HURON MULTIPURPOSE BUILDING

BEADLE COUNTY, SOUTH DAKOTA

February 2022

Geotechnical Report

Prepared For:

U.S. Fish & Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, CO 80225-0486

Prepared By:

DOWL
1300 Cedar Street
Helena, Montana 59601
5028.27083.01

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REGISTERED PROFESSIONAL ENGINEER
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ACRONYMS

ACI .... American Concrete Institute
ASTM .... American Society for Testing and Materials
CBR .... California Bearing Ratio
GWIC .... Groundwater Information Center
H .... Horizontal
LI .... liquidity index
LT .... left
OSHA .... Occupational Safety and Health Administration
pcf .... pounds per cubic foot
PGA .... peak ground acceleration
psf .... pounds per square foot
RT .... right
SPT .... Standard Penetration Test
V .... Vertical

EXECUTIVE SUMMARY

DOWL prepared this geotechnical report for the Huron Multipurpose Building. In this report we specifically address the recommendations for the new multipurpose building for the Huron Wildlife Refuge. Based on the information obtained from our subsurface exploration, the site can be developed for the proposed project. We identified the following geotechnical considerations:

- The subsurface soil generally consists of stiff to very stiff sandy lean clay with occasional layers of medium dense sand.
- The subgrade soil is fine grained, and we recommend placing a separation/stabilization geotextile below the bottom aggregate course in the parking lot and driveway.
- Thickened edge or conventional spread footing foundation can be constructed on the native soil.
- On-site native soils typically appear suitable for use as site grading fill and backfill.
- Close monitoring of the construction operations discussed herein will be critical in achieving the design subgrade support. We therefore recommend that DOWL be retained to monitor this portion of the work.

This section is only a summary. Recognize that we do not provide details in this section, read the report in its entirety for a comprehensive understanding of the items contained herein.

1.0 INTRODUCTION

1.1 Purpose and Scope

DOWL completed a geotechnical investigation for the proposed multipurpose building for the U.S. Fish & Wildlife Services near Huron, South Dakota. The scope of geotechnical services consisted of reviewing existing geotechnical and geological information, field observations, subsurface exploration, laboratory testing, engineering analyses, and preparing this Geotechnical Report. The purpose of these services is to provide geotechnical related recommendations for project planning and design. We conducted this referencing our proposal to USFWS dated September 3, 2021.

Our geotechnical engineering scope of work for this project included drilling six borings to depths ranging from approximately 6 to 31 feet below existing site grades, lab testing for soil engineering properties and engineering analyses to provide foundation, slab on-grade and pavement design and construction recommendations.

1.2 Project Understanding

1.2.1 Existing Site Conditions

The project is located on the south side of 208th Street (US Hwy 14), about 0.3 miles west of 392nd Avenue, which is eight miles west of Huron, South Dakota (see Figure 1). The site is relatively flat, with a small rise near the south side of the site. The elevations range from 1,317 to about 1,326 feet within the project construction area.

The project area is covered in native grasses and is nearly surrounded by ponds and wetlands. We understand that a portion of the site was once used as a borrow source. We illustrate the project area in Photograph 1 and Photograph 2.

Photograph 1: Project Site Looking North Toward 208th Street

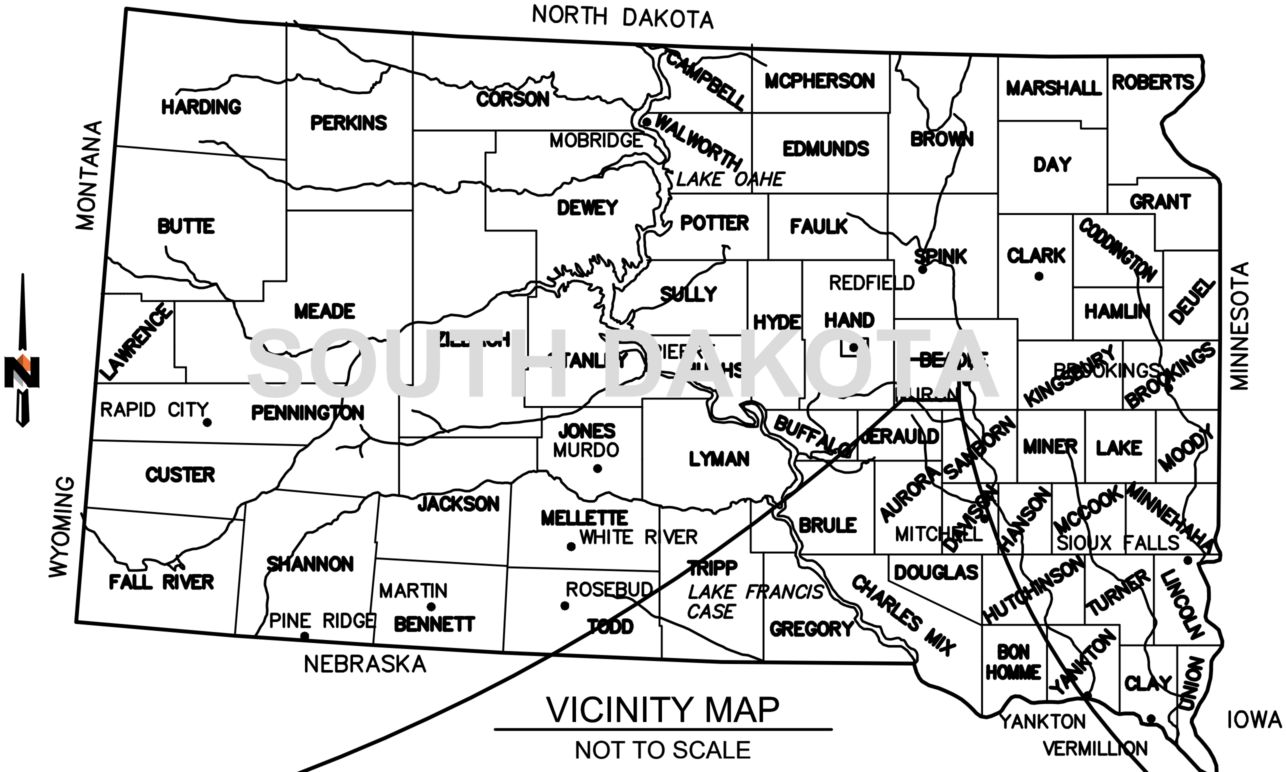
Photograph 2: Project Site Looking East

1.2.2 Proposed Construction

According to the Contract Documents, the project will include the construction of the Huron Multipurpose building, parking lot, sidewalks, access road, and utilities to service the building. The parking lot will be constructed on the north side of the building, and a detention pond on the east end of the parking lot. A waste-water evapotranspiration bed will be constructed about 300 feet northwest of the new building.

New sidewalks and concrete slabs will surround the HQ-Visitor Center and provide access to the building and parking lot. The parking lot may be paved or graveled but will have concrete curb and gutter systems.

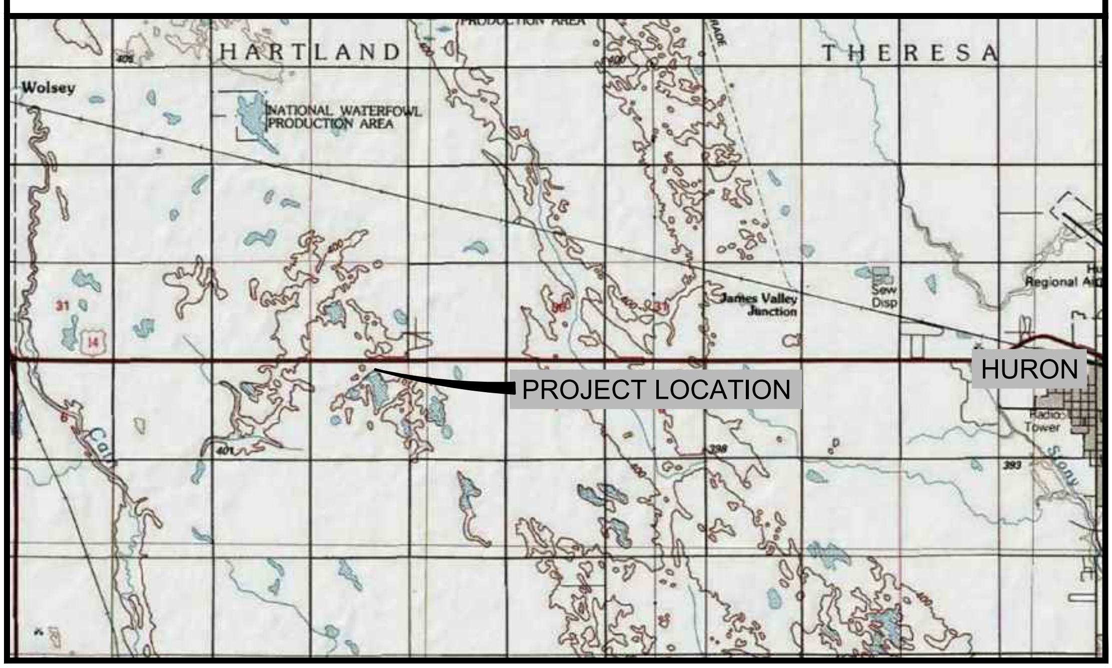
Further, the new building will be a single story, wood framed approximately 9,100 square foot building. No below grade structures are anticipated. Initial program requirements call for steel reinforced footings, foundations, and concrete slabs. Based on the 35 percent grading plan, the finished floor elevation will be 1,322.5 feet, which is up to three feet below the existing grade. According to DOWL's structural engineers, the foundation loads will be up to 20 kips for isolated columns and about 1.2 kips per foot for perimeter walls.



VICINITY MAP

NOT TO SCALE

PROJECT NAME - PROJECT LOCATION



LOCATION MAP

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SCALE IN MILES

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HURON MULTIPURPOSE BUILDING
GEOTECHNICAL INVESTIGATION
VICINITY AND LOCATION MAP

PROJECT	5028.27083.01
DATE	11/15/2020

FIGURE 1

2.0 INVESTIGATION

2.1 Field Investigation

DOWL performed fieldwork on November 16, 2021, which consisted of site observations and drilling six geotechnical borings. We present the boring locations in Figure 2.

Core Engineering advanced the borings to depths ranging from five to 31 feet below the existing ground surface. DOWL geotechnical personnel surveyed the boring elevations relative to a control point left by DOWL surveyors. Latitude and longitude of the explorations were collected using a hand-held GPS.

Table 1: Exploration Summary

Boring Number	Drill Depth (feet)	Surface Elevation (feet)	Latitude (°N)	Longitude (°W)	Location
B-1	31.0	1,326.0	44.36934	98.38301	NE Building
B-2	31.0	1,325.3	44.36923	98.38261	Center of Building
B-3	31.0	1,326.3	44.36910	98.38222	SE Building
B-4	6.0	1,323.1	44.36952	98.38231	SE Parking
B-5	6.0	1,321.9	44.37002	98.38305	Driveway
B-6	6.0	1,317.7	44.36974	98.38418	Leach Field

Core Engineering drilled the borings under the direction of a DOWL geotechnical engineer using a Diedrich Custom 3 drill rig equipped with 3.5-inch I.D. hollow stem augers. We conducted our field exploration referencing the following ASTM standards:

- ASTM D6151 Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
- ASTM D1586 Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
- ASTM D1587 Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils

We performed Standard Penetration Test (SPT) sampling using an automatic hammer and recorded them on the boring logs. We have not corrected SPT values on the logs for hammer efficiency, sampler type, overburden stress, etc. The resistance, or N-value, can be used to estimate the relative density of granular soils and the relative consistency of cohesive soils. We provide the field N-value or resistance data on the exploration logs.

We provide exploration logs in Appendix A which include soil and groundwater conditions as well as SPT information. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in situ, the transition between materials may be gradual and may vary. In Appendix B we present photographs of the site conditions and of the samples obtained during drilling.

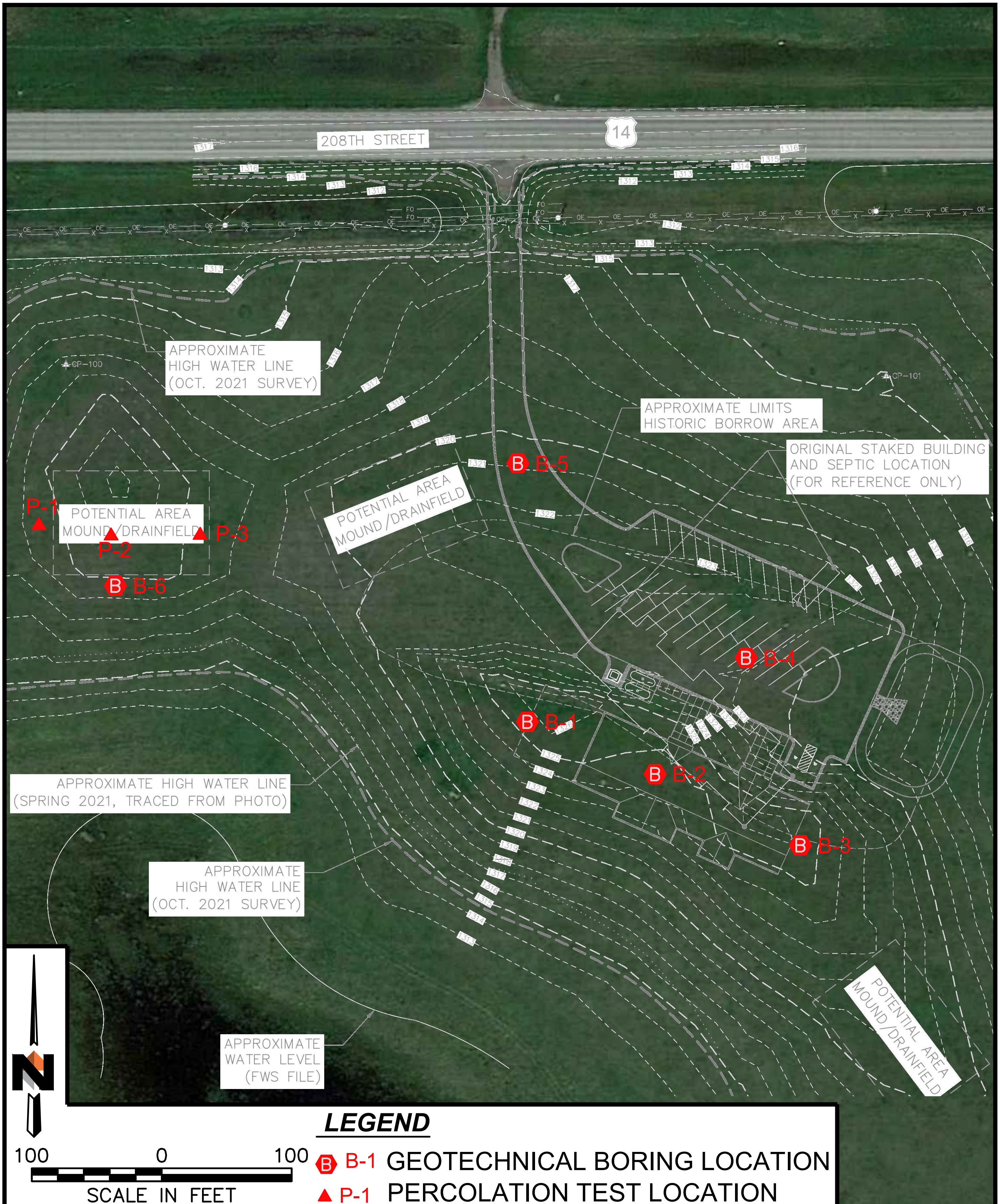
We based the soil descriptions shown on the boring logs on field and laboratory testing referencing ASTM Standards D2487 or D2488. The stratigraphic contacts shown on the individual borehole logs represent the approximate boundaries between soil types. The actual transitions may be more gradual or abrupt. The soil and groundwater conditions depicted are only for the specific dates and locations reported, and therefore, may not necessarily represent other locations and times.

