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Applying Environmental Sequence (ESS) to Optimize Monitoring and Remediation Design for Groundwater Contamination in Glaciated Settings: A Former Nike Missile Site

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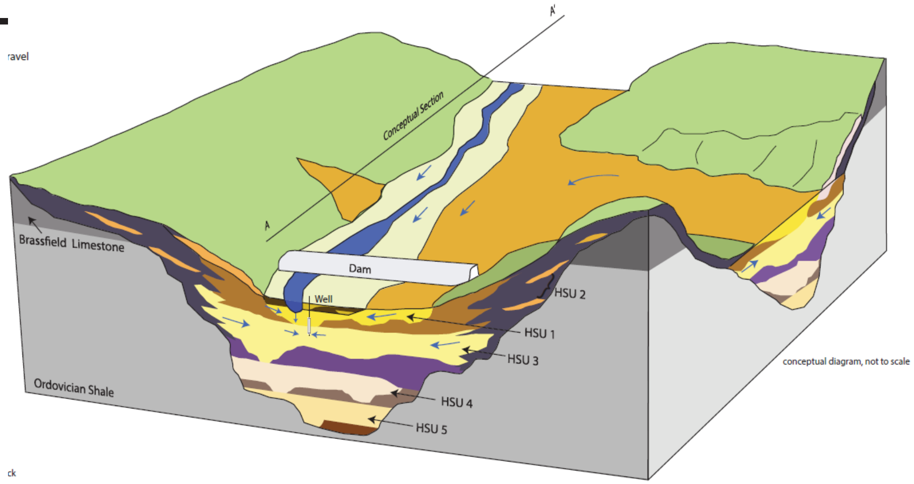
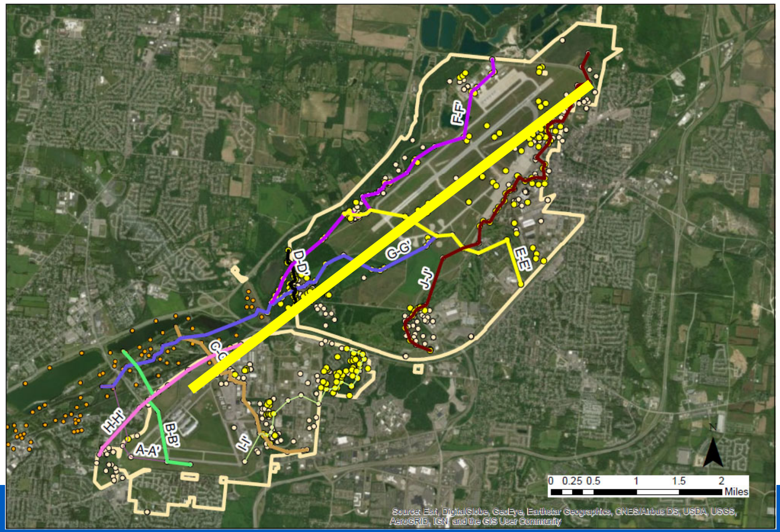
Colin Plank, CPG
Sean Carney(ERT)

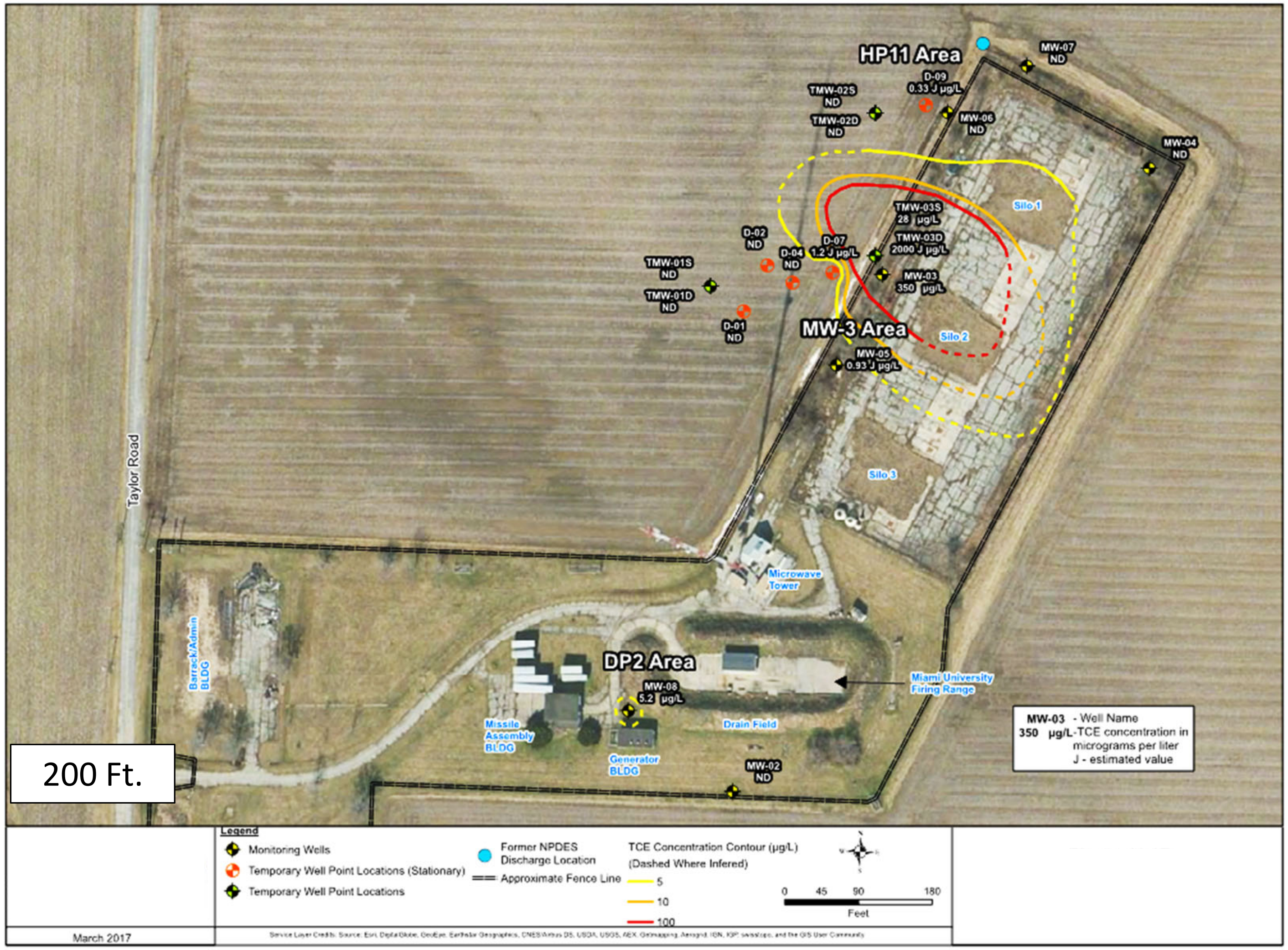
ESS (Remediation Geology) Approach Is Not Just For Large Sites





