GEOTECHNICAL INVESTIGATION REPORT

112 Dexter Street
Elk Rapids, Michigan

July 2020

Prepared For:

Mr. Bob Cruse
540 N Spruce Street
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Prepared By:

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PN: G02-050

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1.0 INTRODUCTION

A geotechnical investigation has been completed for 112 Dexter Street in Elk Rapids, Michigan. The investigation included site reconnaissance, subsurface exploration consisting of test drilling, evaluation of the encountered conditions, engineering analysis, and preparation of this report. The investigation results are reported herein. The investigation was performed for Mr. Bob Cruse in accordance with our proposal dated June 15, 2020.

The encountered subsurface conditions are not suitable to support foundations without special construction or subgrade preparation. The geotechnical conditions will result in higher costs at this site. Subgrade improvement consisting of stone columns is recommended as the preferred alternative for foundation support.

The building's finish floor elevation should be selected to be sufficiently high to avoid future problems with surface- or groundwater. Due to environmental considerations, a higher finish floor elevation is desirable to avoid construction dewatering which may be expensive or unfeasible.

2.0 TYPE OF CONSTRUCTION

The project includes the construction of a two to three story residential building. We have considered that the structure will be of conventional light frame construction with maximum wall loads of 5 kips per foot and a maximum column load of 100 kips.

We have considered that the new building will be of slab-on-grade construction. The site currently slopes down into the site from the east and south.

We should be informed of any changes from our project understanding as this may affect our recommendations. **In particular, heavier structural loads may indicate a different foundation system than described herein.**

3.0 FIELD INVESTIGATION

The field investigation was completed on July 9, 2020 and included the advancement of a series of four borings. Borings B-1 to B-4 were completed at approximate locations shown on Figure No. 1, Site Location Map, attached in Appendix A. A Registered Land Surveyor should locate the borings if more precise location or elevation information is desired.

The borings were advanced with a truck mounted, Acker Renegade drill rig equipped with 4 ¼" inner diameter hollow stem augers. Sampling was completed using Standard Penetration Testing (ASTM D 1586) split barrel sampling. The SPT sampler was advanced with an automatic hammer that provides more consistent driving energy and improved safety compared to other driving methods. Continuous boring logs were recorded and samples were obtained from select intervals and returned to our laboratory. The recovered samples were classified in accordance with the Unified Soil Classification System visual-manual procedure. Observations were made in the field regarding groundwater, drilling conditions, etc. The boring logs in Appendix B may be reviewed for additional details of the investigation.

4.0 SITE AND SUBSURFACE CONDITIONS

The site was a vacant, grass covered lot at the time of our investigation. The site sloped down from Dexter Street (from the east) and Noble Street (from the south). The Elk River was present beyond a wetland to the north, several feet below site grades.

The site was previously developed and fill or possible fill was present in each of the borings to depths of approximately 4 to 6 ft. The fill included crushed brick, cinders and broken glass in Boring B-2. A PVC liner was present in Borings B-3 and B-4. Brown to black sand, occasionally with peat seams or silt, was present beneath the fill. Lean clay (Unified Soil Classification System Group Symbol CL) extended from depths of 6 to 10 ft to the explored depths of 20 ft. The clay was typically stiff to hard in consistency based on estimates of the unconfined compressive strength, obtained with a hand penetrometer, from 1.0 to 4.5 tons per square foot (tsf). A strong petroleum odor was observed in Borings B-1 and B-3.

Groundwater was present in the borings at depths ranging from 2 to 4.5 ft below the ground surface. Groundwater levels will vary due to snowmelt, precipitation, the nearby Elk River level, and other factors. Groundwater levels may be different at the time of construction or later.

This section has included a general description of the subsurface and groundwater conditions for the project. The boring logs attached in Appendix B should be reviewed for additional detail. The described conditions are based on a limited number of test borings and samples. Variations from these locations should be expected.

