The Dirt
on
Soil Investigations

General Scope of Soil Investigations

- Utilize a variety of conventional drilling and sampling methods to collect representative samples of soil and bedrock.
- Conduct laboratory testing of selected soil and bedrock samples to define physical properties.
- Define subsurface soil, groundwater and bedrock characteristics and establish design parameters.
- Generate a report with the findings and offer recommendations for foundation design.

The Reality

Soil investigations are…

- …primarily requested and relied on by foundation designers
- …not tailored for and not relied on by construction contractors

Subsurface investigation could offer more.

Common Ground

- The soil investigations require site reconnaissance and access planning that could be useful to potential contractors
- There are opportunities to gather subsurface information useful to potential contractors to assist with bidding
- Collaborate with structural and electrical engineers as well as construction contractors to determine what is useful.
- Supplemental information gathered during the investigative phase could potentially result in savings during construction.

Top 5 Contractor Comments

5. Soil descriptions were vague and not informative. Bedrock photos would be helpful.

4. Provide accurate water levels and presence of artesian conditions.

3. Maintain appropriate equipment and drill tooling to advance through difficult drilling.

2. Document the effort to access the location with photographs

1. “Costs of collecting good information during the investigation is considerably less than finding it out during construction.”

Documentation of Samples

- Soil classifications should provide supplemental descriptive terms beyond the Unified Soil Classification System (USCS).
- Identify soil conditions that contribute to drilling/sampling difficulty (i.e. cobbles and boulders, weathered bedrock, drilling refusal, sampling refusal).
- Bedrock, when encountered, is the most sought after information from a drilling program
- Photographs offer keen insight into quality of the bedrock.

Descriptive Boring Logs

COLEMAN ENGINEERING COMPANY
635 CIRCLE DRIVE
IRON MOUNTAIN, MICHIGAN 49801
Telephone: (906)-774-3440 Fax: (906)-774-7776

JOB NO.:
PROJECT: BORING NO.: B-1
CLIENT: 1 OF 3
BORING LOCATION: Offset 20' E. of marked locations - See soil boring location drawing ELEV.:
RIG TYPE: Diedrich D-50 ATV DRILL CREW: J. Lantagne / E. Fudala
DRILLING METHOD: 4-1/4" Hollow Stem Auger, 3-7/8" Roller Bit, 2-7/8" Roller Bit & NQ Rock Core BORING DEPTH: 41.5
DATE STARTED: 1/21/16 DATE COMPLETED: 1/22/16 REVIEWED BY: C. Rasmussen DATE: 1/29/16
HOLE CLOSURE: Bentonite Chips & Soil Cuttings

SAMPLE									TEST RESULTS				
NUMBER	SPT VALUES BLOWS/6"(N)	RECOVERY	LEGEND	DEPTH (FT)	SOIL DESCRIPTION	WATER TABLE	ELEV. (FT)	COMMENTS	+4 -4 -200	MOISTURE CONTENT (%)	LL PL	T (tsf)	q_a (tsf) q_u (tsf)
1	49-25-10 (35)	1.3		0	(FILL) SILTY GRAVEL, light brown, fine to coarse, angular to subangular, with sand, moist			4-1/4" Hollow Stem Auger 0.0' to 5.0' 2" SPT Sampling 140# wt., 30" drop Auto Hammer 3" casing 0.0' to 23.3' Frost: 0.8' deep					
				2	± 2.0' (SP) POORLY GRADED SAND, light brown, fine to medium, trace silt, moist								
2	5-5-5 (10)	1.3		3									
3	4-9-7 (16)	1.1		5	...light grayish brown, fine to coarse, some gravel	▽		3-7/8" & 2-7/8" Roller Bits with Acuagel drilling fluid 5.0' to 23.3' Pressuremeter test at 5.0' E = 1.0 ksi					
4	6-6-8 (14)	1.0		10	...fine to medium, trace gravel								
				13	± 13.0' (ML) SILT, light grayish brown, with organics, wet								
5	1/1'-1 (-)	1.0		15				Pressuremeter test at 15.0' E = 0.3 ksi					
				20	± 20.0'								

