ALLENDER BUTZKE ENGINEERS INC.
GEOTECHNICAL • ENVIRONMENTAL • CONSTRUCTION Q. C.

December 15, 2023

Dept. of Administrative Services
109 SE 13th Street
Des Moines, IA 50319
Attn: Mr. Brad Tonyan

RE: Geotechnical Exploration
CBC District 2 Geothermal
1401 S 17th Ave
Marshalltown, Iowa
PN 231408

Dear Mr. Tonyan:

As authorized, Allender Butzke Engineers Inc. (ABE) has completed the soil borings for the above referenced project. The geotechnical exploration was conducted to evaluate the soil profile at this site for consideration of new geothermal wells. In general, the borings encountered clay fill, B-Horizon loess, and loess soils overlying eolian sand and sandy glacial till with thicker glacial outwash (sand) deposits. Weathered shale bedrock was encountered in all borings below depths between 25 and 31 feet. Details of our findings are described below and on the Boring Logs enclosed in the Appendix.

Three borings were conducted at this site to depths of 26 to 33.5 feet below existing grades on December 8, 2023. Approximate locations of the borings are shown on the enclosed Site Plan and were measured in the field from existing landmarks. The boring surface elevations, indicated on the enclosed Boring Logs, were determined by differential leveling and referenced to the finish floor elevation of the existing building at the north-central walk-in door. For reference in this letter, we have assigned this location an arbitrary elevation of 100.0 feet. Methods of drilling, sampling, standard laboratory testing, and classifying of subsurface materials are discussed in the Boring Log Description/Legend pages of the Appendix.

Detailed descriptions of soils encountered by this exploration are provided on the Boring Logs enclosed in the Appendix. The Profile of Borings (Plate A-1) presented in the Appendix depicts the relative deposit elevations in the borings. Following is a discussion of the subsurface materials encountered in the borings. Unless otherwise indicated, the depths of soil stratum and groundwater levels are referenced from below existing grade at the individual boring locations at the time of drilling.

Dark brown and brown sandy lean clay (CL) and sandy lean to fat clay (CL-CH) fill was encountered at ground surface in each of the borings. The damp to moist fill extended to depths of 2.5 to 10 feet.

Underlying the fill, Boring Nos. 1 and 3 encountered dark brown lean to fat clay (CL-CH) B-Horizon loess which extended to depths of 4 to 4.5 feet. Brown-gray lean clay (CL) loess was encountered in Boring Nos. 1 and 2 underlying the fill and/or B-Horizon loess. The very moist loess extended to depths of 9 to 15 feet. Eolian sand consisting of brown-gray silty sand (SM) underlaid the loess in Boring No. 1 and the B-Horizon loess in Boring No. 3. The damp eolian sand extended to depths of 7 to 11 feet.

Brown-gray sandy lean clay (CL) and dark gray sandy lean to fat clay (CL-CH) glacial till was encountered in each of the borings underlying the loess and/or eolian sand. Brown-gray and red-brown clayey sand (SC) glacial outwash layers were encountered within the glacial till in Boring Nos. 1 and 2. The glacial outwash layers were encountered near a depth of 14 feet in both borings and extended to depths of 22 and 20 feet in Boring No. 1 and 2, respectively. The moist glacial till extended to a depth of 27 feet in Boring No.1, 25 feet in Boring No. 2, and 31 feet in Boring No. 3.

Light gray shale bedrock was encountered in each of the borings underlying the glacial till near depths of 25 to 31 feet. All borings terminated in the bedrock near depths of 26 to 33.5 feet.

The borings were monitored during and shortly after drilling operations to detect moisture seepage and groundwater accumulation. The results of our groundwater level observations are noted on the Boring Logs enclosed in the Appendix.

During drilling operations, moisture seepage was noted near depths of 14.5 to 21 feet below existing grades in each of the soil borings. Groundwater accumulation was observed between depths of 21.5 to 31.5 feet in each of the soil borings at the completion of drilling operation. It should be recognized that these short-term water levels are not necessarily a true indication of the groundwater table. Long-term observations would be necessary to accurately define the groundwater variations at this site. Fluctuation of groundwater levels can occur due to seasonal variations in the amount of rainfall, surface drainage, subsurface drainage, site topography, irrigation practices, and ground cover (pavement or vegetation).

We appreciate the opportunity to provide our geotechnical engineering services for this project. If you have any questions or need further assistance, please contact us at your convenience.

Respectfully submitted,
ALLENDER BUTZKE ENGINEERS INC.

