

MEMORANDUM

TO: Mark Hite, P.E.
Director
Division of Structural Design

FROM: Bart Asher, P.E., L.S.
TEBM, Geotechnical Branch

BY: Daryl J. Greer, P.E. 
Geotechnical Branch

DATE: July 8, 2015

SUBJECT: Garrard/Mercer Counties
FD52 040 0152 000-001
FD52 084 0152 018-019
BRO 5129 (012)
MARS No. 8469001D
KY 152 Bridge and Approaches over Herrington Lake
Retaining Wall @ Sta. 26+70
Item No. 7-1116.00
Geotechnical Engineering Structure Foundation Report

The geotechnical engineering overview report for the subject project has been completed by Stantec Consulting Services, Inc. We have reviewed and concur with the recommendations as presented in this report.

A copy of the report is attached. If you have any questions, please contact this office at 502-564-2374.

Attachments

cc: K. Sandefur
W. McKinney
R. Powell
R. Sprague
M. Simpson
K. Caudill
R. Gossom
D. Byers (WMB)
A. Grace (Stantec)
B. Greene



Report of Geotechnical Exploration

Retaining Wall at Sta. 26+70
KY 152 over Herrington Lake
Item No. 7-1116.00
Garrard and Mercer Counties,
Kentucky
Project ID: S-078-2015



July 6, 2015

rpt_003_175562020

Charlie Raymer, PE
WMB, Inc.
1950 Haggard Court
Lexington, Kentucky 40505

Re: Report of Geotechnical Exploration
Retaining Wall at Sta. 26+70
KY 152 over Herrington Lake
Item No. 7-1116.00
Garrard and Mercer Counties, Kentucky
Project ID: S-078-2015

Dear Mr. Raymer:

Stantec Consulting Services Inc. (Stantec) is submitting the geotechnical engineering report for the referenced project with this letter. Also included are the subsurface data sheets presenting the boring layout, logs of borings, geotechnical notes for the retaining wall, as well as pertinent engineering analyses.

The referenced project also includes replacing the KY 152 bridge over Herrington Lake and relocating the approach roadways. In addition, there is a second retaining wall proposed for the project. The geotechnical considerations for the bridge, approach roadways, and second retaining wall are addressed under separate covers. This report presents results of the field exploration along with our recommendations for the design and construction of the retaining wall located near KY 152 Station 26+70. As always, we enjoy working with your staff and if we can be of further assistance, please contact our office.

Sincerely,

STANTEC CONSULTING SERVICES INC.

Derek J. Gerdeman
Project Engineer

Adam Crace, PE
Senior Associate

/hnh

Report of Geotechnical Exploration
Retaining Wall at Sta. 26+70
KY 152 over Herrington Lake
Item No. 7-1116.00
Garrard and Mercer Counties, Kentucky
Project ID: S-078-2015

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Report of Geotechnical Exploration
Retaining Wall at Sta. 26+70
KY 152 over Herrington Lake
Item No. 7-1116.00
Garrard and Mercer Counties, Kentucky
Project ID: S-078-2015

1. Introduction

1.1. Project Overview

The Kentucky Transportation Cabinet (KYTC) is planning to replace the Kennedy Bridge, KY 152 over Herrington Lake. The existing bridge has been in service since 1933 and is currently operating under a reduced service load of 15 tons. It is proposed that a new bridge will be constructed just downstream of the existing bridge. As part of the bridge replacement project, short pieces of roadway will be relocated and/or reconstructed at both ends of the bridge. Two retaining walls are also proposed as part of this project. The geotechnical considerations for the bridge and approach roadways are addressed under separate cover. This report addresses the geotechnical considerations associated with the retaining wall located from approximate station 26+70 to 27+39. The map provided in Appendix A illustrates the project location.

1.2. Structure Location and Description

Structure plans indicate the proposed gravity type retaining wall will be 69 feet in length beginning at KY 152 station 26+70, 26 feet Left and ending at station 27+39, 26 feet left. Appendix B presents structure drawings received from the project designer, WMB Inc. (WMB) which depicts the proposed plan layout and profile of the retaining wall.

2. Site Topography and Geologic Conditions

The project area lies within the Bluegrass Physiographic Region of Kentucky. The Bluegrass Region is characterized by gently rolling hills with rich fertile soils. Weathering of the underlying limestone bedrock has produced caves, sinkholes, and springs. The proposed retaining wall is located close to the Kentucky River Palisades, which formed when the Kentucky River and its tributaries cut through the limestone bedrock to form high cliffs and steep gorges within the study area. Existing topographic relief at the site varies from approximate elevation 790 feet at the abutments to approximate elevation 550 feet below Herrington Lake.

Available geologic mapping (USGS Geologic Map of Bryantsville (1971) Quadrangle, Kentucky) indicates the site is underlain by limestone and possibly dolomite bedrock of the Middle Ordovician age. According to the USGS Quadrangle, the limestones are predominantly light gray to gray, micro-crystalline to fine grained, thin to medium bedded, with shale stringers. The dolomite is described as light gray to gray, micro-crystalline grained, and thick bedded.

Karst activity exists with the Bluegrass Physiographic Region of Central Kentucky. However, based on USGS Geologic mapping, no known karstic features are present in the project vicinity.