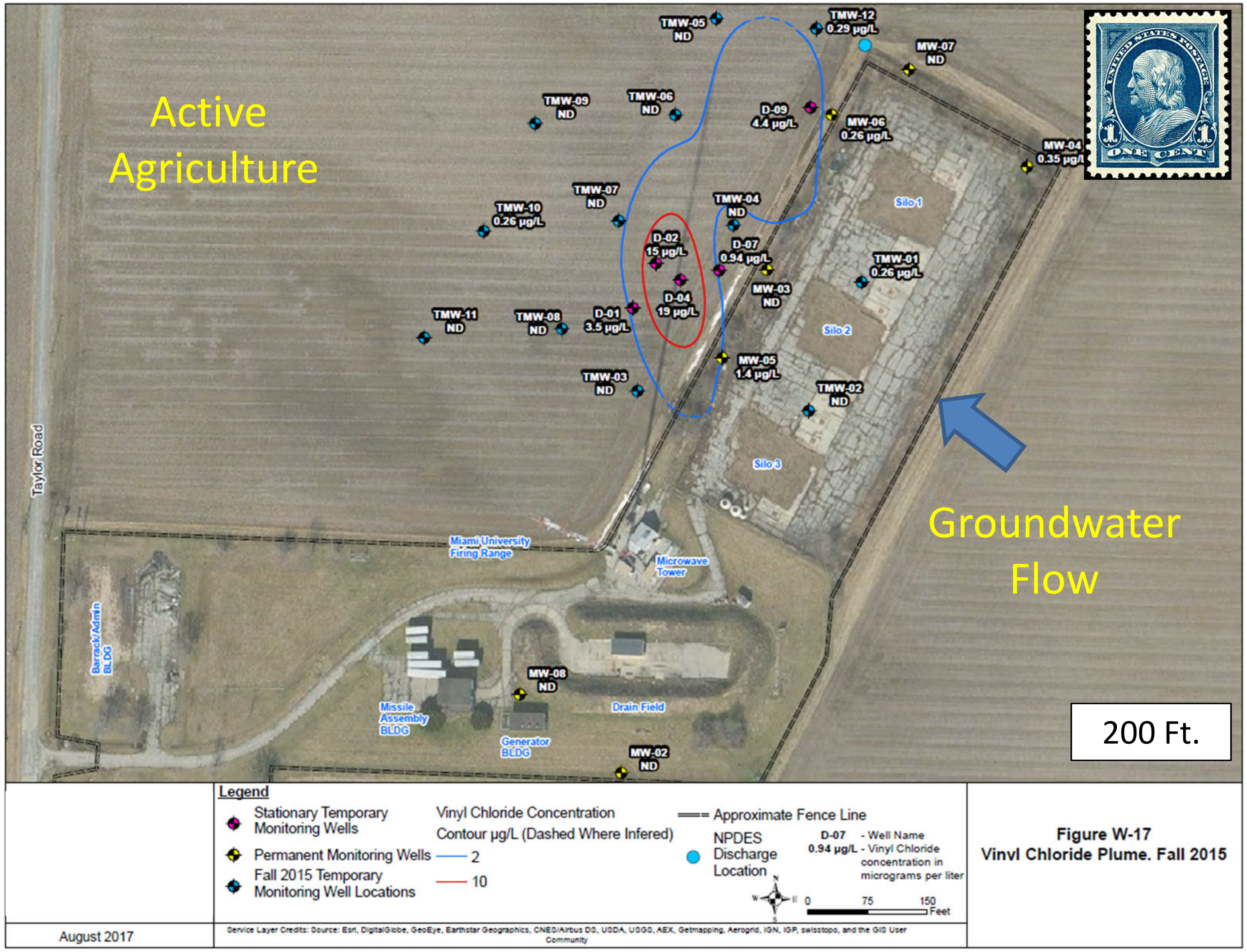
Agenda

- Project objectives and workflow
- Data processing and graphic grain size logs
- Stratigraphic Interpretation
- Hydrostratigraphy and contaminant migration
- Implications for site management