2.2 Percolation Testing

DOWL performed soil percolation tests at the western potential mound area, referencing South Dakota Rule 74:53:01:37 of the South Dakota Department of Environment and Natural Resources. DOWL tested infiltration rates at depths of 24 inches below ground surface. DOWL did not perform tests in the eastern potential mound area. We provide test results in Appendix E. We illustrate the location of each percolation test on Figure 2, and a summary of the results in Table 2.

Table 2: Percolation Test Results

Percolation Test	Percolation Rate (minutes/inch)	Soil Type
P-1	120	CL
P-2	120	CL
P-3	120	CL



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HURON MULTIPURPOSE BUILDING
GEOTECHNICAL INVESTIGATION
EXPLORATION LOCATIONS

PROJECT	5028.27083.01
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FIGURE 2

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2.3 Laboratory Testing

We transported samples to DOWL's laboratory for testing. We selected representative field samples for laboratory testing after visual examination of the soil and consideration of the design criteria. DOWL performed tests for index and engineering soils properties in Lander, Wyoming and Billings, Montana. Energy Labs, of Lander, Wyoming, completed corrosion testing of select soil samples. Laboratory testing included:

Table 3: Laboratory Tests

Test	Purpose
Natural Moisture Content ASTM D 2216	Provides a measure of natural (in-situ) water content.
Atterberg Limits ASTM D 4318	Provides an indicator of the consistency and swell potential of fine-grained soils.
Particle-Size Distribution ASTM D 421	Provides a measure of grain sizes of the soils for classification and identification of physical characteristics.
Moisture-Density Relationship (Standard Proctor) ASTM D 698	Provides a measure of the relationship of water content to the density of soil during compaction.
California Bearing Ratio (CBR) ASTM D 1883	To determine the strength and stability of subgrade soil and base course.
Consolidation ASTM D2435	Used to estimate settlement under structural loads.
Corrosion Tests (pH, Resistivity, and Soluble Sulfates)	To determine the potential for corrosive interaction of soils with concrete and metal.

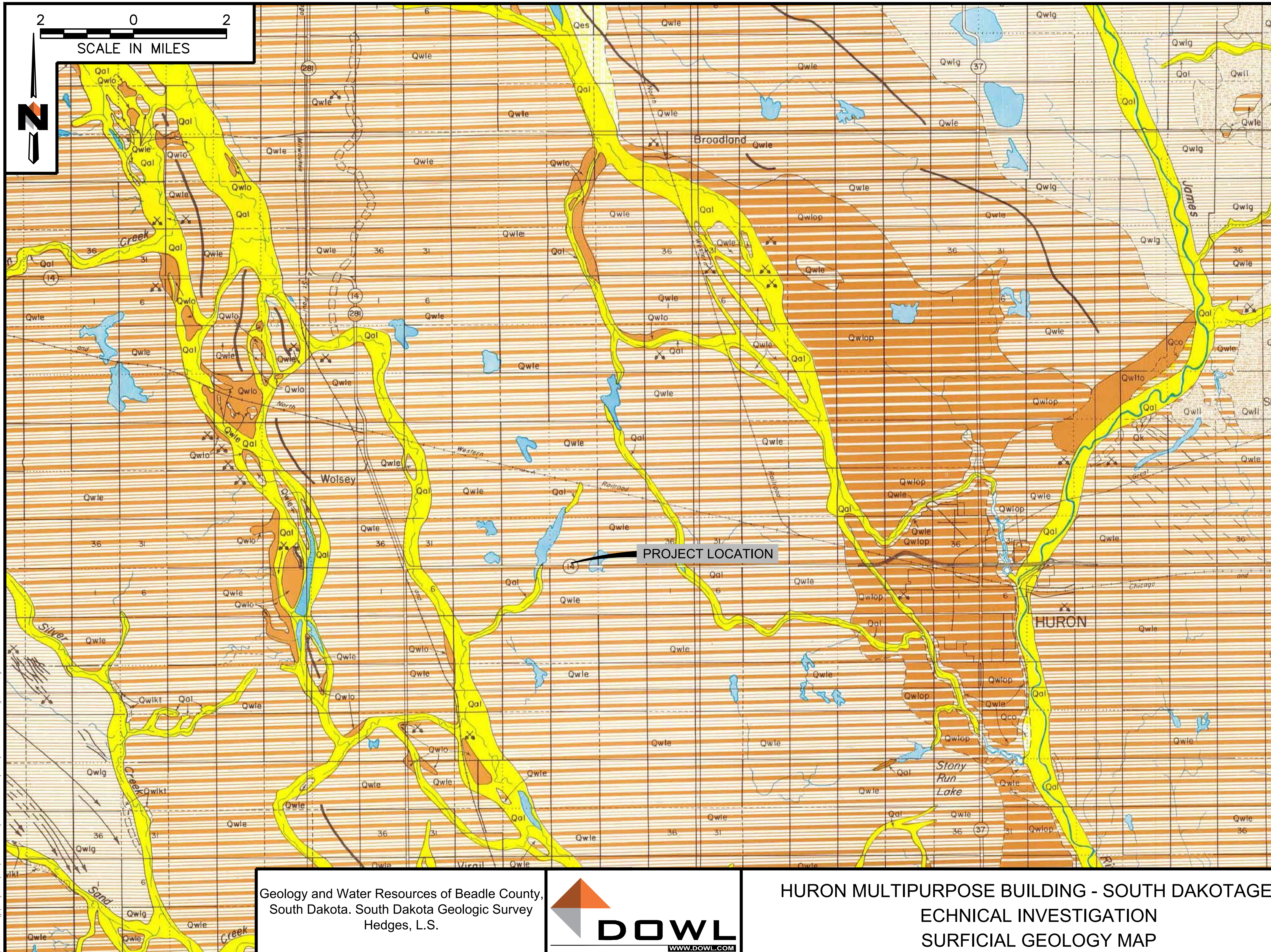
We present laboratory test results on the summary table and figures in Appendix C.

3.0 SUBSURFACE CONDITIONS

3.1 Site Geology

We present a surficial geology map of the project area in Figure 3. The Huron Multipurpose Building is located on glacial outwash plain deposits from the Upper Wisconsin glacial expansion, specifically, the Laurentide Ice Sheet. Thickness of the outwash is reported to be about 30 feet and consist mainly of silt, fine to medium sand, and occasional gravel. The last cycle of the Wisconsin Glaciation consisted of the Laurentide Ice Sheet spreading from present day Canada down into the Upper Midwest states including South Dakota. The spreading of the glacial till cut through the existing geologic formations creating an unconformity.

The surficial bedrock underlying the outwash consists of the Mobridge member of the Pierre Shale, an Upper Cretaceous shale with calcareous, marl, and chalk beds. The unit is fossiliferous. It is light gray to dark gray, argillaceous chalk, marl, and shale. Pierre Shale bedrock was not encountered in our boreholes. The regional thickness of the Mobridge member is about 30 feet (Hedges, 1968).



EXPLANATION

RECENT

Qal — Alluvium

(Silt, sand and clay, some gravel; light brown to black; poorly sorted, usually bedded; fossiliferous; present in most stream valleys; 2-25 feet thick.)

Qes — Aeolian Sand

(Sand, fine to medium, quartzose, subrounded, partially pitted; dark brown to black; locally found adjacent to outwash valleys; maximum thickness 6 feet.)

Qco — Colluvium

(Coteau du Missouri escarpment: Till, reworked; poorly sorted to unsorted; forms smooth apron at foot of Coteau; at least 5 feet thick.
James River trench: Silt, tan to brown; may be reworked lacustrine or outwash deposits; occurs at foot of bluffs in James River trench; more than 5 feet thick.)

PLEISTOCENE — LATE WISCONSIN

Qwll — Lacustrine Deposits

(Lake Dakota: Silt, tan to brown, laminated; sandy near base; some coarse sand and gravel present; as much as 15 feet thick.
Lake Byron channel: Clay, silt and sand; dark brown to black; bedded; more than 5 feet thick.)

Qwlop — Outwash Plain Deposits

(Silt and fine to medium sand; occasional gravel; poorly sorted to well sorted; usually gravelly at base and grades upwards to fine sand or silt; as much as 30 feet thick.)

Qwlo — Outwash Deposits

(Sand and gravel, poorly sorted to well sorted; some silt and clay; confined in stream valleys; may be covered with alluvium; as much as 30 feet thick.)

Geology and Water Resources of Beadle County, South Dakota. South Dakota Geologic Survey Hedges, L.S.

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HURON MULTIPURPOSE BUILDING - SOUTH DAKOTAGEOT
ECHNICAL INVESTIGATION
SURFICIAL GEOLOGY MAP

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FIGURE 3

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3.2 Observed Soil Conditions

The generalized soil profile encountered at the proposed construction site consists of sandy lean clay with occasional layers of silty or clayey sand. In Appendix A we present the exploration logs with lithology descriptions as well as other engineering properties. In the following paragraphs we provide a general description of the soil strata.

3.2.1 Sandy Lean Clay

Sandy lean clay and sandy silty clay were encountered below the topsoil to the maximum depths explored, with the exception of occasional layers of silty or clayey sand. The clay is generally brown in color and ranges from firm to hard in consistency (5≤SPT≤41). The moisture content ranges from 12 to 19 percent while liquid limits and plasticity indices range from 28 to 35 and 6 to 21, respectively. Traces of gravel and occasional cobbles were encountered in the clay.

3.2.2 Silty/Clayey Sand

Silty or clayey sand was encountered in B-1 from 3 to 5 feet, in B-2 from 15 to 20 feet, in B-3 from 29 to 31 feet, and in B-4 from 4.5 to 6 feet. The sand is brown and ranged in consistency from loose to dense (8≤SPT≤41).

3.3 Groundwater

Groundwater was encountered at depths of 17 to 29 feet below ground surface in the borings at the time of field exploration. These observations represent groundwater conditions at the time of the observations only, and may not be indicative of other times, or at other locations. In fact, at the time of the subsurface exploration, the surface water was near elevation 1315 feet, which is about six feet higher than the elevations observed in the borings. Had we installed piezometers, the subsurface groundwater elevation may correspond with the surface water near the site. In addition, groundwater conditions can change with varying seasonal and weather conditions, and other factors. Consider the possibility of groundwater fluctuations when developing design and construction plans for the project.

Fluctuations in groundwater levels can be documented by implementing a groundwater monitoring plan. Such a plan would include installation of groundwater piezometers, and periodic measurement of groundwater levels over a period of time.

Table 4: Groundwater Depths

Boring	Depth (ft)	Elevation (ft)
B-1	19	1,307
B-2	29	1,296
B-3	17	1,309

3.4 Seismicity

3.4.1 Design Accelerations

DOWL utilized site soil and geologic data, our knowledge of local geology, the project location, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE, 2021), and the National Earthquake Hazards Reduction Program (NEHRP) to estimate Seismic Site Classification of "D" at the project site. We queried the ASCE 7 Hazard tool website (ASCE, 2021) for the seismic parameters. We provide those parameters in Table 5, below based on the soil conditions and project location:

Table 5: Seismic Design Parameters

Period (seconds)	Modified Acceleration Coefficient for Site Class D (g)
0.0 (peak)	PGA_M = 0.085
0.2 (short	S_{DS} = 0.120
1.0 (long)	S_{D1} = 0.037

3.4.2 Liquefaction

Liquefaction is the partial or total loss of strength of soils that can occur during strong earthquake shaking of significant duration. Liquefaction is a process where high shear deformations result in progressive build-up of pore water pressure. Because the seismic load occurs rapidly, soil does not have time to drain, and the effective stress may be reduced to near zero, resulting in a temporary loss of shear strength. Earthquake-induced liquefaction generally occurs only under particular conditions which include saturation, strong earthquake ground shaking of long duration, and loose granular soil. Liquefaction can also occur in silts and fine-grained soils. Typically, liquefaction occurs where the groundwater table is shallow (5 to 10 feet deep) and generally only at depths less than approximately 50 feet.

Loose, saturated, sand, silt, and fine gravel may liquefy when exposed to seismic shaking. To be liquefiable a clay or silt (CL or ML) soil must have a plasticity index (PI) of less than 7, or if the soil classifies as a silty clay (CL-ML), the plasticity index must be less than 5 (Idriss R. W., 2006). Based on the laboratory test results, the plasticity indices of the soil at this site range from 6 to 21, and do not classify as liquefiable.

4.0 ENGINEERING ANALYSIS AND RECOMMENDATIONS

4.1 Foundations

Based on information from the subsurface exploration, laboratory testing results, and our analysis, it is our opinion the proposed structure can be supported on a spread footing foundation system bearing on native soil. We provide specific recommendations in the following sections.

4.1.1 *Thickened-Edge Foundation*

The building may be founded on a thickened-edge-slab foundation according to the parameters listed below:

- Prior to placement of structural fill, proof roll subgrades to identify and repair soft spots.
- Footing subgrades shall be inspected by a DOWL geotechnical engineer to verify foundation conditions are similar to those encountered in the borings. Remove and replace soft or loose zones or zones of unsuitable material, if encountered, with structural fill.
- Protect the footing excavations from flooding after excavation.
- Insulate the exterior perimeter of the building to protect the foundation from frost.

Table 6: Foundation Design Parameters

Footing Design Criteria	Recommendations		Notes
Perimeter Footings	**Maximum Allowable Bearing Pressure**		16 inches minimum width, 24 inches minimum below interior grade
Static Loads (Dead &Sustained Live):	1,500 psf		
Transient Loads (Wind & Seismic):	1,900 psf		
Interior Column Footings	**Maximum Allowable Bearing Pressure**		Minimum width 18 inches square, 24 inches minimum below grade unless constrained by slab
Static Loads (Dead & Normal Live):	2,000 psf		
Transient Loads (Wind & Seismic):	2,600 psf		The resultant load is assumed to be in the middle 1/3 of the footing
Maximum Settlement Estimate	**Total (in)**	**Differential (in)**	Based on a 3x3 footing with a maximum load of 20 kips.
	1 inch	0.5 inch over 25 feet	
Subgrade Preparation and Structural Fill	Compact subgrade to 95% standard Proctor		If structural fill is necessary below foundations follow specifications in Section 4.6.4.

Design uplift of shallow foundations from wind and seismic events using the weight of the foundation and soil above the footing. You can include soil resistance in the shape of a truncated pyramid above the foundation. The pyramid edges are defined by straight lines extending from the top of the footing on either side at a 2V:1H (vertical to horizontal) slope.

4.2 Lateral Earth Pressures

Design below-grade walls for building, landscape, retaining walls, and any structure retaining soil to resist both lateral earth pressures from the retained soil adjacent to the structure, as well as hydrostatic pressures from retaining water (if undrained, not recommended). Also, account for lateral surcharge loads from equipment, slopes, or vehicles adjacent to the walls in the structural wall design. Recommended lateral earth pressures for below-grade wall design are provided below.

Table 7: Lateral Earth Pressures

Lateral Earth Pressure Case	Equivalent Fluid Pressure (pcf)
Structural Fill	
At-rest (no wall movement)	63
Active (wall moves away from soil mass)	37
Passive (wall moves into soil mass)	375
Native (clay) soil	
At-rest (no wall movement)	73
Active (wall moves away from soil mass)	46
Passive (wall moves into soil mass)	272

- The above equivalent fluid pressures assume fully drained conditions and no hydrostatic forces acting on the wall.
- Construct below grade walls, retaining walls, or other retaining structures with adequate drainage and water proofing systems as specified by the Architect and Structural Engineer to reduce the potential for instability, leakage, or seepage.
- The retaining walls move away from or toward the soil to develop active and passive resistance, respectively. For walls that cannot tolerate movement, structurally design walls utilizing at-rest equivalent earth pressures.
- We based the above equivalent fluid pressures on the assumption that the surface of backfill adjacent to walls slopes down and away from the wall a minimum of 5 percent for 10 feet to provide drainage.
- Lateral surcharge pressures due to equipment, slopes, storage loads, etc., are not included in the above lateral earth pressure recommendations. Use the lateral earth pressures coefficient of 0.5, acting over the below-grade wall height to estimate the lateral surcharge loads from equipment, adjacent foundations, and slopes behind and above walls.