Based on USGS Geologic mapping, several unnamed faults are present within approximately one mile of the project location. The unnamed faults fall to the north, southwest and south of the project. The Kentucky River Fault Zone is also located near the project location. At the closest point, the Kentucky River Fault Zone is approximately 3.25 miles to the southeast of the project location. None of these faults are known to have been active within recent history.

Residual clayey and silty soils are the predominant soil type mapped within the area of the proposed retaining wall. Soils tend to be fairly thin in the vicinity of the project.

3. Summary of Borings

Two borings were drilled during the 2014 field exploration for the proposed retaining wall. The borings drilled consisted of one rock core boring and one rockline sounding. The borings were staked in the field by WMB survey personnel. The locations and logs of the borings are shown on the Subsurface Data Sheet located in Appendix C. Table 1 presents a summary of the borings drilled. All measurements are expressed in feet.

Table 1. Summary of Borings

| Hole No. | Station, Offset | Surface Elevation | Top of Rock Elevation | Refusal/Begin Core Elevation | Length of Core ^b | Bottom of Hole Elevation |
|----------|------------------|-------------------|-----------------------|------------------------------|-----------------------------|--------------------------|
| B-14 | 26+60, 48.0' Lt. | 782.3 | 779.4 ^a | 779.4 | N/C | 779.4 |
| B-21 | 27+39, 26.0' Lt. | 787.7 | 786.0 | 786.0 | 6.3 | 779.7 |

a. Top of rock in this case indicates rock-like resistance to augering. An exact determination cannot be made without performing rock coring.

b. N/C denotes no rock coring performed.

Stantec personnel performed drilling and sampling operations in December, 2014. The drill crews operated a truck-mounted drill rig equipped with hollow-stem augers as well as wire line rock coring tools.

The Subsurface Data Sheet in Appendix C provides a boring layout that depicts the location of the boring in relation to the planned structure as well as a graphical log presenting the results of the drilling, sampling, and laboratory testing programs. Refer to Appendix D for the Coordinate Data Submission Form summarizing the as-drilled boring location, surface elevation, and associated latitude and longitude.

4. Soil and Bedrock Conditions

Drilling operations for the proposed retaining wall indicate that soils are fairly shallow with a thickness of two feet or less. The rock core specimens obtained in the boring consist primarily of limestone. The limestone was described as light gray in color, medium- to thick-bedded, medium- to microcrystalline-grained, and having shale stringers.

The project engineer determined the location of the base of weathered rock in the boring. The percent recovery and rock quality designation (RQD) were also determined for each core run.

The RQD is defined as the sum of all core pieces longer than four inches, divided by the total length of the coring run. KYTC modifies the RQD by excluding from the sum those portions of core which can be broken by hand pressure. The resultant is multiplied by 100 to express the RQD in percent. The RQD provides a simple quantitative indication of rock competency. A detailed graphical log of the boring is presented on the Subsurface Data Sheet in Appendix C.

5. Laboratory Testing

Laboratory soil testing was not completed for the subject retaining wall. Soils in the vicinity of the wall are less than 2 feet.

6. Retaining Wall Analyses

6.1. General

The gravity wall configuration evaluated for the subject retaining structure was developed based on plan view and profile drawings provided by WMB. This project will be designed using the Load and Resistance Factor Design (LRFD) methodology. LRFD is a design approach in which applicable failure and serviceability conditions can be evaluated considering the uncertainties associated with loads and materials resistances. Where applicable, the following engineering analyses followed the current AASHTO LRFD guidelines. This report provides recommendations for design and construction of a cast-in-place gravity retaining wall bearing on bedrock.

6.2. External Stability

Stantec evaluated the external stability (sliding, eccentricity, and bearing capacity) of the gravity wall at the tallest section which is located at KY 152 Station 26+70. For the purposes of modeling the gravity wall, the stem was estimated to be one foot and the batter on the front of the wall was estimated to be 1:12 (H:V). The base width of the wall was modeled at 0.5 times the wall height. These wall dimensions are in accordance with Case II of Standard Drawing RGX – 002.

The friction angles used in the analyses were $\phi = 38$ degrees for the granular backfill behind the wall and $\delta = 35$ degrees for the contact between the concrete retaining wall foundation and bedrock. Due to vehicular traffic being able to operate near the top of the retaining wall, a 2-foot soil surcharge load was also considered in the analyses.

Using the above parameters, LRFD checks for eccentricity (overturning) and sliding were satisfied. The required bearing capacity (Meyerhof Stress) was also determined to be 2,240 psf at the service limit state. The results of the external stability analyses are presented in Table 2.

Table 2. Summary of Retaining Wall Analyses

| Wall Dimension | | Required Bearing Capacity (psf) | Capacity Demand Ratio | |
|----------------|------------|---------------------------------|-----------------------|---------|
| Height (ft) | Width (ft) | | Overturning | Sliding |
| 8.7 | 4.35 | 2,240 | 1.6 | 1.2 |

6.3. Bearing Capacity Analyses

Based upon inspection of the rock core and quality of the rock encountered, it is assumed that the retaining wall footing will bear in the weathered zone of the limestone bedrock. The wall footings shall be designed at the service limit state. In accordance with NAVFAC DM 7.2, page 7.2-142, a presumptive bearing resistance of 20 ksf is being recommended for weathered limestone bedrock at the service limit state. Since the required bearing capacity was calculated to be 2.2 ksf, the allowable bearing capacity exceeds the required bearing capacity. For checking the strength and extreme limit states, the nominal bearing resistance is 60 ksf. Use resistance factors of 0.55 and 1.0 for the strength and extreme limit states, respectively.