AS-Auger Sample · BS-Bag Sample · RC-Rock-Core · GS-Grab Sample · PS-Piston Tube · 2SS-2" Split Spoon · 3SS-3" Split Spoon · 2ST-2" Shelby Tube · 3ST-3" Shelby Tube
▽ while drilling 6.0 · ▼ after drilling · after hours
BORING NO.: B-1

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6	woh-3-5 (8)	0.8		20	(PT) PEAT, black, amorphous, moist (Swamp Deposits) ± 20.5' (SM) SILTY SAND, brown, fine to medium, moist, loose								
				23	(Glacial Outwash) 23.3' Cored through boulder 23.3' to 29.8'								
7 8	0' Run 1	NR 0.5		24				Driller's note: Cobbles and/or boulders 23.3' to 29.8' - cored through 2 boulders NQ Rock Core 23.3' to 29.8' Run 1: 23.3' to 24.8' Drill: 1.5' Recover: 0.5'					
9	Run 2	0.5		25				Run 2: 24.8' to 29.8' Drill: 5.0' Recover: 0.5'					
10	8-6-7 (13)	1.0		30	29.8' (GM) SILTY GRAVEL, light brown, fine, angular to subrounded, with fine to coarse sand, wet, medium dense			4-1/4" Hollow Stem Auger 29.8' to 41.5'					
11	10-7-5 (12)	0.7		35									
				40									

AS-Auger Sample · BS-Bag Sample · RC-Rock-Core · GS-Grab Sample · PS-Piston Tube · 2SS-2" Split Spoon · 3SS-3" Split Spoon · 2ST-2" Shelby Tube · 3ST-3" Shelby Tube
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Bedrock Core

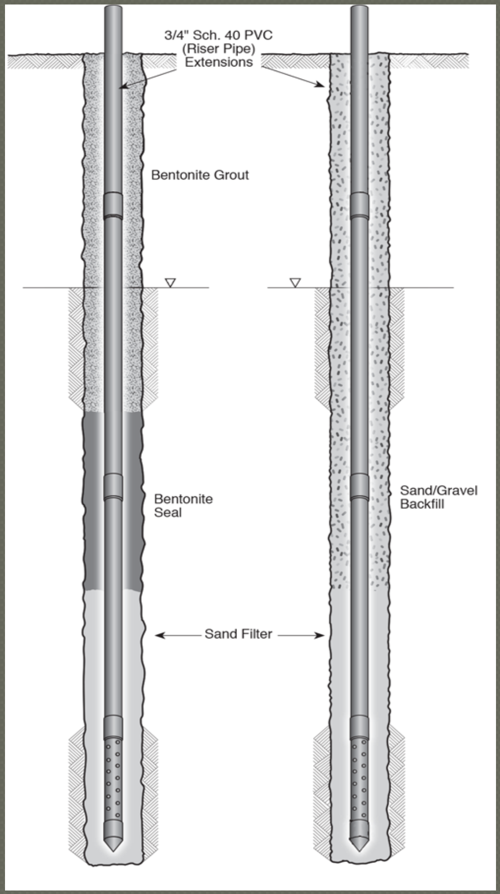
Extremely fractured with High angle joints RQD near 0