4.2.1 Coefficient of Friction

We recommend using a coefficient of friction of 0.45 between cast-in-place concrete and structural fill and 0.3 between cast-in-pace concrete and the native sandy soil. The friction value may be combined with the passive pressure to resist horizontal loads.

4.3 Slabs-on-Grade

4.3.1 Interior Slabs

The native, clay soil can be used to support the floor slabs. Compacted structural fill can also be used to support the floor slabs. Design the floor slabs using the recommendations in Table 8.

Table 8: Floor Slab Recommendations

Description	Value
Interior floor system	Slab on-grade concrete.
Floor slab subgrade	Scarify, moisture condition and recompact at least 8 inches of on-site soil or structural fill placed and compacted in accordance with Section 4.6.5 of this report.
Base layer	4 inches of granular material is acceptable.
Modulus of subgrade reaction	110 pounds per cubic inch (pci)

For slabs that will carry significant weight, we also recommend doweled joints be considered for the slab connections. Subgrade areas that become soft, loose, wet, or disturbed or that cannot be re-compacted to structural fill requirements discussed above must be over-excavated as described in Section 4.6.

Some differential movement of a slab-on-grade floor system is possible if the moisture content of the subgrade soils is increased. To reduce the effects of some differential movement, separate floor slabs from bearing walls and columns with expansion joints, which allow vertical movement. Use floor slab control joints to reduce damage due to shrinkage cracking.

If the floor coverings are sensitive to moisture, place a vapor retarder below the slab, underlain by 4 inches of clean drain gravel. A choker layer such as fine-concrete aggregate (ASTM C 33 sand) may be used to reduce the potential for drain gravel puncturing the vapor barrier.

4.3.2 Exterior Slabs

Exterior slabs on-grade, exterior architectural features, and utilities founded on, or in backfill or the site soils will likely experience some movement due to the volume change of the material. Damage from potential movement may be reduced by:

- Minimizing moisture increases in the backfill
- Controlling moisture-density during placement of the backfill
- Designing for vertical movement between the exterior features and adjoining structural elements
- Designing control joints

Exterior slabs are susceptible to frost action which can generate substantial frost heave at certain times of the year. The potential for frost heave may not be acceptable at entries, bays, or other critical areas adjacent to the building that will be exposed to weather. One approach to provide partial frost protection would be to place and compact a minimum of 30 inches of aggregate base course beneath the slab. Alternatively, if partial frost protection is unacceptable, over-excavate and replace the native soil with aggregate base course to the anticipated frost depth (48 inches).

Where some movement of the exterior slabs is acceptable, such as for the propane tank or picnic shelters, we recommend placing at least 12 inches of structural fill below the slabs. Prepare slab subgrades in accordance with the recommendations in Section 4.6.1.

4.4 Drainage

Drainage is critical to the long-term performance of the structure. In the following sections we provide recommendations for surface and subsurface drainage.

4.4.1 Surface Drainage

To reduce the potential for movement due to an increase in the moisture content of subgrade soil, we strongly encourage the implementation of the following recommendations.

- Per the IBC (ICC, 2018), slope the ground surface within 10 feet of the structure downward a minimum of 5 percent away from the structure. Slope the ground surface beyond 10 feet of structures downward at least two percent away from the structure.
- Apron slabs and pavement may be used to further reduce infiltration adjacent to structures. Aprons should consist of asphalt or Portland cement concrete pavement that is placed directly adjacent to the foundation stem walls. An elastomeric sealant should also be considered between aprons and foundation stem walls to further reduce the potential for moisture to infiltrate the area directly adjacent to foundations. Slope apron slabs and pavement a minimum of 2 percent, downward, away from the building.
- Install eve gutters, downspouts, and extensions such that they dispose of water a minimum of 8 feet away from the structure.
- Seal cracks in sidewalks, driveway and apron slabs, floor slabs, and foundation walls. Maintain sealant between adjacent slabs and between slabs and adjacent walls.
- Do not construct landscaping, curbs or other barriers that could impair drainage.
- Do not burry metal rain gutter discharge pipes because they can leak, which often goes undetected. Seepage problems can also be caused by clogging, crushing, and poor grading of the pipes.
- Do not construct infiltration basins adjacent to or up gradient of the structures. If detention is required by statute, infiltration basins should be located down gradient and at least 30 feet from foundations.

4.5 Pavement Design

The primary purpose of a pavement section to distribute concentrated wheel loads to the subgrade in a manner such that the subgrade is not over-stressed. Performance of the pavement section is a function of subgrade strength and traffic loading. For purposes of designing a pavement section, subgrade soil is represented by a soil support value for flexible pavements (asphaltic concrete) or by a modulus of subgrade reaction value for rigid pavements (Portland cement concrete). Subgrade strength decreases when the moisture content of the subgrade increases. Therefore, proper drainage, both surface and subsurface, is essential for long-term pavement performance.

Pavement design procedures are based upon strength properties of the subgrade soil and pavement materials, along with the design traffic conditions (especially truck traffic).

4.5.1 Traffic

Specific traffic information was not available for this project. DOWL estimated the traffic breakdown shown in Table 9. We calculated equivalent single axle loads (ESALs), as shown in the table below, assuming an annual growth rate of one percent. If future projects are planned that will impact general traffic routes, contact DOWL to revise our recommendations as necessary.

Table 9: Traffic Loading

Vehicle Description	ADT (Design Lane)	Axle Load (kips)*
Passenger Car	55	2S 2S
Pickup Truck/Van	25	2S 4S
Recreational Vehicle	1	4S 4S
Garbage Truck	1	20S 35T
Semi-Tractor Trailer	1	12S 34T 34T
Calculated 18-kip ESALs	34,658 (flexible) 90,564 (rigid)	

*S-Single, T-Tandem

4.5.2 Design Parameters

We used the pavement design parameters shown in the table below.

Table 10: Pavement Design Parameters

Pavement Design Parameter	Design Value	Source
Initial serviceability	4.2	AASHTO 1993
Terminal serviceability	2.0	AASHTO 1993
Reliability	85%	AASHTO 1993
Drainage coefficient	0.9	AASHTO 1993
Flexible Pavement		
Design life	20 years	AASHTO 1993
Standard Deviation	0.45	AASHTO 1993
Asphalt layer coefficient	0.40	AASHTO 1993
Base layer coefficient	0.14	AASHTO 1993
Subbase layer coefficient	0.08	AASHTO 1993
Subgrade resilient modulus	4,000 psi	CBR value
Rigid Pavement		
Design life	20 years	AASHTO 1993
Standard Deviation	0.35	AASHTO 1993
PCC Modulus of Rupture	580 psi	AASHTO 1993
Elastic Modulus	3,605,000 psi	4,000 psi concrete strength
Modulus of subgrade reaction, k	110 pci	CBR value
JPCP Load Transfer, J	4.2	AASHTO 1993

4.5.3 Flexible Pavement

Based on our design calculations, anticipated traffic, and the field conditions, we recommend the pavement sections shown below for the entire parking lot if the parking lot is paved:

3.5 inches asphalt
6.0 inches aggregate base course
Geotextile separation/stabilization fabric (See Section 4.6.9)

4.5.4 Rigid Pavement

For areas subject to concentrated and repetitive loading conditions such as dumpster pads and ingress/egress aprons, we recommend using a reinforced concrete pad at least 6 inches thick underlain by at least six inches of granular base. The granular base must overlie a geotextile recommended in Section 4.6.10 Geosynthetics. In addition, we recommend signage and/or curbing be used to restrict truck traffic in car parking and drive lane areas.

Provide sawed or hand-formed joints at spacings not greater than 15 feet on center. Construct the joints to be at least one-fourth of the slab thickness. Provide expansion joints at the end of each construction sequence and between the concrete slab and adjacent structures.

4.5.5 Gravel Surfacing

DOWL understands that portions of the site may have a permanent gravel surfacing section and therefore not paved with asphalt. The primary purpose of a gravel surfacing section is to distribute concentrated wheel loads to the subgrade in a manner to reduce rutting. Performance of the surfacing section is a function of subgrade strength and traffic loading. For purposes of designing a section, subgrade soil is represented by a soil strength value such as California Bearing Ratio (CBR). Subgrade strength decreases when the moisture content of the subgrade increases. Therefore, proper drainage of both surface and subgrade is essential for long-term pavement performance. DOWL recommends the following surfacing section:

8.0 inches aggregate base course
Geotextile separation/stabilization fabric (See Section 4.6.9)

4.5.6 Construction Considerations

- Remove unsuitable material including soft and/or organic soil encountered. Scarify, moisture condition, and compact the subgrade soil to a depth of 8 inches below the pavement surfacing materials as described in Section 4.6.1.
- Aggregate Base Course shall meet the requirements in Table 1 in Section 882.2 Aggregates for Granular Bases and Surfacing, Specific Requirements Aggregates, in South Dakota Department of Transportation's 2015 Standard Specifications for Roads and Bridges (SDDOT, 2015).
- Subbase Course shall meet the requirements in Table 1 in Section 882.2 Aggregates for Granular Bases and Surfacing, Specific Requirements, in South Dakota Department of Transportation's 2015 Standard Specifications for Roads and Bridges.
- Gravel Surfacing shall meet the requirements in Table 1 in Section 882.2 Aggregates for Granular Bases and Surfacing, Specific Requirements, in South Dakota Department of Transportation's 2015 Standard Specifications for Roads and Bridges.
- Pit Run shall meet the requirements in Table 1 in Section 882.2 Aggregates for Granular Bases and Surfacing, Specific Requirements, in South Dakota Department of Transportation's 2015 Standard Specifications for Roads and Bridges.
- Asphalt shall meet the requirements in Section 890, Asphalt Material in South Dakota Department of Transportation's 2015 Standard Specifications for Roads and Bridges.
- Portland cement pavement shall meet the requirements in Section 380, Part D Rigid Pavement, Portland Cement Concrete Pavement in South Dakota Department of Transportation's 2015 Standard Specifications for Roads and Bridges.
- Compact asphaltic concrete to at least 92% of its theoretical maximum Rice density (ASTM D2041).
- Compact all pavement materials (and subgrade) in accordance with the Table 11 in Section 4.6.5.
- Sub-excavate any unstable areas and replace with moisture conditioned and compacted aggregate base.
- Place and compact structural fill in level lifts, not more than 8 inches in loose thickness, up to planned grade.

- Grade pavement such that surface water drains into the curb or storm drains at a minimum two percent slope.

4.5.7 *Maintenance*

- The pavement's life will be dependent on achieving adequate drainage throughout the section and especially at the subgrade.
- Slope surface and subgrade, crushed surfacing, and asphalt surfaces at no less than 2 percent to an appropriate stormwater disposal system or other appropriate location that does not impact adjacent buildings or properties.
- Maintain grades outside of paved areas to prevent the collection of water adjacent to the pavement.
- Seal cracks and perform surface maintenance on pavement surfaces every 3 to 5 years to reduce the potential for surface water infiltration into the underlying pavement subgrade.
- Water that ponds at the pavement subgrade surface can induce heaving during freeze-thaw process, which can readily damage pavement.
- Do not allow inverted crowns at the subgrade or pavement surfaces without center concrete gutters designed to have asphalt overlap.

4.6 Earthwork

4.6.1 *Subgrade Preparation*

- Soil containing vegetation and organics (topsoil) extended approximately 3 to 12+ inches below the existing ground surface in the locations explored. Remove soil containing vegetation and organics below planned improvements or structures.
- Scarify, moisture condition, and compact subgrade soil as specified in the table in Section 4.6.5.
- Grade the exposed subgrade surfaces to remove mounds and depressions which could prevent uniform compaction. If unexpected fills or obstructions are encountered during site clearing or excavation, remove such features, and clean the excavation prior to placing backfill and/or construction.
- The site soil is moisture sensitive and susceptible to disturbance when moist or wet and may be expected to pump or rut under construction traffic. Soil disturbance negatively impacts the soil's performance. Disturbed soil is not allowed below any structure or pavement, and especially at footing or slab subgrades.
- Moisture condition and compact disturbed soil or fill placed to achieve site grades to the requirements in Table 12. This may require considerable moisture conditioning and soil processing due to the clayey nature of the on-site soil.
- Remove pumping or rutting subgrade areas to depths between 12 and 18 inches or as directed by DOWL.
- Replace over-excavations with granular structural fill. Contact DOWL's geotechnical engineer to review and approve the exposed subgrade.

- Once prepared and approved by DOWL, it is the contractor's sole responsibility to protect subgrades from degradation.

4.6.2 Excavation

Based on the materials encountered in the soil borings, conventional earthmoving equipment should be capable of excavating the site soils.

4.6.3 Temporary Slopes

Excavations must conform to OSHA Standards for Excavations, 29 CFR Part 1926.652 Appendix B to Subpart P. Based on field observations and laboratory tests, the soil at the site are classified as OSHA Type B. OSHA requires that Type B soil excavation slope angles not exceed 1H:1V (horizontal to vertical). If sandy soil or groundwater is encountered, that soil will classify as Type C. The nature and extent of subsurface variations and groundwater conditions between the boring locations may not become evident until construction. Evaluation of soil conditions by the contractor’s OSHA compliance representative shall occur at the time of construction. Temporary excavation slopes may be required for soil improvement excavations and utility trenches. Conduct excavations and shoring in accordance with OSHA standards. Do not allow surcharges within a horizontal distance equal to half the excavation depth. Construction vibrations can cause excavations to slough or cave. Ultimately, the contractor is solely responsible for site safety and excavation configurations.

Plan excavations to allow for water collection points and utilizing conventional sumps and pumps to remove nuisance water seeps or precipitation. If site soil excavations are not backfilled quickly, they may degrade when exposed to runoff and require over-excavation and replacement with structural fill. We recommend construction activities, particularly earthwork, be performed as rapidly as possible and/or during drier conditions to reduce the potential for remedial earthwork.

4.6.4 Structural Fill

Consider fill placed within the planned building footprint as structural fill. The on-site lean clay is not suitable for use as grading fill and trench backfill.

Table 11: Fill Specifications

Soil/Fill Product	Allowable Use	Material Specifications
Non-Structural Fill (Landscape Fill)	Any area that will not have structures (typically landscape areas)	• Soil classified as GM, GW, SM, SW, SC, CL, CH, or ML according to the USCS. • Soil may not contain particles larger than 8 inches in median diameter. • Soil must be less than 3 percent deleterious substances such as wood, metal, plastic, waste, etc. • Approved by Landscape Architect
General Fill	• Site grading outside the building footprint. • Utility backfill areas • Non-structural fill • Foundation wall backfill	• Soil classified as GP, GM, GW, GC, SP, SM, SW, SC, CL, or ML according to the USCS. • Site soil must have less than three percent vegetation, organics, and debris. • Soil may not contain particles larger than 6 inches in diameter. • Soil must contain less than 3% (by weight) of organics, vegetation, wood, metal, plastic, or other deleterious substances
Structural Fill	• General fill • Over-excavations • Soil improvements • Retaining Wall backfill	• Soil classified as GP, GM, GW, SP, SM, or SP with at least 30 percent retained on a number 4 sieve and less than 15 percent passing a number 200 sieve. • Soil may not contain particles larger than 2 inches in diameter. • Soil must contain less than 3% (by weight) of organics, vegetation, wood, metal, plastic, or other deleterious substances
Unsatisfactory Soil	NONE	• Soil classified as MH, OH, CH, OL or PT may not be used at the project site • Any soil type not maintaining moisture contents within 5% of optimum during compaction is unsatisfactory soil that must be moisture conditioned prior to disposal and replacement • Any soil containing more than 3% (by weight) of organics, vegetation, wood, metal, plastic, or other deleterious substances

4.6.5 Compaction Requirements

Place fill material in lifts not exceeding eight inches in uncompacted thickness. Moisture condition and compact fill according to the table below.

