REPORT OF GEOTECHNICAL EXPLORATION (FINAL)

SAN-101-1.65 Culvert Replacement

PID: 107719
Sandusky County, Ohio

Date:

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Prepared for:

Ohio Department of Transportation, District 2

Bowling Green, Ohio

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Project/File:

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Executive Summary

The Ohio Department of Transportation (ODOT) is planning to replace a culvert on State Route (SR) 101 over Racoon Creek near mile point 1.65, approximately 400 feet south of intersection of SR 101 and South Ridge Road (County Road 175). The new culvert will be a box culvert with dimensions of 20 feet by 10 feet, allowing for the culvert to also be classified as a bridge. Stantec Consulting Services Inc. (Stantec) was contracted to perform the geotechnical exploration and provide design recommendations for the project.

Terracon advanced four soil borings and one hand auger boring to obtain geotechnical data for the proposed culvert replacement. Two borings were advanced for the culvert at diagonally opposite ends, one in the northbound lane and the other in the southbound lane. Two additional borings were advanced in the southbound lane north of the existing culvert to obtain data for bank erosion analysis. The hand auger boring was advanced down slope of the creek bank, west of SR 101.

The surface materials encountered include approximately 9 to 14 inches of asphalt followed by 8 to 17 inches of aggregate base in the borings. Topsoil thickness was not recorded in the hand sample boring. Fill soils encountered in these borings were classified as gravel and stone fragments with sand (A-1-b), gravel and stone fragments with sand and silt (A-2-4), coarse and fine sand (A-3a), and sandy silt (A-4a). These soils were further described as brown to gray, very loose to medium dense for granular soils, and damp to wet. Glacial tills classifying as plastic and non-plastic sandy silt (A-4a), plastic and non-plastic silt (A-4b), and silt and clay (A-6a) were encountered at depths ranging from 10.5 feet to 16.0 feet in the borings. The soils were described as brown to gray, dense to very dense or hard, damp, and plastic soils possessing low to moderate plasticity. Groundwater was encountered at a depth of 14.0 feet in boring B-001-0-25, 41.0 feet in boring B-003-0-25 and 44.0 feet in B-004-0-25. Ground water was not encountered in borings B-002-0-25 or H-001-0-25.

Bedrock at the site was encountered at depths ranging from 41.0 to 45.5 feet. The bedrock was gray dolomite described as moderately strong to strong, slightly to highly weathered, fine-grained, thin bedded, and moderately to highly fractured.

The existing culvert is planned to be replaced by a 4-sided box culvert that is 20 feet by 10 feet at straight line mileage (SLM) 1.65 of SR 101. Bearing capacity calculations were performed at the inlet and outlet for the culvert utilizing information obtained from borings B-001-0-25 and B-002-0-25. The base of the culvert is planned to be at an elevation of 700 feet to match the elevation of the creek bed. Since foundation soils at both the inlet and outlet of the proposed culvert are granular at an elevation of 700 feet, it was assumed that drained and undrained properties would be the same in the bearing capacity analysis. A nominal bearing capacity of 17.5 kips per square foot (ksf) was determined for headwall and wingwall design. A resistance factor of 0.45 is to be applied for footings in sand, resulting in a factored bearing capacity of 7.9 ksf for headwall and wingwall design. The soil at the foundation elevation is expected to have an internal angle of friction of approximately 32 degrees, which exceeds the requirement of 28 degrees needed for the ODOT standard headwall design.

Stantec water resources engineers conducted a stream reconnaissance on June 19, 2025, to evaluate embankment slope conditions and the stream bank of Racoon Creek at the project site. Based on observations made at the site, the most likely cause of erosion issues at the project site is the low width to depth ratio of the stream, which results in increased stream velocities. Increasing the width to depth ratio and bank stabilization measures could promote channel stability and reduce erosive forces at the project location.

Three alternatives are recommended to address the bank stress and promote slope stability in Appendix C. The preferred alternative is a bioengineered toe bank stabilization without channel realignment. This alternative minimizes the impacts related to construction and has a low potential for long-term maintenance among other benefits. The other alternatives that were considered were hard armoring stabilization and channel realignment. The evaluation matrix in Section 5 of Appendix C summarizes the guidelines for the recommendation.

Acronyms / Abbreviations

Acronym / Abbreviation	Full Name
ASTM	American Society for Testing and Materials
AASHTO	American Association of State Highway and Transportation Officials
ER	Energy Ratio
CR	County Route
GDM	Geotechnical Design Manual
KSF	Kips per Square Foot
LRFD	Load and Resistance Factor Design
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
OSHA	Occupational Safety and Health Administration
PI	Plasticity Index
PSI	Pounds per Square Inch
SGE	Specifications for Geotechnical Explorations
SPT	Standard Penetration Test
SLM	Straight Line Mileage
SR	State Route
TIMS	Traffic Information Mapping System
USDA	United States Department of Agriculture

1 INTRODUCTION

The Ohio Department of Transportation (ODOT) is planning to replace a culvert on State Route (SR) 101 over Racoon Creek near mile point 1.65, approximately 400 feet south of intersection of SR 101 and South Ridge Road (County Road 175). The new culvert will be a box culvert with dimensions of 20 feet by 10 feet.

Stantec Consulting Services Inc. (Stantec) was contracted to perform the geotechnical exploration and provide design recommendations for the project. Figure 1 shows the site vicinity.

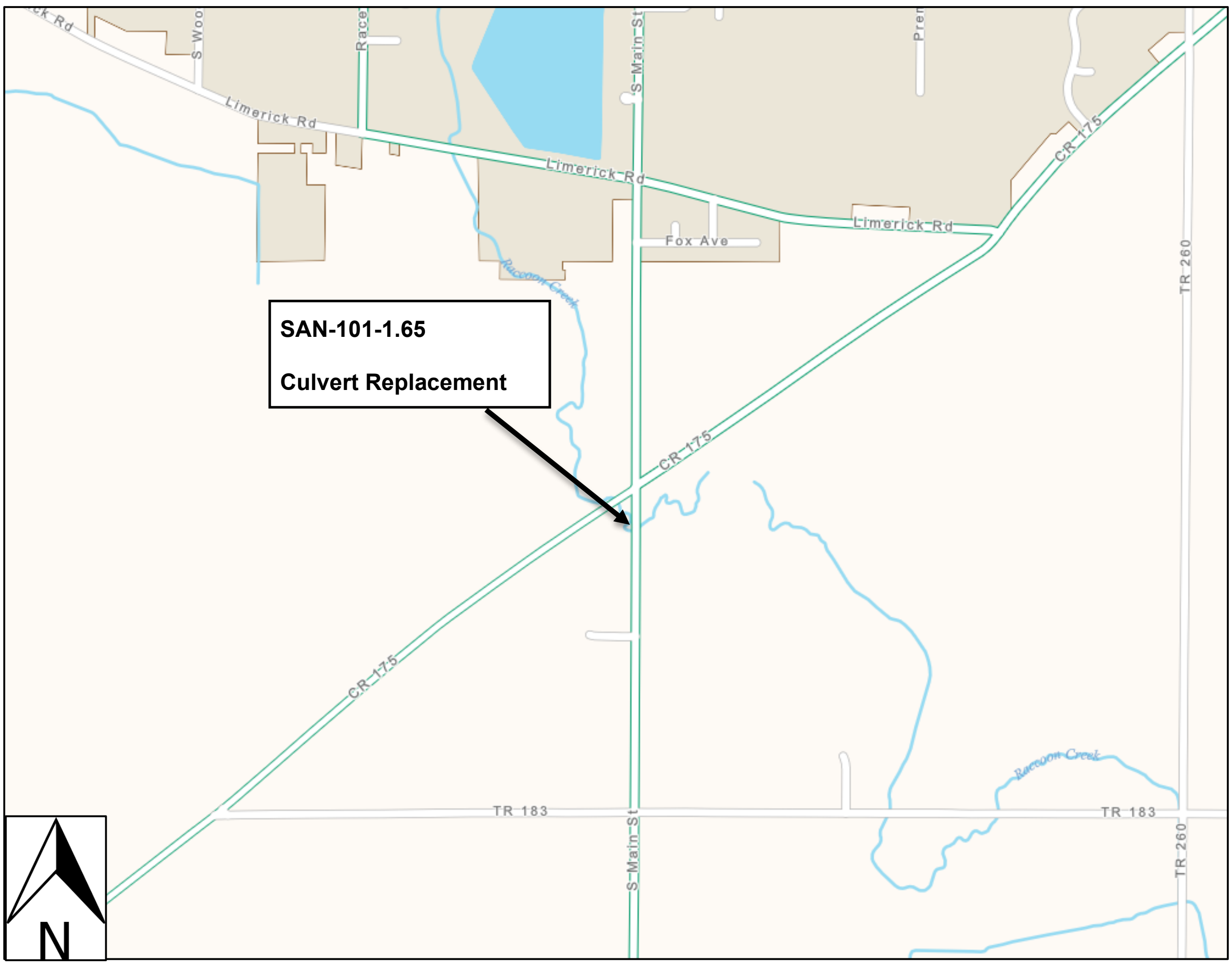


Figure 1: Site Vicinity (from ODOT Traffic Information Mapping System (TIMS, 2025))

2 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 GENERAL

The *Physiographic Regions of Ohio Map* (Ohio Department of Natural Resources (ODNR), 1998) indicates that the project is located within the Central Ohio Clayey Till Plain of Till Plains in Central Lowland. The Central Ohio Clayey Till Plain is described as a surface of clayey till and well-defined moraines with intervening flat-lying ground moraines and intermorainal lake basins. The region also consists of no boulder belts, about a dozen silt, clay and till filled lake basins ranging in area from a few to 200 square miles. The region has moderate relief (generally about 100 feet) with elevations of 700 to 1150 feet. The geology consists of clayey, high-lime Wisconsinan-age till from a northeastern source (Erie glacial lobe) and lacustrine materials over Lower Paleozoic-age carbonate rocks and shales in the east with thin to no loess.

2.2 SOIL GEOLOGY

According to the *Ohio Geology Interactive Map* (ODNR, 2025), the quaternary geology of the project consists of beach sand formed at the shores of glacial lakes. The soil survey (*Web Soil Survey of Sandusky County, Ohio)*, United States Department of Agriculture (USDA, 2025) indicates that the project site is underlain by soils from Shoals silt loam and Tedrow loamy fine sand. The soil from Shoals silt loam consists of silt loam and sandy loam and is described as poorly drained with moderately high to high capacity of transmitting water. Similarly, the soil from Tedrow loamy fine sand consists of loamy fine sand and is described as poorly drained with high to very high capacity of transmitting water. The *Ohio Geology Interactive Map* (ODNR, 2025) indicates that the project site consists of 51 to 80 feet of glaciated till.

2.3 BEDROCK GEOLOGY

Bedrock mapping (*Ohio Geology Interactive Map*, ODNR, 2025) and *Descriptions of Geologic Map Units* (ODNR, 2011) indicate that the overburden soils at the project site are underlain by sedimentary rock of the Salina group. The Salina group consists of dolomite and is described as gray, yellow gray to olive-gray, and laminated to thin bedded. The diagnostic feature consists of occasional thin bed and laminae of dark shale and anhydrite and/or gypsum and parts of brecciated zones.

According to the *Ohio Oil and Gas Well Viewer* map (ODNR, 2025), there are no oil and gas wells within a 5-mile radius of the project site. The nearest oil and gas wells are about 5.5 miles northeast of the project site. The well logs show dolomite and shale bedrock.

According to the *Ohio Mine Locator* (ODNR, 2025), there are no mines within a 5-mile radius of the project site. Three historic quarries and one active limestone surface mine are located about 6 miles southeast of the project site.

The *Karst Interactive Map* (ODNR, 2025) indicates there are two suspected and field verified karstic areas about two miles northeast of the project site.

2.4 HYDROLOGY

Drainage from the site location flows into Racoon Creek located at the project site. Water from Racoon Creek flows west then north into Sandusky Bay near Bay View, Ohio approximately 11.4 miles north of the site.

2.5 HYDROGEOLOGY

The *Ohio Geology Interactive Map* shows that the site is underlain by the Lake Maumee Lacustrine Aquifer (sand and gravel aquifer), which has a yield of 5 to 25 gallons per minute. Bedrock aquifers within the dolomite located at the site typically yield 250 to 500 gallons per minute. According to the Groundwater Resources of Sandusky County map (ODNR, 1980), the project site is in an area where wells with yields of 500 to 1,000 gallons per minute can be achieved. However, it was noted that the hardness of dissolved solids, hydrogen sulfide, and sulfates may deter the use of wells in the area.

A search was performed using the ODNR *Ohio Water Wells Map* (2025) to review the geology recorded on logs of water wells located near the project site. According to the map, three water wells have been drilled within a 500-foot radius of the project site. The well logs indicate that bedrock depth ranges from 45 to 62 feet. The bedrock encountered at these wells was described as limestone. The logs also indicate that static water depth in the area ranges from 16 to 35 feet.

2.6 SEISMIC

A review of the seismic data available in the project vicinity was completed using the ODNR *Ohio Earthquake Epicenters Map* (2025). Overall, Ohio has a relatively limited amount of seismic activity. Within a 10-mile radius of the project, there have been zero earthquakes recorded. The nearest earthquake epicenter is located approximately 11.8 miles west of the project site, with a magnitude of 3.3. The available data reviewed included events that occurred in Ohio from 1886 to present day.

2.7 SITE RECONNAISSANCE

Stantec representatives visited the site on May 13, 2025, to record observations and mark borehole locations. The land surrounding the project site was described as rural with residential housing, cultivated fields, and a golf course nearby. The pavement of SR 101 was observed to be in fair condition. The existing culvert was observed to be in fair to poor condition. Flow within the creek was minimal, but slow movement was observed travelling from east to west.

3 EXPLORATION

3.1 HISTORIC EXPLORATION PROGRAMS

The ODOT Transportation Information Maps System (TIMS) shows no historic projects completed along SR 101 near the project site. However, TIMS provides information for one project completed near the site location. A geotechnical investigation for the reconstruction of Race Street in Clyde, Ohio occurred in 1989, located approximately 0.8 miles northwest of the project site. The soils were primarily described as silty sand (A-4a) or silty clay (A-6b). Bedrock was not encountered during drilling.

3.2 PROJECT EXPLORATION PROGRAM

Terracon advanced four soil borings and one hand auger boring to obtain geotechnical data for the proposed culvert replacement. Two borings were advanced for the culvert at diagonally opposite ends, one in the northbound lane and the other in the southbound lane. Two additional borings were advanced in the southbound lane north of the existing culvert to obtain data for bank erosion analysis. The hand auger boring was advanced down slope of the creek bank, west of SR 101.

These borings were marked and staked using the approximate location of the culvert provided by District 2. All borings were marked with paint on the roadway. No survey was performed for the boring locations; thus, these locations were picked up using phone GPS application after completion. Locations were verified using basemaps provided by ODOT, which were also used to obtain elevations, stations, and offsets for each boring. A summary of these borings is shown in Table 1. Boring locations are shown on the Geotechnical Profile sheets in Appendix A.

Table 1. Boring Summary

Boring No.	Station (feet)	Offset (feet)[1]	Alignment	Ground surface Elevation (feet)[1]	Bottom of Boring Elevation (feet)
B-001-0-25	86+80	8 Rt.	SR 101	717.0	655.5
B-002-0-25	87+36	7 Lt.	SR 101	716.8	660.7
B-003-0-25	88+09	7 Lt.	SR 101	716.6	660.1
B-004-0-25	88+82	7 Lt.	SR 101	717.0	656.0
H-001-0-25	88+12	23 Lt.	SR 101	711.0	703.0

The soil borings were performed with a Mobile B-57 (#1059) track-mounted drill rig using 3¼-inch inside diameter (ID) hollow stem augers to advance the borings through soil. The SPT sampling was performed at 2.5-foot intervals to a depth of 40 feet below the existing ground surface, then at 5-foot intervals thereafter until bedrock was encountered. At B-003-0-25 and B-004-0-25, continuous sampling was used to a depth of 10 feet in each boring prior to using the sampling described previously. The energy ratio (ER) of the B-57 automatic hammer and drill rod system was measured to be 87.1 percent on January 31, 2025. The depths and elevations of the SPTs with the corresponding N_{60}-values are shown on the boring logs in Appendix A. The hand auger boring was advanced until refusal. Samples of each different soil horizon were collected.

Upon encountering competent bedrock in the soil borings, 10 to 15 feet of rock coring was performed using NQ2-size equipment. Recovery and rock quality designation (RQD) values were recorded as percentages for each coring run. These values are shown on the boring logs contained in Appendix A.

The materials encountered were logged by a geotechnical engineer, with attention given to soil type, consistency, and moisture. The borings were checked for the presence of groundwater during drilling with the depth of water recorded, if encountered. The soil borings were sealed with cement/bentonite grout, then capped with asphalt cold patch.

The samples obtained from the borings were returned to Stantec's geotechnical laboratory for visual classification and tested for water content. Engineering classification testing was performed on samples taken near proposed subgrade and samples reflecting each of the main soil horizons. The engineering classification tests conducted on the samples were sieve and hydrometer analysis (ASTM D 422) and Atterberg limits (ASTM D 4318). The samples were classified according to the ODOT classification method. Three rock core samples were subjected to unconfined compressive strength of rock core (UCR) testing (ASTM D 7012). Results from Stantec's laboratory program are shown on the boring logs in Appendix A.

