

FIGURE

C - 3

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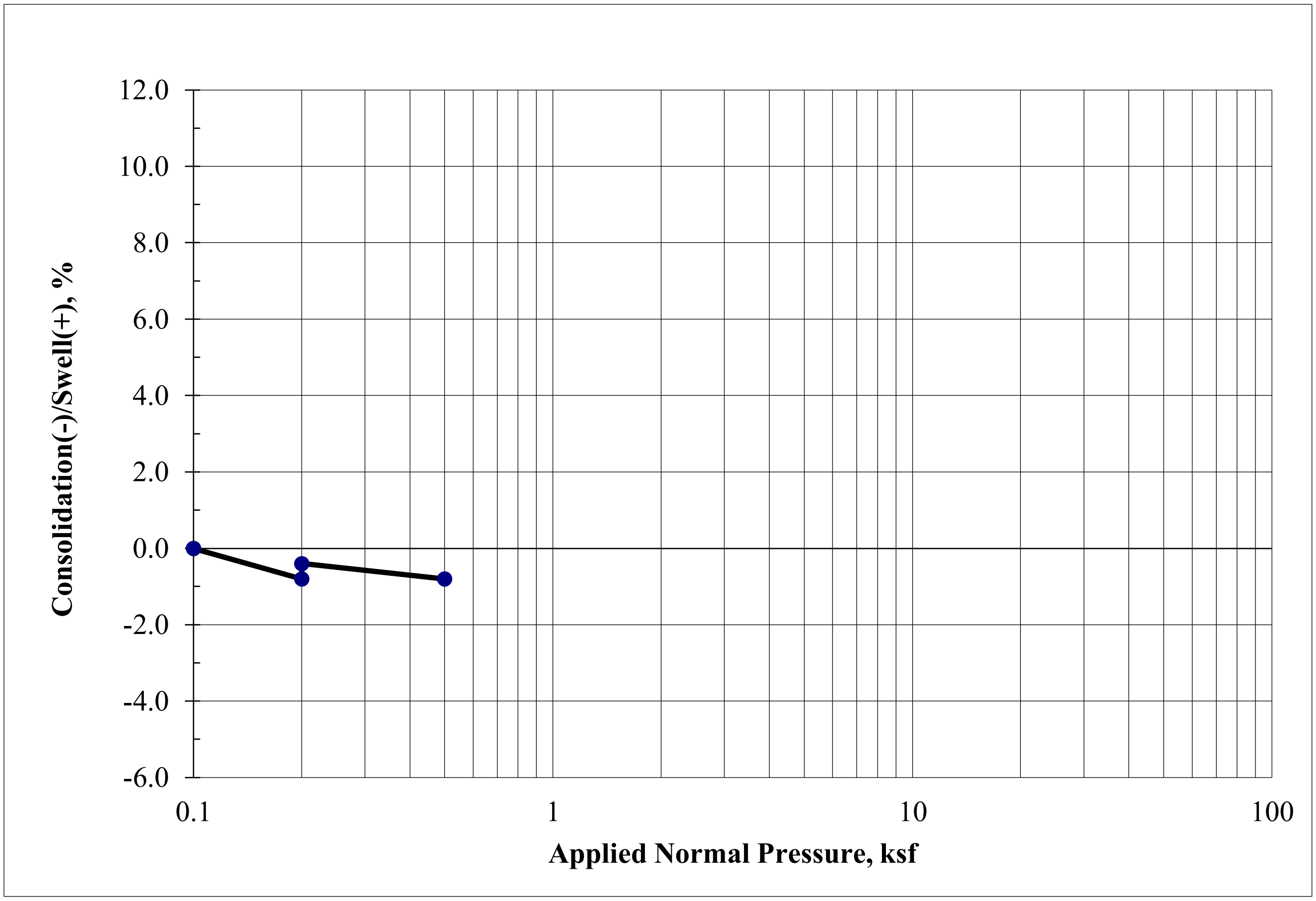
Checked By:	J. McCall		

SWELL/CONSOLIDATION TEST - ASTM D 4546



Boring ID	P-2
Sample Depth (ft)	4.0
Date Sampled	8/24/2020

Swell/ Consolidation (%)	0.4
Natural Moisture Content (%)	16.5
Saturated Moisture Content (%)	20.6
Dry Density (pcf)	104.5

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SWELL/ CONSOLIDATION TEST RESULTS

FIGURE

C-4

Project No.	220-063	Date:	11/19/2020
Report By:	DG	Yeh Lab:	Colorado Springs
Checked By:	JTM		