Table 12: Compaction Specifications

Application	Moisture Content (% of optimum)	Minimum Compaction
Subgrade	±3	95% ASTM D698
Below Foundations	±3	98% ASTM D698
Below Slabs-On-Grade	±3	97% ASTM D698
Base and Subbase Courses	±4	97% ASTM D698
Utility Trenches	±3	95% ASTM D698
Site Grading Fill	±3	95% ASTM D698
Foundation Backfill	±3	95% ASTM D698

4.6.6 Testing and Observations

We recommend the following compaction testing frequencies:

- **Footing Subgrade** - One compaction test every 50 linear feet (LF) of footing trench or 2 tests per wall line, whichever results in the greater number of tests, per each 1-foot lift of fill.
- **Foundation/Retaining Wall Backfill** - One compaction test every 100 LF of wall or 2 tests per wall line (interior and exterior sides), whichever results in the greater number of tests, per each 1-foot lift of backfill.
- **Interior and Exterior Slab Subgrade** - One compaction test every 1,000 square feet (sf) of slab area or 2 tests per slab area, whichever results in the greater number of tests, per 1-foot lift of fill.
- **Pavements** - One compaction test every 2,500 sf of pavement area on each subgrade, subbase, and base course layer as applicable, per each 1-foot lift of backfill.
- **Trenches** - One compaction test every 150 linear feet or 2 per trench, whichever results in the greater number of tests, per each 1-foot lift of backfill

To verify that construction conforms to the intent of the specifications, we recommend that DOWL be retained to observe and record the following:

- Site preparation including grubbing, stripping, excavating, and proof-rolling
- Removal of topsoil and root zone beneath slabs and pavements
- Interior and exterior slab subgrades
- Excavations and sub-excavations prior to placing backfill/fill materials or prior to construction of footings and slabs
- Approve additional excavation, replacement, or stabilization if unsuitable soil is identified by the geotechnical engineer during excavation or proof-rolling operations

4.6.7 Cold Weather Construction

Do not place concrete, pavement or fill on frozen soil. Do not use frozen soil as fill or backfill. Remove frozen soil, snow, and/or ice from the subgrade or fill soil prior to continuing with construction. Limit winter excavations to areas small enough to be refilled to finished floor grade or higher on the same day. Contact DOWL to monitor fill placed during freezing conditions to reduce the potential for placing frozen material.

4.6.8 Wet Weather/Soil Construction

- Ideally perform earthwork construction during times when the soil moisture content is less than two percent above optimum.
- The site clay is susceptible to pumping or rutting from heavy loads such as rubber-tired equipment or vehicles any time of the year.
- If possible, do not perform earthwork after rainfall when the soil is wet. Allow the soil to dry sufficiently to allow construction traffic without disturbing the subgrade.
- If the subgrade soil becomes wet, it may be necessary to perform earthwork with track-mounted equipment that reduces vehicular pressure applied to the soil if construction commences in wet areas or before the soil can dry enough to support wheeled vehicles.
- Even though the silt and clay subgrade is firm, it still may be easily disturbed when wet. If it is necessary, the contractor may place an initial 12-inch lift of granular structural fill to help reduce the compaction energy on the unstable subgrade. Thicker structural fill lifts can only be installed over sensitive subgrades at DOWL's recommendation during construction. Initial thicker fill lifts and over-excavations to remove soft, wet soil can only be placed after the contractor has attempted to moisture condition and recompact the native soil and was unsuccessful.
- Depending on precipitation, the site soil may be slightly over optimum moisture content. The contractor should expect these conditions and be prepared to install runoff management facilities and to replace wet or disturbed soil with structural fill.

4.6.9 Geosynthetics

Geosynthetic fabrics are applicable when constructing on soft or wet soil, for foundations soil improvement applications, as separation fabrics between drainage aggregate, below the construction access road, the proposed parking lot, and at the base of structural fill regarding over-excavations. Where required, apply geosynthetics directly on approved subgrades, taut, free of wrinkles, and over-lapped at least 12 inches. Consult DOWL to review geosynthetic applications or other subgrade improvement alternatives. Geogrid is required to help support any area that exhibits unusually high groundwater, soft pumping, or rutting conditions. Geotextile fabric placed at the bottom of the footing excavation must meet the requirements for separation/stabilization geotextile in Section 831, Geotextiles and Impermeable Plastic Membrane of the South Dakota Department of Transportation 2015 Standard Specifications for Road and Bridges (AASHTO Designation: M 288).

4.7 Soil Chemistry and Corrosion

Based on the results shown in the table below, concrete in contact with the on-site soil classifies as exposure class S2 according to ACI 318 table 19.3.1.1 (ACI, 2014). To achieve the required protection against sulfate related corrosion, we recommend specifying Type V cement or increasing the amount of Type II cement in the concrete to achieve a maximum water-to-cement ratio of 0.45 (by weight, normal weight concrete) and a minimum compressive strength, f'c, of 4,500 pounds per square inch (psi). Details can be found in the above ACI reference and in the Portland Cement Association publication "Design and Control of Concrete Mixtures."

According to Corrosion/Degradation of Soil Reinforcement for Mechanically Stabilized Earth Walls (FWHW, 2009) the soil at the site is "very corrosive" to steel. Based on that publication and the tests above, we estimate a corrosion rate of 1.2 ounce per square foot per year for carbon steel and 0.3 ounce per square foot per year for galvanized steel.

Table 13: Soil Chemistry Test Results

Sample Location	Soluble Sulfate (ppm)	Resistivity (ohm-cm)	pH
Boring B-2 at 4.5 feet	1980	526	8.5

5.0 GEOTECHNICAL DESIGN CONTINUITY

Geotechnical design continuity will be an important aspect of the successful completion of this project. In our opinion, geotechnical continuity can occur in three stages: in planning, design, and construction project aspects. Specifically, we recommend DOWL maintain the geotechnical design continuity in the following aspects:

- **Plan and Specification Review:** We recommend you retain DOWL to review final design and construction plans and specifications to verify our geotechnical recommendations are incorporated into construction documents as well as to provide additional recommendations based on the final design concepts. These efforts can help provide document continuity and reduce the potential for errors as the project concepts evolve.
- **Geotechnical Design Confirmation:** The potential soil variation may have a significant impact on foundation construction. As such, we recommend you retain DOWL to provide geotechnical engineering oversight during site grading and foundation excavation to observe the potential variability in the soil conditions and provide consultation regarding potential impacts on foundation construction.
- **Construction Observation and Testing:** We recommend you retain DOWL, or another accredited testing firm to provide observation and testing during site preparation, grading, structural fill placement and backfilling to verify compliance with the recommendations presented in this report. Having DOWL provide inspection and oversight during this process will reduce the potential for an unforeseen construction error which may ultimately impact the project. If we are not retained to perform the recommended services, we cannot be responsible for related construction errors or omissions.

6.0 LIMITATIONS

DOWL based the conclusions and recommendations presented in this report on the assumption that site conditions are not substantially different than those exposed by the explorations. If during construction, subsurface conditions are different from those encountered in the explorations, advise DOWL at once to review those conditions and reconsider recommendations if necessary. The geotechnical recommendations provided herein are based on the premise that an adequate program of tests and observations will be conducted during construction in order to document compliance with DOWL's recommendations and to confirm conditions exposed during subgrade preparations. DOWL geotechnical personnel must review final designs to verify that recommendations provided herein have been properly implemented.

If there is a substantial lapse of time between submission of this report and the start of work at the site, and especially if conditions have changed due to natural causes or construction operations at or near the site, contact DOWL to review this report and to evaluate the applicability of the conclusions and recommendations presented herein.

DOWL prepared this report for the U.S. Fish & Wildlife Service and their Consultants use on this project. DOWL recommends you make this report available to prospective contractors for information and factual data only, but not as a warranty of subsurface conditions. DOWL prepared this report, including engineering analyses, recommendations, figures, and design details specifically for the Huron Multipurpose Building. These recommendations are not applicable to other construction sites. Do not separate the figures from the text for independent use.

DOWL performed these services consistent with the level of care and skill ordinarily exercised by members of the profession currently practicing in this area under similar time and budgetary constraints. No warranty is made or implied.

Any conclusions made by a construction contractor or bidder relating to construction means, methods, techniques, sequences, or costs based upon the information provided in this report are not the responsibility of U.S. Fish & Wildlife Services or DOWL.

7.0 REFERENCES

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Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will <u>not</u> likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will <u>not</u> be adequate to develop geotechnical design recommendations for the project.

Do <u>not</u> rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do <u>not</u> rely on an executive summary. Do <u>not</u> read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept* *responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are <u>not</u> final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are <u>Not</u> Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will <u>not</u> of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are <u>not</u> building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

Telephone: 301/565-2733
e-mail: info@geoprofessional.org www.geoprofessional.org

Appendix A

Exploration Logs

Geotechnical Report

DOWL

SOIL CLASSIFICATION/LEGEND

Unified Soil Classification System

Criteria for Assigning Group Symbols and Names			Soil Classification Generalized Group Descriptions	
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	GW	Well-graded gravels
			GP	Poorly-graded gravels
		GRAVELS w/ FINES More than 12% fines	GM	Gravel and silt mixtures
			GC	Gravel & clay mixtures
	SANDS 50% or more of coarse faction passes No. 4 sieve	CLEAN SANDS Less than 5% fines	SW	Well-graded sands
			SP	Poorly-graded sands
		SANDS with FINES More than 12% fines	SM	Sand and silt mixtures
			SC	Sand and clay mixtures
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	SILTS & CLAYS Liquid limit less than 50	INORGANIC	CL	Low-plasticity clays
			ML	Non-plastic and low-plasticity silts
		ORGANIC	OL	Non-plastic and low plasticity organic clays Non-plastic and low-plasticity organic silts
	SILTS & CLAYS Liquid limit greater than 50	INORGANIC	CH	High-plasticity clays
			MH	High-plasticity silts
		ORGANIC	OH	High-plasticity organic clays High-plasticity organic soils
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color and has an organic odor		PT	peat

Component Definitions By Gradation

Component	Size Range
Boulders	Greater than 12-in.
Cobbles	3-in. to 12-in.
Gravel	3-in. to No. 4 (4.75 mm)
Coarse gravel	3-in. to ¾-in.
Fine gravel	¾-in. to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (.075 mm)
Coarse sand	No. 4 (4.75 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.425 mm)
Fine sand	No. 40 (0.425 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

Silt and Clay Descriptions

Description	Typical Unified Designation
Silt	ML (non-plastic)
Clayey Silt	CL-ML (low plasticity)
Silty Clay, Lean Clay	CL
Clay, Fat Clay	CH
Plastic Silt	MH
Organic Soils	OL, OH, Pt

Relative Density or Consistency Utilizing Standard Penetration Test Values

Cohesionless Soils[a]			Cohesive Soils[b]		
Density[c]	N blows/ft[c]	Relative Density (%)	Consistency	N blows/ft[c]	Undrained Shear Strength[d] (psf)
Very loose	0 to 4	0 - 15	Very soft	0 to 2	<250
Loose	5 to 10	15 - 35	Soft	3 to 4	250 - 500
Med. Dense	11 to 29	35 - 65	Firm	5 to 8	500 – 1,000
Dense	30 to 49	65 - 85	Stiff	9 to 15	1,000 – 2,000
Very Dense	Over 50	>85	Very Stiff	16 to 30	2,000 – 4,000
			Hard	Over 30	>4,000

(a) Soils consisting of gravel, sand and silt, either separately or in combination, possessing no characteristics of plasticity and exhibiting drained behavior.
(b) Soils possessing the characteristics of plasticity, and exhibiting undrained behavior.
(c) Undrained shear strength = ½ unconfined compressive strength.
(d) Qp - Denotes pocket penetrometer field measurement (tons per square foot) approximation to unconfined compressive strength.

Descriptive Terminology Denoting Components Proportions

Descriptive Terms	Range of Proportion
Trace or Scattered	0 - 5%
Few	5 - 10%
Some or Adjective[a]	15 - 30%
And	30 - 50%

(a)Use gravelly, sandy or silty as appropriate.

Samples

- **Split Spoon Sampler (2.0" OD)**
- **Ring Sampler (3.0" OD)***
  *Indicates increased blow counts due to sampler size.
- **Shelby Tube Sampler (3.0" OD)**
- **Bulk Sample (auger cuttings)**
- **Core Barrel**

Unless otherwise noted, drive samples advanced with 140-lb. hammer and 30-in. drop.

Groundwater Elevation

- ▼ Water Elevation Noted During Drilling
- ▽ Water Elevation Recorded After Drilling Complete

Soil Moisture

Dry	Absence of moisture, dusty, dry to the touch
Slightly Moist	Minor existence of moisture, not dusty, but still dry to the touch
Moist	Damp but no visible water
Very Moist	Zones of visible moisture and usually above the water table
Wet	Visible free water, usually soil is below water table

Project No.: 5028.27083.01

LOG OF BOREHOLE B-1

CLIENT: US Fish & Wildlife Services

PROJECT: Huron Multipurpose Building

BORING LOCATION: North Easteast End of Building

SITE: Huron, South Dakota

Surface Elevation: 1326.0

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BLOWS PER 6"	N BLOWS/FT	SAMPLE NUMBER	IN. RECOVERED / IN. DRIVEN	ADDITIONAL DATA/ REMARKS
0	Dark brown TOPSOIL, sandy silt, moist		3, 2, 3	5	1	14/18 78%	Glacial Outwash Deposits
0.2	Dark brown Sandy Silty CLAY, firm, moist	1325.8	7, 9, 6	15	2	13/18 72%	
3.0	Light brown Clayey SAND, medium dense, moist	1323					
5.0	Brown Sandy LEAN CLAY, very stiff, moist, occasional gravel	1321			3	24/24 100%	Moisture=15% D. Density=105 pcf Fines=47% Sand=49% Gravel=4% LL=28, PI=9
			6, 9, 12	21	4	16/18 89%	
			6, 9, 13	22	5	18/18 100%	Moisture=16 Fines=50% Sand=48% Gravel=2% LL=28, PI=9
					6	24/24 100%	
19.0	Brown, LEAN CLAY, hard, moist	1307	8, 17, 21	38	7	15/18 83%	
	dark gray, very stiff		7, 11, 18	29	8	16/18 89%	
			2, 11, 13	24	9	18/18 100%	
31.0		1295					

Elevation scale: 1325, 1320, 1315, 1310, 1305, 1300, 1295. Depth scale: 0, 5, 10, 15, 20, 25, 30, 35.

