# Geotechnical Engineering Report

**Forest Canal 1 (West) Box Culvert**
**SH-55, Farmway Road to Middleton Road**
**ITD Project No. A022(715); Key No. 22715**
**Canyon County, Idaho**

April 28, 2022
Terracon Project No. 62185117A

**Prepared for:**

Horrocks Engineers
Meridian, Idaho

And

Idaho Transportation Department
Boise, Idaho

**Prepared by:**

Terracon Consultants, Inc.
Boise, Idaho

April 28, 2022

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Attn: Mr. John Stone, P.E.
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Re: Geotechnical Engineering Report
Forest Canal 1 (West) Box Culvert
SH-55, Farmway Road to Middleton Road
ITD Project No. A022(715); Key No. 22715
Canyon County, Idaho
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Dear Mr. Stone:

In accordance with our agreement dated November 2, 2021, we have prepared this Geotechnical Engineering Report for the above referenced project. The accompanying report presents findings of the subsurface exploration and recommendations for the design of foundations for the proposed Forest Canal 1 (West) box culvert. This report was prepared in general accordance with the Idaho Transportation Department (ITD) *Materials Manual*.

This report incorporates comments from ITD on the draft version dated February 25, 2022. Responses to the comments are include in the Bluebeam session for this report.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service assistance to you in any way, we are available at your convenience.

Sincerely,
**Terracon Consultants, Inc.**

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## 230.01 INTRODUCTION

The proposed project on SH-55 is approximately 9½ miles in length and extends from Pear Lane (MP 6.2) to Middleton Road (MP 15.6) in Canyon County, Idaho. The project will include reconstruction and widening of SH-55 mainline, shared use path construction, intersection improvements, irrigation facilities, four bridge replacements, and sound wall construction. Project design consists of two phases. Phase 1 is the SH-55 segment between Farmway Road (MP 10.6) and Middleton Road (MP 15.6), and Phase 2 is the segment between Pear Lane (MP 6.2) and Farmway Road (MP 10.6).

The purpose of this investigation is to provide geotechnical engineering recommendations for the design of the Forest Canal 1 (West) box culvert. The structure is located at about MP 11.008, which is approximately 0.1 mile east of Wintergreen Drive. A Site Location Map showing the location of the structure is provided in Appendix A.

Currently, Forest Canal 1 (West) crosses beneath SH-55 in a 48-inch-diameter reinforced concrete pipe (RCP). The existing RCP is about 72-feet long and has reinforced concrete headwalls and wing walls. We understand that the existing RCP has had issues with blockage due to weeds and that a new box culvert was selected as the preferred structure type.

Based on information provided in the Final Structure Concept Report, dated March 15, 2021, prepared by Horrocks, the interior dimensions of the new box culvert will be 5-feet wide and 5-feet tall with a wall and slab thickness of 8 inches. The box culvert will be pre-cast and have a length of approximately 166 feet. We understand precast or cast-in-place wingwalls will be constructed at each end of the new box culvert.

The new box culvert will follow the alignment of the existing RCP and be constructed at a skew of approximately 1.6 degrees (northeast/southwest). For the purposes of this report, we assume new approach embankments associated with the new road widening and construction will be less than 5 feet in height. Fill above the box culvert will have a maximum height of approximately 3 feet.

The recommendations in this report are based the following publications:

- *AASHTO LRFD Bridge Design Specifications,* 9th Edition, 2020 (*AASHTO LRFD*).
- *ITD Materials Manual,* 2020.
- *ITD Standard Specifications for Highway Construction, 2018,* and the 2021 *Supplemental Specifications*.

Terracon previously prepared a Phase I Materials Report, dated May 21, 2020, that was completed under ITD Key No. 21906. Terracon has prepared a Roadway Materials Report for the proposed pavements and embankments (dated April 20, 2022) and Geotechnical Engineering Reports for the other bridges that are part of the first phase of the project. Terracon will prepare a Geotechnical Engineering Report for the sound walls that are included in the first phase of this project.

## 230.02 FIELD EXPLORATION AND LABORATORY TESTING

### 230.02.01 Borings

Terracon drilled 2 borings (borings S-1 and S-2) to depths of about 31½ to 36½ feet below the existing ground surface (ground surface elevations of approximately 2546.0 and 2543.2 respectively). These borings were located to the northwest and southeast sides of the proposed box culvert. The borings were drilled using a truck-mounted drill rig equipped with hollow-stem augers. A Terracon field engineer/geologist recorded logs of the borings during the drilling operations.

The boring locations were selected by Terracon based on site access, utility, and safety considerations. After drilling, T-O Engineers surveyors recorded the boring locations and elevations. Boring locations and elevations are shown on the boring logs in **Appendix A**.

Elevations shown on the boring logs are based on the North American Vertical Datum of 1988 (NAVD 88).

### 230.02.02 Field Tests

Disturbed samples were collected from the borings using a 2-inch-outside-diameter split-spoon sampler following Standard Penetration Test (SPT) methods in general accordance with ASTM D1586. Encountered soils were visually classified at the time of drilling per ASTM D2488.

The SPT N-value provides a reasonable estimate of the relative in-place density of non-cemented sandy type materials. However, the N-value only provides an indication of the relative stiffness of cohesive materials since the penetration resistance of these soils may be affected by the moisture content. Considerable care must be exercised in interpreting the N-value in gravelly soils, particularly where the size of the gravel particles exceeds the inside diameter of the sampling spoon.

An automatic SPT hammer was used to advance the split-spoon sampler in the boring performed for this project. A greater efficiency is typically achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. Published correlations between the SPT values and soil properties are based on the cathead and rope method. The higher efficiency of the automatic hammer affects the standard penetration resistance blow count (N-value) by increasing the penetration per hammer blow over what would be obtained using the cathead and rope method. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

### 230.02.03 Geophysical Exploration

Geophysical studies were not conducted at this site.

### 230.02.04 Laboratory Tests

Soil samples collected in the field were taken to the laboratory where soils were visually classified using the Unified Soil Classification System and in general accordance with ASTM D2488 or ASTM D2487 if laboratory data was available. The Unified Soil Classification System is described in **Appendix C**. Representative samples were selected for testing to determine the engineering and physical properties of the soils. The following table lists the tests performed and provides a brief description of the purpose of each.

**Table 1. Laboratory Testing**

| Tests Conducted | To Determine |
|---|---|
| **Moisture Content (ASTM D2216)** | Moisture content of the soil sample. |
| **Gradation Analysis (ASTM D6913 / C136)** | Particle size distribution of the sample. |
| **Percent Passing the No. 200 Sieve (ASTM D1140)** | Percent of clay/silt sized particles in the sample. |
| **Atterberg Limits (ASTM D4318)** | Plasticity Index, Liquid Limit, and Plastic Limit of the soil sample. |

Results of the field and laboratory tests are generally summarized on the boring logs. Graphical results of the gradation analyses are included in **Appendix B**. The laboratory test data, along with the field information, were used to prepare the boring logs included in **Appendix A**.

## 230.03 SURFACE CONDITIONS

Forest Canal 1 (West) crosses beneath SH-55 between Ashland Drive and Wintergreen Drive south of Caldwell in Canyon County, Idaho. The project is generally in an area of agricultural fields. Rural residence are located southeast and southwest of the existing RCP culvert. A residential subdivision is further to the southwest of the crossing.