Bedrock core

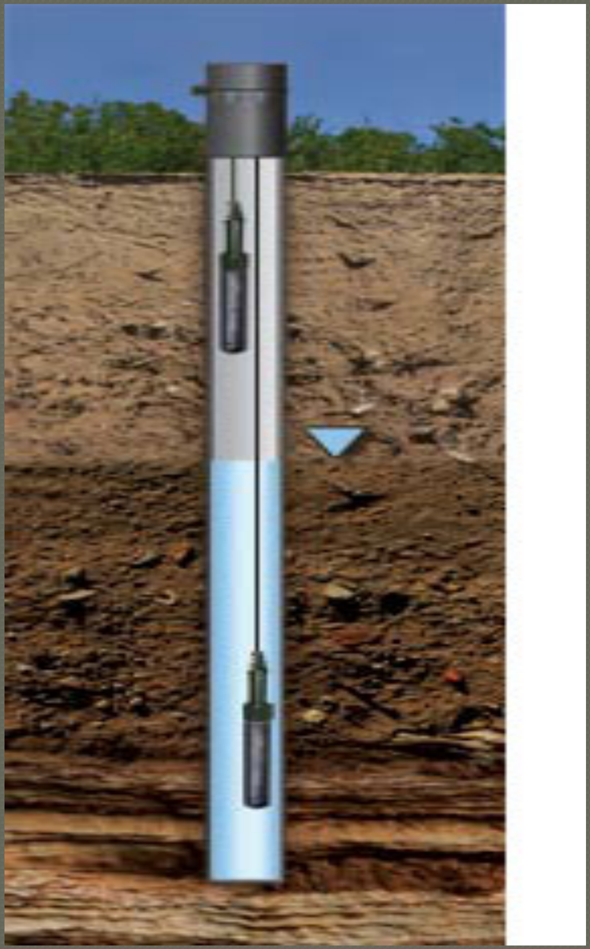
Very sound and intact, RQD 90

Groundwater Monitoring

CONVENTIONAL MONITORING WELL



AUTOMATED MONITORING



Appropriate Drilling Equipment

- All terrain drill carriers
- All terrain water tankers
- Soil drilling and sampling tools
  - Augers
  - Mud rotary bits
  - Conventional and specialty samplers
- Bedrock coring equipment
- Sufficient length of drill rod

Tracked All Terrain Drill Rig

Rubber track, lightly loaded, equipped with sufficient tooling to sample to 150 feet of soil and/or bedrock drilling

Access

- Mobile drilling equipment to access a structure location is similar to that needed for construction equipment.
- Documentation of drilling access difficulties and insight can assist with construction bids.
- Digital photographic documentation is commonplace and can provide valuable information