6.4. Global Stability Analyses

Global stability analyses were not performed for the subject retaining wall. The proposed wall will bear on bedrock, therefore, global stability analyses are not necessary.

7. Conclusions and Recommendations

Stantec developed the following recommendations based upon reviews of available data, information obtained during the field exploration, results of engineering analyses, and discussions with WMB personnel. The recommendations are also based on the structure configuration presented in drawings provided by WMB and are specific to the wall height and geometry discussed herein.

7.1. Design of the subject retaining wall shall be in accordance with the 2014 AASHTO LRFD Bridge Design Specifications.

7.2 Wall dimensions shall be in accordance with Case II of the Kentucky Department of Highways Standard Drawing RGX – 002.

7.3. Wall footings shall be designed at the service limit state using a factored bearing resistance of 20.0 ksf for weathered limestone bedrock. For checking the strength and extreme limit states, the nominal bearing resistance is 60.0 ksf. Use resistance factors of 0.55 and 1.0 for the strength and extreme limit states, respectively.

7.4. Non-erodible Granular Embankment shall be placed in the entire area between the wall and a 1:1 (H:V) line sloping upward and away from the base of the heel of the wall to the top of the wall.

7.5. Granular Embankment used as backfill shall be non-erodible and shall conform to the requirements of Section 805 of the current Kentucky Transportation Cabinet Standard Specifications for Road and Bridge Construction. Contrary to Section 805 of the Standard Specifications, the maximum size limit shall be reduced to 4 inches. The Granular Embankment material shall be wrapped with Type IV geotextile fabric in accordance with Sections 214 and 843 of the current Kentucky Transportation Cabinet Standard Specifications for Road and Bridge Construction to provide separation from the clay embankment and/or foundation materials.

7.6. It is estimated that the embankment material behind the retaining wall will consist of granular embankment. Using an estimated $\phi = 38^\circ$, the following fluid pressures are applicable:

| <u>Slope of Backfill</u> | <u>Equivalent Fluid Pressure</u> |
|--------------------------|----------------------------------|
| Level | 43 psf |
| 3:1 (H:V) | 57 psf |
| 2:1 (H:V) | 69 psf |

7.7. The footing width of the gravity wall shall be no less than $\frac{1}{2}$ of the total wall height (including embedment). The Designer shall verify wall stability based on final wall design dimensions.

7.8. The minimum wall embedment shall be 2 feet as measured from the ground surface in front of the wall to the base of the footing.

7.9. Drainage systems behind the wall will be necessary. The drainage systems shall consist of 4-inch diameter pipe with weep-holes installed at the locations as indicated by Standard Drawing RGX 002-06 or by the Designer, and/or perforated pipe installed at the base of the wall and "daylighted" to promote dewatering of the granular backfill.

7.10. **A plan note should be included by the Designer:** Foundation excavations should be properly braced/shored to provide adequate safety to people working in or around the excavations. Bracing should be performed in accordance with applicable federal, state, and local guidelines.

7.11. **A plan note should be included by the Designer:** Structure excavation shall be completed just prior to foundation construction in order to prevent the bedrock from being exposed for an extended period of time and deteriorating. Rock excavation may be required to reach the required bearing elevation of the wall.

7.12. Prior to placement of any concrete or reinforcing steel in a foundation excavation, the excavation bottom should be clean, and all soft, wet, or loose materials should be removed. In no case should concrete be placed upon compressible or water-softened materials.

7.13. If the designer requires more information or would like to investigate other foundation alternates or wall types, contact Stantec.

8. Closing

8.1. The conclusions and recommendations presented herein are based on data and subsurface conditions from the borings drilled during the geotechnical exploration using that degree of care and skill ordinarily exercised under similar circumstances by competent members of the engineering profession. No warranties can be made regarding the continuity of conditions between borings.

8.2 General soil and rock descriptions and indicated boundaries are based on an engineering interpretation of all available subsurface information and may not necessarily reflect the actual variation in subsurface conditions between borings and samples. Collected data and field interpretation of conditions encountered in individual borings are shown on the drafted sheets in Appendix C.

8.3. The observed water levels and/or conditions indicated on the boring logs are as recorded at the time of exploration. These water levels and/or conditions may vary considerably, with time, according to the prevailing climate, rainfall, tail water elevations and/or other factors and are otherwise dependent on the duration of and methods used in the exploration program.