4 FINDINGS

4.1 CULVERT BORINGS

The surface materials encountered include approximately 9 to 13 inches of asphalt underlain by 10 to 17 inches of aggregate base in borings B-001-0-25 and B-002-0-25. Fill soil overlying glacial tills were encountered below the surficial materials in these borings.

Fill soils encountered in these borings were classified as coarse and fine sand (A-3a) and sandy silt (A-4a). These soils were described as brown to gray, very loose to medium dense (SPT N_{60} values ranging from 1 to 23 blows per foot [bpf] with an average of 7 bpf), and damp to wet (moisture content of 8 to 29 percent with an average of 15 percent). A small layer of cohesive sandy silt (A-4a) was observed in B-002-0-25. This soil was described as brown to gray, very stiff (SPT N_{60} values of 17 and 22 bpf), damp (moisture content of 9 and 12 percent), and having low plasticity (plasticity index [PI] of 4).

Glacial tills classifying as plastic and non-plastic sandy silt (A-4a), non-plastic silt (A-4b), and silt and clay (A-6a) were encountered below a depth of 16.0 feet in B-001-0-25 and 14.7 feet in B-002-0-25. The soils were described as brown to gray, very dense or hard (SPT N_{60} values ranging from 36 to 115 bpf with an average of 64 bpf), damp (moisture content of 9 to 19 percent with an average of 13 percent), and plastic soils possessing low to moderate plasticity (PI of 8 to 12 with an average of 10).

Groundwater was encountered at a depth of 14 feet in boring B-001-0-25. Groundwater was not encountered in boring B-002-0-25.

Bedrock was encountered at depths of 45.5 feet and 43.0 feet in borings B-001-0-25 and B-002-0-25, respectively. The bedrock was gray dolomite described as moderately strong to strong, slightly to highly weathered, fine-grained, thin bedded, and moderately to highly fractured. Two unconfined compressive strength of rock tests were completed on a dolomite specimen from B-001-0-25 and B-002-0-25, resulting in a compressive strength of 10,620 and 12,910 pounds per square inch (psi), respectively.

4.2 BANK EROSION AND HAND SAMPLE BORINGS

The surface materials encountered include approximately 14 inches of asphalt underlain by 8 to 10 inches of aggregate base in borings B-003-0-25 and B-004-0-25. Topsoil thickness was not recorded in the hand sample boring. Fill soil overlying glacial tills were encountered below the surficial materials in these borings.

Fill soils encountered in these borings were classified as gravel and stone fragments with sand (A-1-b), gravel and stone fragments with sand and silt (A-2-4), and coarse and fine sand (A-3a). These soils were further described as brown, very loose to medium dense (SPT N_{60} values ranging from 3 to 19 bpf with an average of 6 bpf), and damp to wet (moisture content of 7 to 22 percent with an average of 14 percent). A small layer of cohesive sandy silt (A-4a) was observed in H-001-0-25. This soil was described as brown, damp (moisture content of 11), and having low plasticity (PI of 6).

Glacial tills classifying as non-plastic sandy silt (A-4a), plastic and non-plastic silt (A-4b), and silt and clay (A-6a) were encountered below a depth of 11.0 feet in B-003-0-25 and 10.5 feet in B-004-0-25. The soils were described as brown to gray, dense to very dense or hard (SPT N_{60} values ranging from 42 to 136 bpf with an average of 71 bpf), damp (moisture content of 9 to 16 percent with an average of 12 percent), and plastic soils possessing low to moderate plasticity (PI of 3 to 13 with an average of 8).

Groundwater was encountered at depths of 41 feet in boring B-003-0-25 and 44 feet in B-004-0-25. Groundwater was not encountered in boring H-001-0-25.

Bedrock was encountered at a depth of 41.0 feet in borings B-003-0-25 and B-004-0-25. The bedrock was gray dolomite described as strong, moderately to highly weathered, fine-grained, thin bedded, and moderately to highly fractured. One unconfined compressive strength of rock test was completed on a dolomite specimen from boring B-003-0-25, resulting in a compressive strength of 13,260 psi.

5 ANALYSIS AND RECOMMENDATIONS

5.1 GENERAL

The recommendations that follow are based on the information discussed in this report and the interpretation of the subsurface conditions encountered at the site during the fieldwork. If future design changes are made, Stantec should be notified so that such changes can be reviewed, and the recommendations amended, as necessary.

These conclusions and recommendations are based on data and subsurface conditions from the borings advanced during this exploration using the 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.

5.2 CULVERT

The existing culvert is planned to be replaced by a box culvert that is 20 feet by 10 feet at straight line mileage (SLM) 1.65 of SR 101. Bearing capacity calculations were performed at the inlet and outlet for the culvert utilizing information obtained from borings B-001-0-25 and B-002-0-25. The spread footings for the headwalls and wingwalls of the culvert are planned to be at an elevation of 694 to 696 feet, based on preliminary design drawings provided by ODOT. Since foundation soils at both the inlet and outlet of the proposed culvert are granular at these elevations, it was assumed that drained and undrained properties would be the same in the bearing capacity analysis. A nominal bearing capacity of 17.5 kips per square foot (ksf) was determined for headwall and wingwall design. A resistance factor of 0.45 is to be applied for footings in sand (from Table 10.5.5.2.2-1 of the 2024 AASHTO LRFD), resulting in a factored bearing capacity of 7.9 ksf for headwall and wingwall design. Detailed calculations for the bearing capacity analysis are provided in Appendix B. Foundation soils are expected to have an internal angle of friction of approximately 32 degrees, which exceeds the requirement of 28 degrees needed for the ODOT standard headwall design.

For the bearing capacity analysis, it was assumed that the culvert would bear on very dense silt or sandy silt encountered in the borings below an elevation of approximately 700 feet. Soil must be excavated to ensure foundations bear on this very dense silt or sandy silt soil. It is also recommended to over excavate any silt material an additional 2 feet below the foundation interval. Any over excavation may be backfilled with select granular material type B to the foundation elevation. According to the Occupational Safety and Health Administration (OSHA) 1946 Subpart P App A – Soil Classification, excavated soils most closely fall under Type C. Sloped excavations thus require a 1.5:1 horizontal to vertical slope according to OSHA 1926 Subpart P App B – Sloping and Benching. This recommendation applies to trenches where workers will be present and are planned to be open long term.

A review of the boring logs indicates that perched water is contained in the granular fill (coarse and fine sand) soil south of the existing culvert. During drilling, the perched groundwater was observed about 6 feet above the inlet and outlet headwall footing elevations. It should be anticipated that stream diversion and dewatering will be necessary to install the headwall footings. The dewatering plan should include temporary barriers or earth berms to isolate the footing excavation from stream flow and sump pumps to remove stream and groundwater infiltration into the isolated area. Other methods like well points could be considered to lower the perched groundwater table; however, the temporary barriers or earth berms and pumping will still be necessary to isolate the footing excavation from stream flow.

5.3 BANK EROSION

Stantec water resources engineers conducted a stream reconnaissance on June 19, 2025, to evaluate embankment slope conditions and the stream bank of Racoon Creek at the project site. The following observations were made during the reconnaissance:

- Bankfull elevation approximately matched the top of bank, indicating little channel incision and the hardpan bottom identified near the road embankment suggests limited downcutting potential.
- Minor, recent planform changes were evident. These changes were likely the result of downstream-condition alteration through installation of the new box culvert under South Ridge Road.
- The channel adjacent to the bank showed signs of scour, where other areas within the project area showed signs of equilibrium with the sediment load. The principal indication of a net degradation condition was the exposed hardpan bottom, which was not apparent upstream of SR 101.
- The hardpan clay observed at the toe of the bank of concern promotes bed and bank stability.
- SR 101 and South Ridge Road are close enough together, only 3 meander bends between the culverts, that significant lateral migration of the channel was not observed and not likely to occur.

The most likely cause of erosion issues at the project site is the low width to depth ratio of the stream, which results in increased stream velocities. Increasing the width to depth ratio and bank stabilization measures could promote channel stability and reduce erosive forces at the project location. More detailed discussion of the stream reconnaissance and recommendations are provided in Stantec's internal memo included as Appendix C.

5.4 SPECIAL BENCHING

Special benching is recommended where fill is being placed atop existing embankment slopes. Special benching should follow recommendations outlined in Section 800 of the ODOT Geotechnical Design Manual (GDM). A minimum horizontal distance of 8 feet should be maintained between the benching backslope and the planned embankment slope. Slopes for the benching should be excavated at 1:1 (horizontal to vertical) and embankment fill should be placed as soon as possible after benches and excavations are completed. An analysis in GeoStudio 2024.2.1 showed that 5-foot-wide benches will provide adequate stability. Vertical distance between benches is recommended to not exceed 7 feet. It is understood that there may be locations where embankment fill will be placed on weak soil. In this case, it is recommended that the weak soil be undercut 2 feet, geogrid be placed at the bottom of the undercut, and the undercut be backfilled with #57 stone to create a bridge over weak soil.

Appendix A Geotechnical Profile (Final)

PROJECT DESCRIPTION

THIS PROJECT, SAN-101-1.65, IS THE EXPLORATION FOR A CULVERT REPLACEMENT LOCATED ALONG SR 101 APPROXIMATELY 400 FEET SOUTH OF THE INTERSECTION OF COUNTY ROAD 175 NEAR CLYDE, OHIO. THE NEW CULVERT WILL BOX WITH DIMENSIONS OF 25 FEET BY 10 FEET.

HISTORIC RECORDS

THE ODOT TRANSPORTATION INFORMATION MAPS SYSTEM (TIMS) SHOWS NO HISTORIC PROJECTS COMPLETED ALONG SR 101 NEAR THE PROJECT SITE. HOWEVER, TIMS PROVIDES INFORMATION FOR ONE PROJECT COMPLETED NEAR THE SITE LOCATION.

A GEOTECHNICAL INVESTIGATION FOR THE RECONSTRUCTION OF RACE STREET IN CLYDE, OHIO OCCURRED IN 1989, LOCATED APPROXIMATELY 0.8 MILES NORTHWEST OF THE CURRENT PROJECT SITE. THE SOILS WERE PRIMARILY DESCRIBED AS SILTY SAND (A-4A) OR SILTY CLAY (A-6B). BEDROCK WAS NOT ENCOUNTERED DURING DRILLING OF THIS PROJECT.

GEOLOGY

THE PROJECT IS LOCATED WITHIN THE CENTRAL OHIO CLAYEY TILL PLAIN OF TILL PLAINS IN CENTRAL LOWLAND. THE CENTRAL OHIO CLAYEY TILL PLAIN IS DESCRIBED AS SURFACE OF CLAYEY TILL AND WELL-DEFINED MORAINES WITH INTERVENING FLAT-LYING GROUND MORAINES AND INTERMORAINAL LAKE BASINS. THE REGION ALSO CONSISTS OF NO BOULDER BELTS, ABOUT A DOZEN SILT, CLAY AND TILL FILLED LAKE BASINS RANGE IN AREA FROM A FEW TO 200 SQUARE MILES. THE REGION HAS MODERATE RELIEF (GENERALLY ABOUT 100 FEET) WITH ELEVATIONS OF 700 TO 1150 FEET. THE GEOLOGY CONSISTS OF CLAYEY, HIGH-LIME WISCONSINAN-AGE TILL FROM A NORTHEASTERN SOURCE (ERIE GLACIAL LOBE) AND LACUSTRINE MATERIALS OVER LOWER PALEOZOIC-AGE CARBONATE ROCKS AND SHALES IN THE EAST WITH THIN TO NO LOESS.

THE OVERBURDEN SOILS AT THE PROJECT SITE ARE UNDERLAIN BY SEDIMENTARY ROCK OF THE SALINA GROUP. THE SALINA GROUP CONSISTS OF DOLOMITE AND IS DESCRIBED AS GRAY, YELLOW GRAY TO OLIVE-GRAY, AND LAMINATED TO THIN BEDDED. THE DIAGNOSTIC FEATURE CONSISTS OF OCCASIONAL THIN BED AND LAMINAE OF DARK SHALE AND ANHYDRITE AND/OR GYPSUM AND PARTS OF BRECCIATED ZONES.

RECONNAISSANCE

STANTEC REPRESENTATIVES VISITED THE SITE ON MAY 13, 2025 TO RECORD OBSERVATIONS AND MARK BOREHOLE LOCATIONS. THE LAND SURROUNDING THE PROJECT SITE WAS DESCRIBED AS PRIMARILY RESIDENTIAL WITH A GOLF COURSE LOCATED NEARBY. THE PAVEMENT OF SR 101 WAS OBSERVED TO BE IN FAIR CONDITION. THE EXISTING CULVERT WAS OBSERVED TO BE IN FAIR TO POOR CONDITION. FLOW WITHIN THE CREEK WAS MINIMAL, BUT SLOW MOVEMENT WAS OBSERVED TRAVELLING FROM EAST TO WEST.

SUBSURFACE EXPLORATION

TERRACON ADVANCED FOUR SOIL BORINGS AND ONE HAND AUGER BORING TO OBTAIN GEOTECHNICAL DATA FOR THE PROPOSED CULVERT REPLACEMENT. TWO BORINGS WERE ADVANCED FOR THE CULVERT AT DIAGONALLY OPPOSITE ENDS, ONE IN THE NORTHBOUND LANE AND THE OTHER IN THE SOUTHBOUND LANE. TWO ADDITIONAL BORINGS WERE ADVANCED IN THE SOUTHBOUND LANE NORTH OF THE EXISTING CULVERT TO OBTAIN DATA FOR BANK EROSION ANALYSIS. THE HAND AUGER BORING WAS ADVANCED DOWN SLOPE OF THE CREEK BANK, WEST OF SR 101.

THE SOIL BORINGS WERE PERFORMED WITH A MOBILE B-57 (#1059) TRACK-MOUNTED DRILL RIG USING 3¼-INCH INSIDE DIAMETER (ID) HOLLOW STEM AUGERS TO ADVANCE THE BORINGS THROUGH SOIL. THE SPT SAMPLING WAS PERFORMED AT 2.5-FOOT INTERVALS TO A DEPTH OF 40 FEET BELOW THE EXISTING GROUND SURFACE, THEN AT 5-FOOT INTERVALS THEREAFTER UNTIL BEDROCK WAS ENCOUNTERED. AT B-003-0-25 AND B-004-0-25, CONTINUOUS SAMPLING WAS USED TO A DEPTH OF 10 FEET IN EACH BORING PRIOR TO USING THE SAMPLING DESCRIBED PREVIOUSLY. THE ENERGY RATIO (ER) OF THE B-57 AUTOMATIC HAMMER AND DRILL ROD SYSTEM WAS MEASURED TO BE 87.1 PERCENT ON JANUARY 31, 2025.

EXPLORATION FINDINGS

CULVERT BORINGS

THE SURFACE MATERIALS ENCOUNTERED INCLUDE APPROXIMATELY 9 TO 13 INCHES OF ASPHALT FOLLOWED BY 10 TO 17 INCHES OF AGGREGATE BASE IN BORINGS B-001-0-25 AND B-002-0-25. FILL SOIL OVERLYING GLACIAL TILLS WERE ENCOUNTERED BELOW THE SURFICIAL MATERIALS IN THESE BORINGS.

FILL SOILS ENCOUNTERED IN THESE BORINGS WERE CLASSIFIED AS COARSE AND FINE SAND (A-3A), AND SANDY SILT (A-4A). THESE SOILS WERE FURTHER DESCRIBED AS BROWN TO GRAY, VERY LOOSE TO MEDIUM DENSE FOR GRANULAR SOILS, AND DAMP TO WET. A SMALL LAYER OF COHESIVE SANDY SILT (A-4A) WAS OBSERVED IN B-002-0-25. THIS SOIL WAS DESCRIBED AS BROWN TO GRAY, VERY STIFF, DAMP, AND HAVING LOW PLASTICITY. GLACIAL TILLS CLASSIFYING AS PLASTIC AND NON-PLASTIC SANDY SILT (A-4A), NON-PLASTIC SILT (A-4B), AND SILT AND CLAY (A-6A) WERE ENCOUNTERED AT A DEPTH OF 16.0 FEET IN B-001-0-25 AND 14.7 FEET IN B-002-0-25. THE SOILS WERE DESCRIBED AS BROWN TO GRAY, VERY DENSE OR HARD, DAMP, AND PLASTIC SOILS POSSESSING LOW TO MODERATE PLASTICITY. GROUNDWATER WAS ENCOUNTERED AT A DEPTH OF 14 FEET IN BORING B-001-0-25. GROUND WATER WAS NOT ENCOUNTERED IN BORING B-002-0-25.

BEDROCK AT THE SITE WAS ENCOUNTERED AT DEPTHS OF 45.5 FEET AND 43.0 FEET IN BORINGS B-001-0-25 AND B-002-0-25, RESPECTIVELY. THE BEDROCK WAS GRAY DOLOMITE DESCRIBED AS MODERATELY STRONG TO STRONG, SLIGHTLY TO HIGHLY WEATHERED, FINE-GRAINED, THIN BEDDED, AND MODERATELY TO HIGHLY FRACTURED.