At the project location, SH-55 is paved with hot mix asphalt surfacing. Unpaved access roads are located on each side of the canal, and weeds and grasses are growing on the canal banks. Near the structure, the Forest Canal 1 generally flows to the north, and the existing 48-inch diameter RCP crosses SH-55 at a skew of approximately 3 degrees. The invert elevation of the RCP is 2538.0 feet, and the highwater elevation is reported to be 2542.3 feet. The centerline finish grade elevation of SH-55 at the box culvert is about 2546.5 feet. Water was not flowing in the canal at the time of our exploration. Overhead power lines are located on the north side of SH-55 and also cross to the south of SH-55 roughly 35 feet west of the canal. An aerial photograph showing the boring/box culvert location is attached in **Appendix A.**

## 230.04 SUBSURFACE CONDITIONS

Subsurface conditions encountered at the boring locations are indicated on the boring logs included in **Appendix A**. Stratification boundaries shown on the boring logs represent the approximate locations of changes in the soil. In-situ, the transition between materials may be gradual.

Asphalt encountered in boring S-1 was about 9 inches thick. Fill was encountered in borings S-1 and S-2 to depths of about 4 feet and 2 feet below the existing ground surface (bgs), respectively. The fill was variable and generally composed of clayey sand with gravel, sandy silty clay, and gravel with silt and sand. Based on SPT blow counts, fill materials were medium dense/medium stiff. Native soils encountered in borings S-1 and S-2 generally consisted of medium stiff to hard sandy lean clay and sandy silty clay to depths of about 6½ and 5 feet bgs, respectively (approximately 2,540 and 2,535 feet). Below these fine-grained soils was medium dense to dense silty sand to about 20 feet bgs (approximately 2,526, 2,523 feet). Portions of this stratum were weakly to moderately cemented. These soils were generally underlain by dense to very dense sand and gravel deposits with varying amounts of cobbles to the maximum depths explored (approximately 2,507 feet). The boring logs are presented in **Appendix A**.

The borings were monitored for the presence of groundwater. Water was not flowing in the canal at the time of our exploration, and groundwater was not encountered within the borings at the time of drilling. Water levels shown on the logs of wells that are in the vicinity of the structure that are available from the Idaho Department of Water Resources showed recorded groundwater levels of about 40 feet or greater below the ground surface (elevations not available). Fluctuations of the groundwater level will occur due to water level in the canal; seasonal variations in the amount of rainfall, runoff, irrigation; and other factors not evident at the time of exploration. The evaluation of these factors was beyond the scope of this report.

# 230.05 CONCLUSIONS AND RECOMMENDATIONS

## 230.05.01 General

We recommend that the proposed box culvert be placed on compacted crushed Aggregate for Untreated Base and the associated wing walls be supported on spread footings, also on a layer of compacted Aggregate for Treated Base.

## 230.05.02 Foundations

### 230.05.02.01 Spread Footings

Geotechnical design parameters for the proposed box culvert and wing wall foundations are presented separately in the subsections below.

**BOX CULVERT**

The proposed box culvert should be supported on a layer of compacted crushed ¾ Inch Type B Aggregate for Untreated Base, as specified in the 2018 Standard Specifications for Highway Construction, Section 703.04. The layer of compacted ¾ inch Type B Aggregate for Untreated base should have a minimum thickness of 12 inches. Prior to placing the crushed base, all canal sediments, existing fill soils, and any soil disturbed during demolition of the existing RCP should be removed from the box culvert area to expose undisturbed native soils. In accordance with the 2021 Supplemental Specifications for the 2018 Standard Specifications for Highway Construction, the bottom of foundation excavations should be compacted with a minimum of 5 overlapping passes with an approved compactor. The layer of compacted Aggregate for Untreated Base crushed base should extend laterally from the edges of the proposed box culvert at least a horizontal distance of 12 inches and be compacted to Class A Compaction. The box culvert is anticipated to include cutoff walls at the entrance and exit with a depth of approximately 3 feet.

If soft and/or wet subgrade conditions are encountered, these soils should be excavated and replaced or repaired in accordance with Section 205.03.E of the Standard Specifications.

**Table 2. Foundation Recommendations**

| Description | Criteria |
|---|---|
| **Foundation type** | Box culvert floor. |
| **Bearing material** | At least 12 inches of compacted ¾ Inch Type B Aggregate for Untreated Base supported on prepared native soils, as described above. |
| **Nominal (ultimate, unfactored) bearing capacity (for the box culvert with an exterior width of 6 to 7 feet)** | 8.0 kips per square foot (ksf). |

| Description | Criteria |
|---|---|
| **Recommended resistance factor to be used with the nominal (ultimate, unfactored) bearing capacity for strength limit state design[1]** | 0.45 |
| **Presumptive bearing capacity for service limit state for settlement of approximately 1 inch or less (for the box culvert with an exterior width of 6 to 7 feet)** | The weight of the box culvert and the water contained by the box will be less than the soil that it replaces. As a result, settlement should be relatively small. For design purposes, for the service limit state, a presumptive bearing capacity of 2 ksf is expected to settle less than 1 inch. |
| **Recommended resistance factor to be used with the bearing capacity for service limit state design[1]** | 1.0 |
| **Ultimate coefficient of friction to resist sliding** | Precast concrete: 0.50 |
| **Recommended resistance factors when designing resistance to sliding[1]** | Precast concrete: 0.90 |

1. Recommended resistance factors are based on AASHTO LRFD (2020)

Differential settlement of the structure is anticipated to be approximately equal to ½ to ¾ of the total settlement. Differential settlement in directions both longitudinal and transverse to the box culvert should be anticipated below the box culvert.

## WING WALL FOUNDATIONS

Based on the soil conditions encountered during our field exploration, we recommend the proposed wing walls (anticipated to be at approximately 30 degrees relative to the barrel section) be founded on spread foundations supported on a 12-inch minimum layer of ¾ Inch Type B Aggregate for Untreated Base placed and compacted over the native soil. In accordance with the 2021 Supplemental Specifications for the 2018 Standard Specifications for Highway Construction, the bottom of foundation excavations should be compacted with a minimum of 5 overlapping passes with an approved compactor. The layer of crushed base should extend laterally from the edges of the proposed box culvert at least a horizontal distance of 12 inches. The Aggregate for Untreated Base that is placed beneath the proposed box culvert should be compacted to Class A Compaction.

**Table 3. Foundation Recommendations**

| Description | Criteria |
|---|---|
| **Foundation type** | Conventional spread footings. |
| **Bearing material** | At least 12 inches of compacted ¾ Inch Type B Aggregate for Untreated Base supported on prepared native soils. |
| **Minimum embedment depth for frost protection** | 24 inches below the lowest adjacent ground surface. |
| **Minimum footing width** | 3.0 feet |
| **Nominal (ultimate, unfactored) bearing capacity** | See the figure and discussion below. |
| **Recommended resistance factor to be used with the nominal (ultimate, unfactored) bearing capacity for strength limit state design[1]** | 0.45 |
| **Bearing capacity for settlement less than 1 inch** | See the figure and discussion below. |
| **Recommended resistance factor to be used with the bearing capacity for service limit state design[1]** | 1.0 |
| **Ultimate coefficient of friction to resist sliding** | Cast-in-place footings: 0.65<br>Precast footings: 0.50 |
| **Recommended resistance factors when designing resistance to sliding[1]** | Cast-in-place footings: 0.80<br>Precast footings: 0.90 |

1. Recommended resistance factors are based on AASHTO LRFD (2020)

Results of the field exploration and laboratory testing, including SPT results from the borings were used to evaluate the strength of the foundation soil for bearing capacity. This bearing resistance is based on a friction angle of 33 degrees, an undrained shear strength of 0 psf, and a total unit weight of 110 pcf above the footing and 115 pcf below the footing. The ultimate (unfactored) bearing capacity is shown as a function of effective footing width in the figure below. The resistance factors shown in the table above should be applied to the bearing values presented in the plots below.