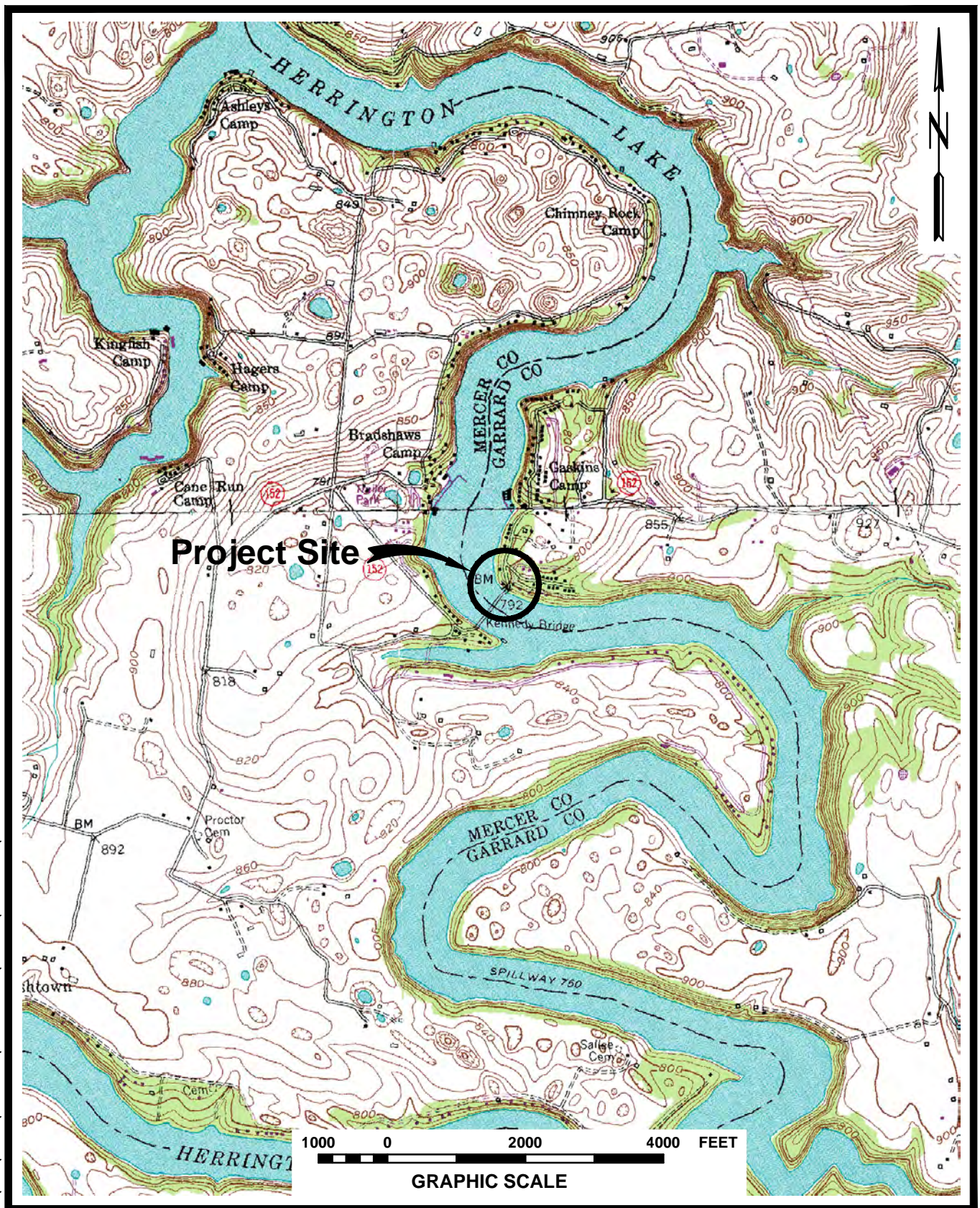
8.4. Stantec exercised sound engineering judgment in preparing the subsurface information presented herein. This information has been prepared and is intended for design and estimating purposes. Its presentation on the plans or elsewhere is for the purpose of providing intended users with access to the same information. This subsurface information interpretation is presented in good faith and is not intended as a substitute for independent interpretations or judgments of the Contractor.

8.5. All structure details shown herein are for illustrative purposes only and may not be indicative of the final design conditions shown in the contract plans.

Appendix A

Location Map

PLOT DATE: 06/09/2015 USER: ELLISON, DOC
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LOCATION MAP
RETAINING WALL AT STATION 26+70
GARRARD/MERCER COUNTIES, KENTUCKY
Portions of USGS 7 1/2-minute Topographic Maps
(BRYANTSVILLE, WILMORE QUADRANGLES) SHOWING PROJECT SITE