Access to transmission tower site in flooded wetland

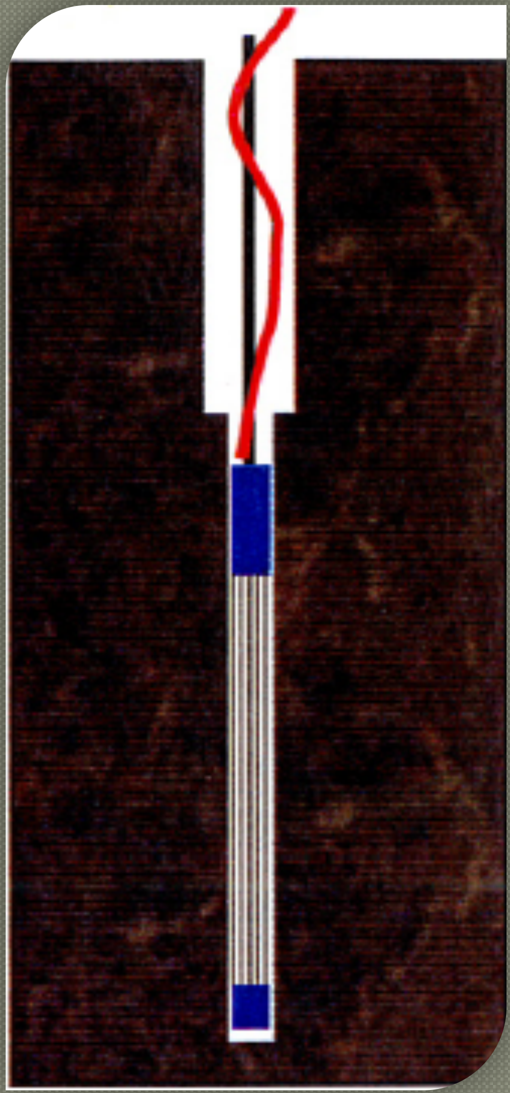
Remote transmission towers

Islands

Protected areas and wetlands

Supplemental Field Testing and Investigation Techniques

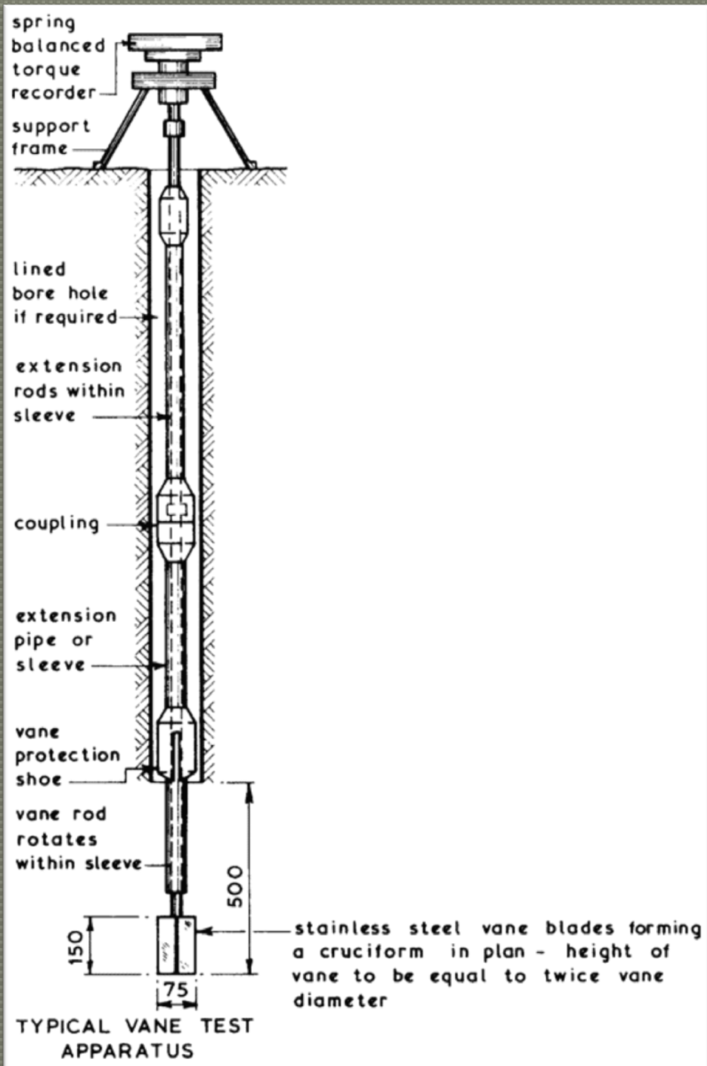
- Borehole Pressuremeter
- Borehole Vane Shear
- Parallel Seismic Investigation
- Electrical Resistivity
- Ground Penetrating Radar
- Cross-Hole Sonic