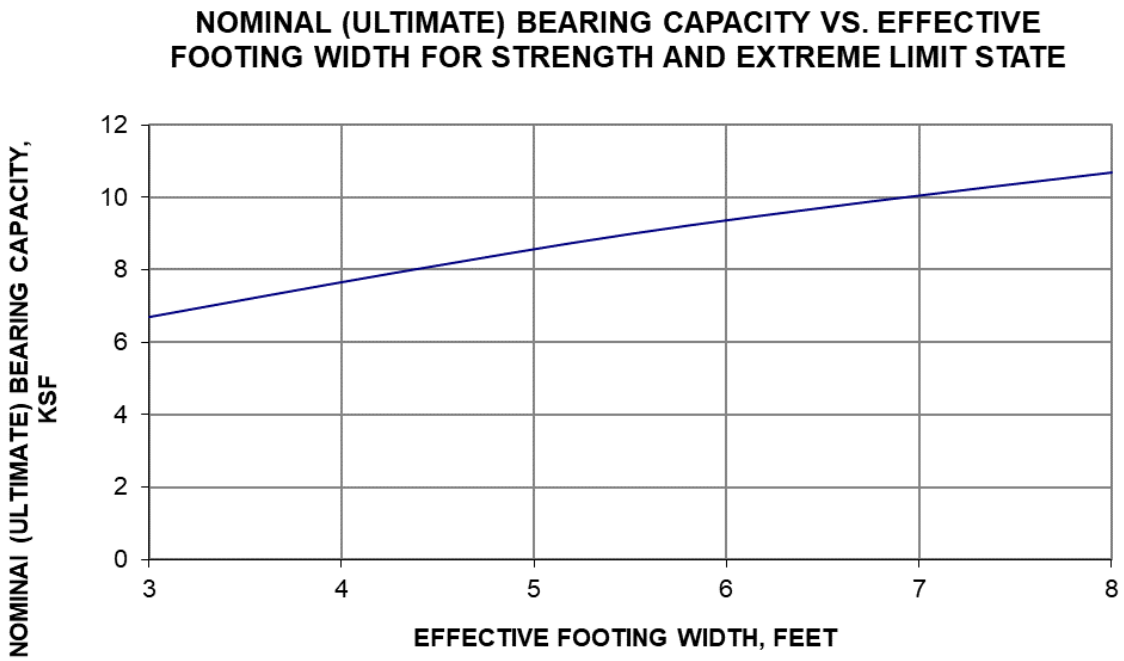



**Figure 1. Wing Wall Nominal (Ultimate, Unfactored) Bearing Capacity for Strength and Extreme Limit State**

The bearing capacity versus footing width at the service limit state for a total estimated settlement of approximately 1 inch is presented on the graph below. Settlement estimates were calculated based on the empirical Hough method and the native soils encountered in our borings. The settlement curve below is the net bearing pressure (i.e., pressures greater than the existing overburden pressure).

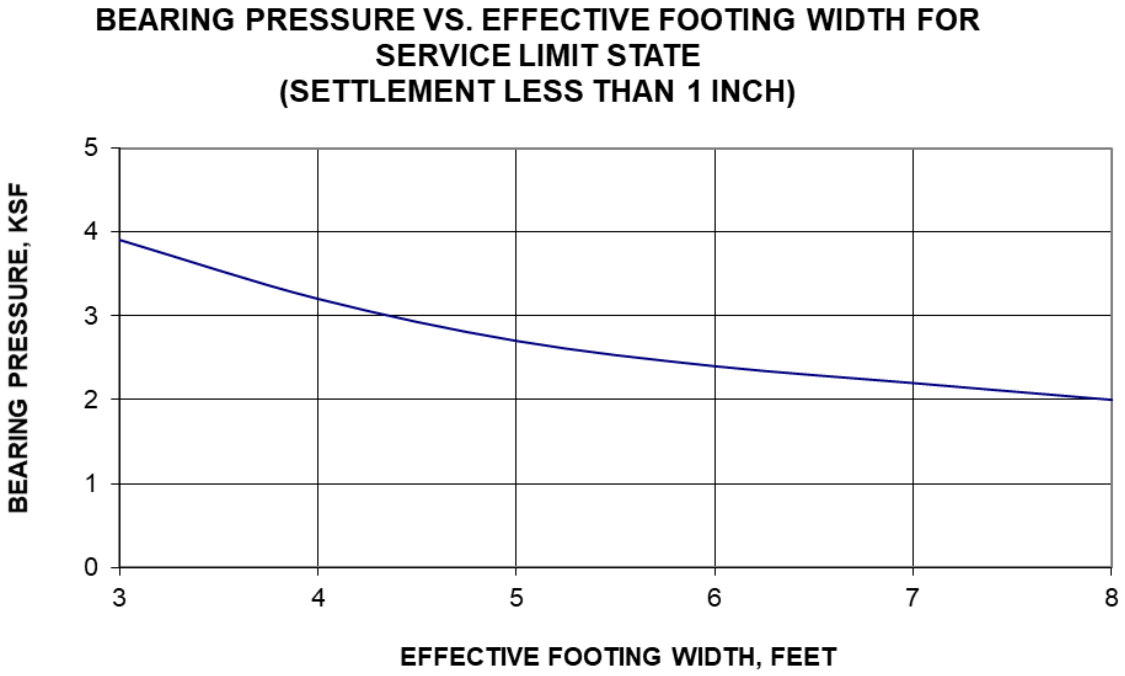



**Figure 2. Wing Wall Bearing Pressure vs. Effective Footing for Service Limit State**

### 230.05.02.02 Deep Foundations

Deep foundations are not recommended for support of the proposed box culvert.

## 230.05.03 Lateral Pressures and Backfill

Unfactored lateral earth pressures are presented in the following table for compacted Aggregate for Granular Subbase or ¾ Inch Type B Aggregate for Untreated Base backfill. The slopes above the walls presented in the following table were requested by the design team roadway group and structural engineer. As indicated in the generalized diagram below, the zone of backfill should extend out horizontally at least two feet from the base of the foundation and upwards at an angle of 60 degrees from horizontal or flatter for the active values to apply, upwards at an angle 45 degrees from horizontal or flatter for the at-rest values to apply, and upwards at an angle of 30 degrees from horizontal or flatter for the passive values to apply. Unless temporary shoring is used, flatter slopes than those listed above may be required during construction for excavation safety.