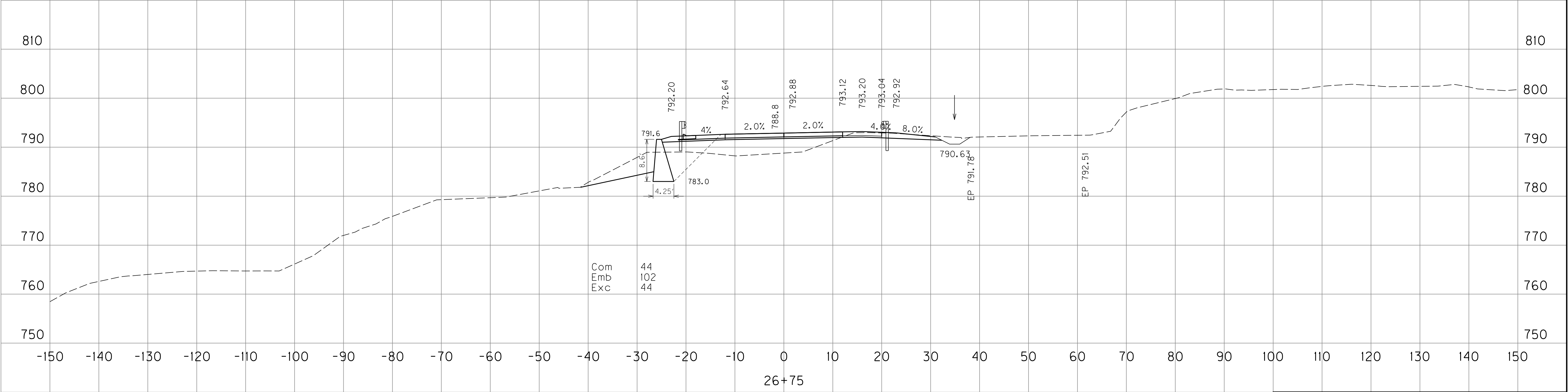
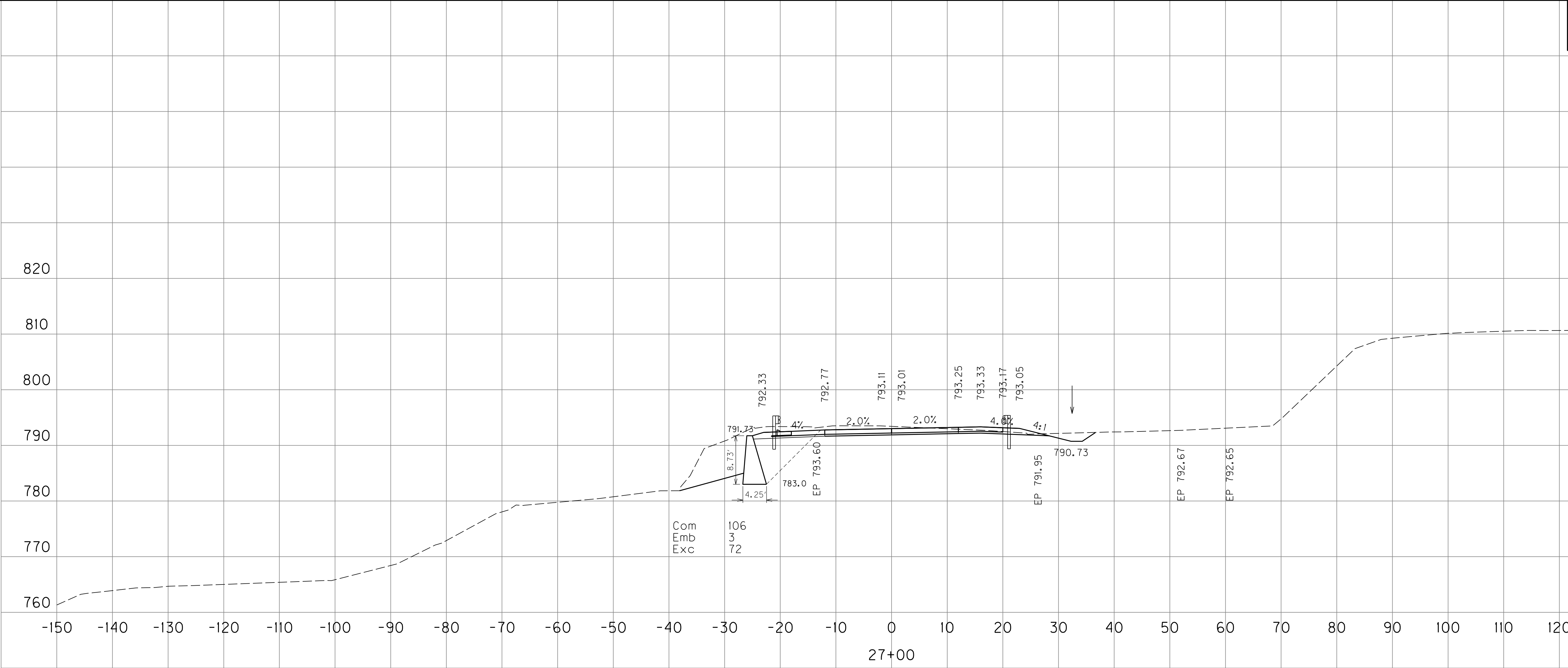
Appendix B