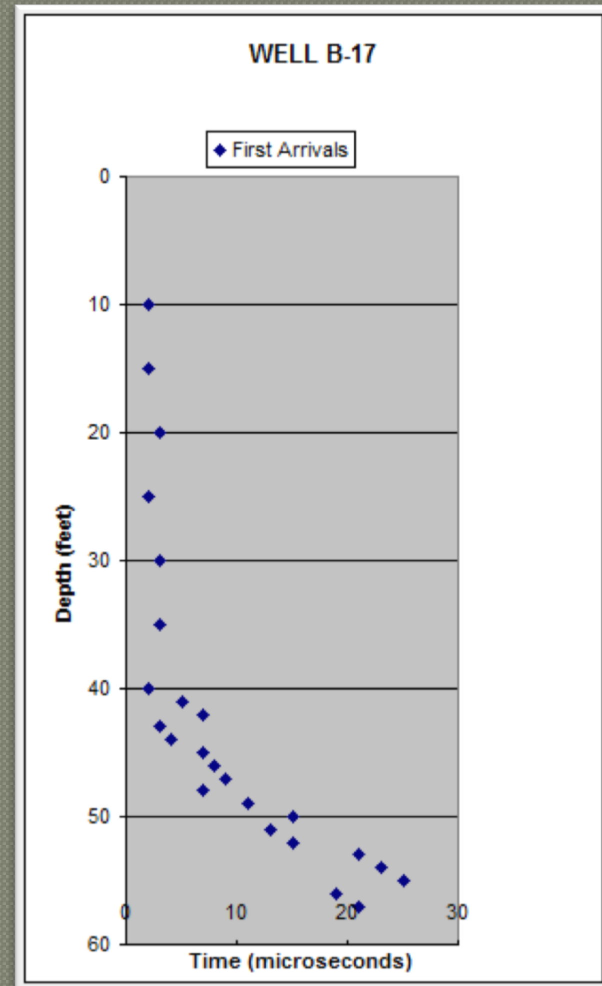
Borehole Pressuremeter

The Pressure Meter Test (PMT) consists of a cylindrical probe in a predrilled hole. The probe is inflated under equal pressure increments. A limit pressure is estimated from the readings and a pressure meter modulus is calculated from the pressure volume changes read during the test.

The PMT can be used to estimate the stress-strain behavior of hard or dense soils, soft or fractured rock, and intact rock.



Borehole Vane Shear

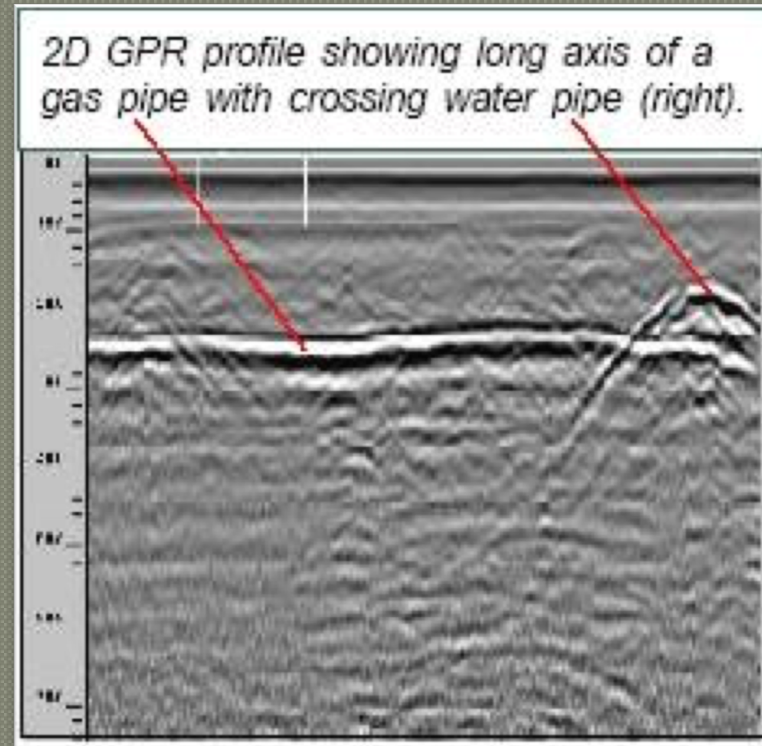


Parallel Seismic Investigation

The Parallel Seismic (PS) method is used for determining the depth of the embedded vertical structures below the ground surface. Data collection is conducted using a seismograph with a Borehole Geophone containing three 14 Hz geophones in an X-Y-Z orientation. The equipment is placed in a borehole drilled adjacent to a structure to be surveyed. A sledgehammer striking the structure is used to generate a seismic wave.

