MEMORANDUM

MATERIALS AND GEOTECHNICAL BRANCH
GEOTECHNICAL PROGRAM
4670 HOLLY STREET, UNIT A, DENVER, COLORADO 80216 303-398-6604 FAX 303-398-6504

C 0252-316
I-25 CBC Extensions
SA 12210

TO: Daniel Hunt, R2 North Engineering, Colorado Springs RE

FROM: Laura Conroy and David Thomas, Geotechnical Program

DATE: August 30, 2012

SUBJECT: **PRELIMINARY GEOTECHNICAL RECOMMENDATIONS FOR CONCRETE BOX CULVERT EXTENSIONS**

1.0 INTRODUCTION

This report presents geotechnical exploration observations and preliminary recommendations for the extension of seven structures along I-25 from mile markers 154.9 to 159.4. The structures are concrete box culverts (CBCs) that allow drainage to pass under I-25. Current plans are to extend the CBCs and add additional CBCs to allow for the widening of I-25 and increase drainage flow. The purpose of the geotechnical exploration is to characterize physical properties of foundation materials at the proposed CBC locations. Preliminary foundation recommendations are provided for design and construction of the proposed structures. The scope of work was based on conversations and communications with you. Table 1 presents a summary of the CBC structure numbers, mile markers, sizes, and proposed extensions/additions.

TABLE 1. CONCRETE BOX CULVERT DATA SUMMARY

Structure No.	I-25 Direction	Mile Marker	Crossing	Current Design	Cell Size (W x H)	Proposed Design
H-17-AG	NB	154.925	Monument Ck.	2-Cell	12 x 10	2-Cell Extend existing 30 ft East
H-17-I	SB	154.926	Monument Ck.	2-Cell	12 x 10	2-Cell Extend existing 30 ft East & 30 ft West
H-17-H	NB	155.748	Smith Ck.	2-Cell	10 x 10	4-Cell Extend existing 100 ft East and Add 2-Cells
H-17-AL	SB	155.749	Smith Ck.	2-Cell	10 x 10	4-Cell Extend existing 20 ft East & 40 ft West and Add 2-Cells
H-17-M	NB/SB	156.970	Draw	2-Cell	10 x 10	2-Cell Extend existing 50 ft East & 40 ft West
H-17-AI	NB/SB	157.703	Jackson Ck.	1-Cell	30 x 17	1-Cell Extend existing 40 ft East & 40 ft West
H-17-BK	NB/SB	159.343	Teachout Ck.	2-Cell	10 x 10	2-Cell Extend existing 40 ft East & 35 ft West

2.0 GEOTECHNICAL INVESTIGATION

Geotechnical field activities were completed on August 6 through 8 and 13 through 15, 2012. A total of 16 borings were advanced using a CME 550 all terrain drill rig with hollow stem auger techniques. Standard penetration tests using split spoon samplers, California samplers, and thin-walled tube samplers (Shelby tubes) were performed in the borings at select intervals in general accordance with ASTM D-l586, D-3550, and D-1587, respectively. Traffic control was provided by Brad Bauer and Lee DeGraffenried with CDOT Maintenance. The borings advanced at each culvert location is indicated in Table 2.

TABLE 2. CULVERT BORING SUMMARY

Structure No.	I-25 Direction	Mile Marker	Crossing	Borings Advanced
H-17-AG	NB	154.925	Monument Ck.	AG-1
H-17-I	SB	154.926	Monument Ck.	I-1, I-2
H-17-H	NB	155.748	Smith Ck.	H-1, H-2
H-17-AL	SB	155.749	Smith Ck.	AL-1 through AL-5
H-17-M	NB/SB	156.970	Draw	M-1, M-2
H-17-AI	NB/SB	157.703	Jackson Ck.	AI-1, AI-2
H-17-BK	NB/SB	159.343	Teachout Ck.	BK-1, BK-2

2.1 GEOLOGY

The geology is similar across the entire site. The overburden soils at the culvert locations generally consist of sand, clay, and/or silt over sedimentary bedrock. The relative density of the sands ranged from very loose to medium dense. The consistency of the clay soils ranged from soft to medium stiff. The consistency of the silt was soft. The bedrock generally consisted of interbedded weakly cemented sandstone, claystone, and siltstone. The hardness ranged from firm to very hard based on local hardness classifications. Two borings performed at culvert H-17-AL (borings AL-4 and AL-5) encountered auger refusal on bedrock at a depth of approximately 6 feet below ground surface (bgs). These were the only two borings that encountered auger refusal. Groundwater was encountered at the culvert locations and generally corresponded with the elevation of the observed surface water in the channel. The boring logs and geology sheets will be presented in the final report after the borings have been surveyed.