BANK EROSION AND HAND SAMPLE BORINGS

THE SURFACE MATERIALS ENCOUNTERED INCLUDE APPROXIMATELY 14 INCHES OF ASPHALT FOLLOWED BY 8 TO 10 INCHES OF AGGREGATE BASE IN BORINGS B-003-0-25 AND B-004-0-25. TOPSOIL THICKNESS WAS NOT RECORDED IN THE HAND SAMPLE BORING. NATURAL SOIL OVERLYING GLACIAL TILLS WERE ENCOUNTERED BELOW THE SURFICIAL MATERIALS IN THESE BORINGS.

EXPLORATION FINDINGS (CONTINUED)

FILL SOILS ENCOUNTERED IN THESE BORINGS WERE CLASSIFIED AS GRAVEL AND STONE FRAGMENTS WITH SAND (A-1-B), GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT (A-2-4), AND COARSE AND FINE SAND (A-3A). THESE SOILS WERE FURTHER DESCRIBED AS BROWN, VERY LOOSE TO MEDIUM DENSE FOR GRANULAR SOILS, AND DAMP TO WET. A SMALL LAYER OF COHESIVE SANDY SILT (A-4A) WAS OBSERVED IN H-001-0-25. THIS SOIL WAS DESCRIBED AS BROWN, DAMP, AND HAVING LOW PLASTICITY. GLACIAL TILLS CLASSIFYING AS NON-PLASTIC SANDY SILT (A-4A), PLASTIC AND NON-PLASTIC SILT (A-4B), AND SILT AND CLAY (A-6A) WERE ENCOUNTERED AT A DEPTH OF 11.0 FEET IN B-003-0-25 AND 10.5 FEET IN B-004-0-25. THE SOILS WERE DESCRIBED AS BROWN TO GRAY, DENSE TO VERY DENSE OR HARD, DAMP, AND PLASTIC SOILS POSSESSING LOW TO MODERATE PLASTICITY. GROUNDWATER WAS ENCOUNTERED AT DEPTHS OF 41 FEET IN BORING B-003-0-25 AND 44 FEET IN B-004-0-25. GROUND WATER WAS NOT ENCOUNTERED IN BORING H-001-0-25.

BEDROCK AT THE SITE WAS ENCOUNTERED AT A DEPTH OF 41.0 FEET IN BORINGS B-003-0-25 AND B-004-0-25. THE BEDROCK WAS GRAY DOLOMITE DESCRIBED AS STRONG, MODERATELY TO HIGHLY WEATHERED, FINE-GRAINED, THIN BEDDED, AND MODERATELY TO HIGHLY FRACTURED

SPECIFICATIONS

THIS GEOTECHNICAL EXPLORATION WAS PERFORMED IN ACCORDANCE WITH THE STATE OF OHIO, DEPARTMENT OF TRANSPORTATION, OFFICE OF GEOTECHNICAL ENGINEERING, SPECIFICATIONS FOR GEOTECHNICAL EXPLORATIONS, DATED JANUARY 2025 .

AVAILABLE INFORMATION

THE SOIL, BEDROCK, AND GROUNDWATER INFORMATION COLLECTED FOR THIS SUBSURFACE EXPLORATION THAT CAN BE CONVENIENTLY DISPLAYED ON THE SOIL PROFILE SHEETS HAS BEEN PRESENTED. GEOTECHNICAL REPORTS, IF PREPARED, ARE AVAILABLE FOR REVIEW ON THE OFFICE OF CONTRACT SALES WEBSITE.

LEGEND

DESCRIPTION	ODOT CLASS	CLASSIFIED MECH.	CLASSIFIED VISUAL
GRAVEL AND/OR STONE FRAGMENTS WITH SAND	A-1-b	1	0
GRAVEL AND/OR STONE FRAGMENTS WITH SAND AND SILT	A-2-4	3	1
COARSE AND FINE SAND	A-3a	6	12
SANDY SILT	A-4a	8	14
SILT	A-4b	5	11
SILT AND CLAY	A-6a	3	12
	TOTAL	26	50
DOLOMITE	VISUAL		
PAVEMENT OR BASE = X = APPROXIMATE THICKNESS	VISUAL		

BORING LOCATION - PLAN VIEW.

DRIVE SAMPLE AND/OR ROCK CORE BORING PLOTTED TO VERTICAL SCALE ONLY. HORIZONTAL BAR INDICATES A CHANGE IN STRATIGRAPHY.

WC — INDICATES WATER CONTENT IN PERCENT.

N_{60} — INDICATES STANDARD PENETRATION RESISTANCE NORMALIZED TO 60% DRILL ROD ENERGY RATIO.

X/Y/Z — NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT):
X= NUMBER OF BLOWS FOR FIRST 6 INCHES.
Y= NUMBER OF BLOWS FOR SECOND 6 INCHES.
Z= NUMBER OF BLOWS FOR THIRD 6 INCHES.

TR — INDICATES TOP OF ROCK.

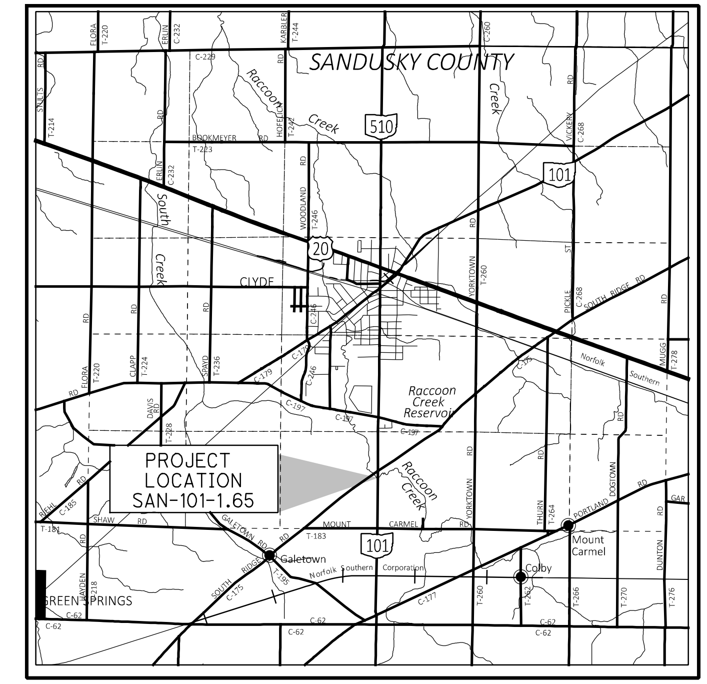
SS — INDICATES A SPLIT SPOON SAMPLE.

ST — INDICATES A SHELBY TUBE SAMPLE.

NP — INDICATES A NON-PLASTIC SAMPLE.

W — INDICATES FREE WATER ELEVATION.

Qu — INDICATES UNCONFINED COMPRESSIVE TEST (ROCK), ASTM D7012.



LOCATION MAP

SCALE IN MILES

0 1 2 3 4

N

PARTICLE SIZE DEFINITIONS

BOULDERS	COBBLES	GRAVEL	COARSE SAND	FINE SAND	SILT	CLAY
12"	3"	2.0 mm	0.42 mm	0.074 mm	0.005 mm	
		No. 10 SIEVE	No. 40 SIEVE	No. 200 SIEVE		

RECON. - JS & NU 05/13/25
DRILLING - AF & GK 06/17-23/2025
DRAWN - MJ 08/2025
REVIEWED - EMK 12/02/2025

GEOTECHNICAL PROFILE - CULVERT
SAN-101-1.65 OVER RACOON CREEK

DESIGN AGENCY
Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200

DESIGNER	REVIEWER	PROJECT ID	SUBSET	TOTAL	SHEET	TOTAL
MSJ	EMK 12-02-25	107719	0	0	P.1	15

SAN-101-1.65

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SAN-101-1.65

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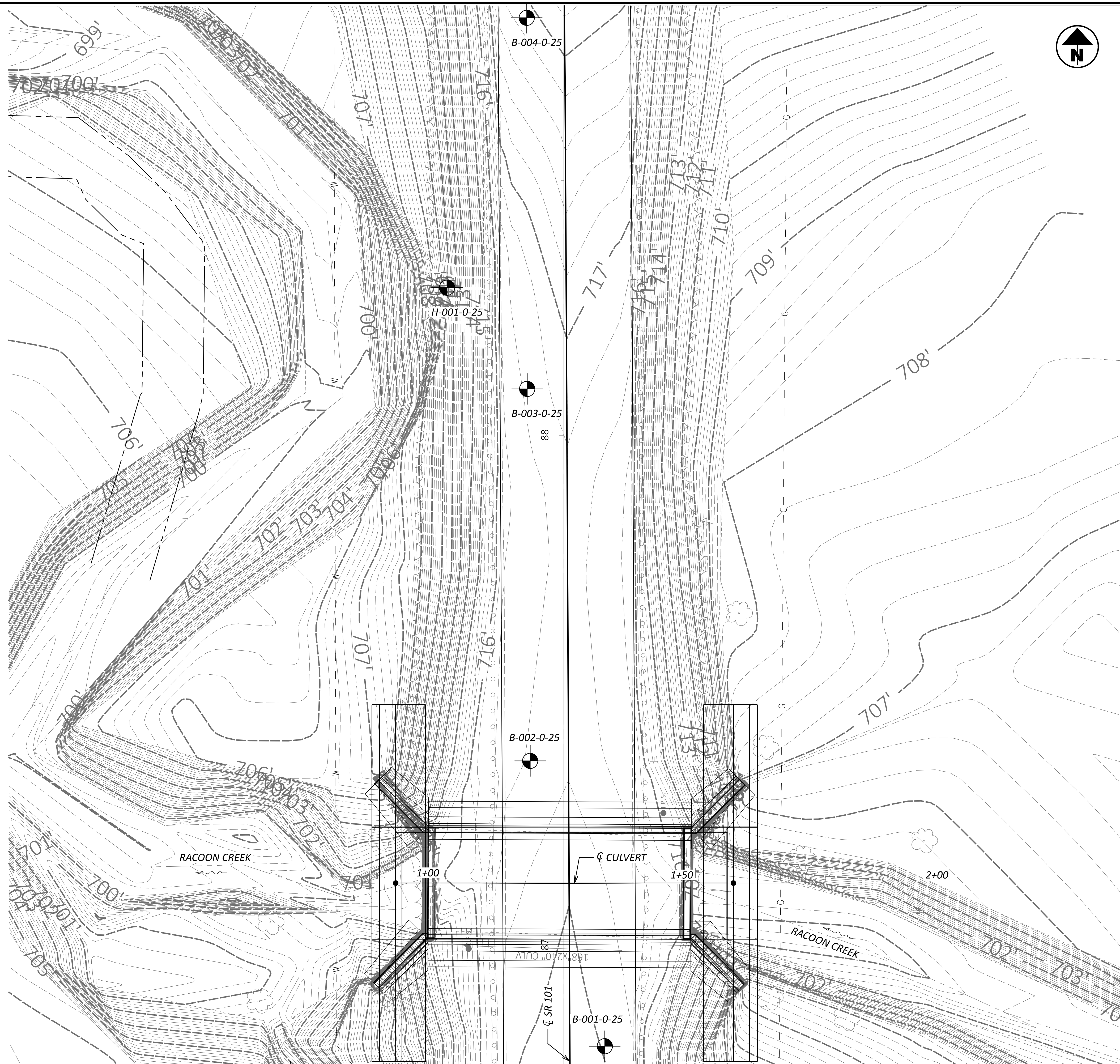

HORIZONTAL SCALE IN FEET
0 5 10 20

GEOTECHNICAL PROFILE - CULVERT
SAN-101-1.65 OVER RACOON CREEK - PLAN

DESIGN AGENCY
Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200

DESIGNER	MSJ
REVIEWER	EMK 12-02-25
PROJECT ID	107719
SUBSET 0	TOTAL 0
SHEET P.2	TOTAL 15

MODEL: Unnamed Plan - Plan 1 [Sheet] PAPERSIZE: 17x11 (in.) DATE: 12/2/2025 TIME: 2:35:33 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107719 PRODUCT: OpenRoadsDesigner 24.00.00.205
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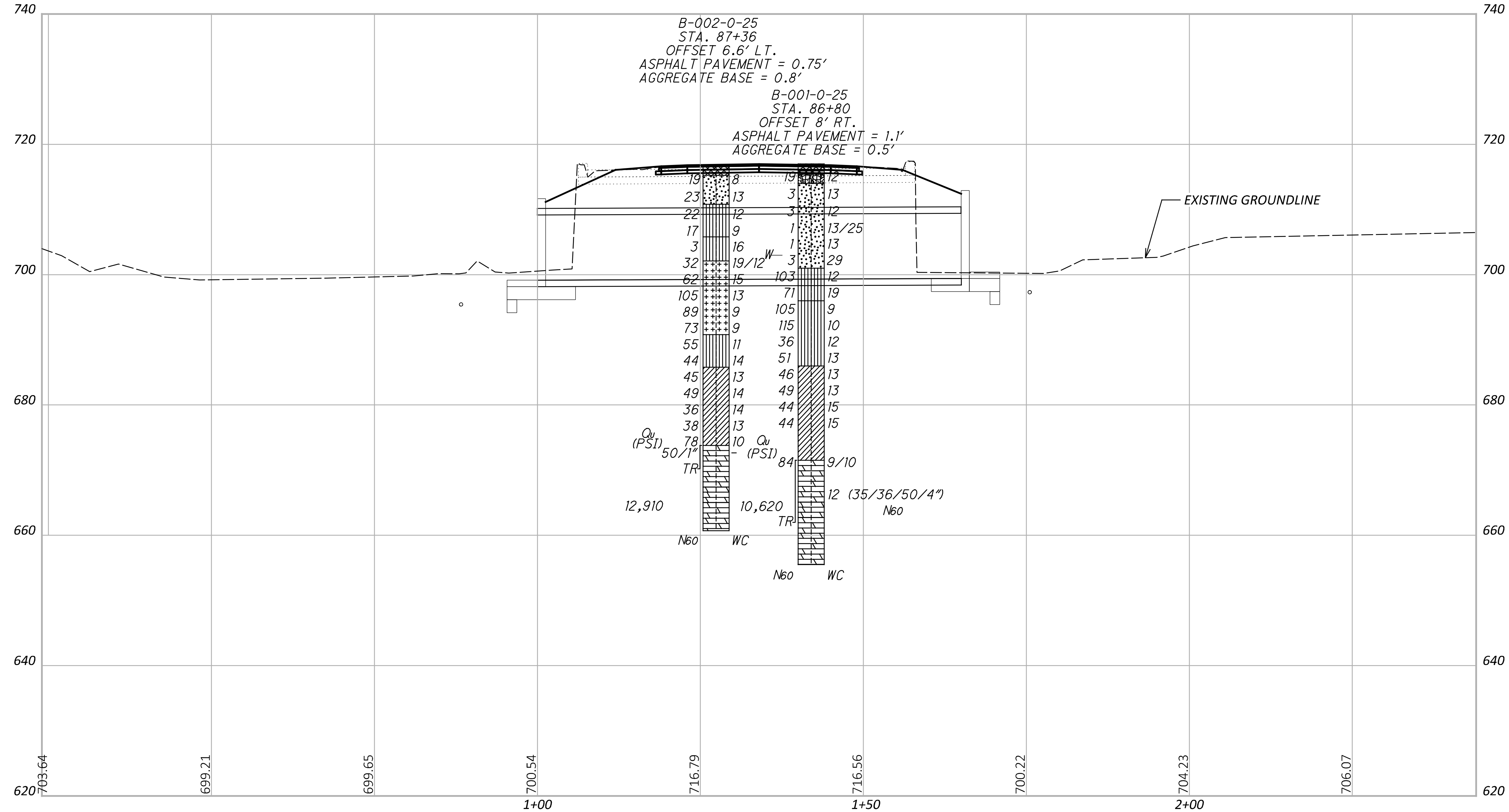
HORIZONTAL SCALE IN FEET
0 5 10 20