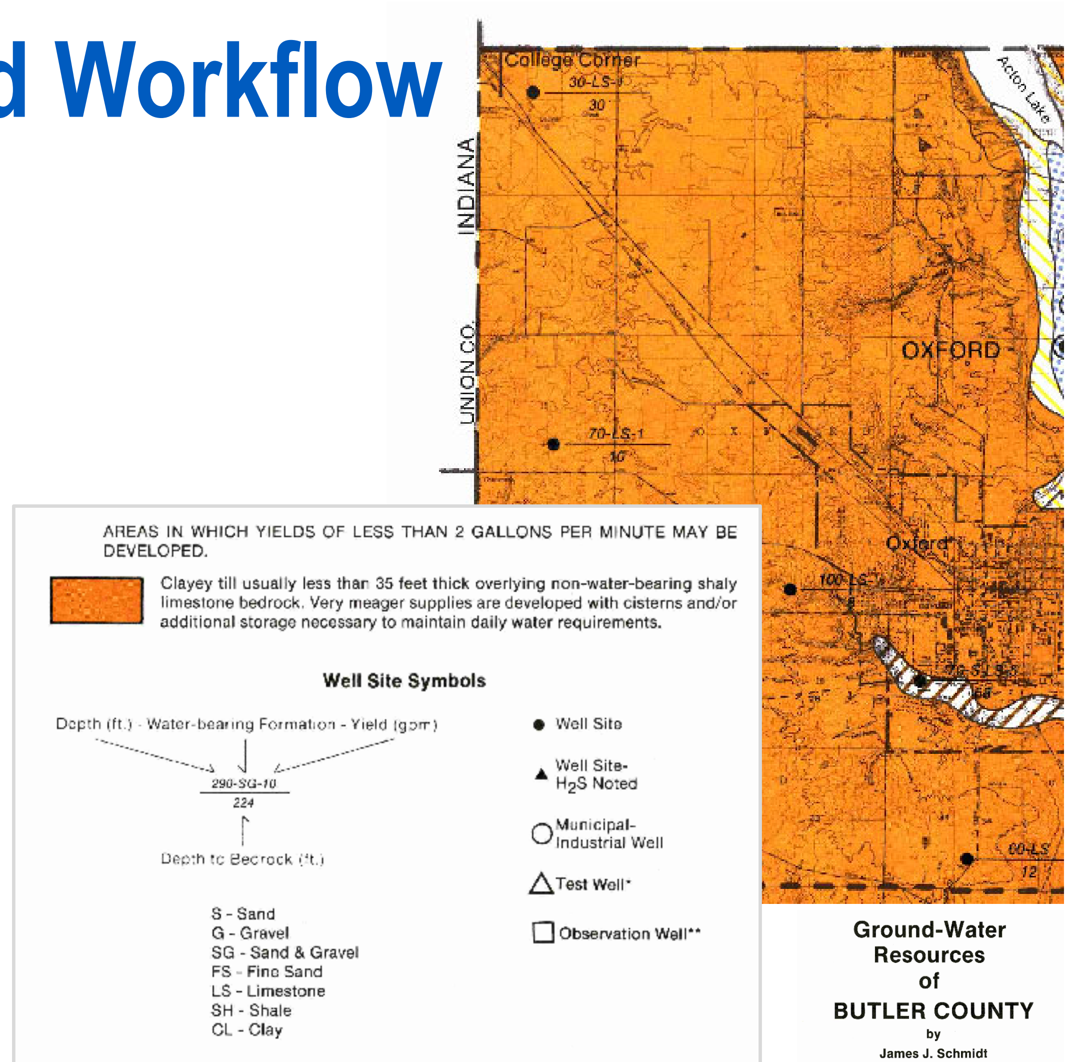
Site Overview

- Vinyl Chloride Plume Migrating Off Site
- Apparent NW Trajectory
- Extensive *Seasonal* Monitoring Well Network (12 Wells)



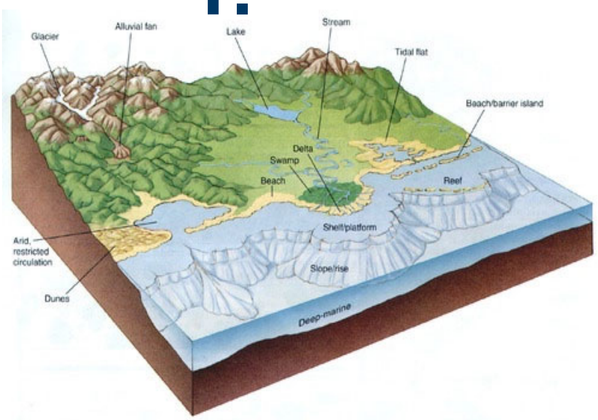
Project Objectives and Workflow

- Objectives
  - Interpret glacial history and stratigraphy to improve CSM, understanding of groundwater flow pathways, and contaminant F&T
  - Assess implications for Site Management Strategy
- Workflow
  - Reviewed regional information on Miami Sub lobe of Wisconsinan glaciation
  - Critical review of site data, generate graphic grain size logs from boring logs
  - Generated cross sections, isopach map of intra-till outwash sands



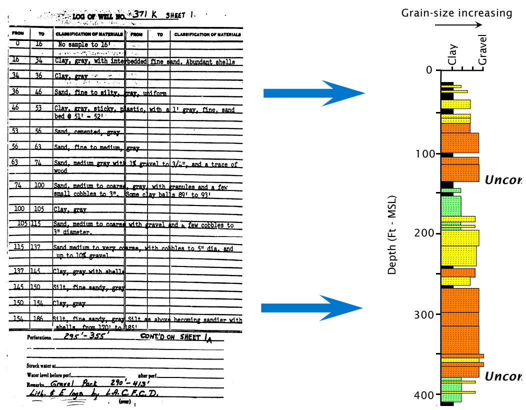
The Environmental Sequence Stratigraphy (ESS) Process

1.