Abigail Ellerman, E.I.
Staff Engineer

Matt Drummond, P.E.
Principal Engineer

I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa.

12/15/2023

Matthew J. Drummond, P.E. License Number 21407 Date

My license renewal date is December 31, 2024.

Pages covered by this seal: All Pages.

1 PC Above
1 Email – DCI Group; Attn: Michael Steen and Travis Hoyle
1 Email – Shive-Hattery; Attn: Michael Jensen

APPENDIX

BORING LOG DESCRIPTION/LEGEND

The material types encountered during the drilling operations were recorded on field logs. The profile represented on the Boring Log is based on final classification performed by a geotechnical engineer using the field logs, laboratory observation and testing. The material stratigraphy demarcation lines shown on the Boring Logs indicate changes in soil characteristics, however, actual soil changes or variations may occur as a gradual transition. Soil profile discussion, Log Boring information, water levels and recommendations presented in this report are based upon measured depths below ground levels existing at time of the field exploration, unless otherwise specified.

DRILLING AND SAMPLING

The borings were conducted with either a truck or all-terrain rotary drill rig using the drilling methods indicated on each Boring Log. Soil sampling and/or in-situ testing such as Shelby Tube (ST), split-spoon (SS), drive cone (DC), or core (C) was conducted at depth intervals which were selected in consideration of the characteristics of the proposed construction. Generally undisturbed soil samples are taken at 5 foot depth intervals or change in soil types. Disturbed soil samples from the auger, either jar size or bulk size samples, may be taken at intermediate intervals for the purpose of soil classification or laboratory testing. Borings conducted for soil classification only, will show no designation of sampling although disturbed sampling is performed. Soil samples obtained in the field were identified and sealed for transportation to the laboratory for performance of pertinent physical testing and engineering classification.

Drilling Methods

CFA - Continuous Flight Auger: 4, 6, or 8-inch diameter (ASTM D1452).
RD - Rotary Drilling: Using drilling fluid in cased or uncased boring (ASTM D2113).
HSA - Hollow Stem Auger: 6 or 8-inch diameter, continuous flight auger remains in boring with soil removed from the hollow stem through which undisturbed sampling is conducted.
HA - Hand Auger: 4-inch or less diameter.

Sample Types

ST - Shelby Tube: Thin-walled tube samples of cohesive soils (ASTM D1587).
SS - Split Spoon with 140 lb. manual hammer: Standard penetration test and split-barrel samples (ASTM D1586).
SSA - Split Spoon with 140 lb. automatic hammer: Standard penetration test and split-barrel samples (ASTM D1586).
DC - Drive Cone: Dynamic in-place testing of soil using a 2-inch diameter cone with a 60 degree point driven into the soil for continuous 1-foot intervals in the same manner as Split Spoon, no sample is obtained.
C - Core: Sampling hard soil or bedrock with a diamond core barrel in a rotary drill boring (ASTM D2113).
SPT - Standard Penetration Test: Number of blows required to drive sampler (split spoon or drive cone) into the soil with a 140-pound weight dropping a distance of 30-inches (ASTM D1586), number of blows recorded for each 6-inch interval in an 18-inch (or more) penetration depth, values shown are for each 6-inch interval (if series of number sets are shown) or a total of the last two 6-inch intervals (if only one number is shown) which is commonly referred to as "N" in blows per foot. High resistance is indicated by a high number of blows for a lesser penetration depth listed in inches.
BS - Bulk Sample: Disturbed.
CPT - Cone Penetration Test: Quasi-static in-place testing of soils using a 60 degree cone and friction sleeve which are steadily pushed into the soil and measure skin friction and end bearing (ASTM D3441).

STANDARD LABORATORY TESTING

Representative undisturbed soil samples obtained by the Shelby Tube sampler were tested for moisture content (ASTM D2216), density (dry) and unconfined compressive strength (ASTM D2166) in the laboratory. Results of these tests appear on the respective Boring Logs. Additional soil testing including particle size analysis (ASTM D422) and Atterberg Limits (ASTM D4318) may be conducted, if necessary, to define in more detail pertinent soil characteristics for classification in accordance with the Unified Soil Classification System. Specialized laboratory tests (if conducted) to determine pertinent soil characteristics are discussed in the "Laboratory Testing" section of the report.

WATER LEVEL MEASUREMENT

Water levels indicated on the Boring Logs are the levels measured in the borings at the times indicated. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels is not possible with short term observations.