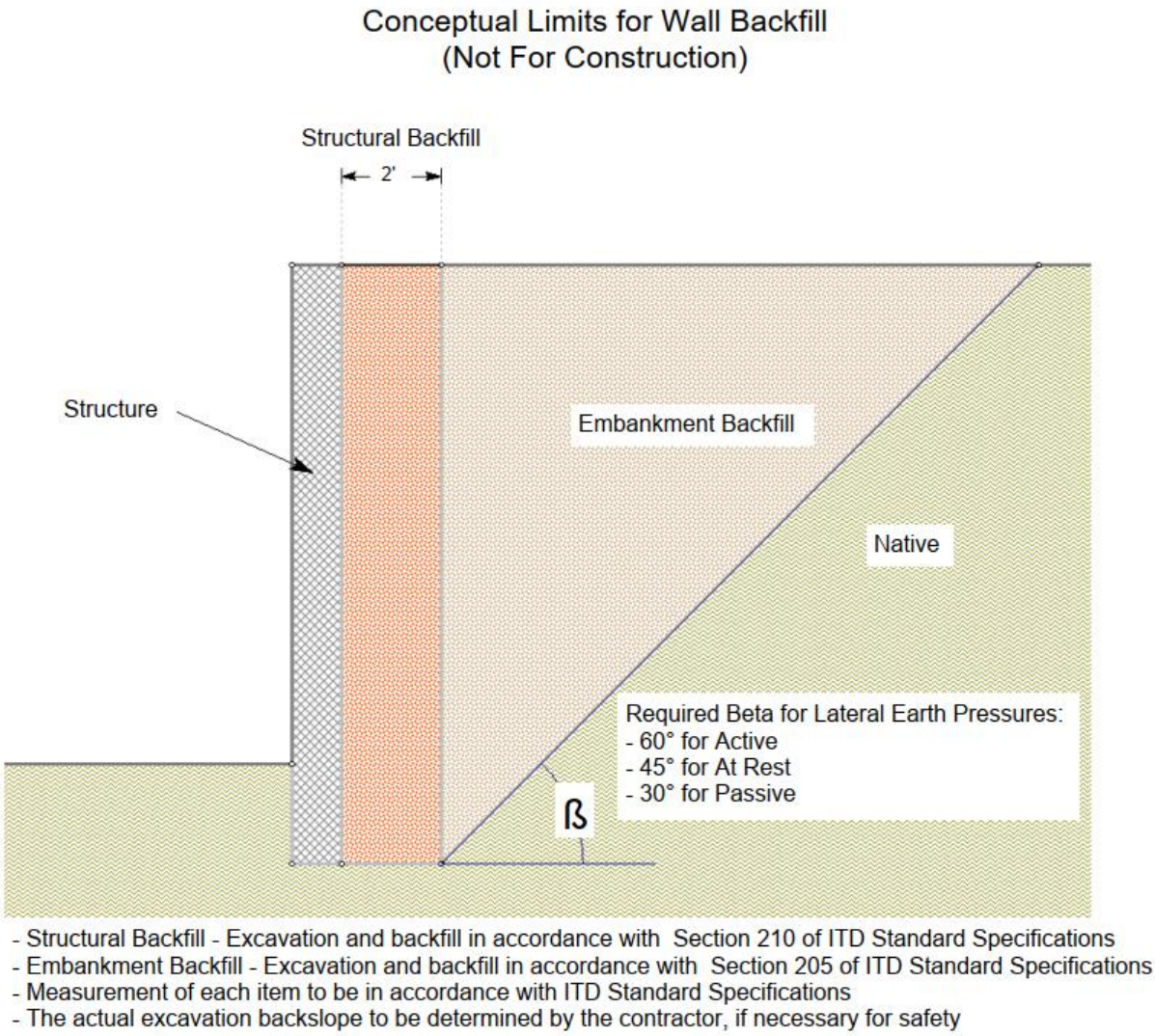



**Figure 3. Conceptual Limits for Wall Backfill**

**Table 4. Lateral Earth Pressures**

| Parameter | Slope Above Wall | Pressure Coefficient | Equivalent Fluid Density (pcf) | |
|---|---|---|---|---|
| | | | Fully Drained Condition Above Groundwater [1] | Soil Below Groundwater Condition [1, 2] |
| Total Unit Weight, pcf | - | - | 125 | 130 |
| Friction Angle, Degrees | - | 34 | 34 | 34 |

| Parameter | Slope Above Wall | Pressure Coefficient | Equivalent Fluid Density (pcf) | |
|---|---|---|---|---|
| | | | Fully Drained Condition Above Groundwater [1] | Soil Below Groundwater Condition [1, 2] |
| Active Earth Pressure Condition | Horizontal | 0.28 | 35 | 81 |
| | 6.0(H):1(V) | 0.29 | 37 | 82 |
| | 4.0(H):1(V) | 0.31 | 38 | 83 |
| | 2.0(H):1(V) | 0.41 | 51 | 90 |
| At-Rest Earth Pressure Condition | Horizontal | 0.44 | 55 | 92 |
| | 6.0(H):1(V) | 0.51 | 64 | 97 |
| | 4.0(H):1(V) | 0.55 | 68 | 99 |
| | 2.0(H):1(V) | 0.64 | 80 | 106 |
| Passive Earth Pressure Condition | Horizontal | 3.54 | 442 | 239 |

1. These are ultimate values that assume compacted granular backfill with an estimated moist and saturated unit weights and internal friction angle as shown above.
2. For the active and at-rest earth pressures, the values presented for the soil-below-groundwater condition include water pressure. The passive earth pressure for the soil-below-groundwater condition does not include water pressure.

We anticipate the proposed wing walls may be constructed with backfill that is either horizontal or upward sloping. The proposed box culvert will have horizontal backfill above the side walls of the new box culvert, with up to approximately 3 feet of fill above the box. Permanent backfill slopes should be constructed no steeper than 2(H):1(V). The unfactored lateral earth pressure values presented above only apply to the specified slope inclination.

Active earth pressures are applicable for a wall that is free to rotate and are only appropriate for cohesionless soils. The amount of movement relative to the wall height to develop active earth pressures is presented in AASHTO LRFD Table C3.11.1-1. At-rest earth pressures are appropriate for a wall that is restrained at the top and for cohesive soils. We anticipate that the proposed box culvert will be a rigid structure so the at-rest earth pressure condition will apply. If wing walls are structurally connected to the box culvert, the at-rest earth pressure condition will also apply to the wing walls. Some movement of the structure would be required to mobilize the full passive pressure. Relative movements to develop passive resistance are provided in AASHTO LRFD Table 3.11.1-1. In accordance with AASHTO LRFD Table 10.5.5.2.2-1, the resistance factor for the passive earth pressure component of sliding resistance should be 0.50. As described in AASHTO LRFD C10.6.3.4, this resistance factor is based on the lateral foundation movement being less than what is needed to mobilize the full passive pressure. The passive resistance should be neglected in the scour zone or the upper 2 feet of the soils profile, whichever is deeper.

Lateral earth pressures should be adjusted for hydrostatic pressures, surcharge loads including the weight of soil above the top of the structure, sloping fill, live loads near the walls (including compaction equipment and traffic), and/or seismic loads as appropriate. The live load surcharge for vehicular loads is often modeled as being equivalent to 2 feet of soil with a unit weight of at least 125 pcf, but these loads should be determined in accordance with Tables 3.11.6.4-1 and 3.11.6.4-2 of AASHTO LRFD.

Fill, debris, and loose soil should be removed before placing backfill behind walls. Class A compaction is recommended for backfill. Compaction near the walls should be in accordance with 2021 Supplemental to ITD Standard Specification Section 210.03.A.

### 230.05.04 Anchors

We do not anticipate that anchors will be used.

### 230.05.05 Drainage

Surface water runoff should be prevented from discharging or infiltrating behind or over the face of the box culvert, wing walls, or slopes. Surface water from the roadway should be collected and discharged to a safe location away from the structure. Project design should provide for drainage of the roadway and maintenance of existing drainage patterns. For a discussion regarding erosion control, see Section 230.05.07 of this report.