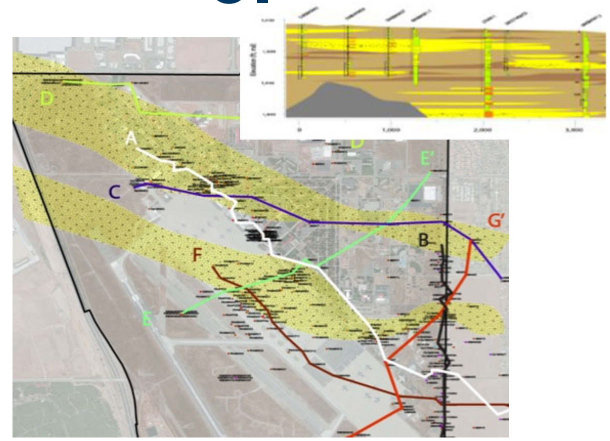
Determine depositional environment, which is the foundation of the ESS evaluation

2.



Leverage existing lithology data: format to emphasize vertical grainsize patterns

3.



Map and predict the subsurface permeability architecture and HSUs **away from the data points**

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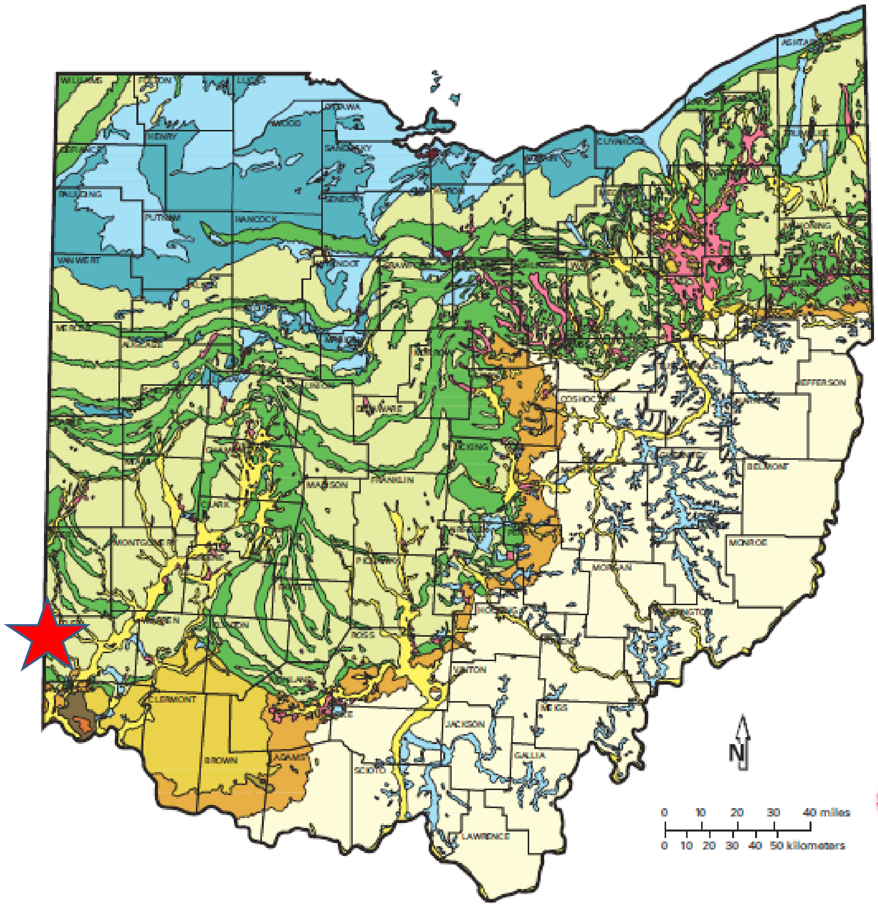
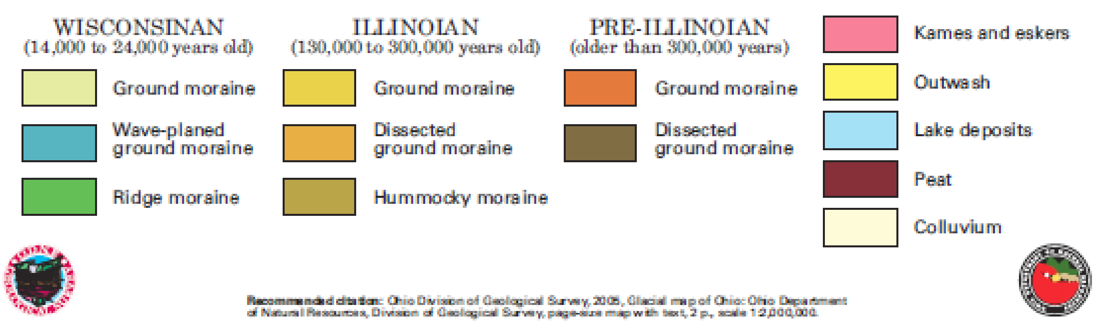
Site Setting- The Glacial Landscape of Ohio