Designer Drawings

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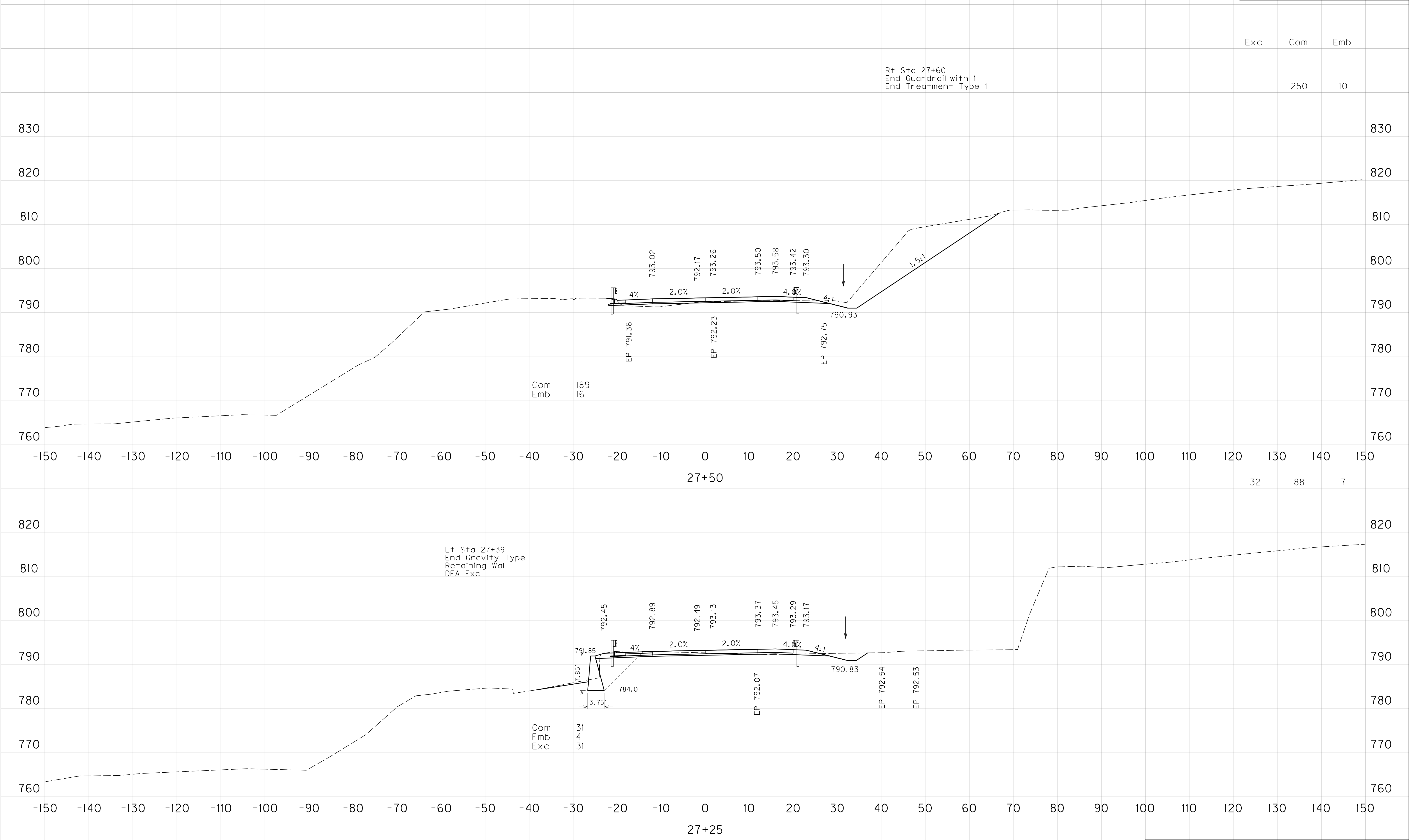
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| MER/GAR | 7-1116.00 | X37 |

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| 48 | 63 | 3 | |



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| MER/GAR | 7-1116.00 | X38 |



Appendix C

Subsurface Data Sheets

FILE NAME: V:\1755\ACTIVE\175562020\GEOTECHNICAL\DRAWING\ SHEET_FILES\RW2670_CONTS.DGN

USER: rflynn
DATE PLOTTED: June 18, 2015

E-SHEET NAME:

MicroStation v8.1i.7.443

GEOTECHNICAL NOTES

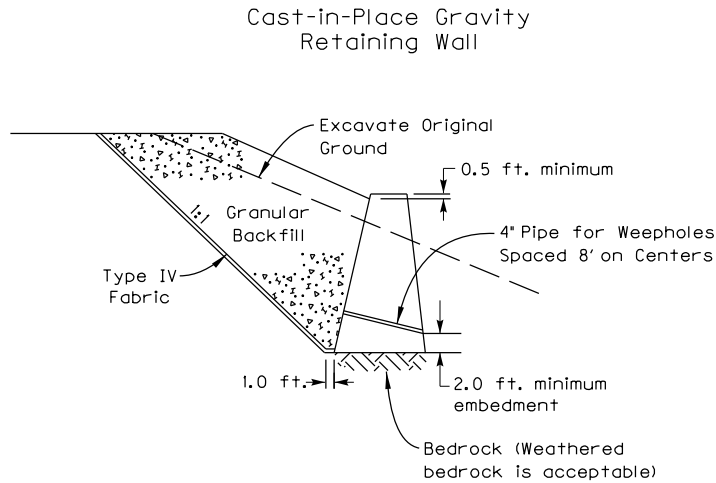
for Cast-in-Place Concrete Gravity Retaining Wall

- Design of the subject retaining wall shall be in accordance with the 2014 AASHTO LRFD Bridge Design Specifications.
- Wall dimensions shall be in accordance with Case II of the Kentucky Department of Highways Standard Drawing RGX-002.
- Wall footings shall be designed at the service limit state using a factored bearing resistance of 20.0 ksf. For checking the strength and extreme limit states, the nominal bearing resistance is 60.0 ksf. Use resistance factors of 0.55 and 1.0 for the strength and extreme limit states, respectively.
- Non-erodible Granular Embankment shall be placed in the entire area between the wall and a 1:1 (H:V) line sloping upward and away from the base of the heel of the wall to the top of the wall.
- Granular Embankment used as backfill shall be non-erodible and shall conform to the requirements of Section 805 of the current Kentucky Transportation Cabinet Standard Specifications for Road and Bridge Construction. Contrary to Section 805 of the Standard Specifications, the maximum size limit shall be reduced to 4 inches. The Granular Embankment material shall be wrapped with Type IV geotextile fabric in accordance with Sections 214 and 843 of the current Kentucky Transportation Cabinet Standard Specifications for Road and Bridge Construction to provide separation from the clay embankment and/or foundation materials.
- It is estimated that the embankment material behind the retaining wall will consist of granular embankment. Using an estimated $\phi = 38^\circ$, the following fluid pressures are applicable:

| Slope of Backfill | Equivalent Fluid Pressure |
|-------------------|---------------------------|
| Level | 43 psf |
| 3:1 (H:V) | 57 psf |
| 2:1 (H:V) | 69 psf |