The box culvert should be designed to resist hydrostatic pressures. Wing walls should either be designed to resist hydrostatic pressures or should include a drainage layer extending to appropriate outlet locations to reduce the potential for hydrostatic pressure on the walls. The drainage layer should consist of drain rock composed of ITD Coarse Aggregate for Concrete No. 2B or 5. The drain rock should be a minimum of 24 inches thick, extend to within 2 feet of finished grade, and should be separated from other soils with a Drainage Geotextile. Weep holes in the wing walls may also be used in conjunction with the drainage layer to reduce the potential for hydrostatic pressures. As an alternative to drain rock, manufactured drainage panels installed in accordance with the manufacturer's recommendations may be used.

### 230.05.06 Embankments

New embankments associated with the project are assumed to be less than 5 feet in height. Embankments should be constructed with granular borrow and have 2(horizontal):1(vertical) or flatter side slopes. Prior to fill placement, existing undocumented fill soils, canal sediments, and disturbed soils should be removed from areas that will receive fill so that embankments are placed on undisturbed native soil or existing embankment slopes. Embankment fill placed on slopes steeper than 3(horizontal):1(vertical) must be keyed in per 205.03.F of the ITD Standard Specifications. For estimating purposes, the depth of stripping is assumed to be 6 inches. The depth of topsoil stripping is likely deeper where trees or other mature vegetation exists. Settlement of the embankment is estimated to be approximately 1 inch or less. Due to the generally coarse-grained nature of the soils

and depth to groundwater, settlement is expected to occur during to construction. Class A compaction is recommended for the embankments associated with the project.

### 230.05.07 Erosion Control

Erosion protection should be provided, as needed, to protect the embankments and structure foundations from erosion and scour. Scour and erosion protection, including rip rap, will be designed by Horrocks based on the approved hydraulics report. Any ground surface disturbed during construction of the box culvert and its foundation should be restored and erosion protection provided as necessary. Roadway runoff should be collected and discharged away from the box culvert and embankment slopes to reduce the potential of erosion of the fill slopes. Erosion control measures, such as vegetation or mulching, should be taken in accordance with the ITD Best Management Practices (BMP) Manual to protect the slopes and drainage areas from the effects of precipitation and surface flows. Discharge areas should be protected with riprap underlain by a Riprap/Erosion Control Geotextile per Section 718.06 of *ITD Standard Specifications for Highway Construction.*

### 230.05.08 Seismic Design

Seismic ground motion parameters were developed for the project based on Section 3.10 of *AASHTO LRFD* and Section 630 of the *ITD Materials Manual*. The seismic parameters were obtained from the USGS Seismic Design Web Services for the 2009 AASHTO Guide Specification. These values are presented in the following table and are for an earthquake having a probability of exceedance of 7 percent in 75 years (approximately 1000-year return period).

**Table 5. Seismic Ground Motion Parameters**

| Ground Motion Parameter | Value |
|---|---|
| Site Soil Classification | D |
| PGA, Peak Ground Acceleration Coefficient on Rock (Site Class B) | 0.076 g |
| Ss, Horizontal Response Spectral Acceleration Coefficient at 0.2-sec Period on Rock (Site Class B) | 0.176 g |
| S1, Horizontal Response Spectral Acceleration Coefficient at 1.0-sec Period on Rock (Site Class B) | 0.064 g |
| FPGA, Site Factor for PGA, | 1.6 |
| FA, Site Factor for Ss | 1.6 |
| FV, Site Factor for S1 | 2.4 |
| $A_S$, Modified PGA for Project Site (Site Class D) | 0.121 g |
| $S_{DS}$, Modified Ss for Project Site (Site Class D) | 0.282 g |
| $S_{D1}$, Modified S1 for Project Site (Site Class D) | 0.153 g |

Seismic design of box culvert should be based on Site Class D. Based on Figure 630.05.01.1 of the *ITD Materials Manual*, the nearest active fault to the site is mapped approximately 25 to 30 miles to the northeast. Therefore, the risk of fault rupture at the site is low. Based on the depth of groundwater and the native soil conditions, the risk of liquefaction at the site is low.

### 230.05.09 Construction

We recommend that construction of the proposed box culvert occur when the Forest Canal is not carrying water, which is expected to generally be late fall and winter, after irrigation is complete for the year. Depending on the time of year that construction occurs and the depth of excavations, groundwater may be encountered during construction. If construction occurs soon after water is drained from the canal, elevated groundwater levels may be encountered due to bank storage and a seasonally elevated perched groundwater level. If groundwater is encountered during construction, a positive means of construction dewatering will be required to complete the excavations and placement of the foundations and backfill in the dry. Fill and concrete should not be placed in standing water.

We expect that construction will likely begin soon after water is taken out of the canal for the season, in order to complete the bridge before the next irrigation season. Soils are likely to be wet after water is taken out of the canal. The Contractor should anticipate soft and/or wet soils, particularly within the excavations for the proposed structure. Wet soils will be prone to rutting or pumping under construction machinery. Soils that rut, pump, or are too wet to be compacted are not suitable for support of the proposed box culvert or the wing walls and should be repaired or excavated and replaced in accordance with Section 205.03.E of the Standard Specifications for Highway Construction. The success in drying the wet soils will depend on the weather, and in the late fall or winter months when this construction is most likely to occur, weather conditions can be wet.

If temporary retaining structures are used during replacement of the box culvert, these temporary structures must be designed by a professional engineer licensed in the State of Idaho.

Construction site safety is solely the responsibility of the Contractor who selects and directs the means, methods, and sequencing of the construction operations. The Contractor must be familiar with, and comply with all applicable federal, state, and local regulations, including OSHA regulations for excavation.

## 230.06 APPENDICES

The appendices contain a vicinity map, exploration plan, boring logs, laboratory test data, and other supporting information.

## 230.07 FOUNDATION INVESTIGATION PLAT

Due to the small size of the proposed box culvert (5 feet by 5 feet, inside dimensions), we understand that this is considered a “minor structure” and will be included on the roadway plans, and that a Foundation Investigation Plat and other bridge drawings are not required.

## 230.08 CURRENT SPECIFICATIONS AND MINIMUM TESTING REQUIREMENTS

This Geotechnical Engineering Report is based on the following ITD documents:

- 2018 *Standard Specifications for Highway Construction*
- 2021 *Supplemental Specifications for the 2018 Idaho Standard Specifications for Highway Construction*
- *2019 Quality Assurance Manual*

## 230.09 SPECIAL PROVISION ITEMS

No new special provisions are needed for construction of this box culvert.

The following modification of existing specification should be included:

**ON PAGE 47 OF 93 OF THE 2021 SUPPLEMENTAL SPECIFICATIONS, SUBSECTION 210.03 – CONSTRUCTION REQUIREMENTS**

Add the following to the end of the first sentence of the second paragraph of Part B:

> Use a smooth blade bucket to excavate fine-grained soils at the bottom of foundation excavations.

The following Note to Contractor should be included:

> **SOFT SUBGRADE SOILS.** The Contractor should anticipate soft and moisture-sensitive subgrade soils, which could occur throughout this project. These soils will be prone to rutting or pumping under construction equipment, especially if they become wetter than optimum moisture content at the time of construction.
>
> The Contractor must protect these soils during construction activities, and the Contractor determines how best to achieve this requirement. No separate measurement or payment will be made for any excavation or replacement of excavated material below subgrade elevation made necessary from construction activities.