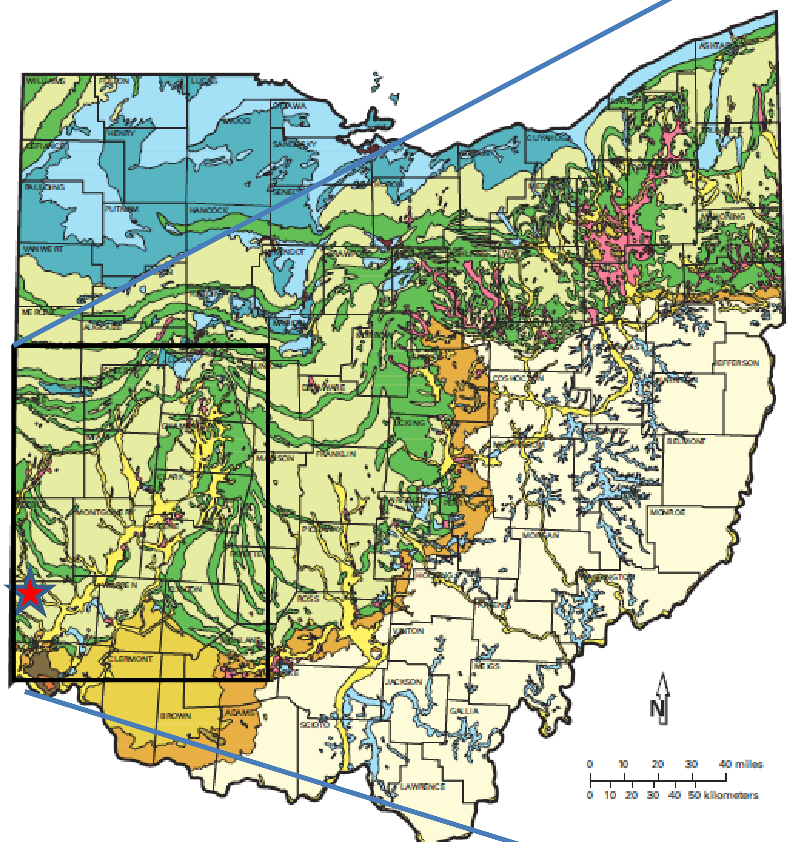


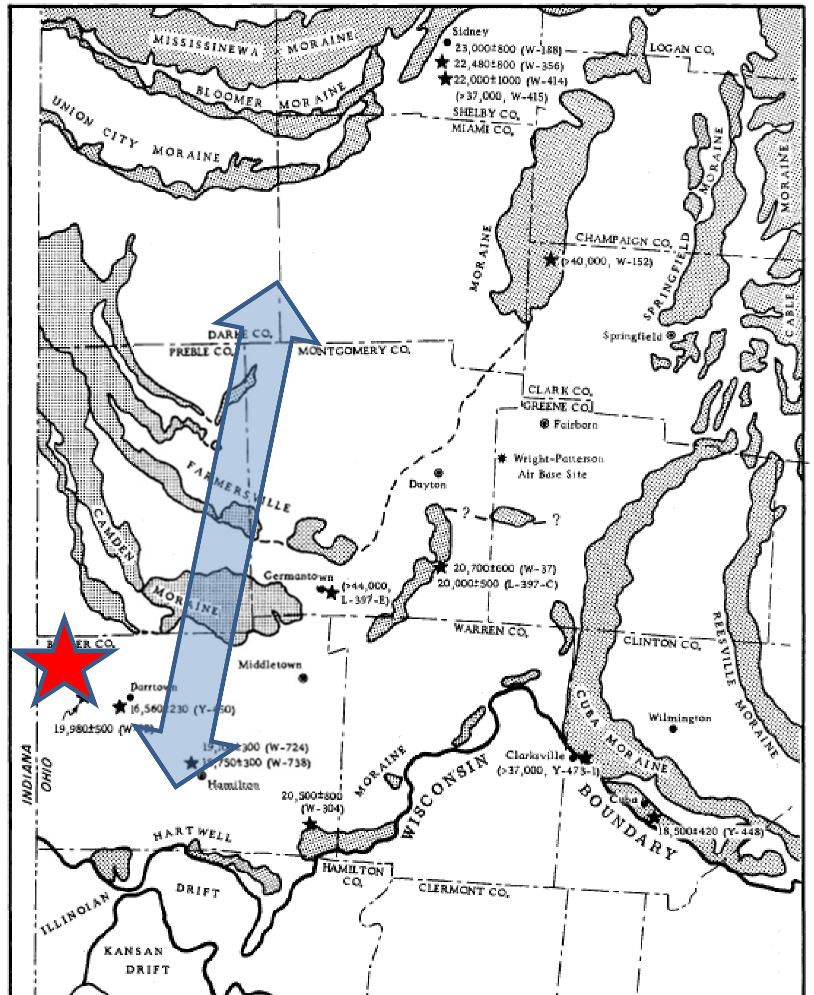
Oxford Ohio:

- Between Camden and Hartwell End Moraines
- Miami Sub lobe of Wisconsinan Ice

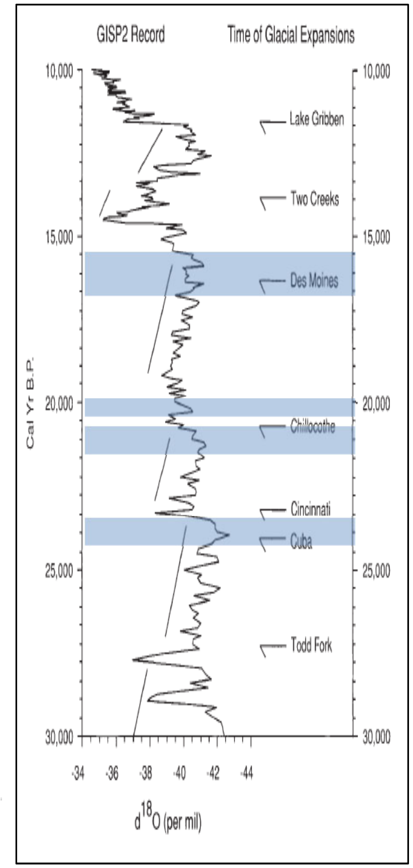


Site Setting



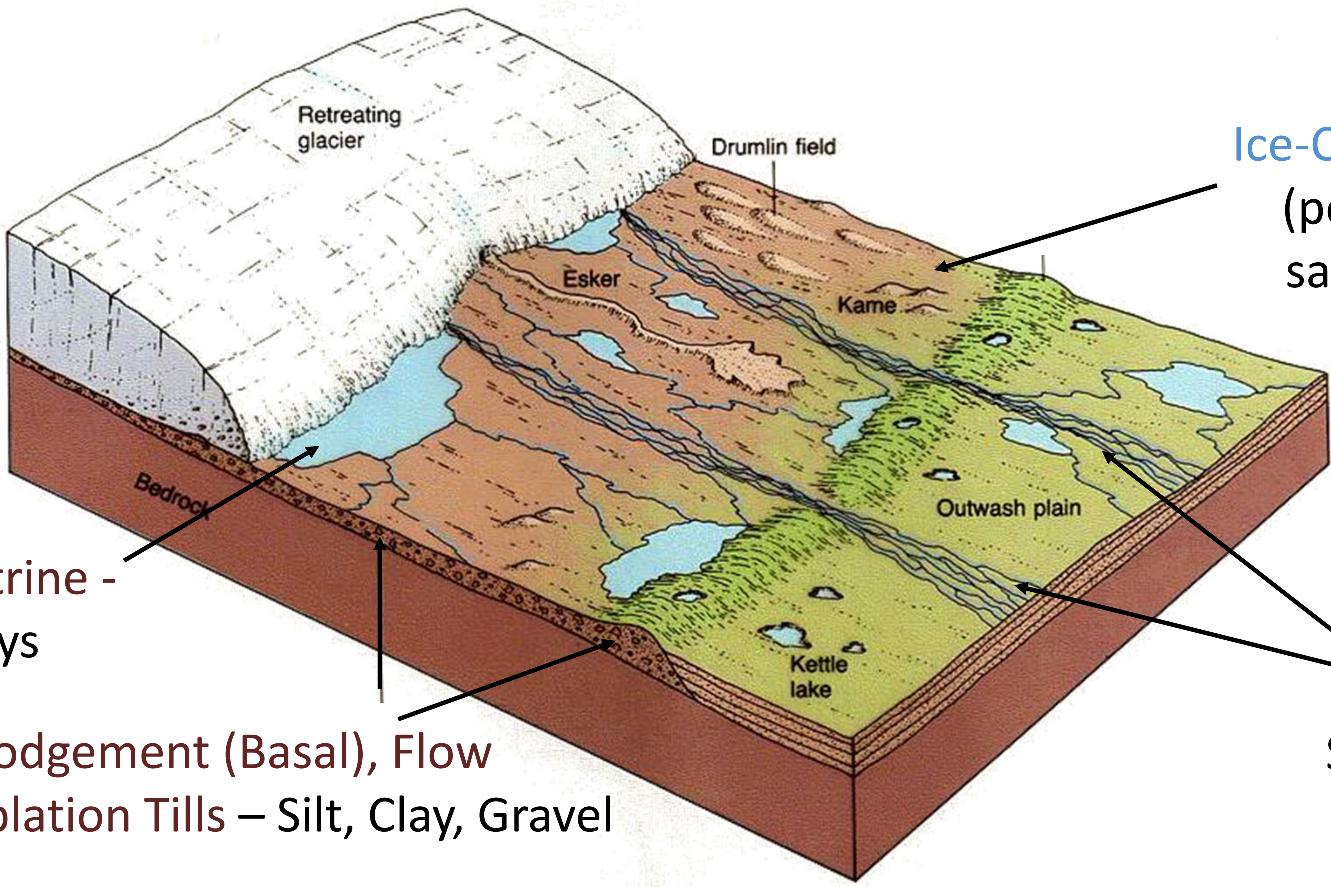


Forsythe, 1961



Lowell et al., 1999

Glacial Facies: Aquifers vs. Aquitards



Aquifers

Ice-Contact Deposits- (poorly stratified sand and gravel)