GEOTECHNICAL PROFILE - CULVERT
SAN-101-1.65 OVER RACOON CREEK - PROFILE

DESIGN AGENCY

Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200

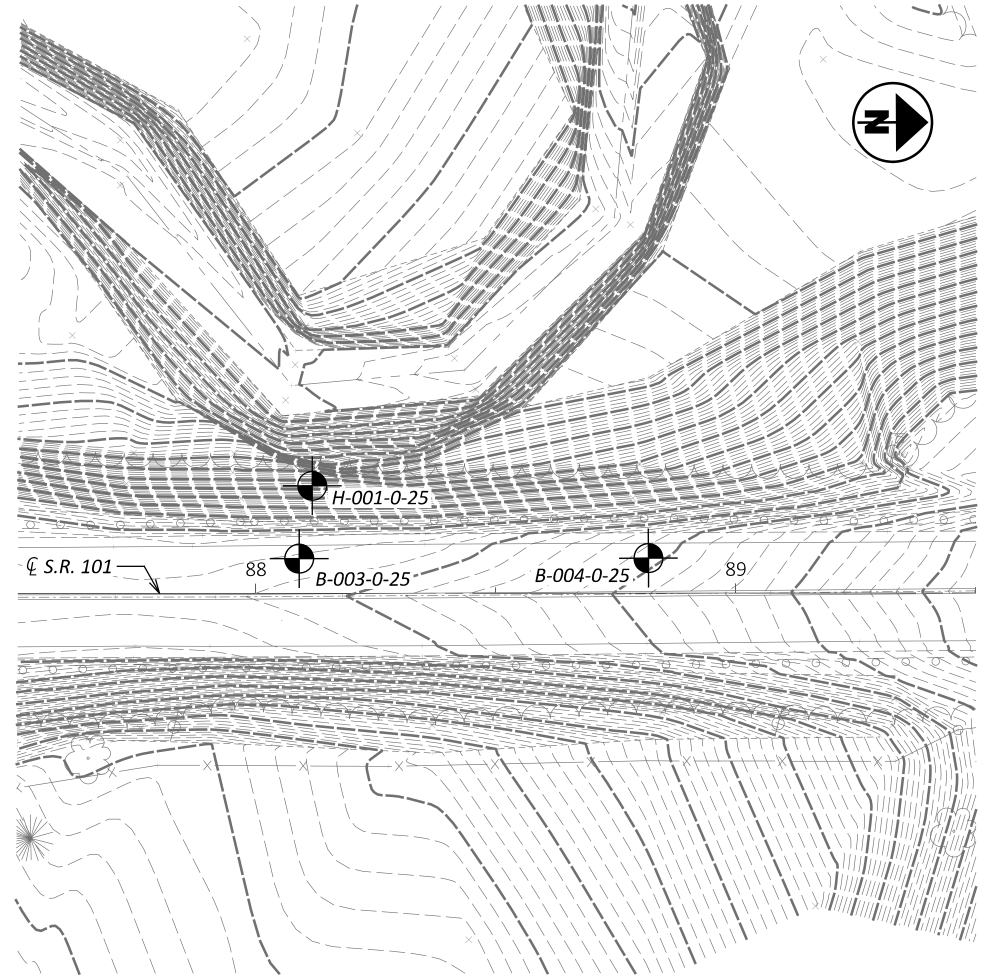
DESIGNER
MSJ

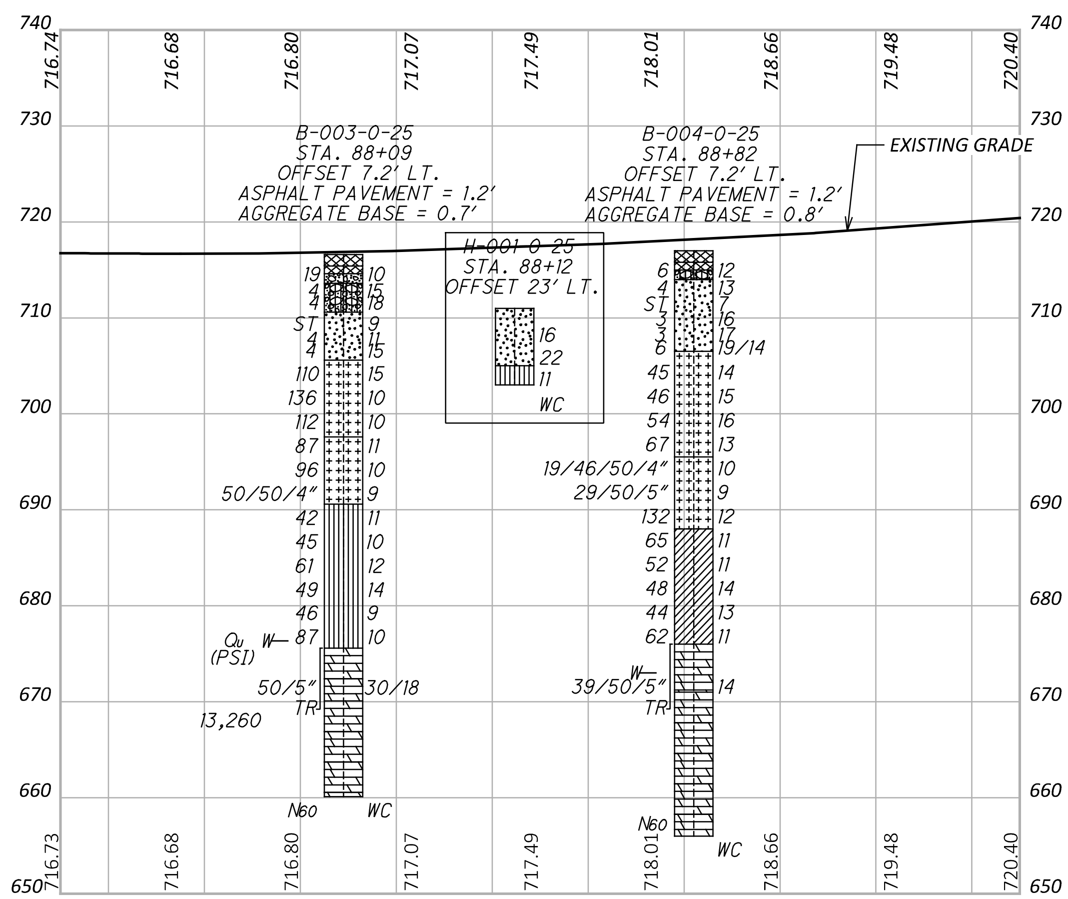
REVIEWER
EMK 12-02-25

PROJECT ID
107719

SUBSET	TOTAL
0	0

SHEET	TOTAL
P.3	15





HORIZONTAL SCALE IN FEET
0 10 20 40

GEOTECHNICAL PROFILE - ROADWAY
SAN-101-1.65 - STA. 87+50.00 TO STA. 89+50.00

DESIGN AGENCY
Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200

DESIGNER	MSJ
REVIEWER	EMK 12-02-25
PROJECT ID	107719
SUBSET / TOTAL	0 / 0
SHEET / TOTAL	P.4 / 15

SAN-101-1.65

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 12/2/2025 TIME: 2:59:00 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107719 PRODUCT: OpenRoadsDesigner 24.00.00.205
pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 02\Sandusky\107719\401-Engineering_Stantec\Geotechnical\Sheets\107719_ZL001.dgn

PROJECT: SAN-101-01.65	DRILLING FIRM / OPERATOR: TERRACON / A. FAY	DRILL RIG: MOBILE B-57 (#1059)	STATION / OFFSET: 86+80, 8' RT.	EXPLORATION ID B-001-0-25
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / GK	HAMMER: MOBILE AUTOMATIC	ALIGNMENT: SR 101	
PID: 107719 SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/31/25	ELEVATION: 717.0 (MSL) EOB: 61.5 ft.	PAGE 1 OF 2
START: 6/17/25 END: 6/17/25	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87.1	LAT / LONG: 41.277956, -82.975071	

MATERIAL DESCRIPTION AND NOTES	ELEV. 717.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT, 13 INCHES	715.9																	
AGGREGATE BASE, 6 INCHES	715.4																	
MEDIUM DENSE, DARK BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP	714.0	2	7 7 6	19	87	SS-1	-	31	9	35	16	9	NP	NP	NP	12	A-2-4 (0)	
VERY LOOSE, BROWN TO GRAY, **COARSE AND FINE SAND**, TRACE TO LITTLE GRAVEL, TRACE TO LITTLE SILT, LITTLE CLAY, MOIST TO WET		5	1 1 1	3	47	SS-2	-	9	11	56	10	14	16	15	1	13	A-3a (0)	
		7	1 1 1	3	47	SS-3	1.00	-	-	-	-	-	-	-	-	12	A-3a (V)	
		9	1 1 0	1	80	SS-4A	-	-	-	-	-	-	-	-	-	13	A-3a (V)	
		10				SS-4B	-	-	-	-	-	-	-	-	-	25	A-3a (V)	
		12	0 1 0	1	33	SS-5	-	-	-	-	-	-	-	-	-	13	A-3a (V)	
		W 703.0 (14)	0 1 1	3	100	SS-6	-	16	9	48	14	13	NP	NP	NP	29	A-3a (0)	
	701.0																	
VERY DENSE, GRAY, **SANDY SILT**, TRACE GRAVEL, LITTLE CLAY, DAMP [GLACIAL TILL]		17	8 31 40	103	80	SS-7	-	-	-	-	-	-	-	-	-	12	A-4a (V)	
SS-8: WET		19	17 23 26	71	100	SS-8	-	1	0	46	42	11	NP	NP	NP	19	A-4a (4)	
	696.0																	
HARD, GRAY, **SANDY SILT**, TRACE GRAVEL, SOME CLAY, DAMP [GLACIAL TILL]		22	20 32 40	105	100	SS-9	4.5+	-	-	-	-	-	-	-	-	9	A-4a (V)	
		24	18 31 48	115	100	SS-10	4.5+	-	-	-	-	-	-	-	-	10	A-4a (V)	
		27	13 12 13	36	100	SS-11	4.5+	9	6	13	41	31	21	13	8	12	A-4a (7)	
		29	10 12 23	51	100	SS-12	4.5+	-	-	-	-	-	-	-	-	13	A-4a (V)	
	686.0																	
HARD, GRAY, **SILT AND CLAY**, SOME GRAVEL, TRACE SAND, DAMP [GLACIAL TILL]		32	10 12 20	46	60	SS-13	4.5+	-	-	-	-	-	-	-	-	13	A-6a (V)	
		34	10 13 21	49	80	SS-14	4.5+	27	3	5	27	38	30	18	12	13	A-6a (7)	
		37	6 14 16	44	73	SS-15	4.5+	-	-	-	-	-	-	-	-	15	A-6a (V)	
		39	6 12 18	44	100	SS-16	4.5+	-	-	-	-	-	-	-	-	15	A-6a (V)	
	671.5	TR (45)	50 27 31	84	100	SS-17A	4.5+	-	-	-	-	-	-	-	-	9	A-6a (V)	
DOLOMITE, GRAY, AUGERABLE.		46				SS-17B	-	-	-	-	-	-	-	-	-	10	Rock (V)	
		50	35 36 50/4"	-	100	SS-18	-	-	-	-	-	-	-	-	-	12	Rock (V)	
	665.5																	
DOLOMITE, GRAY, MODERATELY TO HIGHLY WEATHERED, MODERATELY STRONG TO STRONG, FINE GRAINED, THIN BEDDED, MODERATELY TO HIGHLY FRACTURED; RQD 16%, REC 52%. FROM 52.6 FT. TO 53.0 FT., UCR = 10,620 PSI		54	20		50	NQ2-1											CORE	
	660.0	57																

BORING CONTINUES

GEOTECHNICAL PROFILE - CULVERT
BORING LOG B-001-0-25

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 12/2/2025 TIME: 3:00:53 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107719 PRODUCT: OpenRoadsDesigner 24.00.00.205
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PROJECT: SAN-101-01.65	DRILLING FIRM / OPERATOR: TERRACON / A. FAY	DRILL RIG: MOBILE B-57 (#1059)	STATION / OFFSET: 86+80, 8' RT.
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / GK	HAMMER: MOBILE AUTOMATIC	ALIGNMENT: SR 101
PID: 107719 SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/31/25	ELEVATION: 717.0 (MSL) EOB: 61.5 ft.
START: 6/17/25 END: 6/17/25	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87.1	LAT / LONG: 41.277956, -82.975071

EXPLORATION ID B-001-0-25 — PAGE 2 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 660.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
(CONTINUED) **DOLOMITE**, GRAY, MODERATELY TO HIGHLY WEATHERED, MODERATELY STRONG TO STRONG, FINE GRAINED, THIN BEDDED, MODERATELY TO HIGHLY FRACTURED; RQD 16%, REC 52%. FROM 52.6 FT. TO 53.0 FT., UCR = 10,620 PSI	655.5	57 58 59 60 61 EOB	12		54	NQ2-2											CORE	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; CEMENT/BENTONITE GROUT

B-001-0-25

Run #:	Depth		Recovery		RQD	
NQ2-1	51.5'	56.5'	30.0"/60.0"	50%	12.0"/60.0"	20%
NQ2-2	56.5'	61.5'	32.4"/60.0"	54%	7.2"/60.0"	12%

SAN-101-1.65 PID: 107719

DESIGN AGENCY: Stantec, 10200 Alliance Road, Suite 300, Cincinnati, OH 45242, (513) 842-8200
DESIGNER: MSJ
REVIEWER: EMK 12-02-25
PROJECT ID: 107719
SUBSET 0 TOTAL 0
SHEET P.6 TOTAL 15

GEOTECHNICAL PROFILE - CULVERT
BORING LOG B-001-0-25 (CONTINUED)

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 12/2/2025 TIME: 3:02:50 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107719 PRODUCT: OpenRoadsDesigner 24.00.00.205
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PROJECT: SAN-101-01.65	DRILLING FIRM / OPERATOR: TERRACON / A. FAY	DRILL RIG: MOBILE B-57 (#1059)	STATION / OFFSET: 87+36, 6.6' LT.
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / GK	HAMMER: MOBILE AUTOMATIC	ALIGNMENT: SR 101
PID: 107719 SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/31/25	ELEVATION: 716.8 (MSL) EOB: 56.1 ft.
START: 6/19/25 END: 6/19/25	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87.1	LAT / LONG: 41.278110, -82.975124

EXPLORATION ID: B-002-0-25 — PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)
	716.6																
ASPHALT, 9 INCHES	715.9																
AGGREGATE BASE, 10 INCHES	715.1																
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, TRACE GRAVEL, TRACE SILT, TRACE CLAY, DAMP TO MOIST		2	11 6 7	19	80	SS-1	-	-	-	-	-	-	-	-	-	8	A-3a (V)
		5	5 7 9	23	100	SS-2	-	3	12	67	8	10	NP	NP	NP	13	A-3a (0)
	710.6																
VERY STIFF, BROWN TO GRAY, **SANDY SILT**, TRACE GRAVEL, LITTLE CLAY, DAMP		7	6 7 8	22	80	SS-3	3.00	10	10	25	37	18	18	14	4	12	A-4a (4)
		10	5 7 5	17	40	SS-4	3.00	-	-	-	-	-	-	-	-	9	A-4a (V)
	705.6																
VERY LOOSE, BROWN TO GRAY, **SANDY SILT**, TRACE GRAVEL, LITTLE CLAY, MOIST		12	2 1 1	3	100	SS-5	1.00	6	10	42	25	17	NP	NP	NP	16	A-4a (1)
		14	5 5 17	32	80	SS-6A	-	-	-	-	-	-	-	-	-	19	A-4a (V)
	701.9																
VERY DENSE, GRAY TO BROWN, **SILT**, LITTLE SAND, LITTLE CLAY, DAMP [GLACIAL TILL]		15				SS-6B	-	-	-	-	-	-	-	-	-	12	A-4b (V)
		17	13 18 25	62	100	SS-7	-	0	0	20	63	17	NP	NP	NP	15	A-4b (8)
		20	11 25 47	105	100	SS-8	4.5+	-	-	-	-	-	-	-	-	13	A-4b (V)
		22	20 26 35	89	100	SS-9	4.5+	-	-	-	-	-	-	-	-	9	A-4b (V)
		25	16 28 22	73	100	SS-10	4.5+	-	-	-	-	-	-	-	-	9	A-4b (V)
	690.6																
HARD, GRAY, **SANDY SILT**, TRACE GRAVEL, SOME CLAY, DAMP TO MOIST [GLACIAL TILL]		27	18 18 20	55	100	SS-11	4.5+	10	8	14	35	33	22	13	9	11	A-4a (7)
		30	6 13 17	44	87	SS-12	4.5+	-	-	-	-	-	-	-	-	14	A-4a (V)
	685.6																
HARD, GRAY, **SILT AND CLAY**, SOME GRAVEL, TRACE SAND, DAMP [GLACIAL TILL]		32	8 13 18	45	100	SS-13	4.5+	27	4	6	25	38	30	18	12	13	A-6a (6)
		35	8 14 20	49	93	SS-14	4.5+	-	-	-	-	-	-	-	-	14	A-6a (V)
		37	7 10 15	36	87	SS-15	4.5+	-	-	-	-	-	-	-	-	14	A-6a (V)
		40	5 9 17	38	80	SS-16	4.5+	-	-	-	-	-	-	-	-	13	A-6a (V)
		42	22 24 30	78	100	SS-17	4.5+	-	-	-	-	-	-	-	-	10	A-6a (V)
	673.6	TR															
DOLOMITE, GRAY, AUGERABLE.		44	50/1"	-	0	SS-18	-	-	-	-	-	-	-	-	-	-	Rock (V)
	671.0																
DOLOMITE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, STRONG, FINE GRAINED, THIN BEDDED, MODERATELY TO HIGHLY FRACTURED; RQD 65%, REC 89%.		46–50	55		75	NQ2-1											CORE
FROM 52.1 FT. TO 52.5 FT., UCR = 12,910 PSI		50–55	66		96	NQ2-2											CORE
		55–56	87		100	NQ2-3											CORE
	660.5	EOB															

NOTES: NO GROUNDWATER WAS ENCOUNTERED DURING DRILLING.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; CEMENT/BENTONITE GROUT

DESIGN AGENCY: Stantec, 10200 Alliance Road, Suite 300, Cincinnati, OH 45242, (513) 842-8200

DESIGNER: MSJ — REVIEWER: EMK 12-02-25 — PROJECT ID: 107719 — SUBSET 0 TOTAL 0

GEOTECHNICAL PROFILE - CULVERT
BORING LOG B-002-0-25

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 12/2/2025 TIME: 3:04:44 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107719 PRODUCT: OpenRoadsDesigner 24.00.00.205
pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 02\Sandusky\107719\401-Engineering_Stantec\Geotechnical\Sheets\107719_ZL004.dgn

B-002-0-25

Run #:	Depth		Recovery		RQD	
NQ2-1	45.6'	49.6'	36.0"/48.0"	75%	26.4"/48.0"	55%
NQ2-2	49.6'	54.6'	57.6"/60.0"	96%	39.6"/60.0"	66%
NQ2-3	54.6'	56.1'	18.0"/18.0"	100%	15.6"/18.0"	87%