Column headings: GRAPHIC LOG; SAMPLES: BULK, DRIVEN/PUSH, BLOWS PER 6", N BLOWS/FT, NUMBER, IN. RECOVERED / IN. DRIVEN; TESTS: POCKET PENETROMETER, TSF; M.C. ●; PL |—| LL; N VALUE □ BLOWS/FT 10 20 30 40

DOWL
1300 Cedar Street
Helena, Montana 59601
Telephone: (406) 442-0370
www.dowl.com

STARTED	11/9/21	FINISHED	11/9/21
DRILL CO.	Core Eng.	DRILL RIG	Diedric Custom
DRILLER	P. Engles	HAMMER	Auto
LOGGED BY	S. Brown	APPROVED BY	D. Russell

Project No.: 5028.27083.01

LOG OF BOREHOLE B-2

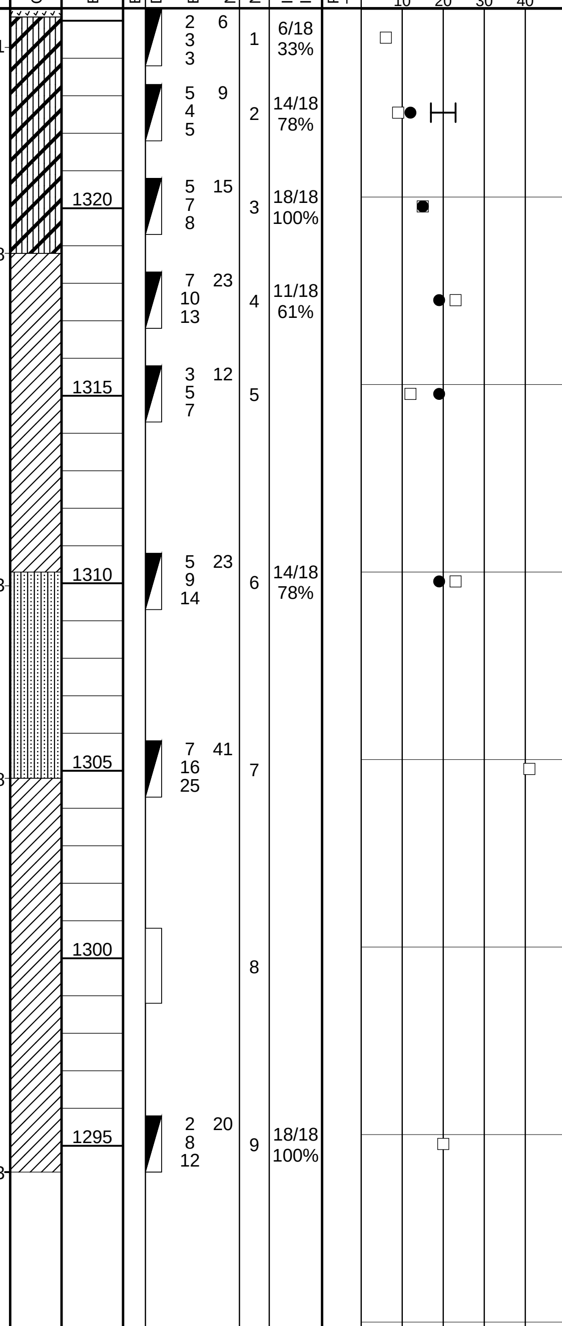
Sheet 1 of 1

CLIENT	PROJECT
US Fish & Wildlife Services	Huron Multipurpose Building
BORING LOCATION: Center of Building	SITE: Huron, South Dakota

Surface Elevation: 1325.3

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	ADDITIONAL DATA/ REMARKS
0	Dark brown TOPSOIL, sandy silt, firm, moist		2 3 3	6	1	6/18 33%	Glacial Outwash Deposits
0.2	Brown Sandy Silty CLAY, stiff, moist	1325.1	5 4 5	9	2	14/18 78%	Moisture=12% Fines=53% Sand=45% Gravel=2% LL=23, PI=6
5		1320	5 7 8	15	3	18/18 100%	
6.5	Brown Sandy LEAN CLAY, very stiff, moist	1318.8	7 10 13	23	4	11/18 61%	
10	stiff	1315	3 5 7	12	5		
15	very stiff	1310	5 9 14	23	6	14/18 78%	
15.0	Brown SILTY SAND, medium dense, moist	1310.3					
20	dense	1305	7 16 25	41	7		
20.5	Gray Sandy LEAN CLAY, hard, moist	1304.8					
25		1300			8		
30	very stiff	1295	2 8 12	20	9	18/18 100%	
31.0		1294.3					
35							

TESTS: M.C. ●; PL ├─┤ LL; N VALUE □ BLOWS/FT (10, 20, 30, 40); POCKET PENETROMETER, TSF



DOWL
1300 Cedar Street
Helena, Montana 59601
Telephone: (406) 442-0370
www.dowl.com

STARTED	11/9/21	FINISHED	11/9/21
DRILL CO.	Core Eng.	DRILL RIG	Diedric Custom
DRILLER	P. Engles	HAMMER	Auto
LOGGED BY	S. Brown	APPROVED BY	D. Russell

Project No.: 5028.27083.01	LOG OF BOREHOLE B-3	Sheet 1 of 1

CLIENT	PROJECT
US Fish & Wildlife Services	Huron Multipurpose Building
BORING LOCATION: Southeast End of Building	SITE: Huron, South Dakota

Surface Elevation: 1326.3

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	ADDITIONAL DATA/ REMARKS
0	Dark brown TOPSOIL, sandy silt, firm, moist		2 4 3	7	1	14/18 78%	Glacial Outwash Deposits
0.5	Brown Sandy LEAN CLAY, firm to stiff, moist	1325.8	4 5 6	11	2	12/18 67%	
5			3 5 9	14	3	14/18 78%	Moisture=18% Fines=57% Sand=40% Gravel=3% LL=28, PI=10
	very stiff, occasional gravel		4 10 10	20	4	16/18 89%	
10			4 7 10	17	5	16/18 89%	
15					6	6/24 25%	Moisture=18% D.Density=106 pcf Fines=54% Sand=45% Gravel=1% LL=30, PI=11
20	hard		5 14 33	47	7	14/18 78%	
25	gravelly		5 20 23	43	8	4/18 22%	
29.0	Brown, SILTY SAND, medium dense, wet	1297.3	2 5 15	20	9	12/18 67%	
31.0		1295.3					

Elevation scale: 1325, 1320, 1315, 1310, 1305, 1300

Column headings: SAMPLES (BULK, DRIVEN/PUSH, BLOWS PER 6", N BLOWS/FT, NUMBER, IN. RECOVERED / IN. DRIVEN); TESTS (POCKET PENE-TROMETER, TSF; M.C.; PL — LL; N VALUE □ BLOWS/FT 10 20 30 40)

DOWL 1300 Cedar Street Helena, Montana 59601 Telephone: (406) 442-0370 www.dowl.com		
	STARTED 11/9/21	FINISHED 11/9/21
	DRILL CO. Core Eng.	DRILL RIG Diedric Custom
	DRILLER P. Engles	HAMMER Auto
	LOGGED BY S. Brown	APPROVED BY D. Russell

LOG OF BOREHOLE B-4

Project No.: 5028.27083.01

CLIENT: US Fish & Wildlife Services	PROJECT: Huron Multipurpose Building
BORING LOCATION: Southeast End of Parking	SITE: Huron, South Dakota

Surface Elevation: 1323.1

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	N VALUE (BLOWS/FT)	ADDITIONAL DATA/ REMARKS
0	Dark brown TOPSOIL, sandy silt, firm, moist		2 2 3	5	1	12/18 67%	□	Glacial Outwash Deposits
0.6	Brown Sandy LEAN CLAY, firm, moist	1322.5						
		1320	2 3 2	5	3	9/18 50%	□	B-4 & B-5 Bulk Sample Fines=75% Sand=25% LL=35, PI=21 MDD=107 pcf OMC=17.7% CBR=4.9
4.5	Brown CLAYEY SAND, loose, moist	1318.6	2 3 5	8	4	12/18 67%	□	
6.0		1317.1						

DOWL
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Helena, Montana 59601
Telephone: (406) 442-0370
www.dowl.com

STARTED	11/9/21	FINISHED	11/9/21
DRILL CO.	Core Eng.	DRILL RIG	Diedric Custom
DRILLER	P. Engles	HAMMER	Auto
LOGGED BY	S. Brown	APPROVED BY	D. Russell

Project No.: 5028.27083.01	LOG OF BOREHOLE B-5	Sheet 1 of 1

CLIENT	PROJECT
US Fish & Wildlife Services	Huron Multipurpose Building
BORING LOCATION	SITE
Driveway	Huron, South Dakota

Surface Elevation: 1321.9

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	SAMPLES: BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	POCKET PENETROMETER, TSF	ADDITIONAL DATA/ REMARKS
0	Dark brown TOPSOIL, sandy silt, firm, moist		2 3 3	6	1	9/18 50%		
1.8	Brown Sandy LEAN CLAY, firm, moist	1320.1 (1320)	4 4 3	7	3	12/18 67%		Glacial Outwash Deposits B-4 & B-5 Bulk Sample Fines=75% Sand=25% LL=35, PI=21 MDD=107 pcf OMC=17.7% CBR=4.9
5	firm to stiff, more sand		4 4 4	8	4	14/18 78%		
6.0		1315.9						

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35

TESTS: M.C. ● PL LL; N VALUE ☐ BLOWS/FT 10 20 30 40

DOWL 1300 Cedar Street Helena, Montana 59601 Telephone: (406) 442-0370 www.dowl.com	

STARTED	11/9/21	FINISHED	11/9/21
DRILL CO.	Core Eng.	DRILL RIG	Diedric Custom
DRILLER	P. Engles	HAMMER	Auto
LOGGED BY	S. Brown	APPROVED BY	D. Russell

Project No.: 5028.27083.01

LOG OF BOREHOLE B-6

CLIENT: US Fish & Wildlife Services	PROJECT: Huron Multipurpose Building
BORING LOCATION: Leach Field	SITE: Huron, South Dakota

Surface Elevation: 1317.7

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	ADDITIONAL DATA/ REMARKS
0	Dark brown TOPSOIL, sandy silt, firm		2 2 4	6	1	10/18 56%	
1.8	Brown Sandy LEAN CLAY, firm, moist	1315.9 / 1315	2 3 3	6	2	6/18 33%	Glacial Outwash Deposits
	ocassional fine gravel		2 3 4	7	3	10/18 56%	
6.0		1311.7					

Tests columns: POCKET PENETROMETER, TSF; M.C. (PL — LL); N VALUE □ BLOWS/FT (10, 20, 30, 40)

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35

DOWL
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Helena, Montana 59601
Telephone: (406) 442-0370
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STARTED	11/9/21	FINISHED	11/9/21
DRILL CO.	Core Eng.	DRILL RIG	Diedric Custom
DRILLER	P. Engles	HAMMER	Auto
LOGGED BY	S. Brown	APPROVED BY	D. Russell

Appendix B

Photograph Log

Geotechnical Report

DOWL

Photograph 1 – B-1 Drilling Location

Photograph 2 - B-1 at 0.0-1.5 feet

Photograph 3 - B-1 at 2.5-4.0 feet

Photograph 4 – B-1 at 4.5-6.0 feet

Photograph 5 – B-1 at 7.0-8.5 feet

Photograph 6 - B-1 at 9.5-11.0 feet

Photograph 7 - B-1 at 14.5-16.0 feet

Photograph 8 - B-1 at 24.5-26.0 feet

Photograph 9 – B-2 at 0.0-1.5 feet

Photograph 10 - B-2 at 4.5-6.0 feet

Photograph 11 - B-2 at 7.5-9.0 feet


Photograph 12 - B-2 at 9.5-11.0 feet


Photograph 13 - B-2 at 14.5-16.0 feet


Photograph 14 - B- at 19.5-21.0 feet


Photograph 15 - B-2 at 29.5-31 feet


Photograph 16 – B-3 Drilling Location


Photograph 17 – B-3 at 0.0-1.5 feet


Photograph 18 - B-3 at 4.5-6.0 feet


Photograph 19 - B-3 at 9.5-11.0 feet


Photograph 20 - B-3 at 14.5-16.0 feet

Photograph 21 - B-3 at 19.5-21.0 feet

Photograph 22 - B-3 at 24.5-26.0 feet

Photograph 23 - B-3 at 29.5-31.0 feet

Photograph 24 - B-4 at 0.0-1.5 feet

Photograph 25 - B-4 at 3.5-5.0 feet

Photograph 26 – B-5 at 0.0-1.5 feet

Photograph 27 - B-5 at 3.5-5.0 feet

Photograph 28 – B-6 at 0.0-1.5 feet

Photograph 29 - B-6 at 3.5-5.0 feet

Photograph 30 – B-6 Drilling Location

Appendix C

Laboratory Test Results

Geotechnical Report

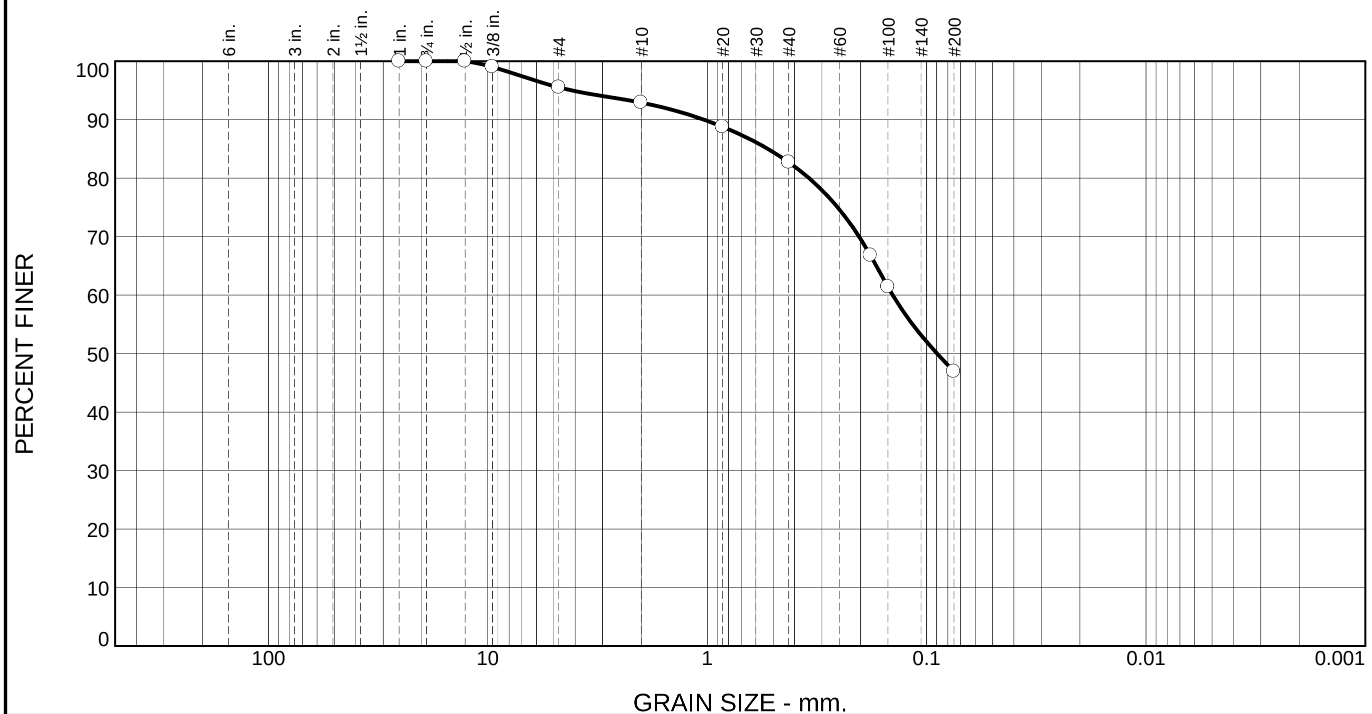
DOWL

5028.27083.01 - Huron Multipurpose Building

Exploration	Sample Type	Depth Range (ft)	USCS Classification Symbol	Natural Moisture - %	Natural Dry Unit Weight - pcf	Fines Smaller Than #200 (0.075 mm)	Sand #200 to # 4 (0.075 - 4.76 mm)	Gravel #4 to 3" (4.76 -76.2 mm)	Liquid Limit - %	Plasticity Index - %	Maximum Dry Unit Weight (ASTM D698)-PCF	Optimum Moisture Content (ASTM D698) - %	CBR (ASTM D1883)	Consolidation - Pc - ksf	Consolidation -Cc	Consolidation - Cs	Resistivity (Ohm-Cm) Saturated	pH	Water Soluble SO4 - mg/kg
B-1	SHELBY	4.5'	SC	15	105	46.9	49	5	28	9				1.2	0.11	0.010			
B-1	SS	10'	CL	16		50.4	48	2	28	9									
B-2	SS	2.5'	CL-ML	12		53.2	45	2	23	6							526	8.5	1980
B-2	SS	4.5'		15															
B-2	SS	7		19															
B-2	SS	9.5'		19															
B-2	SS	14.5'		19															
B-2	SS	19.5'		16															
B-3	SS	4.5'	CL	18		57.3	40	3	28	10									
B-3	SHELBY	14.5'	CL	18	106	54.0	45	1	30	11				0.5	0.06	0.001			
B-4 & B-5	BULK	1 - 4	CL			75.2	25	0	35	21	107	17.7	4.9						

Scott Brown
Lander Lab

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	4.5	2.6	10.2	35.8	46.9	

Test Results (ASTM C 136 & ASTM C 117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	100.0		
1/2	100.0		
3/8	99.0		
#4	95.5		
#10	92.9		
#20	88.8		
#40	82.7		
#80	66.8		
#100	61.4		
#200	46.9		