5.0 ENGINEERING ANALYSIS

The upper fill and natural dark brown to black sand with peat lenses is unsuitable for foundation support. Alternatives that may be considered for foundation support include overexcavation of unsuitable soil and replacement with engineered fill, subgrade improvement (stone columns), or a deep foundation system. Due to shallow groundwater conditions and a history of environmental contamination, overexcavation and replacement with engineered fill does not appear to be practical due to the significant cost of managing contaminated groundwater and soil. Subgrade improvement is expected to be more economical compared to a deep foundation system (helical piers or augercast piles) and is described herein as the preferred alternative.

5.1 Shallow Foundation System

The building will be supported by a conventional shallow and spread foundation system bearing on improved subgrade (stone columns). The following parameters are recommended for foundation design:

Table 5.1.1 – Foundation Design Parameters

Minimum Width of Square or Rectangular Foundations, inches	24
Minimum Width of Continuous Foundations, inches	18
Maximum Net Allowable Foundation Bearing Capacity, psf	4,000
Minimum Embedment Depth for Frost Protection, inches	42

Subgrade preparation as described in the following section. The recommended maximum net allowable bearing capacity is based on a factor of safety greater than 3.0 and predicted settlement of less than 1 inch.

5.2 Site and Subgrade Preparation

Site preparation should include the removal of all vegetation, topsoil and debris within the construction area. Prior to placement of structures or engineered fill, the entire construction area should be compacted by the contractor. At a minimum, the upper 12 inches should be compacted to a minimum of 95% of the material's MDOT Michigan Cone maximum density.

Engineered fill will be required to achieve site grades, for foundation backfill, etc. Engineered fill is controlled material placed in lifts under the observation of the geotechnical engineer. The on-site soil classified as *poorly graded sand* (SP) is expected to be suitable for use as engineered fill provided it is free of topsoil, vegetation, coarse gravel/cobble, debris, or other deleterious material. Imported material should meet the requirements for MDOT Class II sand. Engineered fill should be compacted to a minimum of 95 percent of its MDOT Michigan cone maximum density. Engineered fill should be compacted in lifts of 9 inches or less and a program of inspection, testing, and documentation of the engineered fill should be implemented.

Construction with frozen soil should not occur.

5.3 Stone Columns

Stone columns are recommended to achieve a maximum net allowable bearing capacity of 4,000 psf for foundations. Higher bearing capacity may be achievable with an increased level of stone column improvement. Subgrade improvement with stone columns is completed by a specialty geotechnical contractor. The equipment is advanced into the ground to a planned depth and stone (typically crushed) is inserted and compacted in lifts to the ground surface. Stone columns are constructed at regular intervals beneath proposed foundations and floor slabs to control settlement and increase bearing capacity. Stone columns provide this benefit both by replacing a portion of the subgrade with a higher-strength material and also through compaction of existing soils. Stone column construction is completed relatively quickly and conventional shallow foundations are constructed on the improved subgrade.

Site preparation should include the removal of all vegetation, topsoil, and debris within the construction area. A working platform should be prepared prior to mobilization of the stone column contractor. The working platform is typically at the bottom of footing or bottom of slab and should be coordinated between the general contractor, owner, excavator, and the stone column contractor. In some cases, stone columns may be constructed prior to fill placement provided that material placed subsequently is constructed as engineered fill.

The site preparation to establish the working platform should include compaction of the existing subgrade within the upper 12 inches to a minimum of 95 percent of its Michigan Cone maximum density. Fill placed on the site should be constructed of engineered fill.

The stone column contractor should submit qualifications along with his bid. The qualifications should include a proposed project team including a project manager and field superintendent, each with a minimum of 5 years of experience constructing stone columns on similar projects. The submittal should include a list of at least five previously completed projects of similar scope and purpose including references. Stone columns are typically constructed as a design-build system due to variations in each bidder’s equipment, material, and approach. The stone column contractor should be provided a foundation plan with building loads (including floor slab loads), bottom of footing elevations, and this report as part of the contract documents.