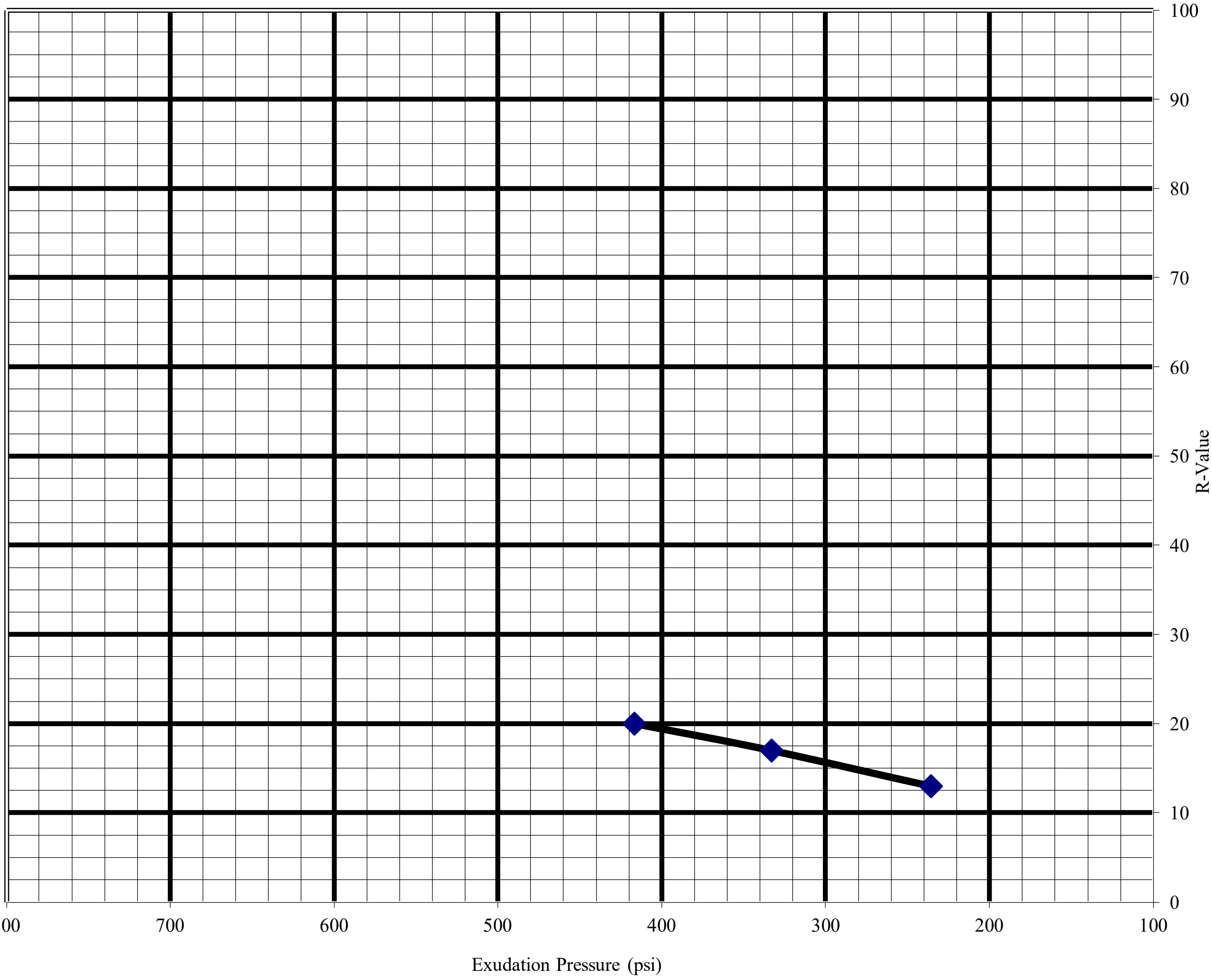
CDOT Region 2 Bridge Bundle
Structure M-22-U

YEH AND ASSOCIATES, INC

R-Value Test Report

Project Number:	220-063	**Project Name:**	CDOT Region 2 Bridge Bundle
Sample Id:	P-1 / P-2	**Depth (ft):**	2.5
Location:	M-22-U	**Station:**	
Date Sampled:	8/24/2020	**Date Tested:**	11/13/2020

R-Value at 300 psi exudation pressure = **15**



Test No.	Compact. Press. (psi)	Density (pcf)	Moist. (%)	Horizont. Pressure (psi)'@ 160 psi	Sample Height (in).	Exud. Pressure (psi)	R Value	R Value Correct.
1	350	123.8	13.0	121	2.51	417	20	20
2	350	120.2	14.0	124	2.46	333	17	17
3	350	120.4	15.0	130	2.50	236	13	13

Sampled by: RD **Tested by:** Kyle Lyons **Checked by:** M.A