SAN-101-1.65 PID: 107719

GEOTECHNICAL PROFILE - CULVERT
BORING LOG B-002-0-25 (ROCK CORE PHOTO)

SAN-101-1.65

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 12/2/2025 TIME: 3:06:27 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107719 PRODUCT: OpenRoadsDesigner 24.00.00.205
pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 02\Sandusky\107719\401-Engineering_Stantec\Geotechnical\Sheets\107719_ZL005.dgn

PROJECT: SAN-101-01.65	DRILLING FIRM / OPERATOR: TERRACON / A. FAY	DRILL RIG: MOBILE B-57 (#1059)	STATION / OFFSET: 88+09, 7.2' LT.	EXPLORATION ID B-003-0-25
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / GK	HAMMER: MOBILE AUTOMATIC	ALIGNMENT: SR 101	
PID: 107719 SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/31/25	ELEVATION: 716.6 (MSL) EOB: 56.5 ft.	PAGE 1 OF 1
START: 6/20/25 END: 6/20/25	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87.1	LAT / LONG: 41.278310, -82.975126	

MATERIAL DESCRIPTION AND NOTES	ELEV. 716.6
ASPHALT, 14 INCHES	715.5
AGGREGATE BASE, 8 INCHES	714.9
MEDIUM DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP	713.6
VERY LOOSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, LITTLE CLAY, MOIST	710.6
VERY LOOSE, BROWN, **COARSE AND FINE SAND**, TRACE GRAVEL, TRACE SILT, TRACE CLAY, DAMP TO MOIST	705.6
VERY DENSE, GRAY, **SANDY SILT**, LITTLE GRAVEL, LITTLE CLAY, DAMP [GLACIAL TILL]	697.6
HARD, GRAY, **SILT**, TRACE SAND, LITTTLE CLAY, DAMP [GLACIAL TILL]	690.6
HARD, GRAY, **SANDY SILT**, SOME GRAVEL, "AND" CLAY, DAMP [GLACIAL TILL]	675.6
DOLOMITE, GRAY, AUGERABLE.	670.1
DOLOMITE, GRAY, HIGHLY TO MODERATELY WEATHERED, STRONG, FINE GRAINED, THIN BEDDED, HIGHLY TO MODERATELY FRACTURED; RQD 33%, REC 79%. FROM 48.7 FT. TO 49.1 FT., UCR = 13,260 PSI	660.1

DEPTHS: W 675.6 TR; EOB

DEPTH	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)
2	10 9 4	19	53	SS-1	-	42	14	23	15	6	NP	NP	NP	10	A-1-b (0)
4	1 1 2	4	60	SS-2	0.50	18	19	31	17	15	NP	NP	NP	15	A-2-4 (0)
5	1 1 2	4	100	SS-3	0.50	-	-	-	-	-	-	-	-	18	A-2-4 (V)
7			100	ST-1	0.50	7	10	67	6	10	NP	NP	NP	9	A-3a (0)
9	1 2 1	4	87	SS-4	-	-	-	-	-	-	-	-	-	11	A-3a (V)
10	1 1 2	4	40	SS-5	-	-	-	-	-	-	-	-	-	15	A-3a (V)
13	16 29 47	110	100	SS-6	4.5+	12	5	14	49	20	NP	NP	NP	15	A-4a (7)
15	25 44 50	136	100	SS-7	4.5+	-	-	-	-	-	-	-	-	10	A-4a (V)
18	26 37 40	112	100	SS-8	4.5+	-	-	-	-	-	-	-	-	10	A-4a (V)
20	26 30 30	87	93	SS-9	4.5+	0	1	9	70	20	20	15	5	11	A-4b (8)
23	14 25 41	96	93	SS-10	4.5+	-	-	-	-	-	-	-	-	10	A-4b (V)
25	26 50 50/4"	-	90	SS-11	4.5+	-	-	-	-	-	-	-	-	9	A-4b (V)
28	9 14 15	42	87	SS-12	4.5+	22	7	10	25	36	26	16	10	11	A-4a (5)
30	8 12 19	45	93	SS-13	4.5+	-	-	-	-	-	-	-	-	10	A-4a (V)
33	11 17 25	61	87	SS-14	4.5+	-	-	-	-	-	-	-	-	12	A-4a (V)
35	8 13 21	49	80	SS-15	4.5+	-	-	-	-	-	-	-	-	14	A-4a (V)
38	10 13 19	46	100	SS-16	4.5+	-	-	-	-	-	-	-	-	9	A-4a (V)
40	7 15 45	87	100	SS-17	4.5+	-	-	-	-	-	-	-	-	10	A-4a (V)
45	50/5"	-	100	SS-18A	-	-	-	-	-	-	-	-	-	30	Rock (V)
				SS-18B	-	-	-	-	-	-	-	-	-	18	Rock (V)
49	40		84	NQ2-1											CORE
54	26		74	NQ2-2											CORE

HOLE SEALED

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; CEMENT/BENTONITE GROUT

DESIGN AGENCY: Stantec, 10200 Alliance Road, Suite 300, Cincinnati, OH 45242, (513) 842-8200
DESIGNER: MSJ
REVIEWER: EMK 12-02-25
PROJECT ID: 107719
SUBSET 0 TOTAL 0
SHEET P.9 TOTAL 15

GEOTECHNICAL PROFILE - CULVERT
BORING LOG B-003-0-25

B-003-0-25

Run #:	Depth		Recovery		RQD	
NQ2-1	46.5'	51.5'	50.4"/60.0"	84%	24.0"/60.0"	40%
NQ2-2	51.5'	56.5'	44.4"/60.0"	74%	15.6"/60.0"	26%

SAN-101-1.65 PID: 107719

GEOTECHNICAL PROFILE - CULVERT
BORING LOG B-003-0-25 (ROCK CORE PHOTO)

DESIGN AGENCY
Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200

DESIGNER	MSJ
REVIEWER	EMK 12-02-25
PROJECT ID	107719
SUBSET 0	TOTAL 0
SHEET P.10	TOTAL 15

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 12/2/2025 TIME: 3:11:03 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107719 PRODUCT: OpenRoadsDesigner 24.00.00.205
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PROJECT: SAN-101-01.65	DRILLING FIRM / OPERATOR: TERRACON / A. FAY	DRILL RIG: MOBILE B-57 (#1059)	STATION / OFFSET: 88+82, 7.2' LT.	EXPLORATION ID B-004-0-25
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / GK	HAMMER: MOBILE AUTOMATIC	ALIGNMENT: SR 101	
PID: 107719 SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/31/25	ELEVATION: 717.0 (MSL) EOB: 61.0 ft.	PAGE 1 OF 2
START: 6/23/25 END: 6/23/25	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87.1	LAT / LONG: 41.278510, -82.975126	

MATERIAL DESCRIPTION AND NOTES	ELEV. (top 718.0)
ASPHALT, 14 INCHES	716.8
AGGREGATE BASE, 10 INCHES	716.0
LOOSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, LITTLE CLAY, DAMP	715.0
VERY LOOSE TO LOOSE, BROWN, **COARSE AND FINE SAND**, TRACE GRAVEL, TRACE SILT, TRACE CLAY, DAMP TO MOIST	707.5
DENSE TO VERY DENSE, BROWN TO GRAY, **SILT**, TRACE GRAVEL, LITTLE SAND, LITTLE TO SOME CLAY, DAMP TO MOIST [GLACIAL TILL]	696.5
HARD, BROWN TO GRAY, **SILT**, TRACE GRAVEL, TRACE SAND, COME CLAY, DAMP [GLACIAL TILL]	689.0
HARD, GRAY, **SILT AND CLAY**, LITTLE GRAVEL, LITTLE SAND, DAMP [GLACIAL TILL]	677.0
DOLOMITE, GRAY, AUGERABLE.	672.0
DOLOMITE, GRAY, HIGHLY WEATHERED, STRONG, FINE GRAINED, THIN BEDDED, HIGHLY FRACTURED; RQD 0%, REC 23%.	661.0

DEPTHS: TR at 41; W 674.0 at 44; depths 1–57.

SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)
7 3 1	6	53	SS-1	0.25	18	16	32	18	16	17	12	5	12	A-2-4 (0)
1 1 2	4	40	SS-2	0.25	-	-	-	-	-	-	-	-	13	A-3a (V)
		100	ST-1	0.25	5	19	61	6	9	NP	NP	NP	7	A-3a (0)
1 1 1	3	100	SS-3	0.25	-	-	-	-	-	-	-	-	16	A-3a (V)
1 1 1	3	87	SS-4	0.25	-	-	-	-	-	-	-	-	17	A-3a (V)
1 1 3	6	100	SS-5A	-	-	-	-	-	-	-	-	-	19	A-3a (V)
			SS-5B	1.50	-	-	-	-	-	-	-	-	14	A-4b (V)
6 17 14	45	100	SS-6	4.00	2	1	12	63	22	NP	NP	NP	14	A-4b (8)
9 14 18	46	100	SS-7	4.5+	-	-	-	-	-	-	-	-	15	A-4b (V)
11 16 21	54	93	SS-8	-	0	0	18	69	13	NP	NP	NP	16	A-4b (8)
14 19 27	67	100	SS-9	4.5+	-	-	-	-	-	-	-	-	13	A-4b (V)
19 46 50/4"	-	100	SS-10	4.5+	1	1	8	66	24	20	17	3	10	A-4b (8)
29 50/5"	-	100	SS-11	-	-	-	-	-	-	-	-	-	9	A-4b (V)
29 41 50	132	100	SS-12	-	-	-	-	-	-	-	-	-	12	A-4b (V)
16 21 24	65	100	SS-13	4.5+	16	8	11	27	38	27	14	13	11	A-6a (7)
10 15 21	52	93	SS-14	4.5+	-	-	-	-	-	-	-	-	11	A-6a (V)
9 14 19	48	80	SS-15	4.5+	-	-	-	-	-	-	-	-	14	A-6a (V)
7 16 14	44	100	SS-16	4.5+	-	-	-	-	-	-	-	-	13	A-6a (V)
17 20 23	62	33	SS-17	4.5+	-	-	-	-	-	-	-	-	11	A-6a (V)
39 50/5"	-	65	SS-18	-	-	-	-	-	-	-	-	-	14	Rock (V)
0		22	NQ2-1											CORE
0		24	NQ2-2											CORE

HOLE SEALED

BORING CONTINUES

GEOTECHNICAL PROFILE - CULVERT
BORING LOG B-004-0-25

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 12/2/2025 TIME: 3:12:59 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107719 PRODUCT: OpenRoadsDesigner 24.00.00.205
pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 02\Sandusky\107719\401-Engineering_Stantec\Geotechnical\Sheets\107719_ZL008.dgn

PROJECT: SAN-101-01.65	DRILLING FIRM / OPERATOR: TERRACON / A. FAY	DRILL RIG: MOBILE B-57 (#1059)	STATION / OFFSET: 88+82, 7.2' LT.	EXPLORATION ID B-004-0-25
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / GK	HAMMER: MOBILE AUTOMATIC	ALIGNMENT: SR 101	
PID: 107719 SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/31/25	ELEVATION: 717.0 (MSL) EOB: 61.0 ft.	PAGE 2 OF 2
START: 6/23/25 END: 6/23/25	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87.1	LAT / LONG: 41.278510, -82.975126	

MATERIAL DESCRIPTION AND NOTES	ELEV. 661.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
(CONTINUED) **DOLOMITE**, GRAY, HIGHLY WEATHERED, STRONG, FINE GRAINED, THIN BEDDED, HIGHLY FRACTURED; RQD 0%, REC 23%.	657.0	57, 58, 59, 60, 61 EOB	0		22	NQ2-3											CORE	

NOTES: NONE
ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; CEMENT/BENTONITE GROUT

B-004-0-25

Run #:	Depth		Recovery		RQD	
NQ2-1	46.0'	51.0'	13.2"/60.0"	22%	0.0"/60.0"	0%
NQ2-2	51.0'	56.0'	14.4"/60.0"	24%	0.0"/60.0"	0%
NQ2-3	56.0'	61.0'	13.2"/60.0"	22%	0.0"/60.0"	0%
SAN-101-1.65 PID: 107719						

GEOTECHNICAL PROFILE - CULVERT
BORING LOG B-004-0-25 (CONTINUED)

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 12/2/2025 TIME: 3:14:56 PM PLTDRV: OHDOT_PDF.pltcfg PENTBL: OHDOT_Pen.tbl USER: Matt.Jennings@stantec.com WORKSPACE: OHDOTCEv02 WORKSET: 107719 PRODUCT: OpenRoadsDesigner 24.00.00.205
pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 02\Sandusky\107719\401-Engineering_Stantec\Geotechnical\Sheets\107719_ZL009.dgn

PROJECT: SAN-101-01.65	DRILLING FIRM / OPERATOR: TERRACON / A. FAY	DRILL RIG: MOBILE B-57 (#1059)	STATION / OFFSET: 88+12, 23' LT.	EXPLORATION ID H-001-0-25
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / GK	HAMMER: MOBILE AUTOMATIC	ALIGNMENT: SR 101	
PID: 107719 SFN: N/A	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/31/25	ELEVATION: 711.0 (MSL) EOB: 8.0 ft.	PAGE 1 OF 1
START: 6/19/25 END: 6/19/25	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87.1	LAT / LONG: 41.278456, -82.975179	

MATERIAL DESCRIPTION AND NOTES	ELEV. 711.0	DEPTHS	SPT/ RQD		REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	ABAN-DONED
BROWN, **COARSE AND FINE SAND**, SOME GRAVEL, LITTLE SILT, LITTLE CLAY, WET		1–2																
		3			100	GS-1	-	21	18	34	14	13	16	13	3	16	A-3a (0)	
	705.0	5–6			100	GS-2	-	-	-	-	-	-	-	-	-	22	A-3a (V)	
BROWN, **SANDY SILT**, TRACE GRAVEL, SOME CLAY, DAMP	703.0	7–8 EOB			100	GS-3	-	1	0	45	33	21	25	19	6	11	A-4a (4)	

NOTES: NO GROUNDWATER WAS ENCOUNTERED DURING HAND SAMPLING.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: NOT RECORDED

DESIGN AGENCY
Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200

DESIGNER MSJ
REVIEWER EMK 12-02-25
PROJECT ID 107719
SUBSET 0 TOTAL 0
SHEET P.13 TOTAL 15

GEOTECHNICAL PROFILE - CULVERT
BORING LOG H-001-0-25

Uniaxial Compressive Strength of Intact Rock Core Specimens
ASTM D 7012, Method C

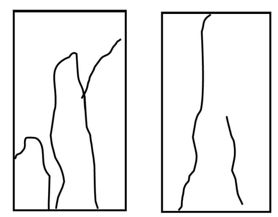
Project Name	02C_SAN-101-1.65	Project Number	175578434
Lithology	Interbedded Limestone and Siltstone, light gray, strong	Lab ID	UCR-1113
Hole Number	B-001-0-25	Depth (ft)	52.6'-53.0'
Date Received	07/09/2025		
Temperature (°C)	24.5	Moisture Condition	As Prepared, Moist
Date Tested	07/28/2025		

Side Planeness	N/A	Height (in)	4.377	Wet Unit Weight (pcf)	159.7
Perpendicularity	N/A	Diameter (in)	1.983	Dry Unit Weight (pcf)	N/A
End Planeness	N/A	Area (in^2)	3.088	Moisture Content (%)	N/A
Parallelism	N/A				

Dimensions were not confirmed.

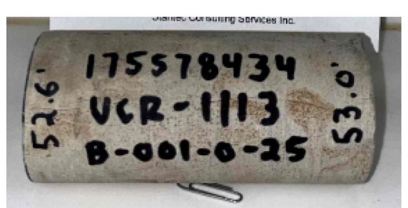
Loading Rate (lbf/sec)	50
Peak Load (lbf)	32800
Failure Type	Cone and Split
Compressive Strength (psi)	10620
Compressive Strength (psf)	1529280
Compressive Strength (tsf)	765

Failure Sketches

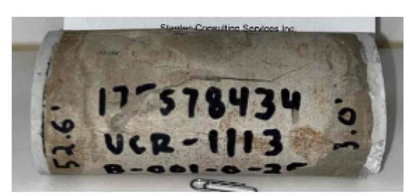


Comments: Fragile nature of specimen inhibited preparation, required capping of ends with Hydro-Stone. Dimensional tolerances were not confirmed.

CORE PREP



POST TEST



Reviewed By REL

Uniaxial Compressive Strength of Intact Rock Core Specimens
ASTM D 7012, Method C

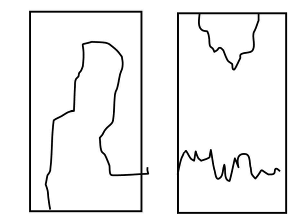
Project Name	02C_SAN-101-1.65	Project Number	175578434
Lithology	Dolostone, light gray, strong	Lab ID	UCR-1114
Hole Number	B-002-0-25	Depth (ft)	52.1'-52.5'
Date Received	07/09/2025		
Temperature (°C)	24.5	Moisture Condition	As Prepared, Moist
Date Tested	07/28/2025		

Side Planeness	N/A	Height (in)	4.319	Wet Unit Weight (pcf)	156.6
Perpendicularity	N/A	Diameter (in)	1.978	Dry Unit Weight (pcf)	N/A
End Planeness	N/A	Area (in^2)	3.071	Moisture Content (%)	N/A
Parallelism	N/A				

Dimensions were not confirmed.