The stone column contractor should prepare a submittal, sealed by a Professional Engineer licensed in Michigan, which includes the following information:

- A ground improvement design that demonstrates the specified tolerances (4,000 psf allowable bearing pressure for conventional foundations with maximum total settlement of less than 1 inch and maximum differential settlement less than ¾ inch).
- A ground improvement quality control plan

- Shop drawing indicating spacing, location and depth of stone columns.
- Load test detail and setup. A minimum of two load tests should be performed for each stone column type. Load tests should be performed in accordance with ASTM D1143 at locations approved by the engineer. Load tests should include at least one stone column and its cell. The load test should be performed to a minimum of 150 percent of the design load.
- Acknowledgement of subgrade conditions described in the geotechnical report and presented in boring logs including groundwater, fill, and organic material.

The contractor should submit daily records of the stone column production including identification, start and finish times, applicable equipment records, and material quantities. The contractor's Professional Engineer should submit a letter documenting the observations and results of the tests and certifying that the bearing pressure has been achieved within settlement tolerances.

Stone column construction will produce construction vibrations. The actual intensity and frequency of the vibrations will depend on the contractor's means and methods. The contractor should be informed of any restrictions on vibrations and should be responsible for monitoring them during construction, if applicable.

Stone column construction should be performed under the observation of the Geotechnical Engineer to confirm the stone column spacing, depth, load tests, materials, and other considerations.

5.4 Floor Slabs

The encountered subsurface conditions included miscellaneous fill, very loose granular soil, and indications of organic material (peat seams, dark brown to black coloration). Floor slabs bearing on these soils should be expected to have an increased risk of settlement or cracking. Stone column subgrade improvement is recommended in floor slab areas to mitigate floor slab distress. Further, a minimum of 12 inches of engineered fill should be placed beneath floor slabs. The encountered material classified as *poorly graded sand* (SP) is expected to be suitable provided that it is free of topsoil, debris, organic material, etc.

A modulus of subgrade reaction, k_{30}, of 100 pci is recommended for design of floor slabs supported on-grade. If the floor slab will have a moisture sensitive covering or be within a moisture-controlled area, a vapor barrier should be provided as recommended in ACI 302.1R *Guide for Concrete Floor and Slab Construction*. The floor slab subgrade should be prepared in accordance with the Site and Subgrade Preparation section of this report.

These recommendations consider that construction will occur above the design groundwater elevation and that hydrostatic pressure will not occur. We should be informed if any building element, such as an elevator pit, will extend close to the groundwater level.

5.5 Groundwater

Groundwater was present within the borings at depths of approximately 2 to 4.5 ft. Groundwater will fluctuate due to snowmelt, precipitation, the nearby river level, the impoundment to the northeast, and other factors. The groundwater level should be expected to be higher than the river level.

Groundwater will be a concern for the design and construction of the building. The building's floor slab should be located higher than the corresponding exterior elevation. The floor slab elevation should be selected to be above future groundwater or surface water levels. FEMA has not established a base flood elevation for this area.

Depending on groundwater conditions at the time of construction, the finish floor elevation for the building, and other factors, groundwater may be present within the depth of excavation for foundation construction. Due to costs associated with temporary groundwater control and potential environmental considerations, it is recommended that the building's finish floor elevation and corresponding bottom of footing elevations be selected to avoid the need for temporary groundwater control during construction. If temporary groundwater control cannot be avoided, the contractor should be responsible for designing and implementing the system.

Groundwater control in these conditions typically could include dewatering wells or wellpoints; however, a cutoff wall may be evaluated in conjunction with other methods as an approach to reduce the dewatering volume if costs for groundwater treatment or disposal are high.

Waterproofing of the slab, if applicable, should be provided as required by the *Michigan Building Code*.