- The footing width of the gravity wall shall be no less than 1/2 of the total wall height (including embedment). The Designer shall verify wall stability based on final wall design dimensions.
- The minimum wall embedment shall be 2 feet as measured from the ground surface in front of the wall to the base of the footing.
- Drainage systems behind the wall will be necessary. The drainage systems shall consist of 4-inch diameter pipe with weep-holes installed at the locations as indicated by Standard Drawing RGX 002-06 or by the Designer, and/or perforated pipe installed at the base of the wall and "daylighted" to promote dewatering of the granular backfill.
- A plan note should be included by the Designer: Foundation excavations should be properly braced/shored to provide adequate safety to people working in or around the excavations. Bracing should be performed in accordance with applicable federal, state, and local guidelines.
- A plan note should be included by the Designer: Structure excavation shall be completed just prior to foundation construction in order to prevent the bedrock from being exposed for an extended period of time and deteriorating. Rock excavation may be required to reach the required bearing elevation of the wall.
- Prior to placement of any concrete or reinforcing steel in a foundation excavation, the excavation bottom should be clean, and all soft, wet, or loose materials should be removed. In no case should concrete be placed upon compressible or water-softened materials.
- If the designer requires more information or would like to investigate other foundation alternates or wall types, contact Stantec.

GRAVITY WALL GENERAL DIMENSIONS



Use the following soil strength parameters for design:

| Retained Fill | Cohesion (psf) | Friction Angle (degrees) | Unit Weight (pcf) |
|---------------------|----------------|--------------------------|-------------------|
| Granular Embankment | 0 | 38 | 120 |

Sheet 1 of 2

| ITEM NUMBER |
|-------------|
| 7-1116.00 |

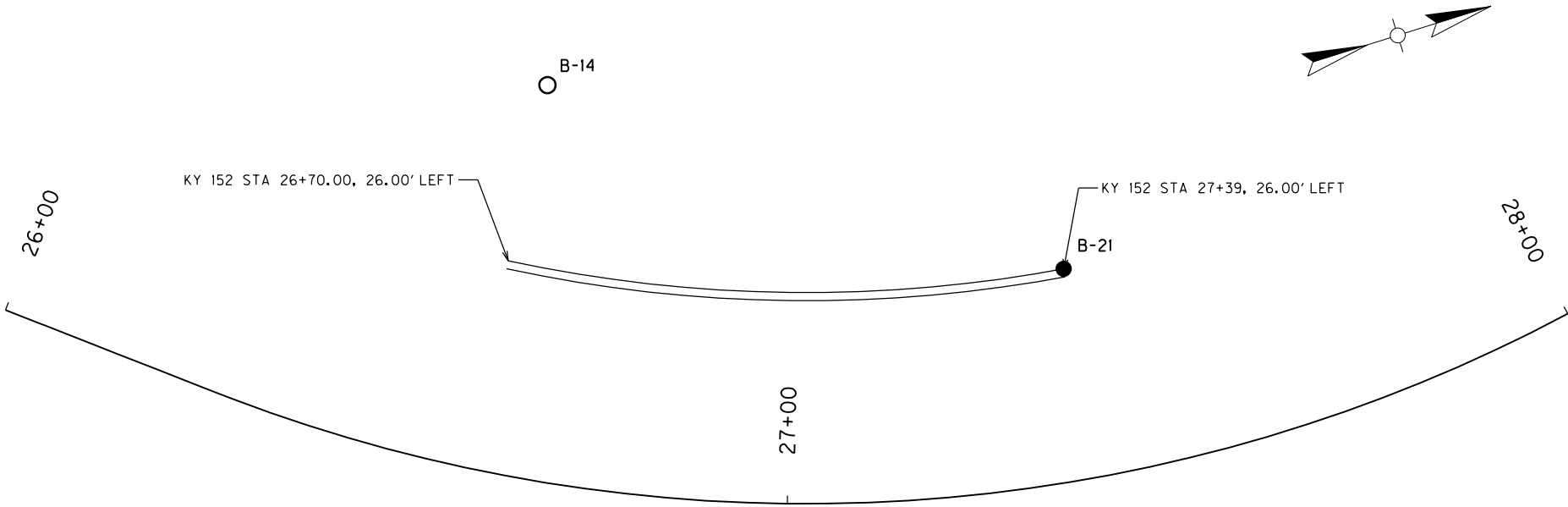
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| REVISION | | DATE | |
| DATE: JUNE, 2015 | | CHECKED BY | |
| DESIGNED BY: AAC | | | |
| DETAILED BY: JRF | | | |
| Commonwealth of Kentucky DEPARTMENT OF HIGHWAYS | | | |
| COUNTY GARRARD/MERCER | | | |
| ROUTE KY 152 | | CROSSING RETAINING WALL AT STA. 26+70 | |
| GEOTECHNICAL NOTES | | | |
| PREPARED BY | | SHEET NO. | |
| Stantec | | DRAWING NO. | |