Loading Rate (lbf/sec)	120
Peak Load (lbf)	39660
Failure Type	Cone
Compressive Strength (psi)	12910
Compressive Strength (psf)	1859040
Compressive Strength (tsf)	930

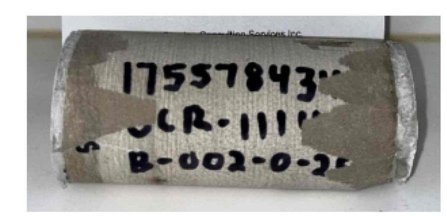
Failure Sketches



Comments: Fragile nature of specimen inhibited preparation, required capping of ends with Hydro-Stone. Dimensional tolerances were not confirmed.

CORE PREP

POST TEST



Reviewed By REL

GEOTECHNICAL PROFILE - CULVERT
LABORATORY TEST DATA

DESIGN AGENCY
Stantec
10200 Alliance Road, Suite 300
Cincinnati, OH 45242
(513) 842-8200

DESIGNER	MSJ
REVIEWER	EMK 12-02-25
PROJECT ID	107719
SUBSET / TOTAL	0 / 0
SHEET / TOTAL	P.14 / 15

SAN-101-1.65

Uniaxial Compressive Strength of Intact Rock Core Specimens

ASTM D 7012, Method C

Project Name	02C_SAN-101-1.65	Project Number	175578434
Lithology	Dolostone, light gray, strong	Lab ID	UCR-1115
Hole Number	B-003-0-25 Depth (ft) 48.7'-49.1'	Date Received	07/09/2025

Temperature (^{o}C) 24.5 Moisture Condition As Prepared, Moist Date Tested 07/28/2025

Side Planeness	N/A	Height (in)	4.537	Wet Unit Weight (pcf)	165.5
Perpendicularity	N/A	Diameter (in)	1.960	Dry Unit Weight (pcf)	N/A
End Planeness	N/A	Area (in^2)	3.018	Moisture Content (%)	N/A
Parallelism	N/A				

Dimensions were not confirmed.

Loading Rate (lbf/sec) 100

Peak Load (lbf) 40010

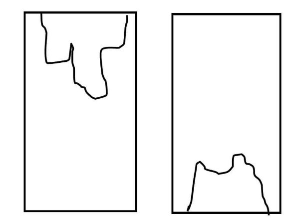
Failure Type Cone

Compressive Strength (psi) 13260

Compressive Strength (psf) 1909440

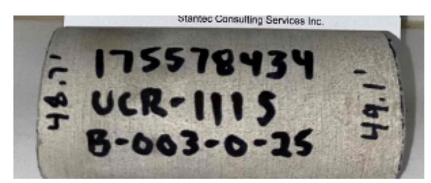
Compressive Strength (tsf) 954

Failure Sketches



Comments Fragile nature of specimen inhibited preparation, required capping of ends with Hydro-Stone. Dimensional tolerances were not confirmed.

CORE PREP



POST TEST

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DESIGNER MSJ
REVIEWER EMK 12-02-25

PROJECT ID 107719

SUBSET 0 TOTAL 0

Appendix B Bearing Capacity Calculations

Material Property Estimation Using N_{60} Values

B-001-0-25

Top Depth	Bot Depth	Avg SPT Depth	Blows 1st	Blows 2nd	Blows 3rd	N-value	Hammer Eff. (%)	N_{60}	ODOT Class.	σ'_v (ksf)	Unit Weight (pcf)	C_N	$N1_{60}$	φ (AASHTO)	ODOT Correction	φ (ODOT)	S_u (psf)
4	5.5	5	1	1	1	2	87.1	3	A-3a	0.530	116	1.45	4	29.5	-0.5	29	N/A
6.5	8	7.5	1	1	1	2	87.1	3	A-3a	0.795	116	1.31	4	29.5	-0.5	29	N/A
9	10.5	10	1	1	0	1	87.1	1	A-3a	1.060	116	1.21	2	29.5	-0.5	29	N/A
11.5	13	12.5	0	1	0	1	87.1	1	A-3a	1.325	116	1.14	2	29.5	-0.5	29	N/A
14	15.5	15	0	1	1	2	87.1	3	A-3a	1.538	116	1.09	3	29.5	-0.5	29	N/A
16.5	18	17.5	8	31	40	71	87.1	103	A-4a	1.660	130	1.06	110	40.5	-2.5	38	N/A
19	20.5	20	17	23	26	49	87.1	71	A-4a	1.663	130	1.06	76	40.5	-2.5	38	N/A
21.5	23	22.5	20	32	40	72	87.1	105	A-4a		130	N/A	N/A	N/A	N/A	N/A	13065
24	25.5	25	18	31	48	79	87.1	115	A-4a		130	N/A	N/A	N/A	N/A	N/A	14335.2083
26.5	28	27.5	13	12	13	25	87.1	36	A-4a		130	N/A	N/A	N/A	N/A	N/A	4536.45833
29	30.5	30	10	12	23	35	87.1	51	A-4a		130	N/A	N/A	N/A	N/A	N/A	6351.04167
31.5	33	32.5	10	12	20	32	87.1	46	A-6a		130	N/A	N/A	N/A	N/A	N/A	5806.66667
34	35.5	35	10	13	21	34	87.1	49	A-6a		130	N/A	N/A	N/A	N/A	N/A	6169.58333
36.5	38	37.5	6	14	16	30	87.1	44	A-6a		130	N/A	N/A	N/A	N/A	N/A	5443.75
39	40.5	40	6	12	18	30	87.1	44	A-6a		130	N/A	N/A	N/A	N/A	N/A	5443.75

B-001 — Water Depth 14 ft; Unit Weight Water 62.4 pcf

Bearing layer (rows 16.5–20.5)

Unrealistic values, assume 3,000 tsf from previous experience with glacial till

Recommend friction angle of 32 degrees in bearing soil

B-002-0-25

Top Depth	Bot Depth	Avg SPT Depth	Blows 1st	Blows 2nd	Blows 3rd	N-value	Hammer Eff. (%)	N_{60}	ODOT Class.	σ'_v (ksf)	Unit Weight (pcf)	C_N	$N1_{60}$	φ (AASHTO)	ODOT Correction	φ (ODOT)	S_u (psf)
1.5	3	2.5	11	6	7	13	87.1	19	A-3a	0.280	122	1.66	31	40.025	-0.5	39.525	N/A
4	5.5	5	5	7	9	16	87.1	23	A-3a	0.560	122	1.43	33	40.075	-0.5	39.575	N/A
6.5	8	7.5	6	7	8	15	87.1	22	A-4a	0.840	122	N/A	N/A	N/A	N/A	N/A	2721.875
9	10.5	10	5	7	5	12	87.1	17	A-4a	1.120	122	N/A	N/A	N/A	N/A	N/A	2177.5
11.5	13	12.5	2	1	1	2	87.1	3	A-4a	1.400	122	1.12	3	29.5	-2.5	27	N/A
14	15.5	15	5	5	17	22	87.1	32	A-4a	1.680	122	1.06	34	40.1	-2.5	37.6	N/A
16.5	18	17.5	13	18	25	43	87.1	62	A-4b	1.976	130	1.01	63	40.5	-2.5	38	N/A
19	20.5	20	11	25	47	72	87.1	105	A-4b	2.276	130	0.96	100	40.5	-2.5	38	N/A
21.5	23	22.5	20	26	35	61	87.1	89	A-4b	2.576	130	0.92	81	40.5	-2.5	38	N/A
24	25.5	25	16	28	22	50	87.1	73	A-4b	2.876	130	0.88	64	40.5	-2.5	38	N/A
26.5	28	27.5	18	18	20	38	87.1	55	A-4a		130	N/A	N/A	N/A	N/A	N/A	6895.41667
29	30.5	30	6	13	17	30	87.1	44	A-4a		130	N/A	N/A	N/A	N/A	N/A	5443.75
31.5	33	32.5	8	13	18	31	87.1	45	A-6a		130	N/A	N/A	N/A	N/A	N/A	5625.20833
34	35.5	35	8	14	20	34	87.1	49	A-6a		130	N/A	N/A	N/A	N/A	N/A	6169.58333
36.5	38	37.5	7	10	15	25	87.1	36	A-6a		130	N/A	N/A	N/A	N/A	N/A	4536.45833
39	40.5	40	5	9	17	26	87.1	38	A-6a		130	N/A	N/A	N/A	N/A	N/A	4717.91667
41.5	43	42.5	22	24	30	54	87.1	78	A-6a		130	N/A	N/A	N/A	N/A	N/A	9798.75

B-002 — Water Depth ft

Bearing layer (rows 16.5–25.5)

Unrealistic values, assume 3,000 tsf from previous experience with glacial till

Bearing Capacity of Soil or Rock

Stantec

SAN-101-1.65
Undrained and drained since granular soil

Using AASHTO 2024 LRFD 10.6.3.1.2a

Performed by: James Samples 8/8/2025
Reviewed by: Jim Swindler 8/18/2025

Using data from B-001-0-25.

cohesion (c)=	0	psf	
friction angle=	32	degrees	
γf=	130	pcf	
γq=	120	pcf	
Nc=	35.5	Cwq=	0.81
Nq=	23.2	Cwγ=	0.5
Nγ=	30.2		

Shape factors

Bearing width (B)	10	ft
Bearing length (L)	48.5	ft
Bearing Depth (D)	3	ft
Sc=	1.0412371	
Sq=	1.128839	
Sγ=	1	
Ncm=	36.963918	
Nqm=	26.189066	
Nγm=	30.2	
qn=	17451.732	psf
	17.5	ksf

Resistance factor (2024 LRFD Table 10.5.5.2.2-1):
0.45 for footings in sand, SPT

qr=	7853.2792	psf
	7.9	ksf

key
- lookup from within sheet
- pull from bearing design
- pull from logs/testing
- in sheet calculation
- from ODOT lookup
- results

Bearing Capacity by AASHTO 2020 LRFD 10.6.3.1.2a

$$q_n = cN_{cm} + \gamma_q D_f N_{qm} C_{wq} + 0.5\gamma_f B N_{\gamma m} C_{w\gamma} \quad (10.6.3.1.2a\text{-}1)$$

in which:

$$N_{cm} = N_c s_c i_c \quad (10.6.3.1.2a\text{-}2)$$

$$N_{qm} = N_q s_q d_q i_q \quad (10.6.3.1.2a\text{-}3)$$

$$N_\gamma m = N_\gamma s_\gamma i_\gamma \quad (10.6.3.1.2a\text{-}4)$$

Assume load inclination factors are equal to 1.0, based on commentary in Section 10.3.1.2a.

Assume depth correction factor, d_q, is 1.0 based on Section 10.6.3.1.2a.

Table 10.6.3.1.2a-1—Bearing Capacity Factors N_c (Prandtl, 1921), N_q (Reissner, 1924), and N_γ (Vesic, 1975)

ϕ_f	N_c	N_q	N_γ	ϕ_f	N_c	N_q	N_γ
0	5.14	1.0	0.0	23	18.1	8.7	8.2
1	5.4	1.1	0.1	24	19.3	9.6	9.4
2	5.6	1.2	0.2	25	20.7	10.7	10.9
3	5.9	1.3	0.2	26	22.3	11.9	12.5
4	6.2	1.4	0.3	27	23.9	13.2	14.5
5	6.5	1.6	0.5	28	25.8	14.7	16.7
6	6.8	1.7	0.6	29	27.9	16.4	19.3
7	7.2	1.9	0.7	30	30.1	18.4	22.4
8	7.5	2.1	0.9	31	32.7	20.6	26.0
9	7.9	2.3	1.0	32	35.5	23.2	30.2
10	8.4	2.5	1.2	33	38.6	26.1	35.2
11	8.8	2.7	1.4	34	42.2	29.4	41.1
12	9.3	3.0	1.7	35	46.1	33.3	48.0
13	9.8	3.3	2.0	36	50.6	37.8	56.3
14	10.4	3.6	2.3	37	55.6	42.9	66.2
15	11.0	3.9	2.7	38	61.4	48.9	78.0
16	11.6	4.3	3.1	39	67.9	56.0	92.3
17	12.3	4.8	3.5	40	75.3	64.2	109.4
18	13.1	5.3	4.1	41	83.9	73.9	130.2
19	13.9	5.8	4.7	42	93.7	85.4	155.6
20	14.8	6.4	5.4	43	105.1	99.0	186.5
21	15.8	7.1	6.2	44	118.4	115.3	224.6
22	16.9	7.8	7.1	45	133.9	134.9	271.8

Table 10.6.3.1.2a-3—Shape Correction Factors s_c, s_γ, s_q

Factor	Friction Angle	Cohesion Term (s_c)	Unit Weight Term (s_γ)	Surcharge Term (s_q)
Shape Factors s_c, s_γ, s_q	$\phi_f = 0$	$1+\left(\frac{B}{5L}\right)$	1.0	1.0
	$\phi_f > 0$	$1+\left(\frac{B}{L}\right)\left(\frac{N_q}{N_c}\right)$	$1-0.4\left(\frac{B}{L}\right)$	$1+\left(\frac{B}{L}\tan\phi_f\right)$

Table 10.6.3.1.2a-2—Coefficients C_{wq} and $C_{w\gamma}$ for Various Groundwater Depths

D_w	C_{wq}	$C_{w\gamma}$
0.0	0.5	0.5
D_f	1.0	0.5
$>1.5B + D_f$	1.0	1.0

Footing depth = 8 ft
Water Depth = 5 ft
Interpolate Cwq = 0.81

Appendix C Stantec Bank Erosion Memo

Stantec **Memo**

To:	Ohio Department of Transportation	From:	Bryce Rizzo Cincinnati
Project/File:	175578434	Date:	October 14, 2025

Reference: SAN-101-1.65 Task 2-C Culvert Replacement, PID 107719

1 Background

The purpose of the project is a bridge replacement on State Route (SR) 101 near mile point 1.65, approximately 400 feet south of the intersection of SR 101 and South Ridge Road (County Road 175) in Clyde, Ohio. The bridge crosses Raccoon Creek. A hydrologic and hydraulic (H&H) analysis was performed to evaluate scour and bank erosion of Raccoon Creek adjacent to SR 101 near the bridge. Model results were used to develop three conceptual alternatives to mitigate further scour and erosion within the project area.

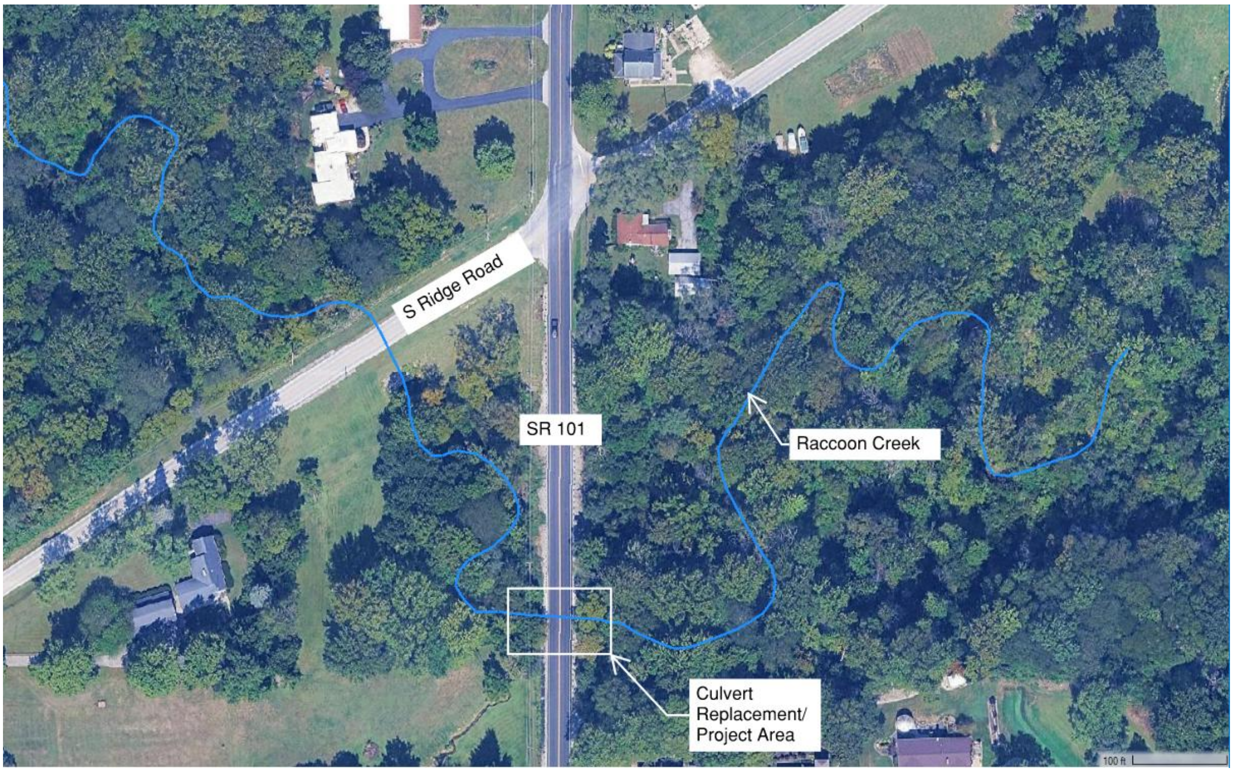

Figure 1. Site Overview

Stantec conducted a stream reconnaissance on June 19, 2025. This reconnaissance is part of a larger effort to evaluate conditions of the uphill embankment slope and streambank of Racoon Creek along SR 101 and South Ridge Road. Stantec visually observed current site conditions and estimated the bankfull stage and dimensions of Raccoon Creek.