6.0 LIMITATIONS

The evaluations and recommendations presented in this report have been developed on the basis of available data relating to the location, type, and finished elevation for the proposed development. Any changes in this data, deviations from encountered conditions, or the final design plans should be brought to our attention for review and evaluation with respect to our geotechnical recommendations. **In particular, we should be informed of the proposed structural wall and column loads.** Variations in the soil conditions from the existing borings are possible and such variations may not become evident until construction occurs and we recommend that we be retained during construction to provide subgrade verification. If changes occur to the location or structural design or if construction reveals differences in the soil conditions from those observed in our investigation and utilized in our analyses, we request the opportunity to review and if necessary, revise our recommendations.

7.0 CLOSURE

We appreciate the opportunity to have provided geotechnical services for 112 Dexter Street and express our interest in providing subgrade verification and materials testing services during construction. We should be contacted if any questions arise regarding the recommendations provided herein.

Very truly yours,

OTWELL MAWBY GEOTECHNICAL, P.C.

Melzar L. Coulter, P.E.	Roger L. Mawby, P.E.
Sr. Geotechnical Engineer	President

MLC/RLM/mc

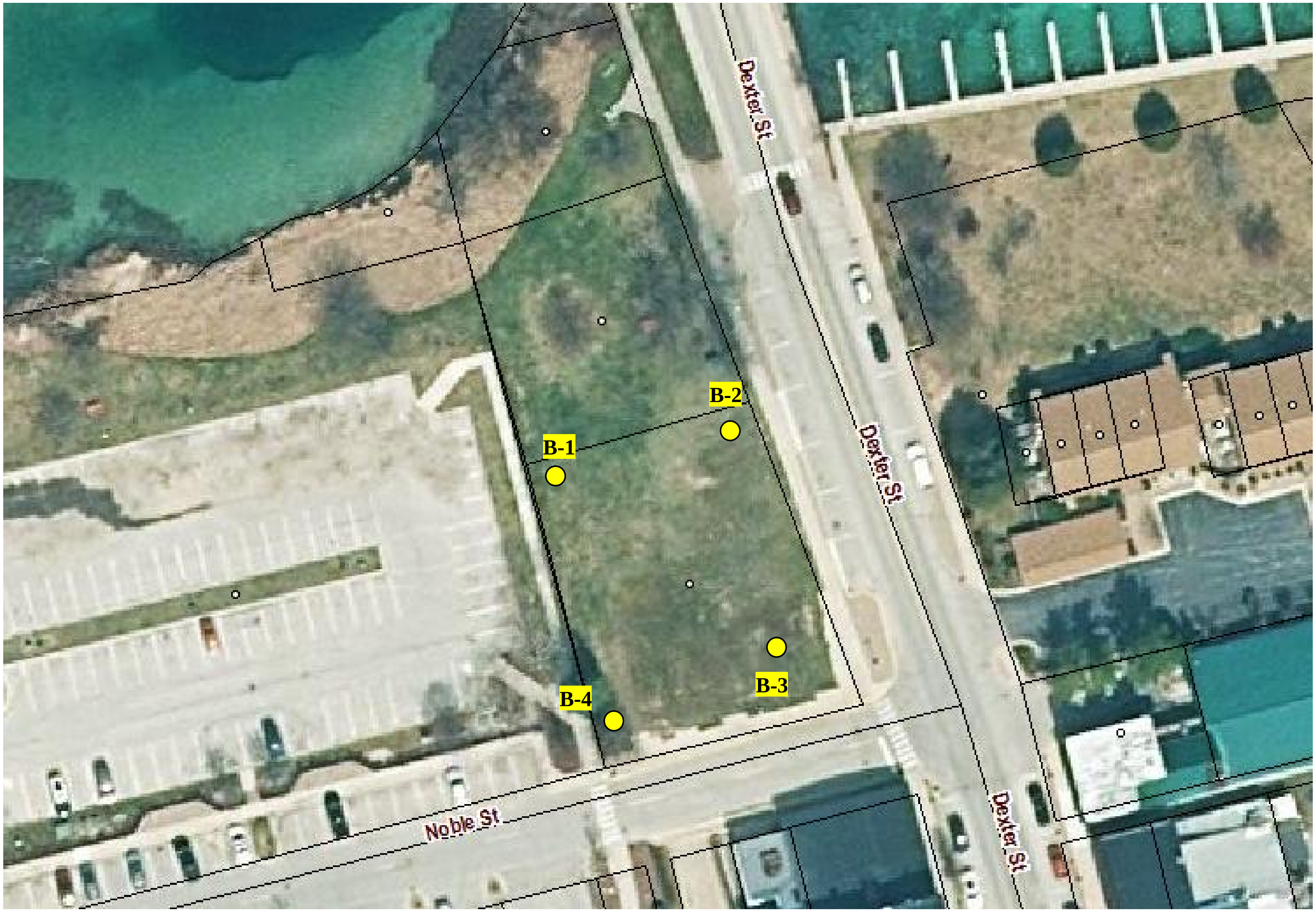
APPENDICES

Appendix A - Site Plan

Appendix B - Boring Logs

Appendix A

Site Plan



- Approximate Soil Boring Location (Typical)

North

112 Dexter Street Elk Rapids, Michigan	Figure 1: Site Location Map		
Otwell Mawby Geotechnical, PC Traverse City, Michigan	Project No: G02-050	Date: 7/24/2020	Source: Antrim County GIS

Appendix B

Boring Logs

Client: Bob Cruse
Project: Dexter Street, G02-050
Location: Elk Rapids, Michigan

Boring Log Of: B-1
Date Drilled: 7/9/20
Drilling Contractor: Pearson
Page 1 of 1

Std. Penetration Resistance (N)	Recovery	Sample Method	Sample Type/Interval	Depth (feet)	Soil Type	Soil Description	Pocket Penetrometer (TSF)	Comments