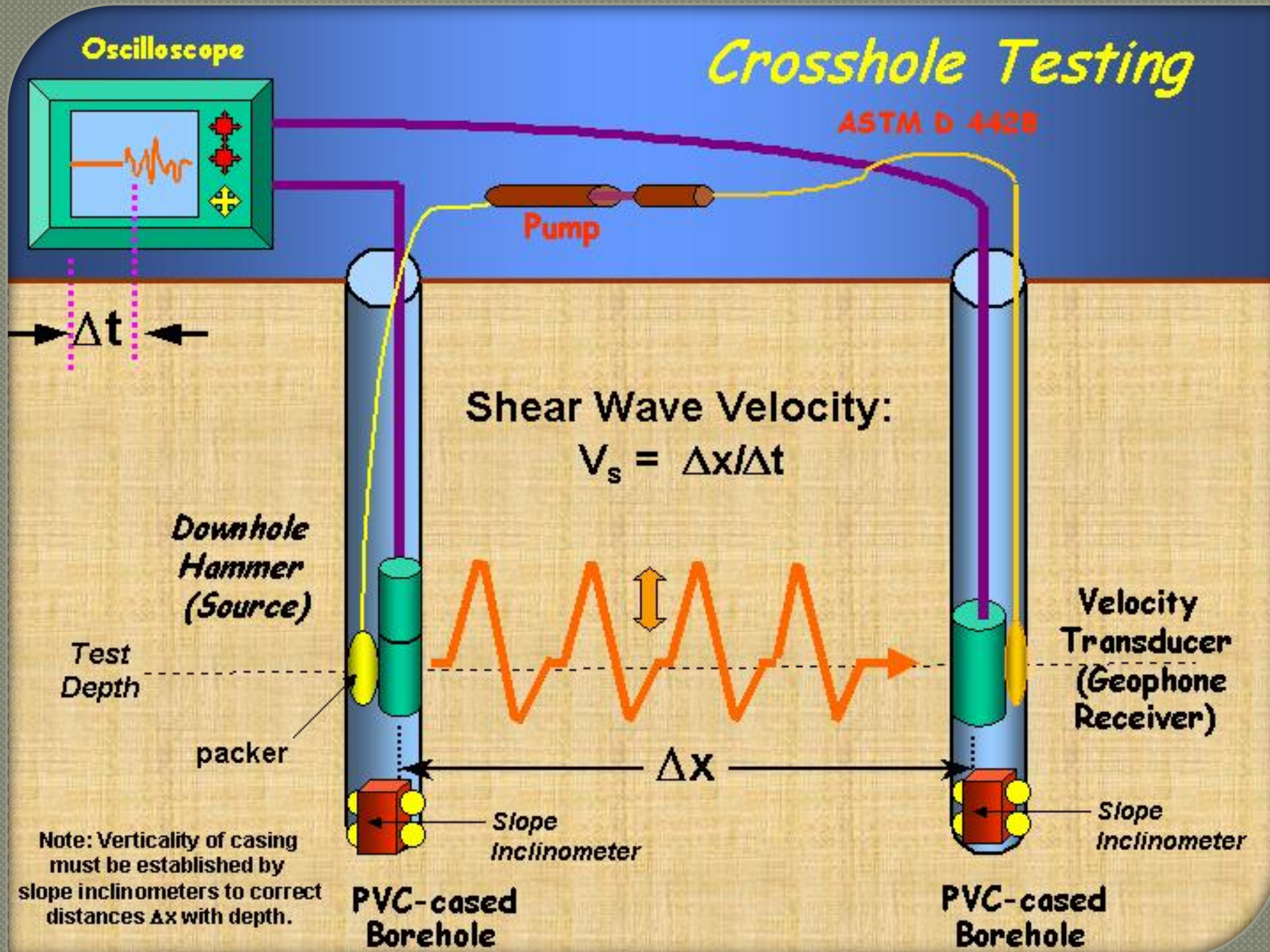
Electrical Resistivity

Wenner Spacing to determine soil resistivity
can be used as a geophysical tool to determine subsurface
conditions. New software can provide 3D modeling of conditions.