Outwash- Stratified Sand and gravel

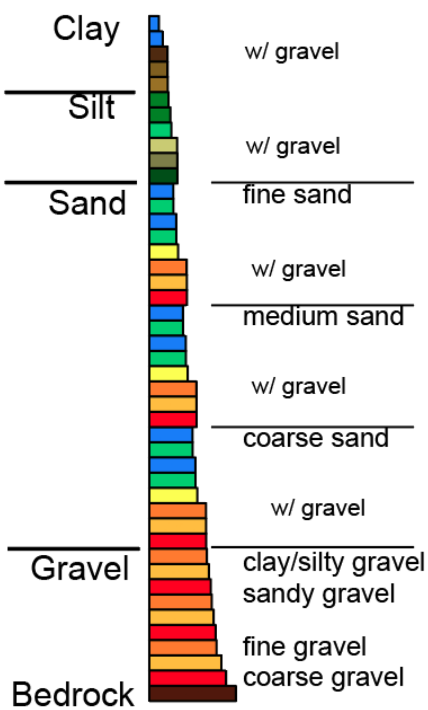
Aquitards

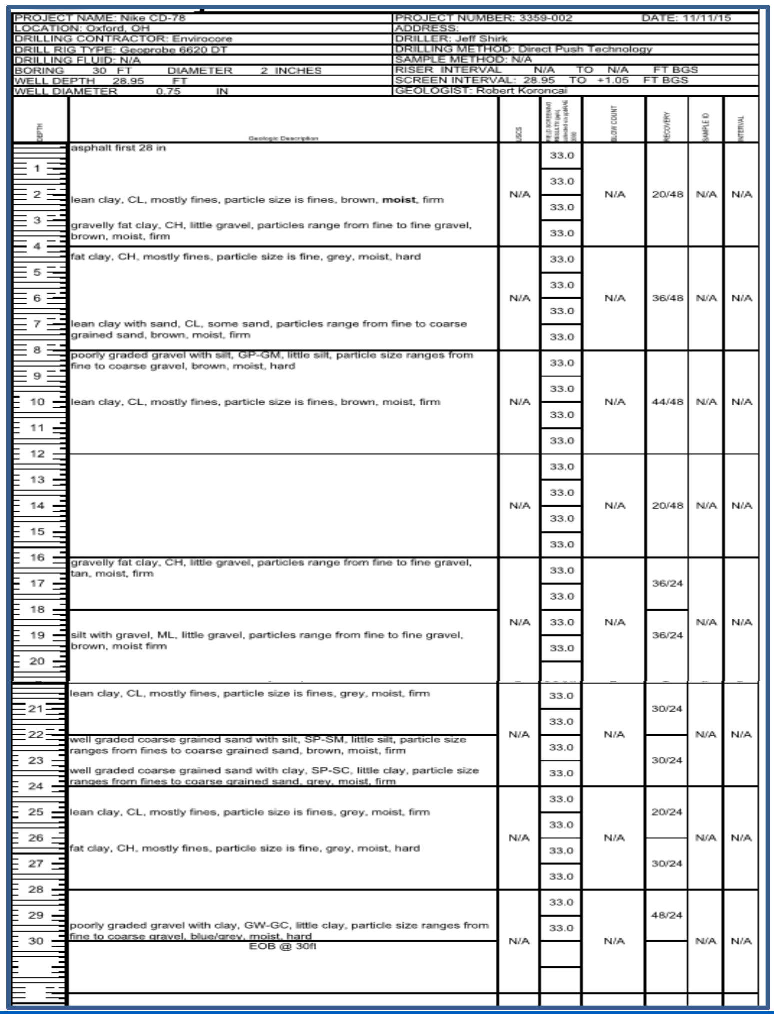
Proglacial Lacustrine - Silts and Clays

Lodgement (Basal), Flow and Ablation Tills – Silt, Clay, Gravel

Data Processing and Presentation:

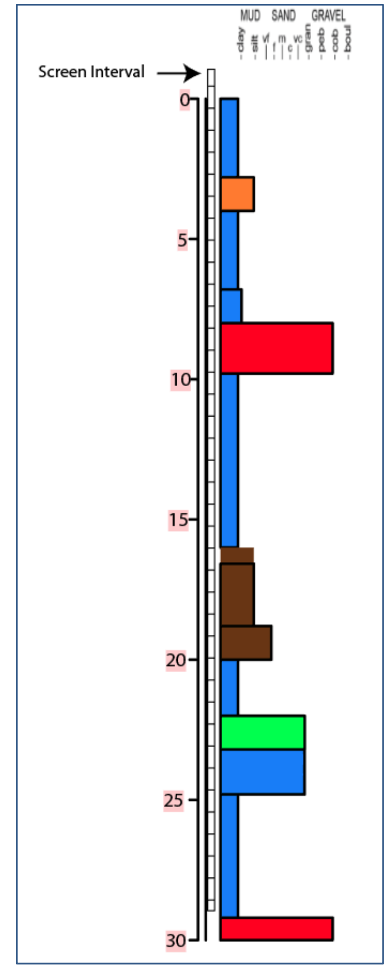
Graphic Grain Size Logs





PROJECT NAME: Nike CD-78	PROJECT NUMBER: 3359-002 DATE: 11/11/15
LOCATION: Oxford, OH	ADDRESS:
DRILLING CONTRACTOR: Envirocore	DRILLER: Jeff Shirk
DRILL RIG TYPE: Geoprobe 6620 DT	DRILLING METHOD: Direct Push Technology
DRILLING FLUID: N/A	SAMPLE METHOD: N/A
BORING 30 FT DIAMETER 2 INCHES	RISER INTERVAL N/A TO N/A FT BGS
WELL DEPTH 28.95 FT	SCREEN INTERVAL: 28.95 TO +1.05 FT BGS
WELL DIAMETER 0.75 IN	GEOLOGIST: Robert Koroncai