3.0 PRELIMINARY RECOMMENDATIONS

The subsurface conditions are favorable for the extension of the CBCs. Settlement is anticipated at the CBC extensions and additions at locations with very loose sands and soft clays.

Settlement in the clays may be time dependent. Pre-loading the site may be one option to help reduce the differential settlement between the unions of the existing culvert and the culvert extension. If movement is not acceptable, a deep foundation could be used to mitigate the differential movement risk. Once laboratory tests have been completed, more detailed settlement information will be available.

3.1 CONCRETE BOX CULVERT

The CBC foundation will be supported on varying materials. The nominal bearing resistance is dependent on the bearing materials, and also on the culvert width if bearing on granular soils. The new extensions and additions are assumed to be the same height and width as the existing CBCs at each location. Table 3 presents the preliminary bearing summary for the new CBC sections.

TABLE 3. PRELIMINARY CONCRETE BOX CULVERT BEARING SUMMARY

Structure No.	I-25 Direction	Mile Marker	Extension Length (ft)	Culvert Width (ft.)	Bearing Material	Nominal Bearing Resistance (ksf)
H-17-AG	NB	154.925	30	24	Sand	11.8
H-17-I	SB	154.926	30	24	Sand	11.7
H-17-H	NB	155.748	240	40	Clay	2.7*
H-17-AL	SB	155.749	195	40	Clay	2.7*
H-17-M	NB/SB	156.970	40/50	20	Clay	2.0*
H-17-AI	NB/SB	157.703	30/40	30†	Sand	4.5
H-17-BK	NB/SB	159.343	35/40	20	Sand	10.0

* – Over-excavation and replacement may be required due to soft clays at bearing depth.

† – Culvert has earth bottom and is supported on timber piles with a 5-foot wide pile cap. A 5-foot wide spread footing was assumed for this analysis.

3.2 WING WALLS AND TEMPORARY EXCAVATIONS

For wing walls, it is assumed new fill will consist of Class 1 Structure Backfill. Class 1 Structure Backfill should be compacted to at least 95 percent of the maximum dry density and within 2 percent of optimum moisture content as determined by AASHTO T180 (ASTM D 1557) and as described in Section 206 of the 2011 *CDOT Standard Specification for Road and Bridge Construction*. Retaining wall parameters for preliminary design are presented in Table 3. Lateral pressures must be reevaluated when sloping backfill or surcharge loads exist. Temporary excavation support may be required where slopes above the groundwater table are steeper than 1:1 (H:V). Excavations below groundwater may require temporary support. Parameters presented in Table 4 also are suitable for preliminary temporary excavation support design.

TABLE 4. PRELIMINARY MATERIAL PARAMETERS FOR RETAINING WALLS AND TEMPORARY EXCAVATIONS

Material	Typical Total Unit Weight γ_T (pcf)	Internal Friction Angle φ (degrees)	Cohesion C (psf)	Earth Pressure Coefficients		
				Active (Ka)	At Rest (Ko)	Passive (Kp)
New Class 1 Structure Backfill	125	34	0	0.28	0.44	3.54
Loose Sand	110	28	0	0.36	0.53	2.77
Medium Dense Sand	120	32	0	0.31	0.47	3.25
Soft Clay	105	20	100	0.49	0.61	2.04
Stiff Clay	115	25	200	0.41	0.53	2.46

The wing wall foundation will be supported on the clays or sands. The nominal bearing resistance is dependent on the bearing materials and also on the width of the wing wall footing if bearing on granular soils. The wing walls were analyzed for two heights, 5 feet and 10 feet, to incorporate the slope of the walls. CDOT Standard Plan M-601-20 was used as a reference for typical footing widths based on wing wall heights. Additional wall heights and footing sizes can be analyzed for the final report if requested. A 1 foot minimum embedment was assumed for the wing wall footings based on CDOT practice. The preliminary nominal bearing resistance value for clay ranged from 2.0 to 2.8 ksf for walls 5 or 10 feet high. The preliminary nominal bearing resistance for sand ranged from 2.6 to 2.8 ksf for walls 5 feet high and 3.7 to 4.0 ksf for walls 10 feet high. A bearing resistance factor of 0.55 for gravity walls may be applied when using the LRFD method. A coefficient of sliding resistance (μ) of 0.30 for clay and 0.35 for sand may be used between concrete and undisturbed foundation soil. The global stability of the walls should be verified after final design is completed.

Please contact the Geotechnical Program at 303-398-6604 with and questions or comments

REVIEW: Liu

COPY: Wrona – Region 2 RTD
Lollar – Region 2 North Engineering Program Engineer
Wieden – Region 2 Materials
Groeneman – Staff Bridge
Cress – Region 2 Hydraulics
Henry/Hernandez – Branch Materials & Geotech
Liu – Branch Materials & Geotech