FILE NAME: V:\1755\ACTIVE\175562020\GEOTECHNICAL\DRAWING\SHEET_FILES\RW2670_PROF.DGN

USER: rflynn
DATE PLOTTED: June 18, 2015

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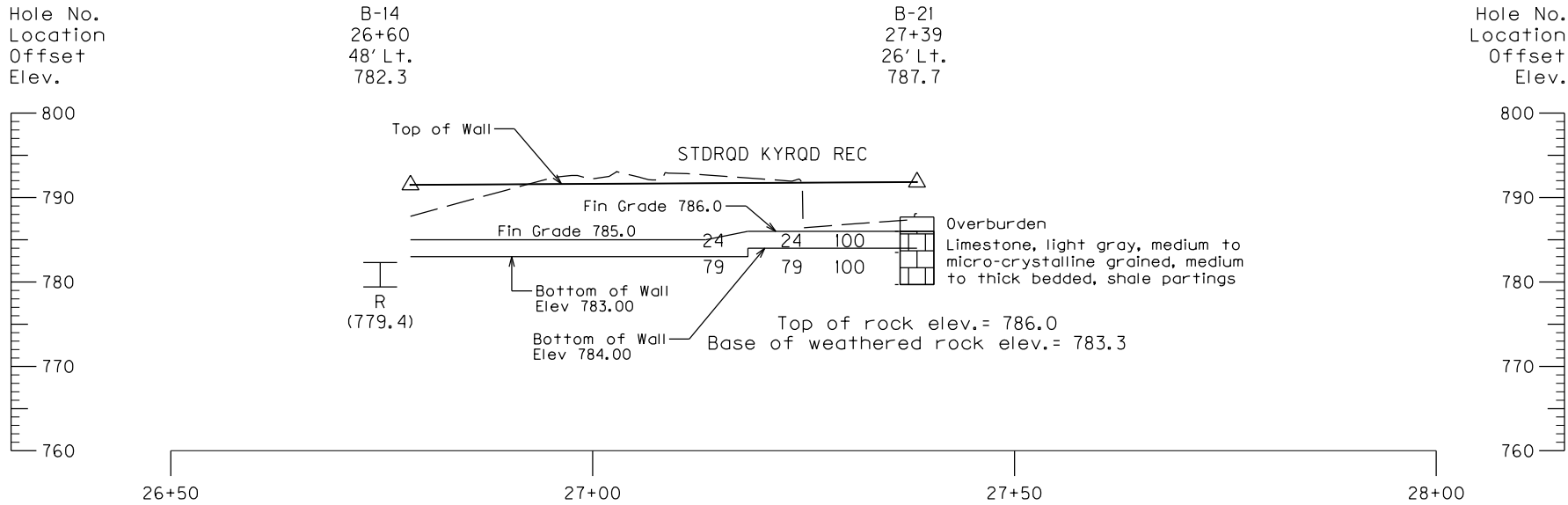


LEGEND

○ Sounding

● Rock Core

BORING LAYOUT
SCALE: 1"=10'




NOTES:

1. This sheet presents geotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Surface elevations are referenced to Mean Sea Level.

SCALE: 1" = 10'

ITEM NUMBER

7-1116.00

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| | | |
| | | |
| REVISION | | DATE |
| DATE: JUNE, 2015 | CHECKED BY | |
| DESIGNED BY: AAC | | |
| DETAILED BY: JRF | | |
| Commonwealth of Kentucky DEPARTMENT OF HIGHWAYS | | |
| COUNTY GARRARD/MERCER | | |
| ROUTE KY 152 | CROSSING RETAINING WALL AT STA. 26 + 70 | |
| LAYOUT AND PROFILE | | |
| PREPARED BY | | SHEET NO. |
|  Stantec | | DRAWING NO. |

Appendix D

Coordinate Data Submission Form

**COORDINATE DATA SUBMISSION FORM
KYTC DIVISION OF MATERIALS - GEOTECHNICAL BRANCH**

County: Garrard/Mercer

Date: June 2015

Road Number: KY 152

Survey Crew / Consultant: WMB, Inc

Contact Person: James Napier, PE, PLS

Item No.: 7-1116.00

Mars No.: 84690

Project No.: BRO 5129, FD52 084 0152 018-019, FD 52 040 0152 000-001

Notes: All coordinates should be NAD-83. Latitude and Longitude in decimal degrees. Station and Offset in KY 152 Stationing. Boring locations were staked by WMB personnel. All borings were drilled by Stantec.

(select one)

Elevation Datum

Sea Level

Assumed

| HOLE NUMBER | STATION | OFFSET | ELEVATION (ft) | LATITUDE | LONGITUDE |
|----------------|----------|------------|----------------|--------------|---------------|
| B-14 | 26+60.00 | 48.00' Lt. | 782.3 | 37.747207210 | -84.703247180 |
| B-21 | 27+39.00 | 26.00' Lt. | 787.7 | 37.747354220 | -84.703104790 |