						Surface Conditions: Grass		
						TOPSOIL (2")		Boring advanced using truck mounted Acker Renegade with 4 1/4" hollow stem augers with split spoon sampler (SS)
5,6, 7,6	13"	SS				Poorly graded SAND; mostly medium to fine sand with gravel; brown to tan; moist (SP)		
WOH/12" 1,3	14"	SS		5		PEAT; black with silt and SAND (Pt)		Possible fill from 0' to 4'.
1,1, 5,6	16"	SS				Poorly graded SAND; mostly medium to fine sand; wet; with peat lenses (SP)	1.5 2.0	Strong petroleum odor.
1,1, 3,7	8"	SS				Lean CLAY; with sand; gray; moist (CL)	1.5	
				10				
4,6, 9,9	21"	SS					2.5 3.0 4.0	
				15				
2,6, 7,13	22"	SS					1.5 3.0 4.0	
				20		End of Boring at 20'		
				25				
				30				WOH = weight of hammer

Well Construction / Boring Data

Top of Casing : N/A
Ground Elev.: N/A
Casing: N/A
Screen: N/A
Screen Setting: N/A

Water Encountered: 2' +/-
Date: 7/9/20
Logging Method: Visual/Manual
Development Method: N/A

Driller: JB
Helper: BP
Logged By: DB

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Client: Bob Cruse
Project: Dexter Street, G02-050
Location: Elk Rapids, Michigan

Boring Log Of: B-2
Date Drilled: 7/9/20
Drilling Contractor: Pearson

Std. Penetration Resistance (N)	Recovery	Sample Method	Depth (feet)	Soil Type / Soil Description	Pocket Penetrometer (TSF)	Comments
			0	Surface Conditions: Grass TOPSOIL (3")		
				Poorly graded SAND; mostly medium to fine sand; crushed brick, cinders and broken glass (fill); moist (SP)		Boring advanced using truck mounted Acker Renegade with 4 1/4" hollow stem augers with split spoon sampler (SS)
3,3, 3,4	17"	SS				
1,3, refusal	-	SS	5			Partial refusal at 5'. Rock fragements in tip of sampler.
6,5, 7,13	16"	SS		- grades with sand (SP-SM)		
7,12, 13,19	19"	SS		Poorly graded SAND with silt; mostly medium to fine sand; brown to black; wet (SP-SM)		Poor recovery sample 8' to 10'; possible coarse gravel/COBBLE
			10			
6,5, 7,9	14"	SS		Lean CLAY; few medium to fine sand; gray; moist (CL)	2.0 1.5	
			15			
				Clayey SAND; gray; wet (SC)		
7,40, 42,29	8"	SS			1.0	
			20	End of Boring at 20'		
			25			
					3.0 2.0	
			30			