## 230.10 REFERENCES

American Association of State Highway and Transportation Officials, *AASHTO LRFD Bridge Design Specifications*, 9th Edition, 2020.

Idaho Transportation Department, *Materials Manual*, October 2020.

Idaho Transportation Department, *Standard Specifications for Highway Construction*, 2018.

Idaho Transportation Department, *2021 Supplemental Specifications for the 2018 Idaho Standard Specifications for Highway Construction*, 2021.

## GENERAL COMMENTS

The analysis and recommendations presented in this report are based upon the data obtained from the boring performed at the indicated location and from other information discussed in this report. This report does not reflect variations that may occur beyond the boring location, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

# APPENDIX A

**Site Location – Forest Canal 1 (West)**

SH-55, Farmway Road to Middleton Road ■ Canyon County, Idaho

Terracon Project No. 62185117A

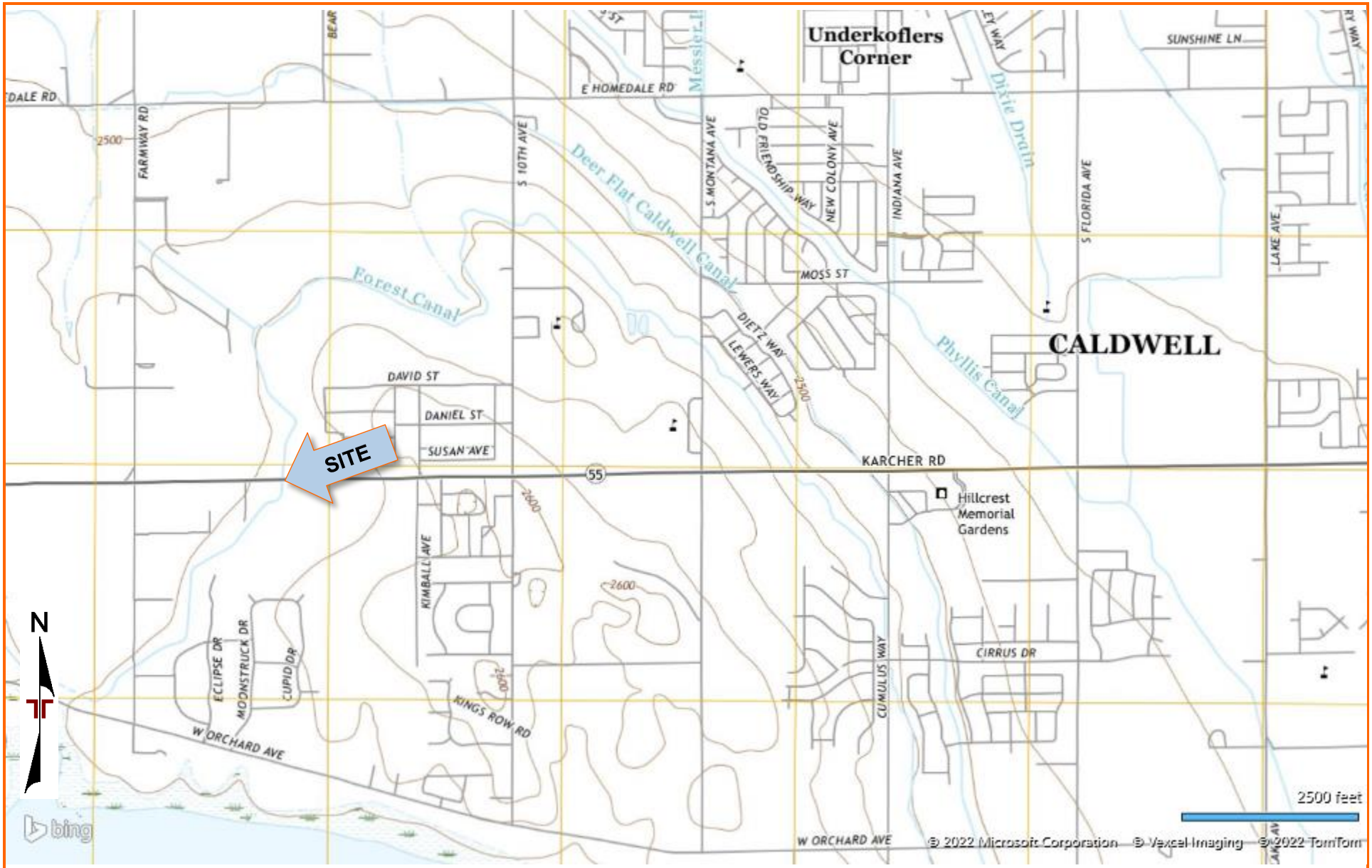



DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

**Boring Exploration Plan – Forest Canal 1 (West)**

SH-55, Farmway Road to Middleton Road ■ Canyon County, Idaho

Terracon Project No. 62185117A

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

# BORING LOG NO. S-1



**PROJECT:** SH-55, Farmway Rd to Middleton Rd, Canyon Co

**CLIENT:** Horrocks Engineers
Meridian, Idaho

**SITE:** SH-55 Pear Lane to Middleton Road
Canyon County, Idaho

LOCATION Forest Canal 1 (West)

Latitude: 43.603993° Longitude: -116.705040°
Northing: 707538.3 Easting: 2371926.6

Approximate Surface Elev.: 2546.0 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | Description | DEPTH (Ft.) | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | WATER CONTENT (%) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|
| 0.8 | 2545+/- | **ASPHALT**, 9 inches thick | | | | | | | |
| 2.5 | 2543.5+/- | **FILL - CLAYEY SAND WITH GRAVEL**, brown | | | 0.8 | 12-10-10 N=20 | | | |
| 4.0 | 2542+/- | **FILL - SANDY SILTY CLAY**, trace gravel, brown | | | 0.7 | 2-3-3 N=6 | | | |
| 6.5 | 2539.5+/- | **SANDY LEAN CLAY (CL)**, brown, medium stiff | 5 | | 0.8 | 2-2-4 N=6 | 18.7 | 26-18-8 | |
| | | **SILTY SAND (SM)**, brown, medium dense | | | 0.8 | 8-11-15 N=26 | | | |
| | | | 10 | | 1 | 15-13-10 N=23 | | | |
| | | trace gravel | 15 | | 1 | 5-6-8 N=14 | | | 49 |
| 20.0 | 2526+/- | | | | | | | | |
| | | **POORLY GRADED GRAVEL WITH SAND (GP)**, light brown, very dense, with cobbles | 20 | | 1 | 12-24-42 N=66 | | | |
| | | | 25 | | 0.8 | 10-28-50/5" N=78/11" | | | |
| 31.4 | 2514.5+/- | | 30 | | 0.8 | 14-46-50/4" N=96/10" | | | |
| | | ***Boring Terminated at 31.4 Feet*** | | | | | | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with Bentonite chips
Surface Capped with Asphalt

Elevations were provided by others.