* (no specification provided)

Material Description

Clayey SAND

Atterberg Limits (ASTM D 4318)

PL= 19 **LL=** 27 **PI=** 8

Classification

USCS (D 2487)= SC **AASHTO (M 145)=** A-4(1)

Coefficients

D_{90}= 1.0348	D_{85}= 0.5288	D_{60}= 0.1427
D_{50}= 0.0896	D_{30}=	D_{15}=
D_{10}=	C_u=	C_c=

Remarks

F.M.=0.96

Date Received: 11-12-21 **Date Tested:** 12-14-21

Tested By: S BROWN

Checked By: D RUSSELL

Title: Geotechnical Engineer

Location: B-1
Depth: 4.5 ft

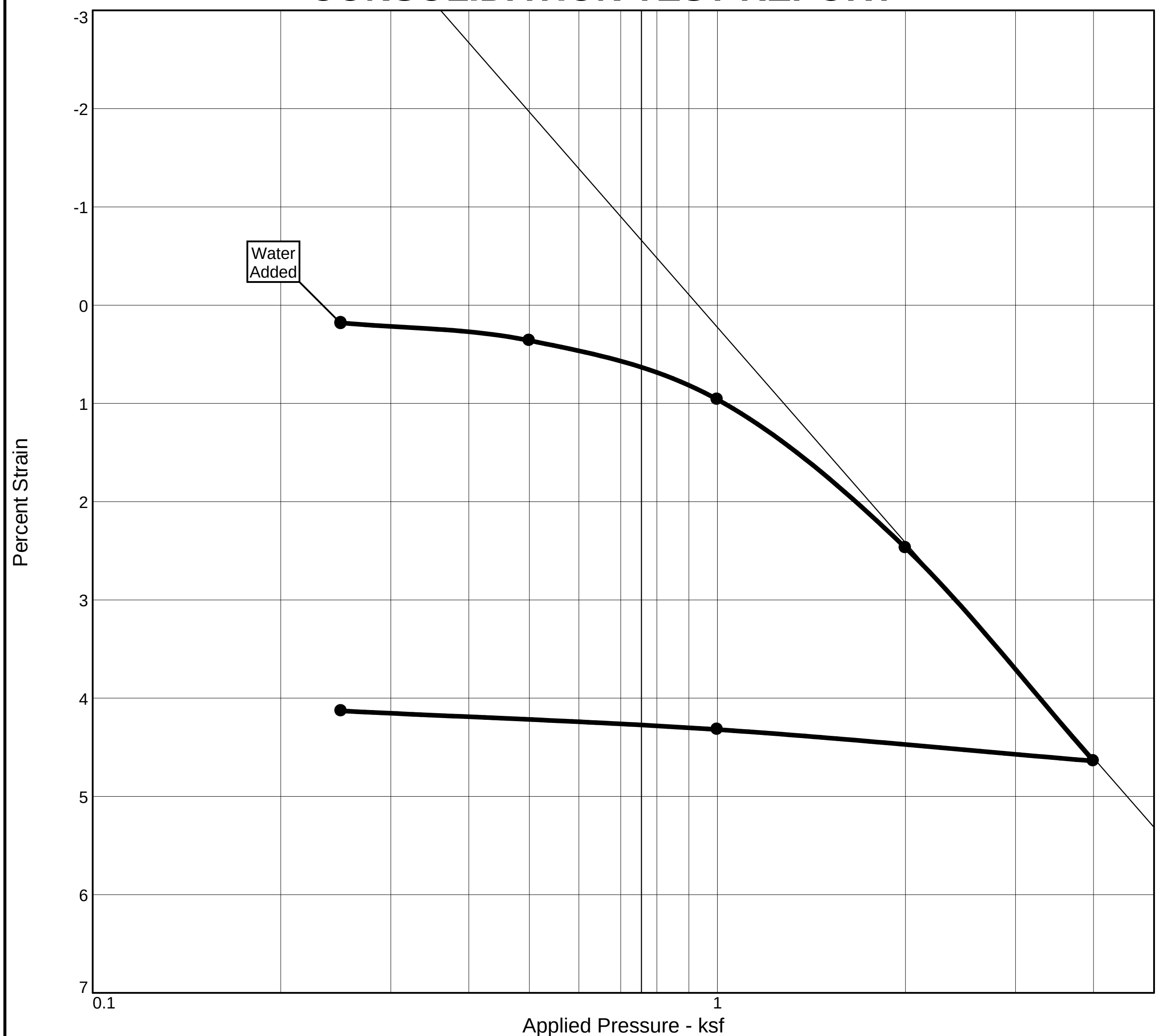
Date Sampled: 11-9-21

DOWL

Client: United States Fish and Wildlife Services
Project: Huron Multipurpose Building

Project No: 5028.27083.01

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (ksf)	P_c (ksf)	C_c	C_s	Swell Press. (ksf)	Swell %	e_o
Sat.	Moist.											
69.3 %	14.9 %	105.3	27	8	2.65	0.54	1.2	0.11	0.01	0.3	0.0	0.571

MATERIAL DESCRIPTION	USCS	AASHTO
Clayey SAND	SC	A-4(1)

Project No. 5028.27083.01 **Client:** United States Fish and Wildlife Services

Project: Huron Multipurpose Building

Location: B-1 **Depth:** 4.5 ft

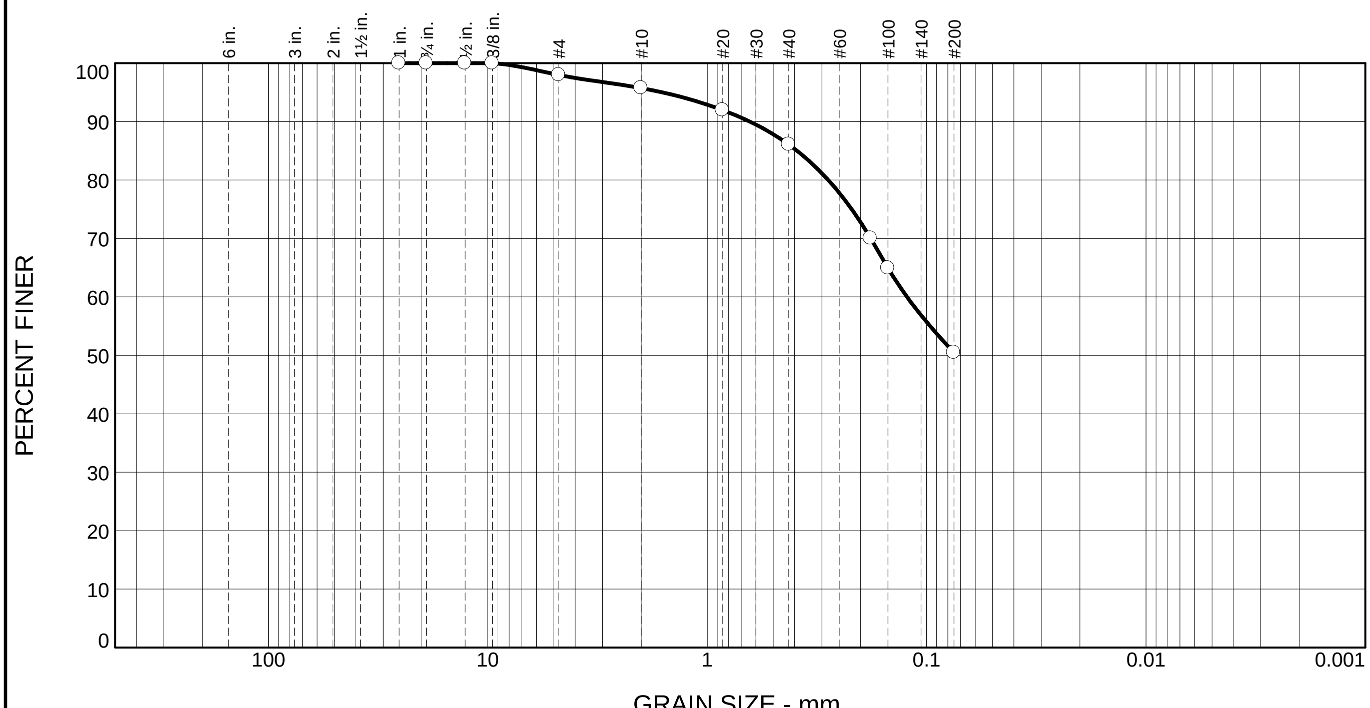
DOWL

Remarks:

Figure

Tested By: S BROWN

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.0	2.3	9.6	35.7	50.4	

Test Results (ASTM C 136 & ASTM C 117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	100.0		
1/2	100.0		
3/8	100.0		
#4	98.0		
#10	95.7		
#20	92.0		
#40	86.1		
#80	70.0		
#100	64.9		
#200	50.4		

* (no specification provided)

Material Description

Sandy LEAN CLAY

Atterberg Limits (ASTM D 4318)

PL= 19 **LL=** 28 **PI=** 9

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-4(2)

Coefficients

D_{90}= 0.6391 D_{85}= 0.3894 D_{60}= 0.1229
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

F.M.=0.76

Date Received: 11-12-21 **Date Tested:** 12-14-21

Tested By: S BROWN

Checked By: D RUSSELL

Title: Geotechnical Engineer

Location: B-1
Depth: 10 ft

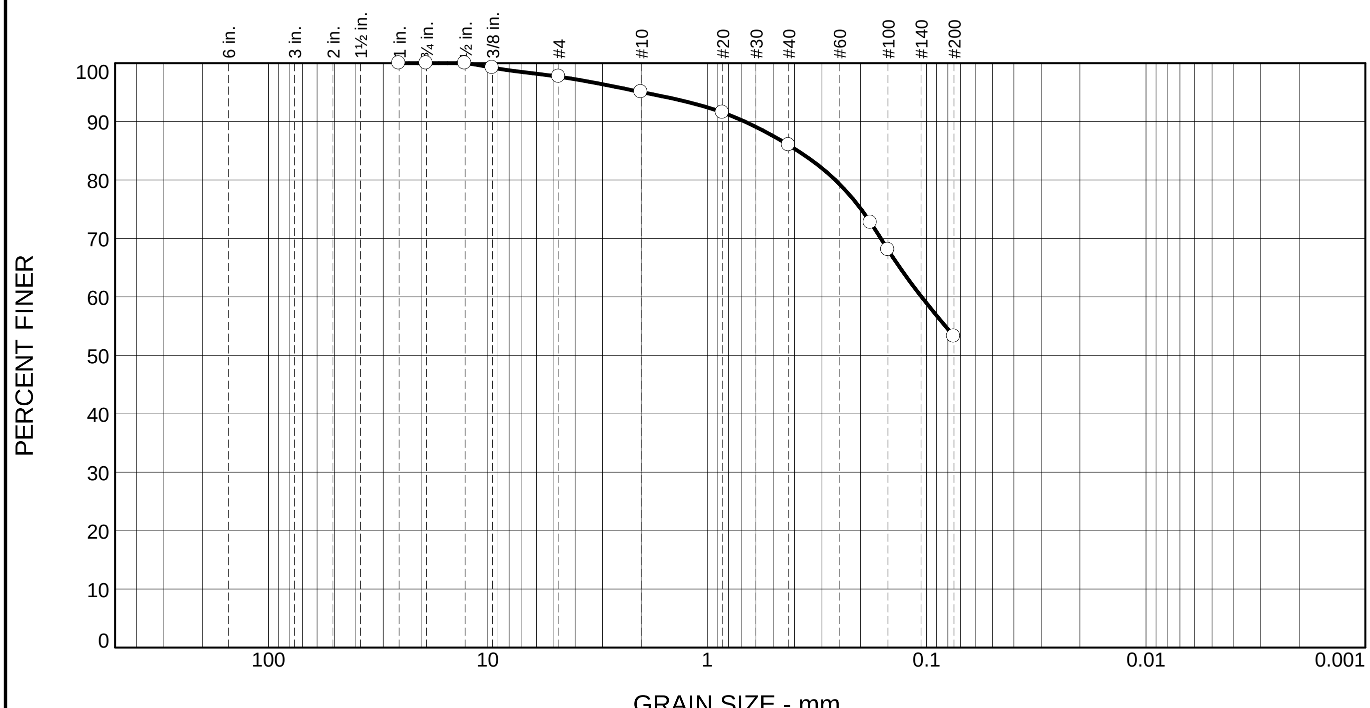
Date Sampled: 11-9-21

DOWL

Client: United States Fish and Wildlife Services
Project: Huron Multipurpose Building

Project No: 5028.27083.01

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.3	2.6	9.1	32.8	53.2	

Test Results (ASTM C 136 & ASTM C 117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	100.0		
1/2	100.0		
3/8	99.2		
#4	97.7		
#10	95.1		
#20	91.6		
#40	86.0		
#80	72.7		
#100	68.1		
#200	53.2		

* (no specification provided)

Material Description

Sandy Silty CLAY

Atterberg Limits (ASTM D 4318)

PL= 17 **LL=** 23 **PI=** 6

Classification

USCS (D 2487)= CL-ML **AASHTO (M 145)=** A-4(1)

Coefficients

D_{90}= 0.6735 D_{85}= 0.3863 D_{60}= 0.1054
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

F.M.=0.75

Date Received: 11-12-21 **Date Tested:** 12-14-21

Tested By: S BROWN

Checked By: D RUSSELL

Title: Geotechnical Engineer

Location: B-2
Depth: 2.5 ft

Date Sampled: 11-9-21

DOWL

Client: United States Fish and Wildlife Services
Project: Huron Multipurpose Building

Project No: 5028.27083.01

LABORATORY ANALYTICAL REPORT

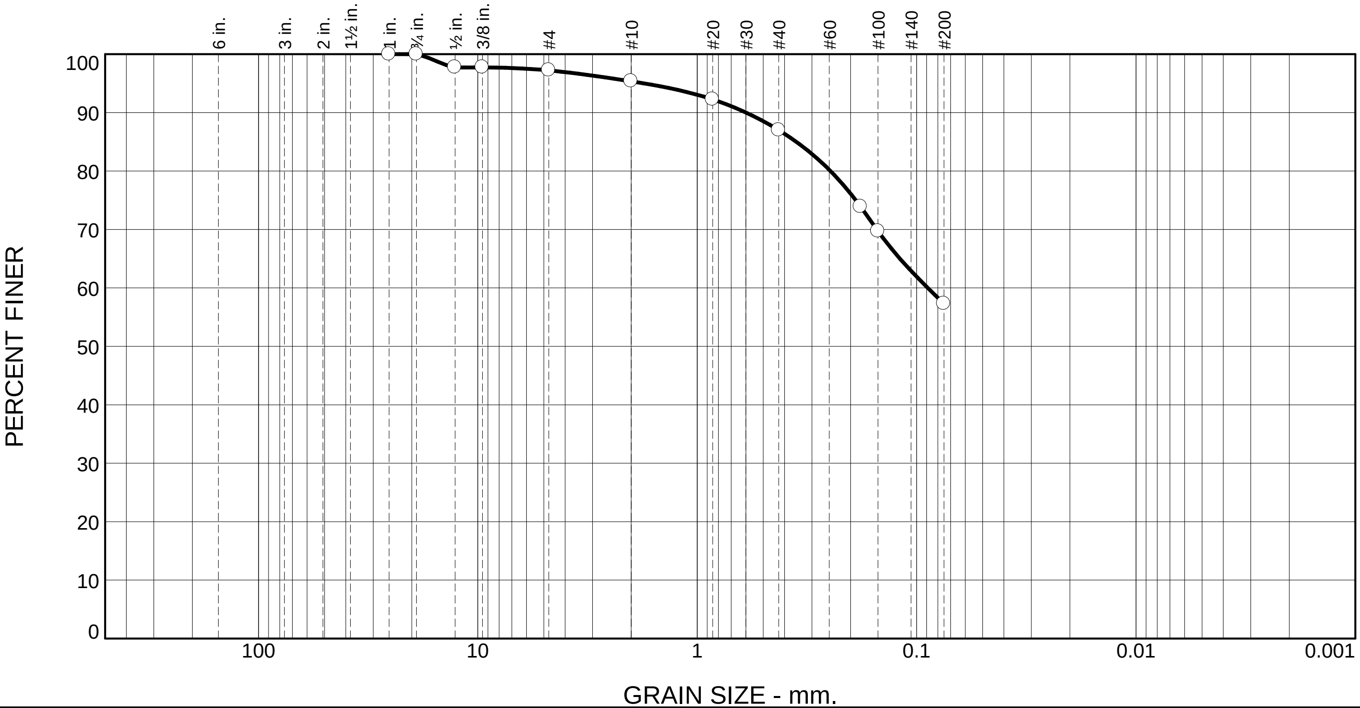
Prepared by Billings, MT Branch

Client:	DOWL	**Report Date:**	01/06/22
Project:	5028.27083.01 Lake Huron	**Collection Date:**	11/16/21 12:00
Lab ID:	B21121758-001	**DateReceived:**	12/21/21
Client Sample ID:	BH-2 4.5-6.0	**Matrix:**	Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
SULFATE BY MT DOT METHOD 532							
Sulfate	1980	mg/kg	D	2		E300.0	12/29/21 14:10 / car
MT DOT 232-16							
pH	8.5	s.u.		0.1		MTDOT 232-1	12/29/21 11:02 / srm
RESISTIVITY OF SOIL							
Resistivity	526	ohm-cm		1		A2510 B	12/29/21 11:02 / srm