Top of Casing : N/A
Ground Elev.: N/A
Casing: N/A
Screen: N/A
Screen Setting: N/A

Well Construction / Boring Data

Water Encountered: 4.45'
Date: 7/9/20
Logging Method: Visual/Manual
Development Method: N/A

Driller: JB
Helper: BP
Logged By: DB

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Client: Bob Cruse
Project: Dexter Street, G02-050
Location: Elk Rapids, Michigan

Boring Log Of: B-3
Date Drilled: 7/9/20
Drilling Contractor: Pearson

std. Penetration Resistance (N)	Recovery	Sample Method	Depth (feet)	Soil Description	Pocket Penetrometer (TSF)	Comments
				Surface Conditions: Grass		
				Poorly graded SAND; mostly medium to fine sand; tan; trace gravel; moist (SP)		Boring advanced using truck mounted Acker Renegade with 4 1/4" hollow stem augers with split spoon sampler (SS)
2,2, 2,2	20"	SS		- PVC liner at 3'		
1,2, WOH/12"	9"	SS	5	- grades wet at 4', grades with silt (SP-SM)		
4,3, 3,4	18"	SS		- grades black		Charged augers with water from 8'
3,3, 4,6	18"	SS		Lean CLAY; gray; moist (CL)	2.0 2.5	Strong petroleum odor in 6'-8' sample
			10			
3,4, 10,11	20"	SS		- grades with some sand	3.5 4.0	
			15		4.5	
5,9, 12,15	24"	SS			4.0 4.5	
			20	End of Boring at 20'		
			25			
			30			

Top of Casing : N/A
Ground Elev.: N/A
Casing: N/A
Screen: N/A
Screen Setting: N/A

Well Construction / Boring Data

Water Encountered: 4.52'
Date: 7/9/20
Logging Method: Visual/Manual
Development Method: N/A

Driller: JB
Helper: BP
Logged By: DB

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Client: Bob Cruse
Project: Dexter Street, G02-050
Location: Elk Rapids, Michigan

Boring Log Of: B-4
Date Drilled: 7/9/20
Drilling Contractor: Pearson

Std. Penetration Resistance (N)	Recovery	Sample Method	Depth (feet)	Soil Description	Pocket Penetrometer (TSF)	Comments
				Surface Conditions: Grass		
			0	TOPSOIL (3.5")		Boring advanced using truck mounted Acker Renegade with 4 1/4" hollow stem augers with split spoon sampler (SS)
1,2, 2,2	16"	SS		Poorly graded SAND; mosty medium to fine sand; fine gravel; PVC liner; brown to gray; moist (SP)		
2,2, 3,5	17"	SS	5	- grades black and with trace gravel - grades wet		Charge augers at 8'
4,6, 6,2	20"	SS		Lean CLAY; gray; moist (CL)	2.0	
1,3, 4,4	13"	SS			3.0	
			10			
3,6, 11,11	18"	SS			3.0 3.5 4.0	
			15			
4,9, 13,16	-	SS			3.0 4.0 4.5	
			20	End of Boring at 20'		
			25			
			30			

Top of Casing : N/A
Ground Elev.: N/A
Casing: N/A
Screen: N/A
Screen Setting: N/A

Well Construction / Boring Data

Water Encountered: 4.35'
Date: 7/9/20
Logging Method: Visual/Manual
Development Method: N/A

Driller: JB
Helper: BP
Logged By: DB

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