Notes:

**WATER LEVEL OBSERVATIONS**

*Groundwater not encountered*

Terracon
11849 W Executive Dr Ste G
Boise, ID

Boring Started: 01-13-2022 | Boring Completed: 01-13-2022
Drill Rig: CME 75 | Driller: Haztech Drilling, Inc.
Project No.: 62185117A | Exhibit: A-1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 62185117A SH-55, FARMWAY RD.GPJ TERRACON_DATATEMPLATE.GDT 2/14/22

# BORING LOG NO. S-2



**PROJECT:** SH-55, Farmway Rd to Middleton Rd, Canyon Co

**CLIENT:** Horrocks Engineers Meridian, Idaho

**SITE:** SH-55 Pear Lane to Middleton Road Canyon County, Idaho

LOCATION Forest Canal 1 (West)

Latitude: 43.604171° Longitude: -116.705142°
Northing: 707603.7 Easting: 2371900.4

Approximate Surface Elev.: 2543.2 (Ft.) +/-

| DEPTH | ELEVATION (Ft.) | Description | DEPTH (Ft.) | SAMPLE TYPE | RECOVERY (Ft.) | FIELD TEST RESULTS | WATER CONTENT (%) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|---|
| | | **FILL - GRAVEL WITH SILT AND SAND**, dark brown | | | 0.2 | 7-8-6 N=14 | | | |
| 2.0 | 2541+/- | | | | | | | | |
| | | **SANDY SILTY CLAY (CL-ML)**, dark brown, hard | | | 0.5 | 10-14-20 N=34 | 21.3 | 27-21-6 | 68 |
| 5.0 | 2538+/- | | | | | | | | |
| | | **SILTY SAND (SM)**, trace gravel, brown, dense, with zones of weak to moderate cementation | 5 | | 0.8 | 7-21-28 N=49 | | | |
| | | | | | 1 | 12-22-24 N=46 | 19.2 | | 19 |
| | | light brown | 10 | | 1 | 12-19-24 N=43 | | | |
| | | | 15 | | 0.8 | 8-20-24 N=44 | | | |
| 20.0 | 2523+/- | | | | | | | | |
| | | **POORLY GRADED SAND WITH GRAVEL (SP)**, light brown, dense to very dense, trace cobbles | 20 | | 0.7 | 3-10-30 N=40 | | | |
| | | | 25 | | 0.7 | 4-26-50/2" N=76/8" | | | |
| | | | 30 | | 0.7 | 10-50/5" N=50/5" | | | |
| | | | 35 | | 0.8 | 5-10-25 N=35 | | | |
| 36.5 | 2506.5+/- | | | | | | | | |
| | | ***Boring Terminated at 36.5 Feet*** | | | | | | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings and bentonite

Elevations were provided by others.

Notes:

**WATER LEVEL OBSERVATIONS**

*Groundwater not encountered*

Terracon
11849 W Executive Dr Ste G
Boise, ID

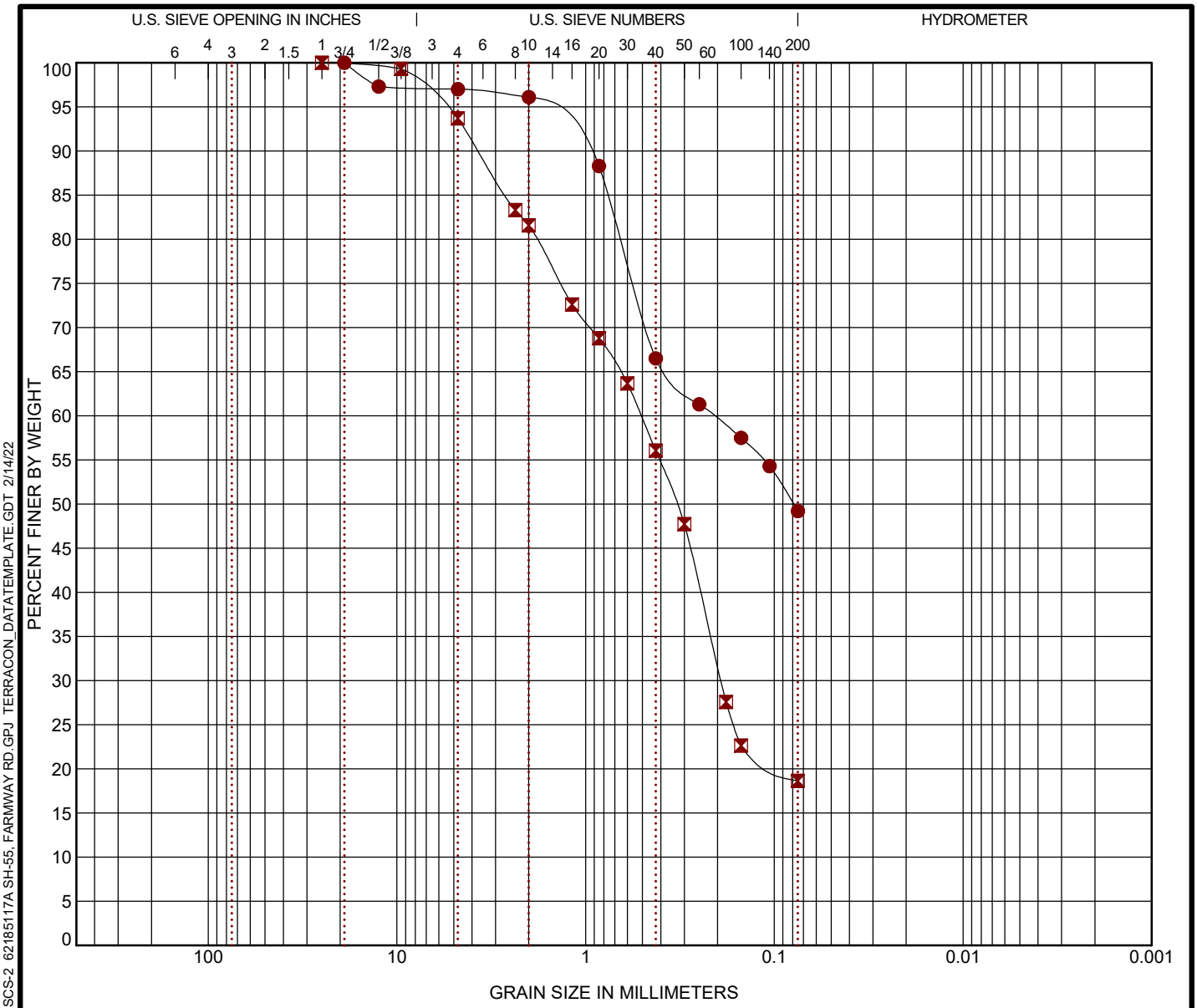
| | |
|---|---|
| Boring Started: 12-18-2021 | Boring Completed: 12-18-2021 |
| Drill Rig: CME 75 | Driller: Haztech Drilling, Inc. |
| Project No.: 62185117A | Exhibit: A-2 |

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 62185117A SH-55, FARMWAY RD.GPJ TERRACON_DATATEMPLATE.GDT 2/14/22

# APPENDIX B

# GRAIN SIZE DISTRIBUTION

**ASTM D422 / ASTM C136**




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Boring ID | Depth | USCS Classification | WC (%) | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● S-1 | 15 - 16.5 | SILTY SAND | | | | | | |
| ⊠ S-2 | 7.5 - 9 | SILTY SAND | 19.2 | | | | | |

| Boring ID | Depth | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | %Cobbles | %Gravel | %Sand | %Silt | %Fines | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ● S-1 | 15 - 16.5 | 19 | 0.21 | | | 0.0 | 3.0 | 47.8 | | 49.2 | |
| ⊠ S-2 | 7.5 - 9 | 25 | 0.508 | 0.191 | | 0.0 | 6.3 | 75.0 | | 18.6 | |