Raccoon Creek through the project area is best described as a perennial stream with gravel bed substrate or hardpan channel bottom. Soils visible in banks were a mixture of stiff, gray, and consolidated silt/clay, silty loam, and gravel alluvial material. The valley in the area is generally unconfined, with the only exception being the culverted sections. The valley can be described as a Terraced Alluvial Valley. This valley type is often associated with low-gradient stream types (Rosgen, 1996). The stream exhibited pool-riffle morphology.

2 Geomorphic Data Collection

The following observations were made by Stantec while on site:

- Bankfull elevation approximately matches top of bank, indicating little channel incision and the hardpan bottom identified near the road embankment suggests limited downcutting potential.
- Minor, recent planform changes were evident. These changes were likely the result of downstream condition alteration through installation of the new box culvert under South Ridge Road.
- The channel adjacent to the bank showed signs of scour, where other areas within the project area showed signs of equilibrium with the sediment load. The principal indication of a net degradation condition was the exposed hardpan bottom, which was not apparent upstream of SR 101.
- The hardpan clay observed at the toe of the bank of concern promotes bed and bank stability.

3 Hydraulic Model Development

A two-dimensional (2D) quasi-steady state hydraulic model was developed for the site using the Hydrologic Engineering Center River Analysis System (HEC-RAS) software version 6.6. The model projection was set to NAD 1983 (2011) StatePlane Ohio North FIPS 3401 (US Feet). The terrain was downloaded from the Ohio Geographically Referenced Information Program (OGRIP), where the most recent collected elevation data for the project area was 2016 LiDAR. Survey for the purpose of the project was collected by ODOT in 2025 and incorporated into the model terrain. The survey included channel bathymetry but did not cover the entire 2D model extents. Therefore, AutoCAD Civil 3D was used to extrapolate the channel bathymetry upstream and downstream of the survey to better represent the channel for the entire 2D model area. The model extents begin approximately 1,200 ft upstream of SR 101 and end approximately 650 ft downstream of South Ridge Road.

The 2D mesh base cell size was set to 10 ft. The channel was refined using 5 ft cells to best capture resulting velocities and shear stresses, for the model purpose of evaluating scour and erosion through Raccoon Creek, adjacent to SR 101. Topographic high points were also refined in the 2D mesh using a cell size of 10 ft.

Two culverts were modeled as SA/2D connections. The structure dimensions and data for the culvert replacement crossing SR 101 were provided by ODOT in a HY-8 report. Survey data was provided by ODOT for the culvert crossing South Ridge Road, which included the culvert dimensions, length, and invert elevations. All other structure inputs for the culvert at South Ridge Road were assumed to be similar to the culvert at SR 101.

A site-specific land cover layer was developed based on publicly available aerial imagery. Polygons were manually generated to cover different land cover types, and each area was assigned Manning's N values based on recommended ranges as reported in the HEC-RAS user's manual. The project area consists of mixed forest and low intensity development areas, which were assigned a Manning's N value of 0.12 and 0.04, respectively. The main channel of Raccoon Creek was assigned a Manning's N value of 0.04 based on channel conditions from aerial imagery.

As per the project scope, the 25-year and 100-year recurrence interval discharges were modeled. Peak flows were estimated utilizing regional regression equations using the USGS Streamstats application. Flows were calculated for the upstream end of the study stream and at the confluence of the tributary entering Raccoon Creek just downstream of SR 101. For the 25-year event, the calculated flow from the tributary contributed only an additional 6 cfs, and for the 100-year event, the calculated flow from the tributary was negligible. The hydraulic model simulations utilized a quasi-steady state condition, where the input hydrographs were gradually increased to the calculated peak flows and held constant. Table 1 provides a summary of the calculated peak flows input into the model. The downstream boundary condition was set as normal depth using a slope of 0.001 ft/ft.

Table 1. Streamstats Calculated Peak Discharges

Event	Raccoon Creek Flow (cfs)	Tributary Contributing Flow (cfs)
25-year	993	6
100-year	1350	0

Reference: **SAN-101-1.65 Task 2-C Culvert Replacement, PID 107719**

4 Geomorphic Assessment

Hydraulic model results showing the 100-year event velocities through the project site can be found in Figure 2 with a section representing the existing bank of concern in Figure .

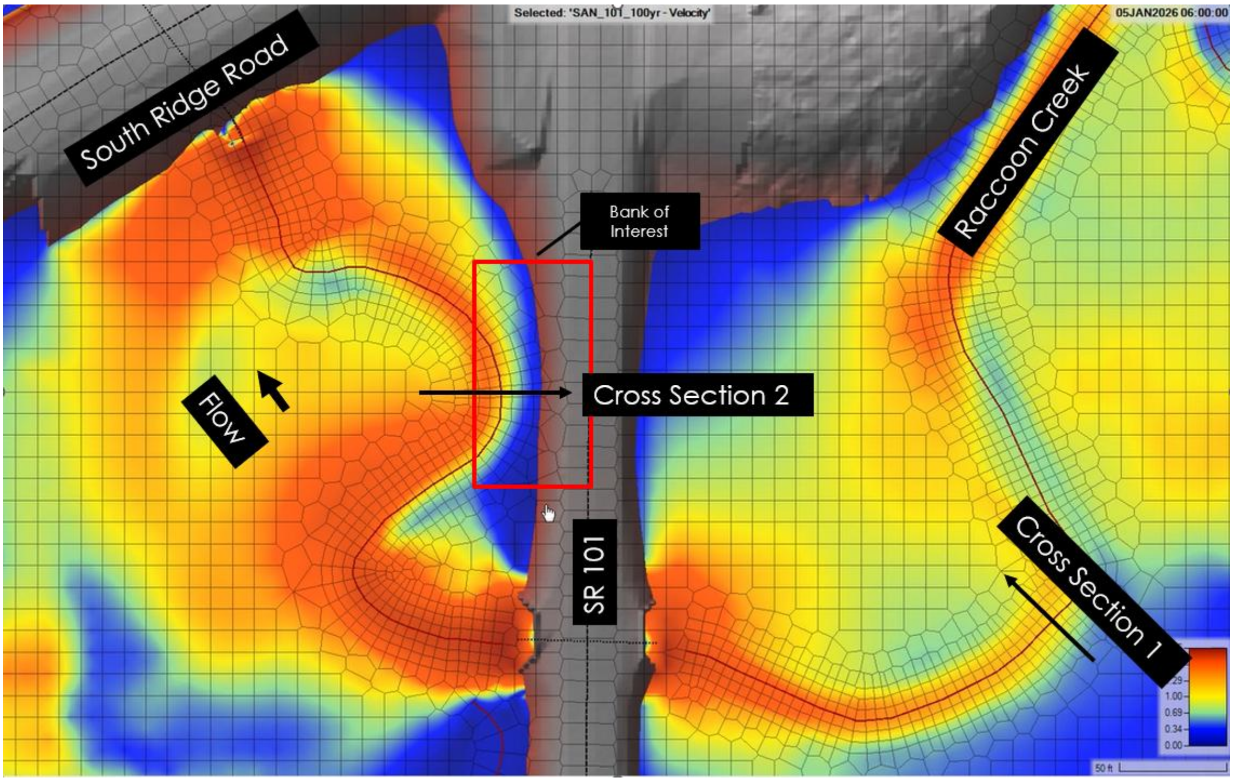

Figure 2. Flow Velocities (ft/s) shown for the 100-yr event

Reference: **SAN-101-1.65 Task 2-C Culvert Replacement, PID 107719**

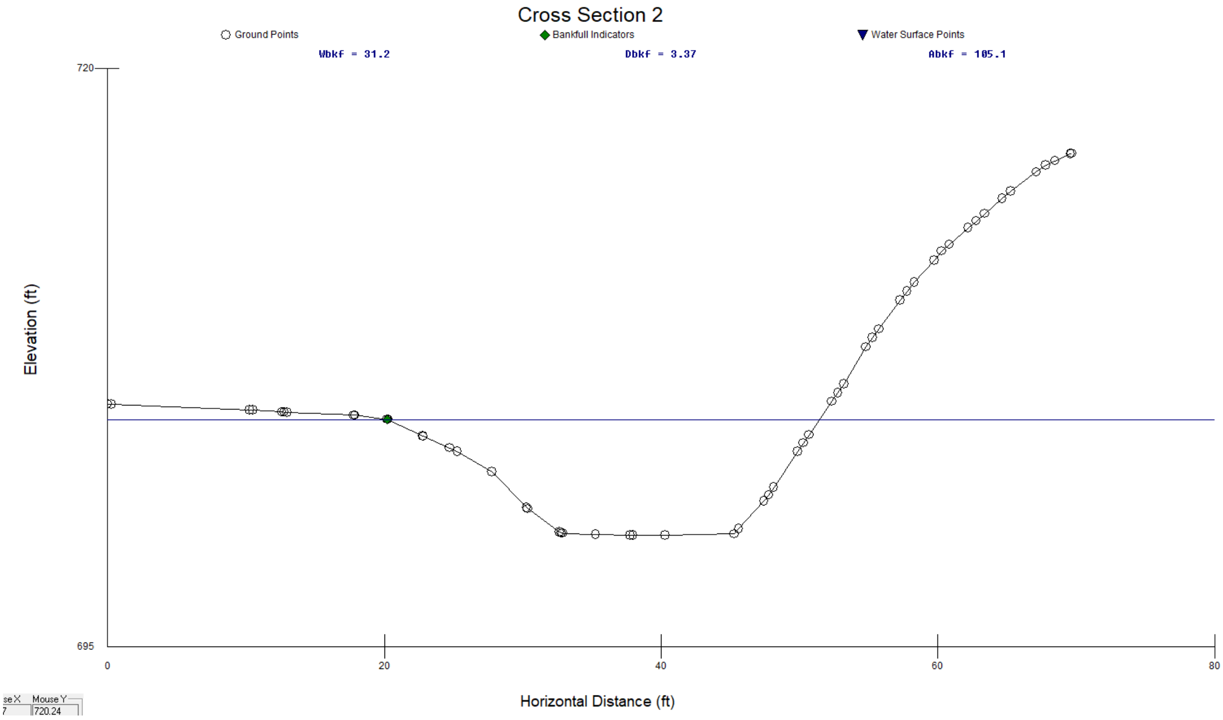

Figure 3. Cross Section 2, The bank of concern, Width to Depth Ratio 9.26.

Geomorphic observations show a low entrenchment (unconfined valley) channel with a low degree of channel incision. This means the bankfull channel shows little vertical departure from its floodplain, and bed degradation (downcutting) is not a likely cause of erosion at the bank of concern.

The most likely cause of ongoing erosion issues at the bank of concern is a relatively low width to depth ratio, leading to increased stream velocities. The increased velocities at this narrowed location mean that deposition of gravel bed load was not present. This higher erosion potential was observed at the toe of the bank of concern shown in Figure 4.

Reference: SAN-101-1.65 Task 2-C Culvert Replacement, PID 107719

Figure 4. Bank of concern looking downstream

In other locations, higher width to depth ratios were observed where sediment was at equilibrium with the sediment supply. Areas where gravel bed load material is present could be used as design references for stable channel dimensions. Cross Section 1 as shown in Figure 2 and in section in Figure 5 depicts these higher width to depth areas and a potential reference design condition for the bank stabilization measures.

Reference: SAN-101-1.65 Task 2-C Culvert Replacement, PID 107719

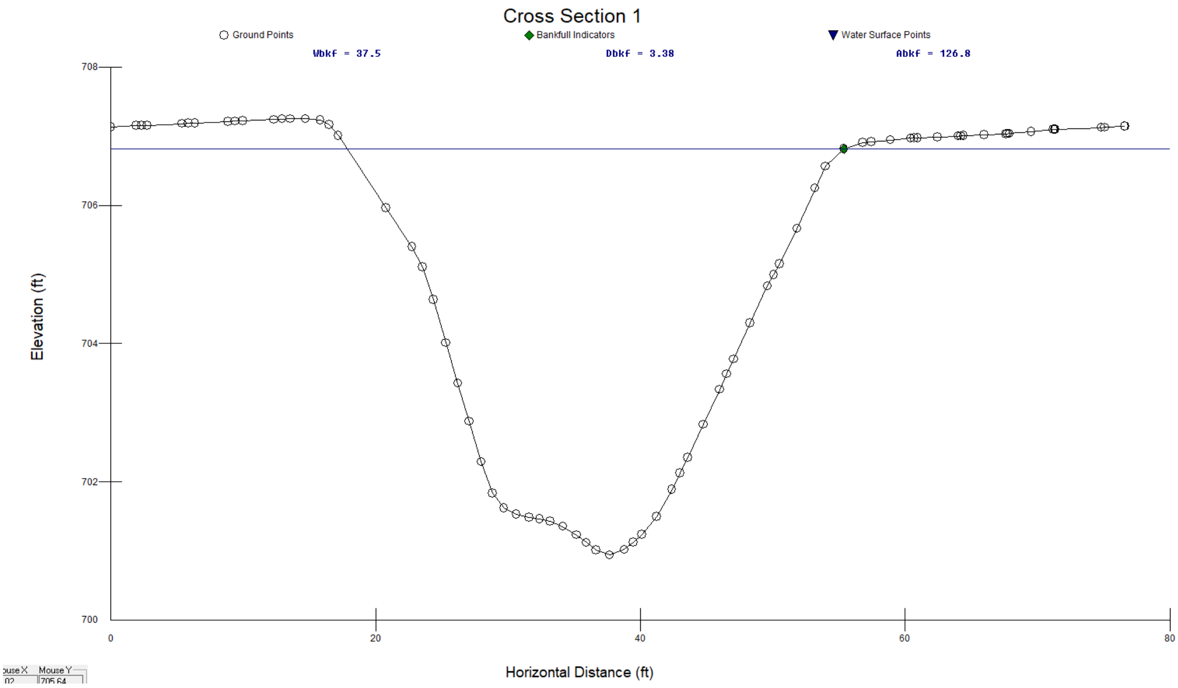

Figure 5. Cross Section 1 showing a potential reference design condition for promoting geomorphic stability at the bank of concern, Width to Depth Ratio 11.09.

Lateral migration was limited on the site. This indicates that the bank erosion issues along SR 101 are likely caused by a localized issue, not downcutting or sediment load issues in Raccoon Creek. It is probable that the embankment of SR 101 encroaches on the historic floodplain and, likely, the historic channel of Racoon Creek leading to the erosion apparent at this location. The 2D model results agree with this observation as signification Channel Shear stress, shown in Figure 6, does not occur at this bank in the 100- or 25-year event. Shear stress values less than 0.5 lbs/ sq. ft. mean bioengineered solutions including erosion control matting would provide adequate shear resistance for bank stabilization.

Reference: SAN-101-1.65 Task 2-C Culvert Replacement, PID 107719

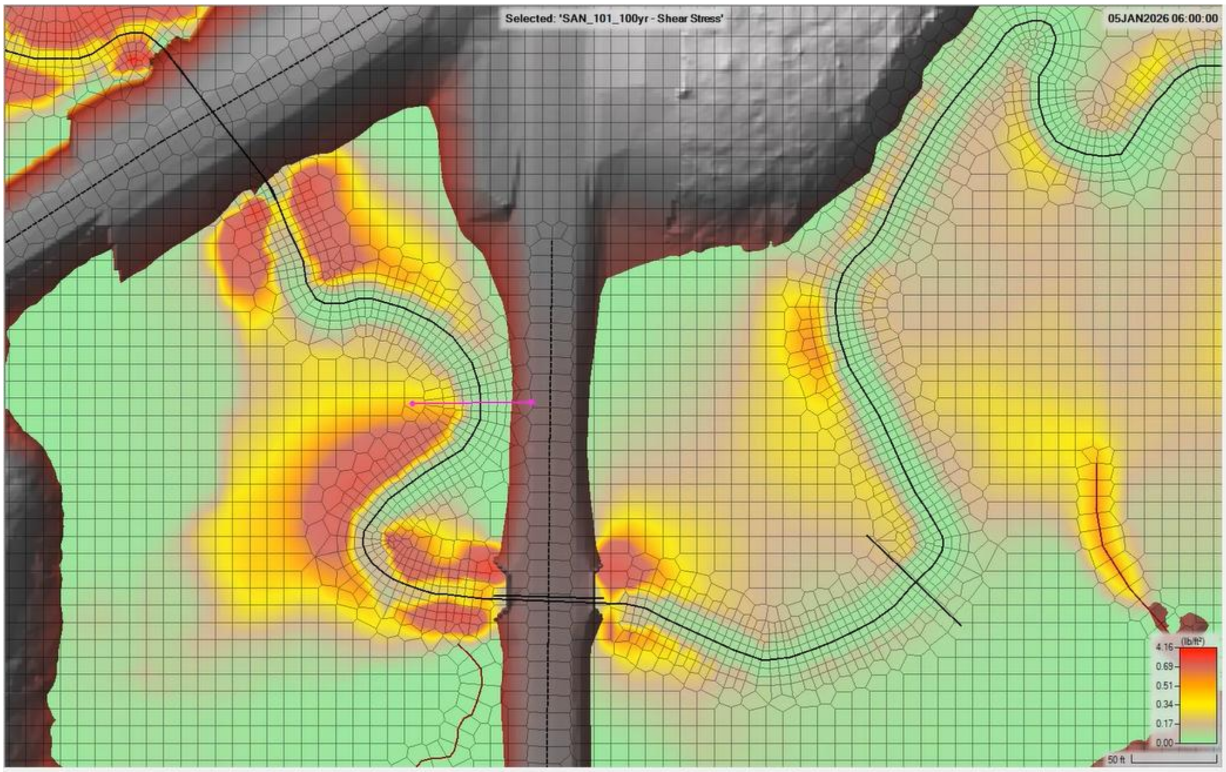

Figure 6. Shear stress maps of Raccoon Creek Near SR 101

5 Proposed Alternatives

The geomorphic alternatives discussed below address the high near bank stress at the toe of the slope that will promote slope stability without compromising channel function. Evaluation of the alternatives with a criteria matrix are also presented below.