BORING LOG DESCRIPTION/LEGEND

DESCRIPTIVE SOIL CLASSIFICATION

Soil description is based on the Unified Classification System as outlined in ASTM Designations D-2487 and D-2488. This classification is primarily based upon visual and apparent physical soil characteristics, comparison with other soil samples, and our experience with the soil. Additional laboratory testing may be conducted, if necessary to define in more detail pertinent soil characteristics. The Unified Soil Classification group symbol shown on the boring logs corresponds with the group names listed below. The description includes soil constituents, moisture conditions, color and any other appropriate descriptive terms.

Group Symbol	Group Name	Group Symbol	Group Name	Group Symbol	Group Name	Group Symbol	Group Name
GW	Well-Graded Gravel	SW	Well-Graded Sand	CL	Lean Clay	CH	Fat Clay
GP	Poorly-Graded Gravel	SP	Poorly-Graded Sand	ML	Silt	MH	Elastic Silt
GM	Silty Gravel	SM	Silty Sand	OL	Organic Clay Organic Silt	OH	Organic Clay Organic Silt
GC	Clayey Gravel	SC	Clayey Sand			PT	Peat

RELATIVE PROPORTIONS			GRAIN SIZE TERMINOLOGY	
Descriptive Term(s) (Of components also present in sample)	Sand and Gravel % of Dry Weight	Fines % of Dry Weight	Major Component of Sample	Size Range
Trace	<15	<5	Cobbles	12 in. to 3 in. (300mm to 75mm)
With	15-30	5-12	Gravel	3 in. to #4 sieve (75mm to 4.75mm)
Modifier	>30	>12	Sand	#4 to #200 sieve (4.75mm to 0.074mm)
			Silt or Clay	Passing #200 sieve (.074 mm)

CONSISTENCY OF FINE-GRAINED SOILS			RELATIVE DENSITY OF COARSE-GRAINED SOILS	
Unconfined Compressive Strength, Qu, psf	Consistency	SPT, bpf	SPT, bpf	Relative Density
< 500	Very Soft	0-2	0-4	Very Loose
500-1,000	Soft	2-4	4-10	Loose
1,000-2,000	Medium Stiff	4-8	10-30	Medium Dense
2,000-4,000	Stiff	8-15	30-50	Dense
4,000-8,000	Very Stiff	15-30	50-80	Very Dense
8,000-16,000	Hard	30-100	80+	Extremely Dense
> 16,000	Very Hard	>100		

BORING LOG DESCRIPTION/LEGEND

ABBREVIATIONS

COMMONLY USED ABBREVIATIONS	
ft. or ' - feet	elev. - Elevation
in. or " - inches	% - Percent
psf - pounds per square foot	No. - Number
plf - pound per lineal foot	TB - Test Boring
pcf - pounds per cubic feet	N - blow count (SPT, bpf)
kip - 1000 pounds	USCS - Unified Soil Classification System
ksf - 1000 pounds per square foot	LL - Liquid Limit
klf - 1000 pounds per lineal foot	PL - Plastic Limit
tsf - tons per square foot	PI - Plasticity Index
bpf - blows per foot (SPT, N)	

BORING LOG NO. 1

Project No.: 231408

Project: **CBC District 2 Geothermal**
1401 S 17th Ave
Marshalltown, Iowa

Client: **Dept. of Administrative Services**
109 SE 13th Street
Des Moines, Iowa 50319

Surface Elevation: **91.1'**
Datum: **North-Central Door Finish Floor = 100'**

Date Drilled: **12/08/2023**
Drilling Depth, ft.: **32.8**

Drilling Method: **4" CFA**
Page: **1** of **1**

Elevation ft.	Depth ft.	Sample No.	Type	SPT bpf	Moisture Content, %	Dry Density pcf	Unconfined Compressive Strength psf	Material Description*	Graphic Log	USCS	Water Level	Depth / Elevation ft.
90	0							Dark brown sandy lean clay, trace organics and gravel, damp to moist **FILL**		CL		2.5
87								Dark brown lean to fat clay, trace sand, moist **B-HORIZON LOESS**		CL-CH		88.6 4
84	6							Brown-gray lean clay, trace fine sand, very moist **LOESS**		CL		87.1 9
81								Brown-gray silty fine to medium sand, damp **EOLIAN SAND**		SM		82.1 11
78	12							Brown-gray sandy lean clay, trace gravel, moist **GLACIAL TILL**		CL		80.1 14
75								Brown-gray clayey fine to medium sand, trace gravel, moist **GLACIAL OUTWASH** Moisture seepage near 21'		SC		77.1 22
72	18											
69								Dark gray sandy lean to fat clay, trace gravel, moist **GLACIAL TILL**		CL-CH		69.1 27
66	24										▼	
63								Light gray weathered shale, moist **BEDROCK**				64.1
60	30							Dense after 32'			▽	32.8
57								End of Boring				58.3
54	36											
51												

*The stratification lines represent the approximate boundary lines between material types: in-situ, the transition may be gradual.