PROJECT: SH-55, Farmway Rd to Middleton Rd, Canyon Co

SITE: SH-55 Pear Lane to Middleton Road Canyon County, Idaho

Terracon
11849 W Executive Dr Ste G
Boise, ID

PROJECT NUMBER: 62185117A

CLIENT: Horrocks Engineers
Meridian, Idaho

EXHIBIT: B-1

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 62185117A SH-55, FARMWAY RD.GPJ TERRACON_DATATEMPLATE.GDT 2/14/22

# APPENDIX C

# UNIFIED SOIL CLASSIFICATION SYSTEM

| Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A] | | | | | Soil Classification | |
|---|---|---|---|---|---|---|
| | | | | | Group Symbol | Group Name [B] |
| **Coarse-Grained Soils:** More than 50% retained on No. 200 sieve | **Gravels:** More than 50% of coarse fraction retained on No. 4 sieve | **Clean Gravels:** Less than 5% fines [C] | Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E] | | GW | Well-graded gravel [F] |
| | | | Cu < 4 and/or [Cc<1 or Cc>3.0] [E] | | GP | Poorly graded gravel [F] |
| | | **Gravels with Fines:** More than 12% fines [C] | Fines classify as ML or MH | | GM | Silty gravel [F, G, H] |
| | | | Fines classify as CL or CH | | GC | Clayey gravel [F, G, H] |
| | **Sands:** 50% or more of coarse fraction passes No. 4 sieve | **Clean Sands:** Less than 5% fines [D] | Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E] | | SW | Well-graded sand [I] |
| | | | Cu < 6 and/or [Cc<1 or Cc>3.0] [E] | | SP | Poorly graded sand [I] |
| | | **Sands with Fines:** More than 12% fines [D] | Fines classify as ML or MH | | SM | Silty sand [G, H, I] |
| | | | Fines classify as CL or CH | | SC | Clayey sand [G, H, I] |
| **Fine-Grained Soils:** 50% or more passes the No. 200 sieve | **Silts and Clays:** Liquid limit less than 50 | **Inorganic:** | PI > 7 and plots on or above "A" | | CL | Lean clay [K, L, M] |
| | | | PI < 4 or plots below "A" line [J] | | ML | Silt [K, L, M] |
| | | **Organic:** | Liquid limit - oven dried / Liquid limit - not dried | < 0.75 | OL | Organic clay [K, L, M, N] |
| | | | | | | Organic silt [K, L, M, O] |
| | **Silts and Clays:** Liquid limit 50 or more | **Inorganic:** | PI plots on or above "A" line | | CH | Fat clay [K, L, M] |
| | | | PI plots below "A" line | | MH | Elastic Silt [K, L, M] |
| | | **Organic:** | Liquid limit - oven dried / Liquid limit - not dried | < 0.75 | OH | Organic clay [K, L, M, P] |
| | | | | | | Organic silt [K, L, M, Q] |
| **Highly organic soils:** | Primarily organic matter, dark in color, and organic odor | | | | PT | Peat |

[A] Based on the material passing the 3-inch (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

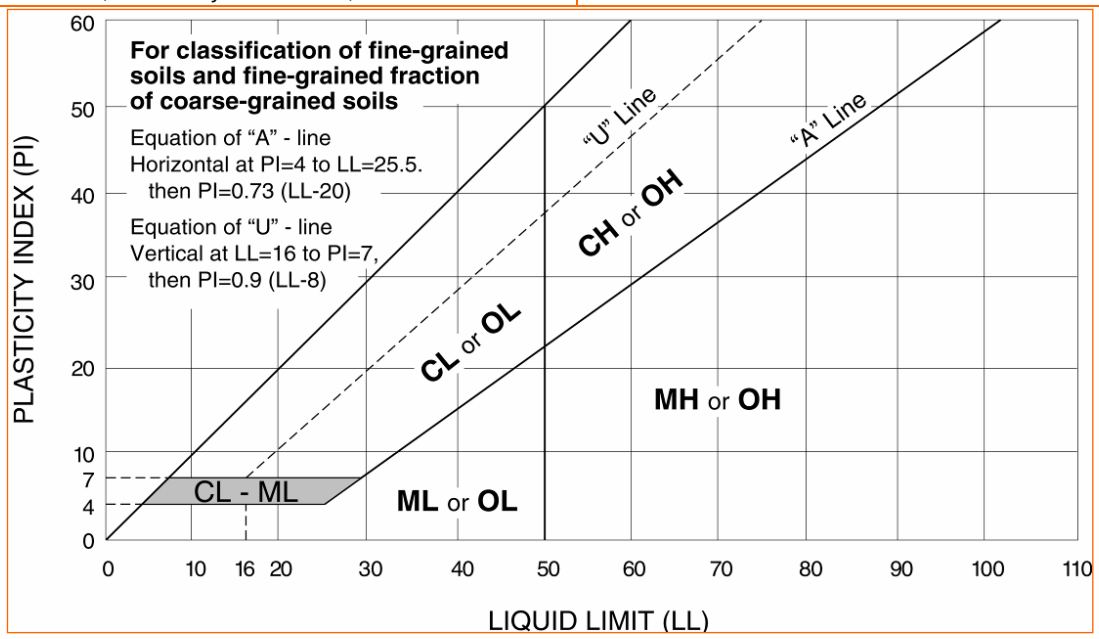
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



# GENERAL NOTES

| SAMPLING | WATER LEVEL | FIELD TESTS |
|---|---|---|
| Auger Cuttings<br>Auger Cuttings<br>Ring Sampler<br>Shelby Tube<br>Standard Penetration Test | **Water Initially Encountered**<br>**Water Level After a Specified Period of Time**<br>**Water Level After a Specified Period of Time**<br>**Cave In Encountered**<br>Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations. | **N** **Standard Penetration Test Resistance (Blows/Ft.)**<br>**(HP)** **Hand Penetrometer**<br>**(T)** **Torvane**<br>**(DCP)** **Dynamic Cone Penetrometer**<br>**UC** **Unconfined Compressive Strength**<br>**(PID)** **Photo-Ionization Detector**<br>**(OVA)** **Organic Vapor Analyzer** |

## DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

## LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

## STRENGTH TERMS

| RELATIVE DENSITY OF COARSE-GRAINED SOILS<br>(More than 50% retained on No. 200 sieve.)<br>Density determined by Standard Penetration Resistance | | CONSISTENCY OF FINE-GRAINED SOILS<br>(50% or more passing the No. 200 sieve.)<br>Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance | | |
|---|---|---|---|---|
| **Descriptive Term (Density)** | **Standard Penetration or N-Value Blows/Ft.** | **Descriptive Term (Consistency)** | **Unconfined Compressive Strength Qu, (psf)** | **Standard Penetration or N-Value Blows/Ft.** |
| Very Loose | 0 - 3 | Very Soft | less than 500 | 0 - 1 |
| Loose | 4 - 9 | Soft | 500 to 1,000 | 2 - 4 |
| Medium Dense | 10 - 29 | Medium Stiff | 1,000 to 2,000 | 4 - 8 |
| Dense | 30 - 50 | Stiff | 2,000 to 4,000 | 8 - 15 |
| Very Dense | > 50 | Very Stiff | 4,000 to 8,000 | 15 - 30 |
| | | Hard | > 8,000 | > 30 |

## RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

Terracon