Report Definitions:
RL - Analyte Reporting Limit
QCL - Quality Control Limit
D - Reporting Limit (RL) increased due to sample matrix
MCL - Maximum Contaminant Level
ND - Not detected at the Reporting Limit (RL)

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.8	1.8	8.4	29.7	57.3	

Test Results (ASTM C 136 & ASTM C 117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	100.0		
1/2	97.7		
3/8	97.7		
#4	97.2		
#10	95.4		
#20	92.3		
#40	87.0		
#80	73.9		
#100	69.7		
#200	57.3		

* (no specification provided)

Material Description

Sandy LEAN CLAY

Atterberg Limits (ASTM D 4318)

PL= 18 **LL=** 28 **PI=** 10

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-4(3)

Coefficients

D_{90}= 0.5983 D_{85}= 0.3533 D_{60}= 0.0890
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

F.M.=0.73

Date Received: 11-12-21 **Date Tested:** 12-14-21

Tested By: S BROWN

Checked By: D RUSSELL

Title: Geotechnical Engineer

Location: B-3
Depth: 4.5 ft

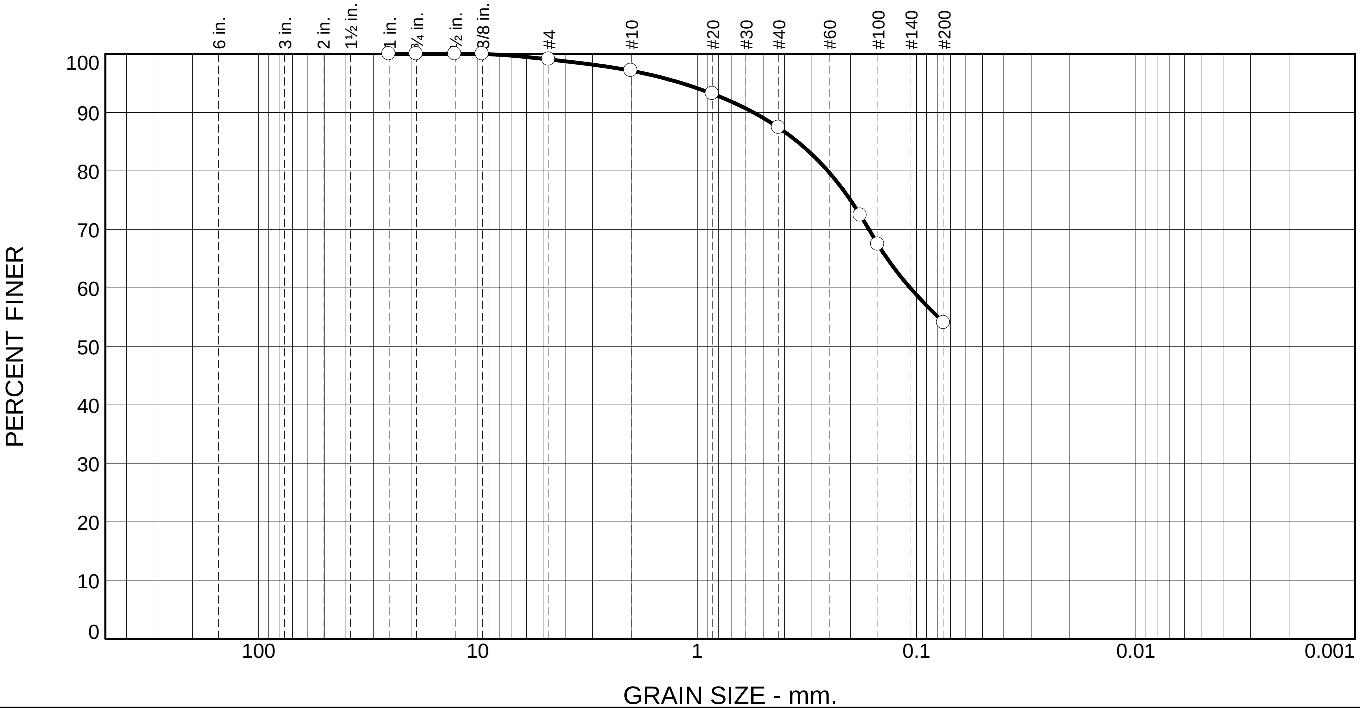
Date Sampled: 11-9-21

DOWL

Client: United States Fish and Wildlife Services
Project: Huron Multipurpose Building

Project No: 5028.27083.01

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.9	2.0	9.7	33.4	54.0	

Test Results (ASTM C 136 & ASTM C 117)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
3/4	100.0		
1/2	100.0		
3/8	100.0		
#4	99.1		
#10	97.1		
#20	93.2		
#40	87.4		
#80	72.4		
#100	67.4		
#200	54.0		

* (no specification provided)

Material Description

Sandy LEAN CLAY

Atterberg Limits (ASTM D 4318)

PL= 19 **LL=** 30 **PI=** 11

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-6(3)

Coefficients

D_{90}= 0.5538 D_{85}= 0.3486 D_{60}= 0.1069
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

F.M.=0.67

Date Received: 11-11-21 **Date Tested:** 12-14-21

Tested By: S BROWN

Checked By: D RUSSELL

Title: Geotechncial Engineer

Location: B-3
Depth: 14.5 ft

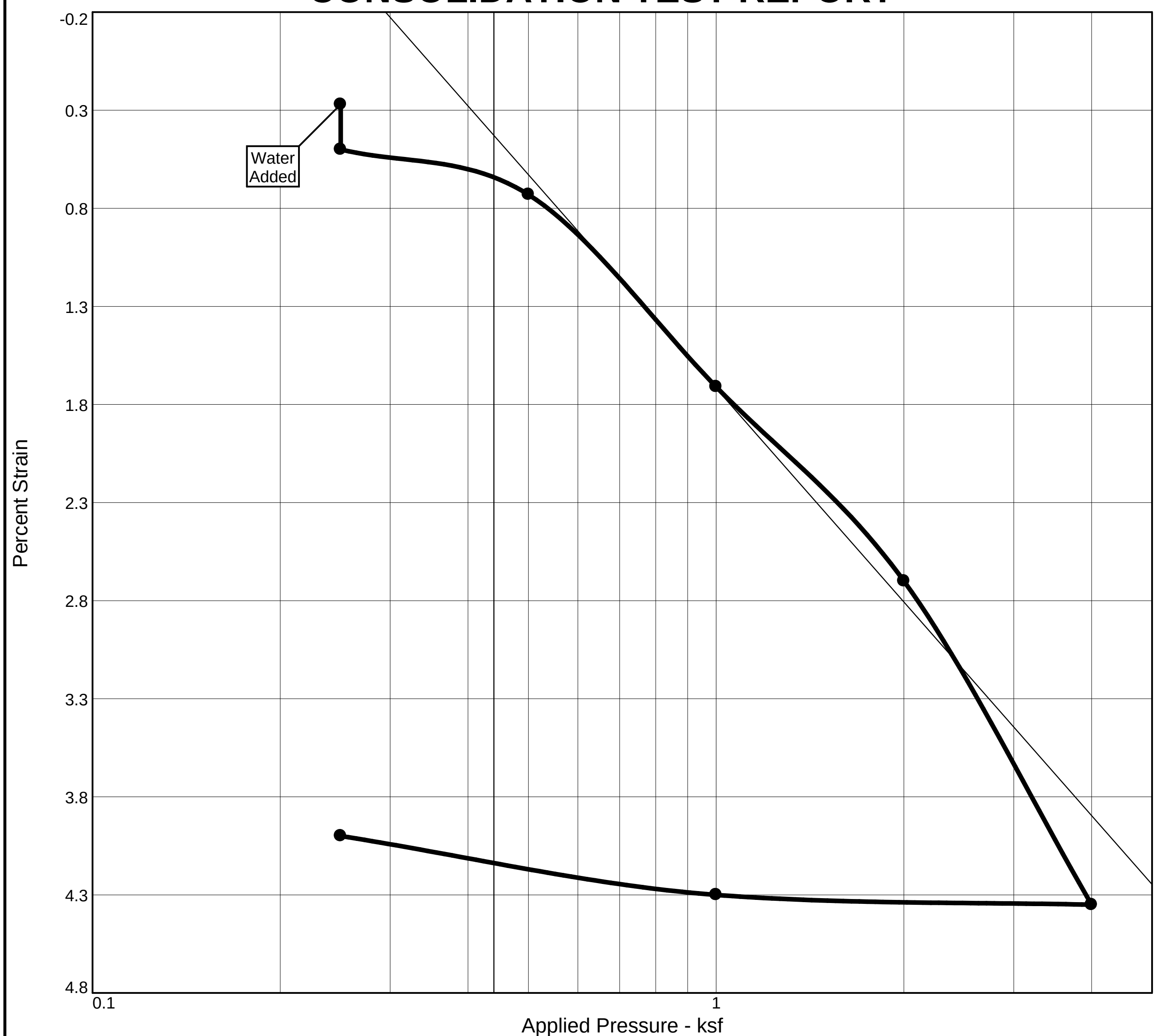
Date Sampled: 11-9-21

DOWL

Client: United States Fish and Wildlife Services
Project: Huron Multipurpose Building

Project No: 5028.27083.01

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (ksf)	P_c (ksf)	C_c	C_s	Swell Press. (ksf)	Clpse. %	e_o
Sat.	Moist.											
87.9 %	18.4 %	106.5	30	11	2.65	1.83	0.5	0.06	0.00		0.2	0.554

MATERIAL DESCRIPTION	USCS	AASHTO
Sandy LEAN CLAY	CL	A-6(3)

Project No. 5028.27083.01 **Client:** United States Fish and Wildlife Services

Project: Huron Multipurpose Building

Location: B-3 **Depth:** 14.5 ft

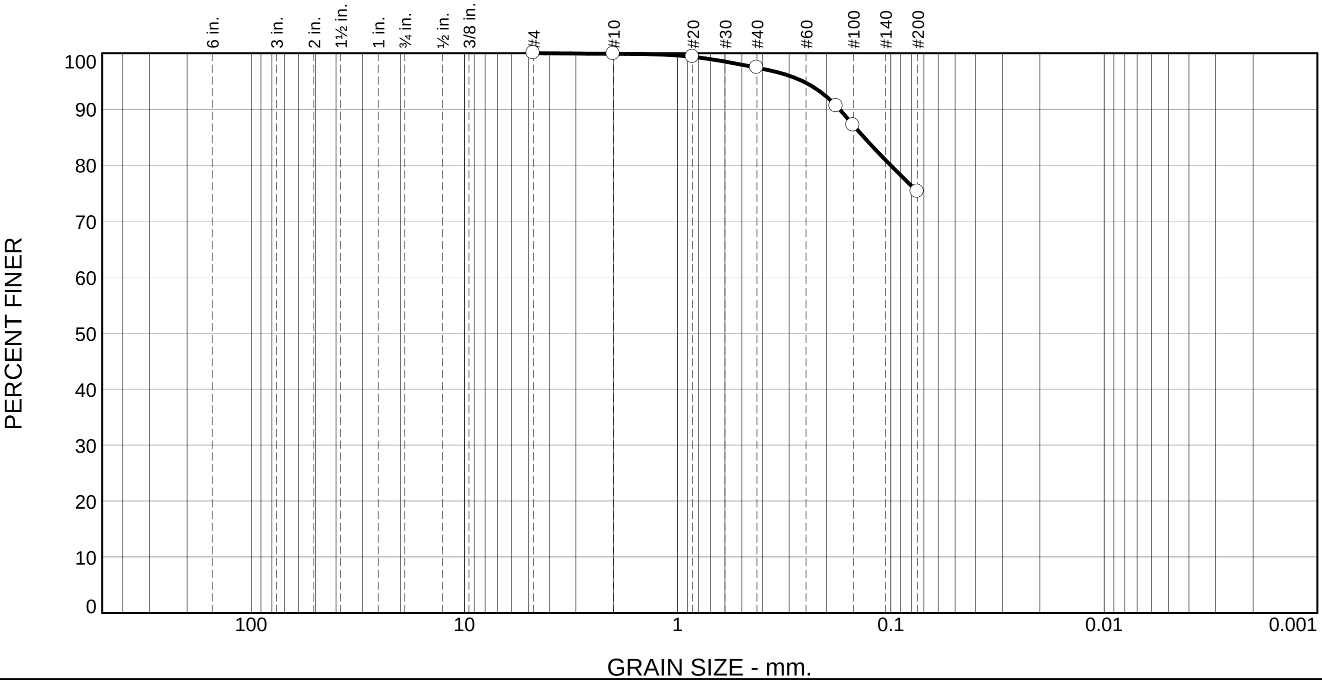
DOWL

Remarks:

Figure

Tested By: S BROWN **Checked By:** D RUSSELL

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	2.5	22.2	75.2	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	99.9		
#20	99.3		
#40	97.4		
#80	90.6		
#100	87.1		
#200	75.2		

* (no specification provided)

Material Description

Lean CLAY with sand

Atterberg Limits (ASTM D 4318)

PL= 21 **LL=** 35 **PI=** 14

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-6(9)

Coefficients

D_{90}= 0.1743 D_{85}= 0.1339 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Sampled by DOWL