Ground Penetrating Radar

Ground penetrating radar utilizes two basic components, a set of antennae to project and receive signals sent into a material, such as soil or concrete, and a data collector to collect the return signal. Data is stored in an on board computer and can provide a real time graphical display.



Cross-Hole Seismic Shear Wave

The test method ordinarily used to determine seismic properties in soils is generally utilized to evaluate drilled caisson foundations and piers.

Considerations for Improvements

- Collaborate with the utility, engineers and contractors to define what is useful or desired.
- Establish communication with stakeholders to customize a scope of work.
- Define a modified scope that addresses additional information desired.

Questions

Contractor Quotes

“we rarely see a boring at every structure that we are drilling at. It seems like owners don't want to spend the initial cost, however in the long run, if we know exactly what we are drilling, we will bid it correctly and be able to give the owner a more realistic price. Otherwise it just opens the door for the chances of a lot of change orders. ”

“taking samples, at the edge of the ROW instead of at the correct location. We had a job that was thru some marshy areas which probably made it difficult to get out to some areas, however short cuts were still taken. This caused us to have to change our plan in a couple of these areas and had to change to permanent pipe, causing an up charge. ***There definitely are difficulties on the front end to get to some locations, however labor & equip rates to get a sample are way less than ours, probably to a very large magnitude.*** ”

“borings not going deep enough due to obstruction or hard soil. It'd be nice for owners to tell the samplers to be prepared to change tooling so we always get a sample to specified depth. Rock is usually a $1000 to $2000/CY adder so knowing what we are looking at is important to putting together an accurate bid. If we just see auger refusal we usually assume rock in these situations or at least add some risk cost. ”

“artesian conditions were not noted with the borings with the original boring company, but when it was completed by another it clearly showed it. I’m not sure if this is a common mistake or not, but that single incident almost delayed the project completion that had $50k a day in LD’s, and the customer was not budging on the date and holding us accountable. Luckily I talked the engineer into approving a temp structure so we could progress with work and address the issue about the foundation later. This allowed us to forgo the 50k a day LD’s if we still completed on time. With this single incident, it could have caused us a lot of money. The test bore and foundation location were directly next to a creek that had a natural spring coming from below the ground surface not more than 100 yards away. I feel that a little more investigation by the testing contractor would have brought a bit more light to the situation early on and maybe they could have questioned if the results they were achieving were actual. I of course am not a test bore expert, but common sense would tell me that if the results don’t match what the site conditions show then questions need to be asked.”

- Photos of the site (other than an aerial)and of the actual boring would be nice. Not just photos of the rock, but of the soil sample as well for each boring.

- A more consistent description of water content and density of each sample. IE, moist, wet or dense to very dense. Some boring have them. Some don't. Some logs I've looked at didn't even give blow counts.

-Give as much information as possible in the soil description. More is always better. Some borings logs I've seen were very generic and lacked any detail.

-A soil profile of the site, (easier on a substation site than a T-line project) would be nice to see.

-Related to T-Line, I would like to see how they accessed the site. Some areas are difficult to access and may present multiple access areas, some easier than others. This could save hundreds of thousands of dollars potentially in matting, mat bridges, etc.

-Photo's of the site are very nice. I have seen this once and liked having them. This helped visualize where the drill site is relative to the existing overhead utilities (primarily Transmission lines)

-Good details of where the bore site is relative to a transmission line. If the test bore is relatively close to where the planned structure is, then obviously we can have a better judgment of what's there. But so many times they were away from the actual foundation location due to overhead clearance issues. With some customers you can argue a change in condition or that conditions are not factual, but with some they will base the potential change order strictly off the borings. I encountered this with over $2 million in change orders the last two years due to drill locations being off so far from actual foundation locations. I understand that the foundations are designed and placed after the test bore, but knowing the exact locations of the test bore is imperative.

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