Water Level Observation

Time: at completion **3** hrs. _____ days

Depth to water: **31.5** ft. ▽ **27** ft. ▼ _____ ft. ▼

ALLENDER BUTZKE ENGINEERS, INC.

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BORING LOG NO. 2

Project No.: **231408**

Project: **CBC District 2 Geothermal**
1401 S 17th Ave
Marshalltown, Iowa

Client: **Dept. of Administrative Services**
109 SE 13th Street
Des Moines, Iowa 50319

Surface Elevation: **93.2'**
Datum: **North-Central Door Finish Floor = 100'**

Date Drilled: **12/08/2023**
Drilling Depth, ft.: **26**

Drilling Method: **4" CFA**
Page: **1** of **1**

Elevation ft.	Depth ft.	Sample No.	Type	SPT bpf	Moisture Content, %	Dry Density pcf	Unconfined Compressive Strength psf	Material Description*	Graphic Log	USCS	Water Level	Depth / Elevation ft.
93	0							Dark brown sandy lean to fat clay, trace gravel, damp to moist		CL-CH		
90								**FILL**				
87	6							Moist after 7.5'				
84												10
								Brown-gray lean clay, trace sand, moist to very moist		CL		83.2
81	12							**LOESS**				
								Moisture seepage near 14.5'				15
78								Dark gray sandy lean to fat clay, trace gravel, moist		CL-CH		78.2
75	18							**GLACIAL TILL**			▽	
72												
69	24										▽	25
								Light gray shale, moist				68.2
								BEDROCK				26
66								End of Boring **Auger Refusal at 26'				67.2
63	30											
60												
57	36											
54												

*The stratification lines represent the approximate boundary lines between material types: in-situ, the transition may be gradual.

Water Level Observation

Time: at completion **1.5** hrs. _____ days

Depth to water: **23.8** ft. ▽ **18.3** ft. ▽ _____ ft. ▽

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BORING LOG NO. 3

Project No.: **231408**

Project: **CBC District 2 Geothermal**
1401 S 17th Ave
Marshalltown, Iowa

Client: **Dept. of Administrative Services**
109 SE 13th Street
Des Moines, Iowa 50319

Surface Elevation: **99.7'**
Datum: **North-Central Door Finish Floor = 100'**

Date Drilled: **12/08/2023**
Drilling Depth, ft.: **33.5**

Drilling Method: **4" CFA**
Page: **1** of **1**

Elevation ft.	Depth ft.	Sample No.	Type	SPT bpf	Moisture Content, %	Dry Density pcf	Unconfined Compressive Strength psf	Material Description*	Graphic Log	USCS	Water Level	Depth / Elevation ft.
99	0							Brown sandy lean to fat clay, trace gravel, damp to moist **FILL**		CL-CH		2.5
96								Brown-gray lean to fat clay, trace sand, moist **B-HORIZON LOESS**		CL-CH		97.2 4.5
	6							Brown-gray silty fine sand, damp **EOLIAN SAND**		SM		95.2 7
93								Brown-gray sandy lean clay, trace gravel, moist **GLACIAL TILL**		CL		92.7
90												
87	12											14
								Red-brown clayey fine to medium sand, trace gravel, moist **GLACIAL OUTWASH** Moisture seepage near 18'		SC		85.7
84												
81	18											20
								Dark gray sandy lean to fat clay, trace gravel, moist Boulder near 22.3' **GLACIAL TILL**		CL-CH	▽	79.7
78												
75	24											
72												
69	30											31
								Light gray weathered shale, moist **BEDROCK**				68.7 33.5
66								End of Boring **Auger Refusal at 33.5'				66.2
63	36											
60												

*The stratification lines represent the approximate boundary lines between material types: in-situ, the transition may be gradual.