Date Received: 12/3/21 **Date Tested:** 12/15/21

Tested By: CC

Checked By: DR

Title: Geotechnical Engineer

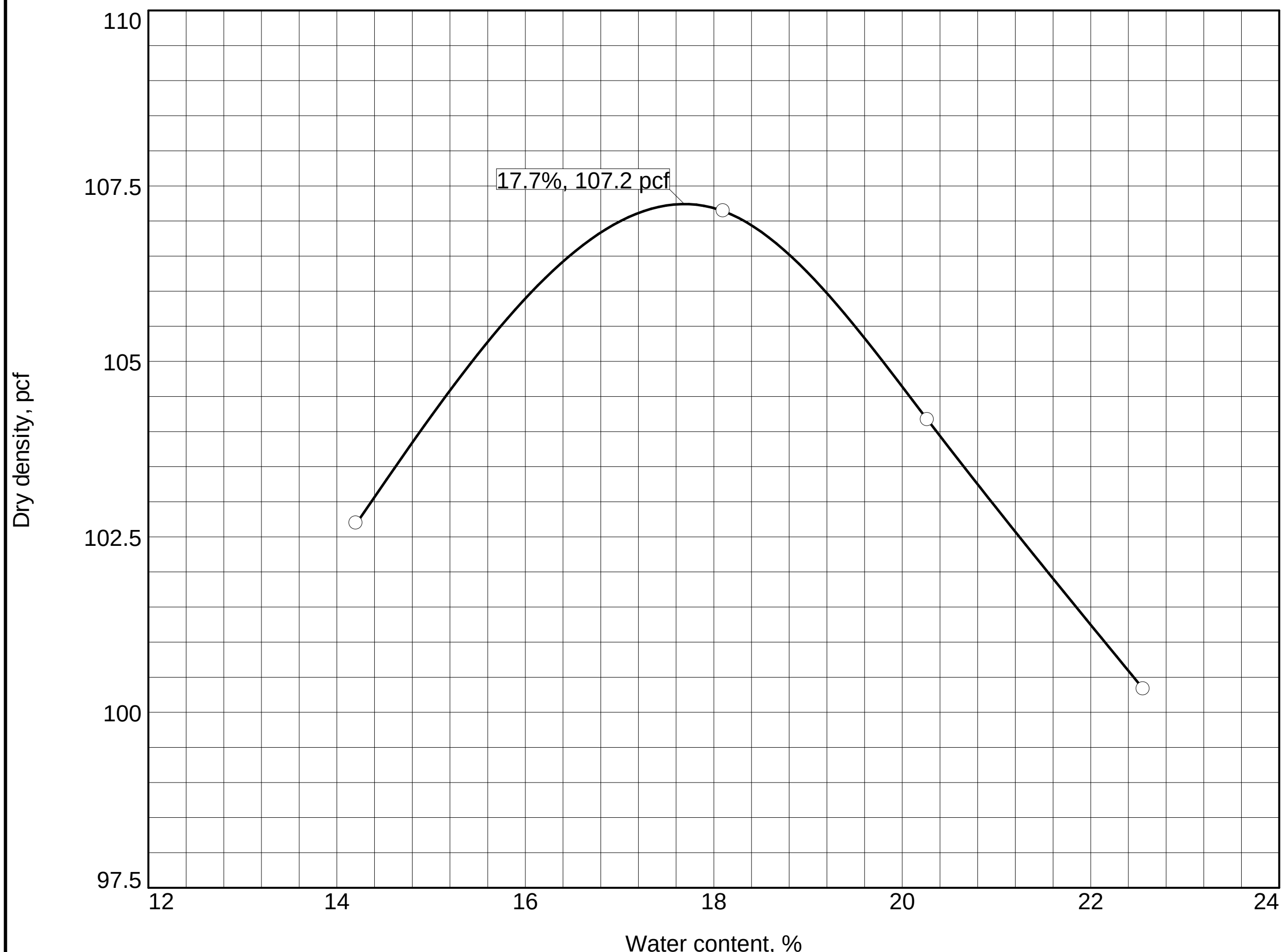
Location: B-4 & B-5
Sample Number: 36013 **Depth:** 1-4 FT **Date Sampled:** 11/16/21

DOWL

Client: United States Fish and Wildlife Services
Project: Huron Multipurpose Building

Project No: 5028.27083.01 **Figure**

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
1-4 FT	CL	A-6(9)	20.9		35	14	0.0	75.2

TEST RESULTS

Maximum dry density = 107.2 pcf

Optimum moisture = 17.7 %

MATERIAL DESCRIPTION

Lean CLAY with sand

Project No. 5028.27083.01 **Client:** United States Fish and Wildlife Services

Project: Huron Multipurpose Building

Date: 12/10/21

○ **Location:** B-4 & B-5 **Sample Number:** 36013

DOWL

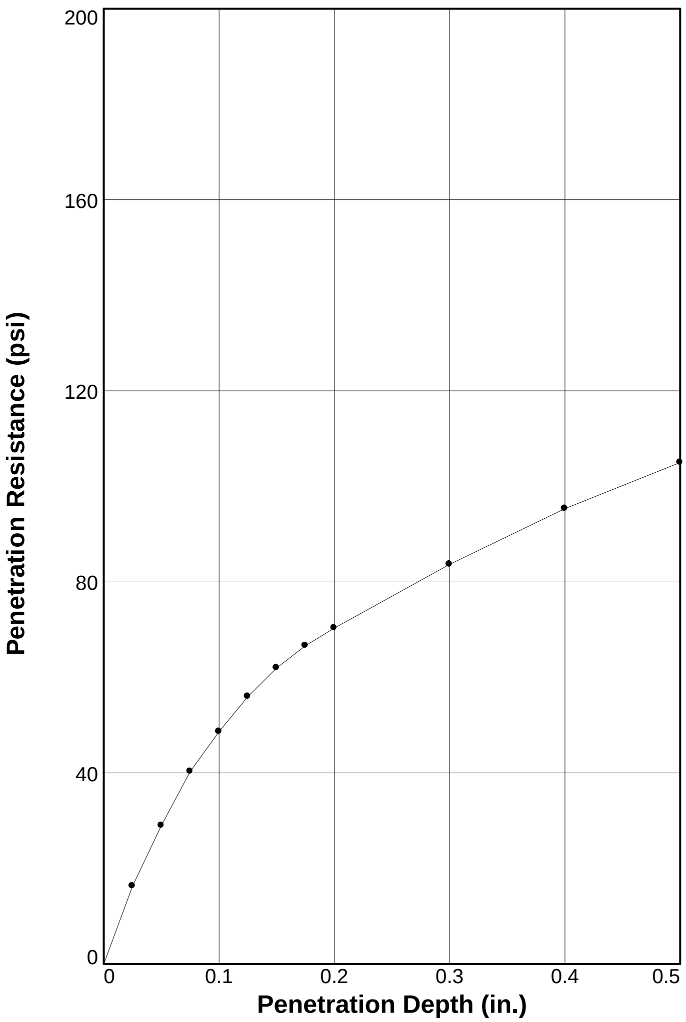
Remarks:

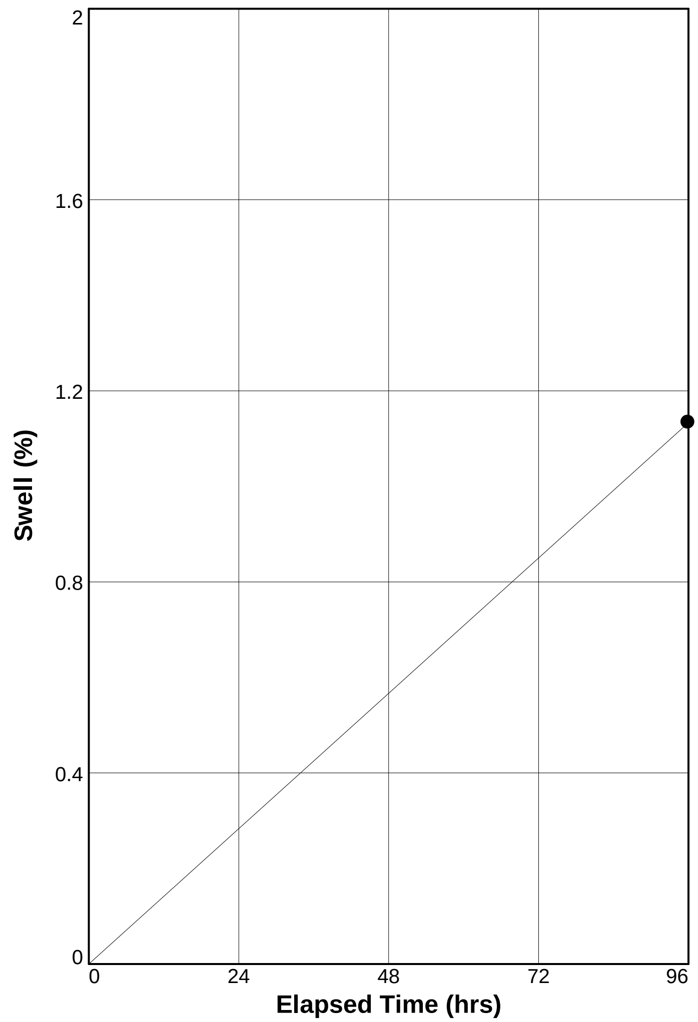
Sampled by DOWL

Figure

Tested By: CC **Checked By:** DR

BEARING RATIO TEST REPORT
AASHTO T 193-13





	Molded			Soaked			CBR (%)		Linearity Correction (in.)	Surcharge (lbs.)	Max. Swell (%)
	Density (pcf)	Percent of Max. Dens.	Moisture (%)	Density (pcf)	Percent of Max. Dens.	Moisture (%)	0.10 in.	0.20 in.			
1 ○	103.3	96.4	15.9	102.2	95.3	22.0	4.9	4.7	0.000	20	1.1
2 △											
3 □											

Material Description	USCS	Max. Dens. (pcf)	Optimum Moisture (%)	LL	PI
Lean CLAY with sand	CL	107.2	17.7	35	14

Project No: 5028.27083.01

Project: Huron Multipurpose Building

Location: B-4 & B-5

Sample Number: 36013 **Depth:** 1-4 FT

Date: 11/16/21

DOWL

Test Description/Remarks:

Sampled by DOWL

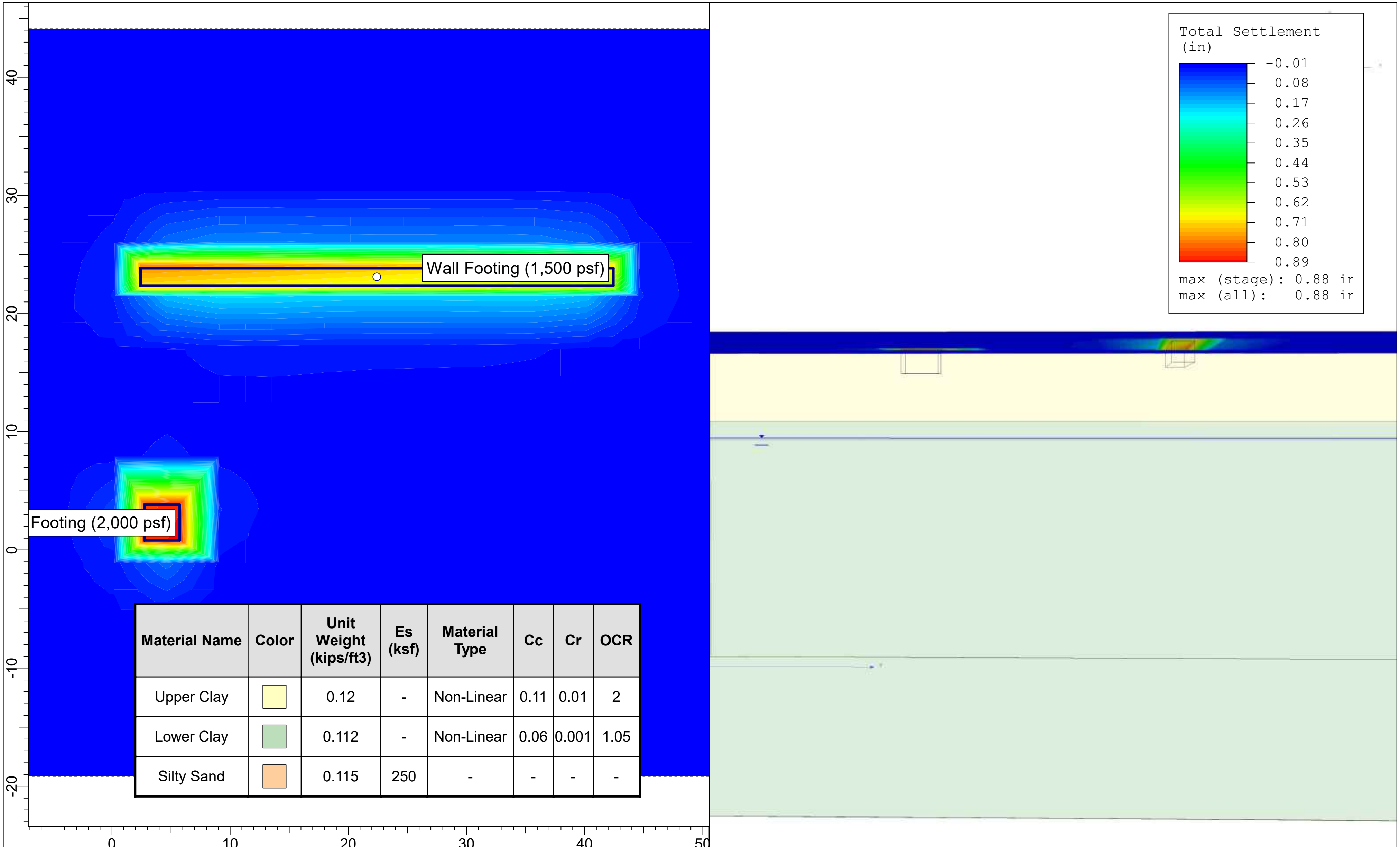
Figure ________

Appendix D

Calculations

Geotechnical Report

DOWL



Material Name	Color	Unit Weight (kips/ft3)	Es (ksf)	Material Type	Cc	Cr	OCR
Upper Clay		0.12	-	Non-Linear	0.11	0.01	2
Lower Clay		0.112	-	Non-Linear	0.06	0.001	1.05
Silty Sand		0.115	250	-	-	-	-

DOWL

SETTLE3 5.013

Project	Lake Huron Multipurpose Building		
Analysis Description	Foundation Settlement		
Drawn By	D. Russell	*Company*	DOWL
Date	12/17/2021	*File Name*	Slab Foundation Settlement.s3z

Appendix E

Percolation Test Results

Geotechnical Report

DOWL

Percolation Test Results

South Dakota Rule 74:53:01:37

Project: Huron MP Building
Job Number: 5028.27083.01
Date: 11/10/2021

Time* (min)	Perc 1 - West, Depth = 24 inches		Perc 2 - Center, Depth = 24 inches		Perc 3 - East, Depth = 24 inches	
	Measurement (ft)	Infiltration Rate (min/in)	Measurement (ft)	Infiltration Rate (min/in)	Measurement (ft)	Infiltration Rate (min/in)
0	8.25		9.25		8.75	
15	8.50	60	9.38	120	8.50	-60
30	8.88	40	9.50	120	8.38	-120
45	9.00	120	9.63	120	8.75	40
60	9.13	120	9.75	120	8.88	120
75	9.25	120	9.75	0	9.00	120
90	9.38	120	9.88	120	9.13	120
105	9.50	120	10.00	120	9.25	120
120	9.63	120	10.13	120	9.38	120
135	9.75	120	10.25	120	9.50	120
	Average (min/in):	**120**		**120**		**120**

*Time readings are cumulative

Average:	120.0	min/in

Alaska

Anchorage	907.562.2000	4041 B Street, Anchorage, AK 99503
Fairbanks	907.374.0275	3535 College Road, Suite 100, Fairbanks, AK 99709
Juneau	907.780.3533	9085 Glacier Highway, Suite 102, Juneau, AK 99801

Arizona

Tempe	480.753.0800	430 W. Warner Road, Suite B101, Tempe, AZ 85284

Montana

Billings	406.656.6399	222 N. 32nd Street, Suite 700, Billings, MT 59101
Bozeman	406.586.8834	1283 North 14th Avenue, Suite 101, MT 59715
Helena	406.442.0370	1300 Cedar Street, Helena, MT 59601

Oregon

Bend	541.385.4772	963 SW Simpson Avenue, Suite 200, Bend, OR 97702
Eugene	541.683.6090	920 Country Club Road, Suite 100B, Eugene, OR 97401
Lake Oswego	503.620.6103	5000 Meadows Road, Lake Oswego, OR 97035
Medford	541.774.5590	831 O'Hare Parkway, Medford, OR 97504
Portland	971.280.8641	720 SW Washington Street, Portland, OR 97205
Salem	503.589.4100	4275 Commercial St SE, Ste 100, Salem, OR 97302

Washington

Redmond	425.869.2670	8420 154th Avenue NE, Redmond, WA 98052
Vancouver	360.314.2391	1111 Main Street, Suite 401 Vancouver, WA 98660

Wyoming

Sheridan	307.672.9006	16 W. 8th Street, Sheridan, WY 82801

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