5.1 Preferred Alternative 1: Bioengineered Toe Bank Stabilization without Channel Realignment

Bioengineering techniques at the toe of the slope of the bank of interest are considered the preferred alternative. A potential section of the bank stabilization measures can be found in Figure 7 and a schematic design of this alternative can be found in Figure 8. This is the preferred alternative because:

- It minimizes the temporary impacts related to construction, especially compared to Alternative 3.
- It benefits the geomorphic performance of the channel by increasing roughness and reducing shear stress.
- It has a low potential for long-term maintenance as the bioengineering techniques are generally considered self-maintaining through vegetative growth and geomorphic equilibrium.

- It has a lower capital cost compared to Alternative 3.
- It addresses the primary goal of promoting slope stability for the embankment upholding SR 101.

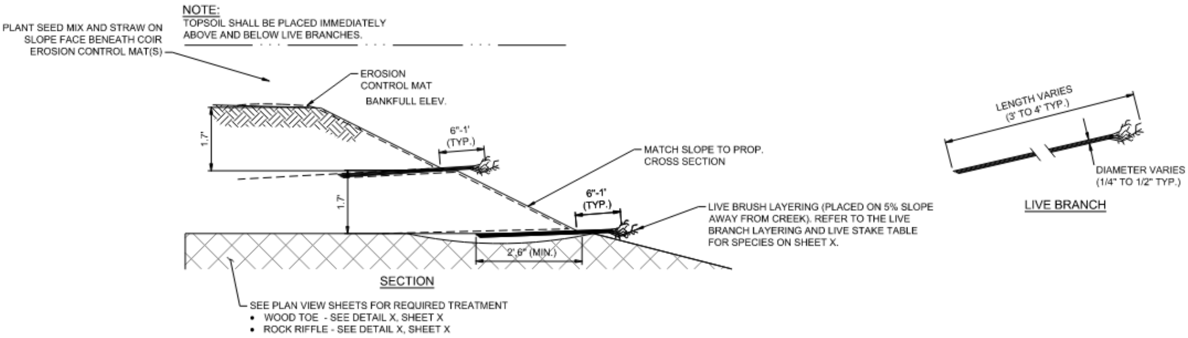

Figure 7. Potential Bank Stabilization Measure for Toe Stability at Bank of Interest

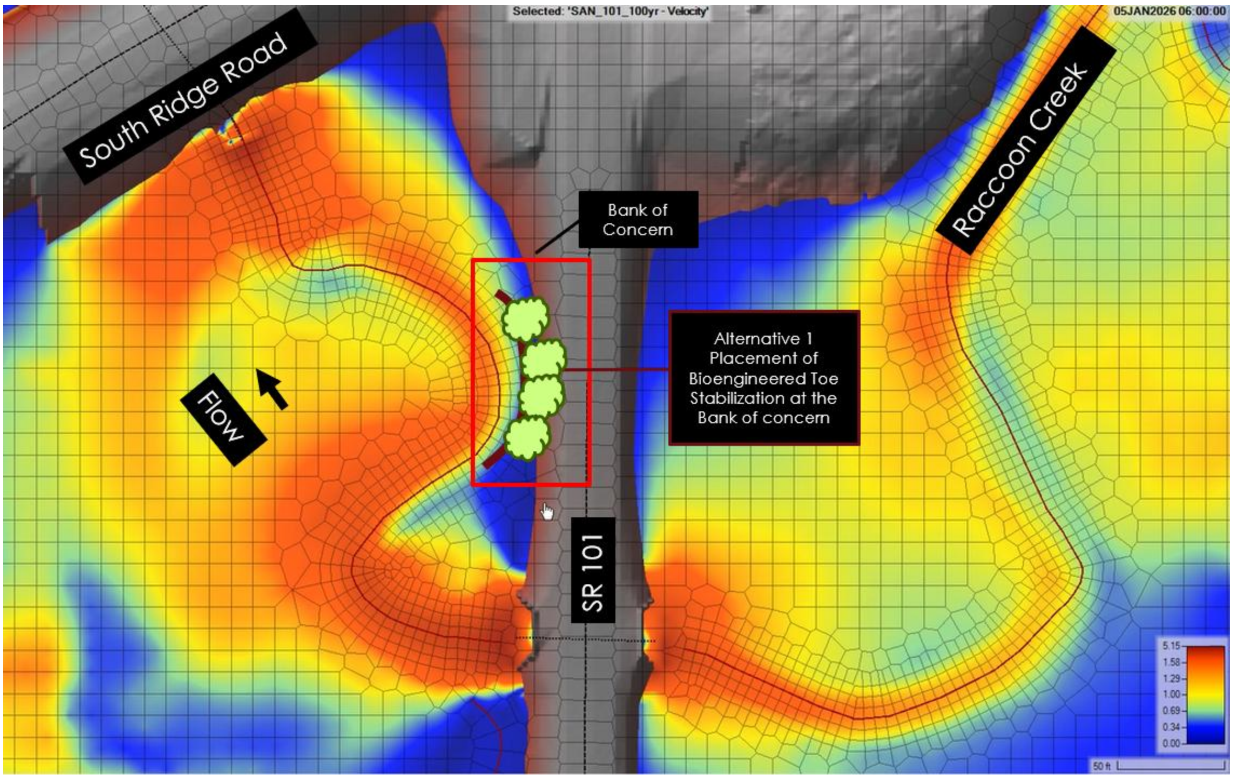

Figure 8. Bioengineered Toe Stabilization Schematic Design

5.2 Hard Armoring Stabilization

Hard armoring solutions are not the preferred alternative because of the likelihood of increased long term maintenance cost. This is because hard armoring solutions act against the normal erosion and depositional patterns of Raccoon Creek. This change means adjacent banks that are not receiving stabilization techniques are at a higher risk for erosion in the future. A potential section of the bank stabilization measures can be found in Figure 9 and a schematic design of this alternative can be found in Figure 10. The benefits and impacts of this alternative are:

- It minimizes the temporary impacts related to construction, especially compared to Alternative 3.
- It benefits the geomorphic performance of the channel by increasing roughness and reducing shear stress. Compared to Alternative 1 it has a negative impact on the stability of its adjacent banks.
- It has a high potential for long-term maintenance as it will increase risk to erosion of adjacent banks.
- It has a lower capital cost compared to Alternative 3.
- It addresses the primary goal of promoting slope stability for the embankment upholding SR 101.

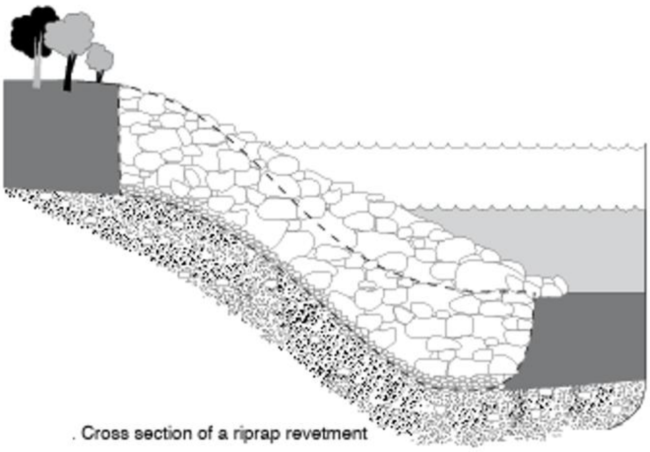

Figure 9. Riprap revetment schematic design from the Ohio Stream Management Guide released by ODNR

Reference: **SAN-101-1.65 Task 2-C Culvert Replacement, PID 107719**

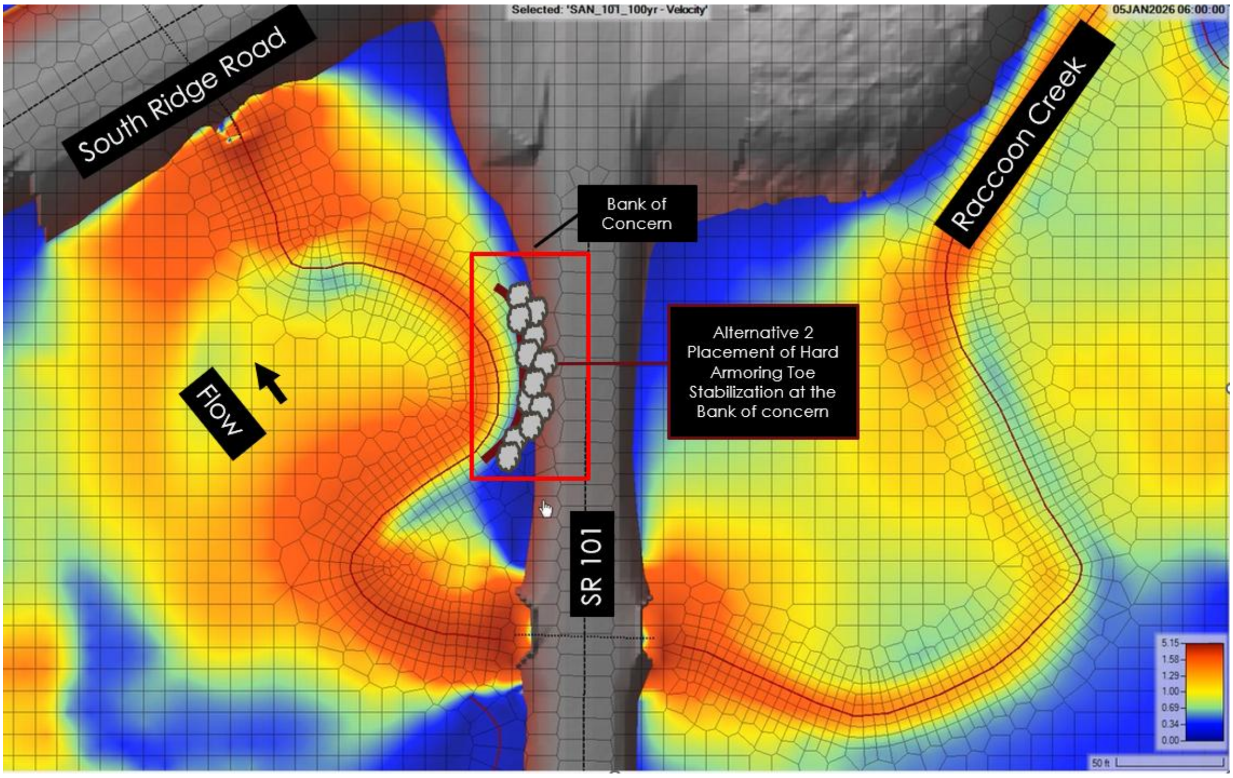

Figure 10. Riprap revetment Schematic Design

5.3 Alternative 3: Channel Realignment

Channel realignment was considered for this section of creek to reduce the near-bank stress at the toe of the bank of concern. This could be slight adjustments to the meander bends, or it could be an entire channel realignment between the two culverts (see Figure 11). Both scenarios would require rebuilding of the channel bed and bank with significant design and construction effort. Although the benefits to hydraulic and geomorphic performance, long-term maintenance, and slope stability are significant, this project will also have significant temporary impacts and capital cost compared to Alternatives 1 and 2.

Reference: **SAN-101-1.65 Task 2-C Culvert Replacement, PID 107719**

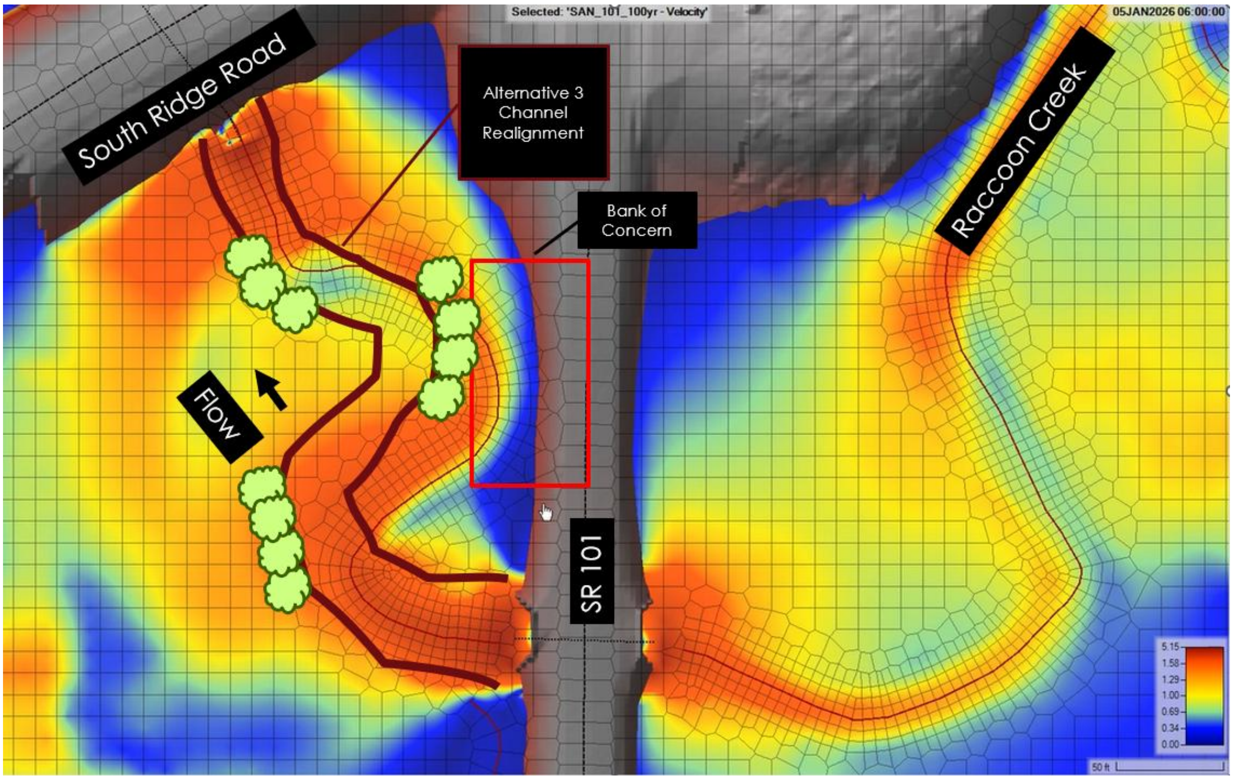

Figure 11. Alternative 3 Channel Realignment Schematic design

5.4 Evaluation Matrix

The evaluation criteria chosen for this analysis included temporary impacts to the site, hydraulic and geomorphic performance, long-term maintenance, and capital cost. When evaluated under these criteria a qualitative score of +1 was given if the proposed solution was generally beneficial for that criterion, a score of 0 was given if there were no benefit or impact or offsetting benefit and impacts, and a score of -1 if there was a net impact for the scoring criteria.

Table 2. Evaluation Matrix

Criteria	*Alternative 1 (Bioengineered Solution*	*Alternative 2 (Hard Armoring Stabilization)*	*Alternative 3 (Channel Realignment)*
Temporary Impacts	0	0	-1
Hydraulic and Geomorphic Performance	0	0	+1
Long Term Maintenance	+1	-1	+1
Capital Cost	+1	+1	-1
Slope Stability	+1	+1	+1
Total	3	1	1

6 Discussion

The stream in this location shows a tendency toward degradation of the stream channel, which has manifested as exposed hardpan and a lack of deposition of bed load. Bank stabilization measures and an increase of the width to depth ratio to match stable cross sections located upstream could promote channel stability and reduce erosive forces at this location. Alternative 1 is the preferred design alternative for the potential benefits and minimized impacts as discussed in Section 5.4.

Other reaches within the project area showed more potential for sediment equilibrium than at the eroding bank observed. These areas had higher width to depth ratios and could be used as a design reference to improve sediment equilibrium at the bank of concern. Rapid lateral migration of the channel was not observed at the bank of concern, which would be indicated by deposition on the opposite bank.

Geotechnical improvements of the slope above bankfull may be required, depending on the findings of Stantec's geotechnical investigations at the site. The above recommendation is for a minimal impact approach to the stream channel, which does not require hardening of the full reach of Racoon Creek between the two culverts; but could reduce the likelihood of bank erosion at the bank of concern.

Reference: SAN-101-1.65 Task 2-C Culvert Replacement, PID 107719

Regards,

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Attachment: Attachment