Water Level Observation

Time: at completion _____ hrs. _____ days

Depth to water: **21.5** ft. ▽ _____ ft. ▼ _____ ft. ▼

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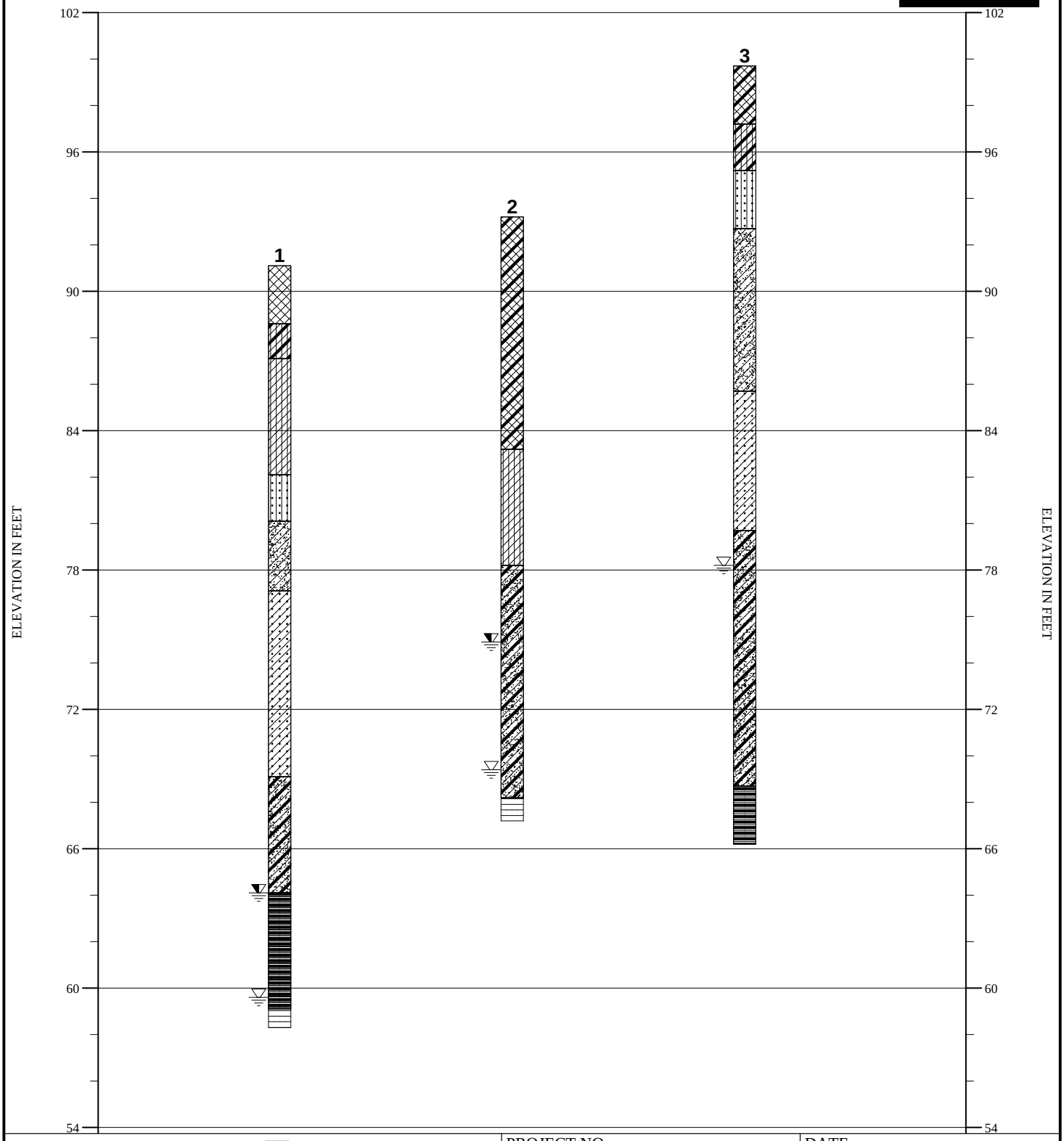
PROFILE OF BORINGS



Strata symbols

- Lean Clay Fill
- Lean to Fat Clay Loess
- Lean Clay
- Silty Sand
- Sandy Lean Clay
- Clayey Sand
- Sandy Lean to Fat Clay
- Weathered Clay Shale
- Clay Shale

PROJECT NO.: 231408	DATE: 12/15/2023
PROJECT: CBC District 2 Geothermal 1401 S 17th Ave Marshalltown, Iowa	
PLATE: A-1	SCALE: 6 feet/in.

ALLENDER BUTZKE ENGINEERS, INC.

PN 231408

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SB-1
SB-2
SB-3

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NOTES