DEPTH	Geologic Description	USCS	[illegible]	BLOW COUNT	RECOVERY	SAMPLE ID	INTERVAL
0–4	asphalt first 28 in lean clay, CL, mostly fines, particle size is fines, brown, **moist**, firm gravelly fat clay, CH, little gravel, particles range from fine to fine gravel, brown, moist, firm	N/A	33.0 33.0 33.0 33.0	N/A	20/48	N/A	N/A
4–8	fat clay, CH, mostly fines, particle size is fine, grey, moist, hard lean clay with sand, CL, some sand, particles range from fine to coarse grained sand, brown, moist, firm	N/A	33.0 33.0 33.0 33.0	N/A	36/48	N/A	N/A
8–12	poorly graded gravel with silt, GP-GM, little silt, particle size ranges from fine to coarse gravel, brown, moist, hard lean clay, CL, mostly fines, particle size is fines, brown, moist, firm	N/A	33.0 33.0 33.0 33.0	N/A	44/48	N/A	N/A
12–16		N/A	33.0 33.0 33.0 33.0	N/A	20/48	N/A	N/A
16–18	gravelly fat clay, CH, little gravel, particles range from fine to fine gravel, tan, moist, firm	N/A	33.0 33.0	N/A	36/24	N/A	N/A
18–20	silt with gravel, ML, little gravel, particles range from fine to fine gravel, brown, moist firm		33.0 33.0		36/24		
20–22	lean clay, CL, mostly fines, particle size is fines, grey, moist, firm	N/A	33.0 33.0	N/A	30/24	N/A	N/A
22–24	well graded coarse grained sand with silt, SP-SM, little silt, particle size ranges from fines to coarse grained sand, brown, moist, firm well graded coarse grained sand with clay, SP-SC, little clay, particle size ranges from fines to coarse grained sand, grey, moist, firm		33.0 33.0		30/24		
24–26	lean clay, CL, mostly fines, particle size is fines, grey, moist, firm	N/A	33.0 33.0	N/A	20/24	N/A	N/A
26–28	fat clay, CH, mostly fines, particle size is fine, grey, moist, hard		33.0 33.0		30/24		
28–30	poorly graded gravel with clay, GW-GC, little clay, particle size ranges from fine to coarse gravel, blue/grey, moist, hard	N/A	33.0 33.0	N/A	48/24	N/A	N/A
30	EOB @ 30ft						



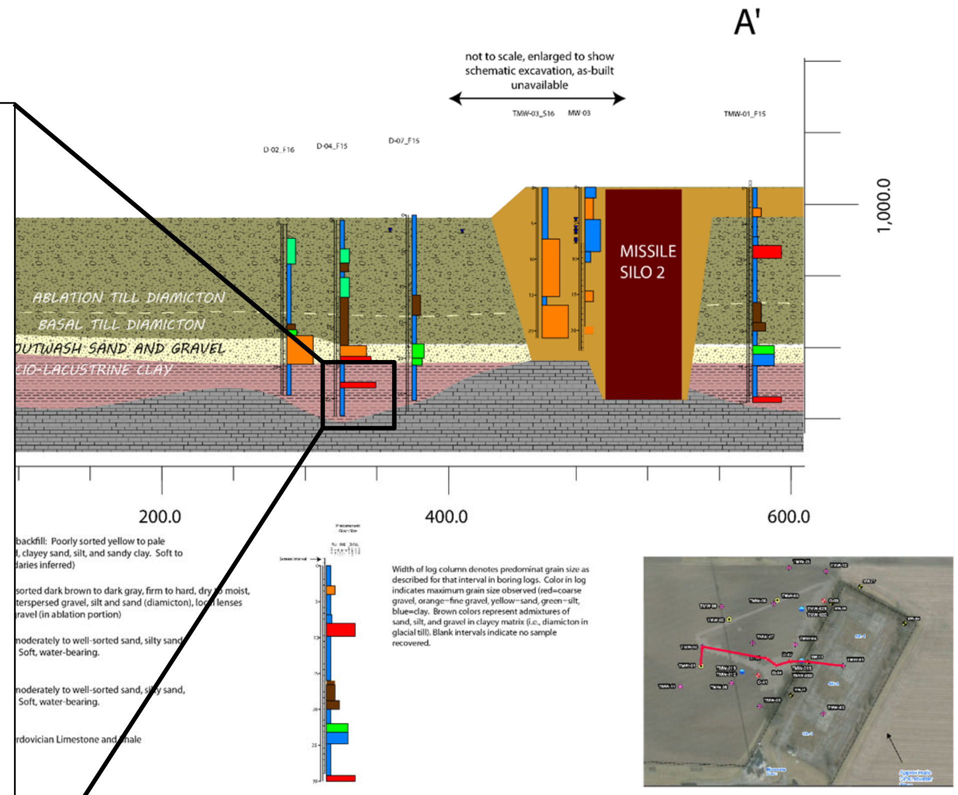
Glacio-Lacustrine Clay

BORING LOG: D-04

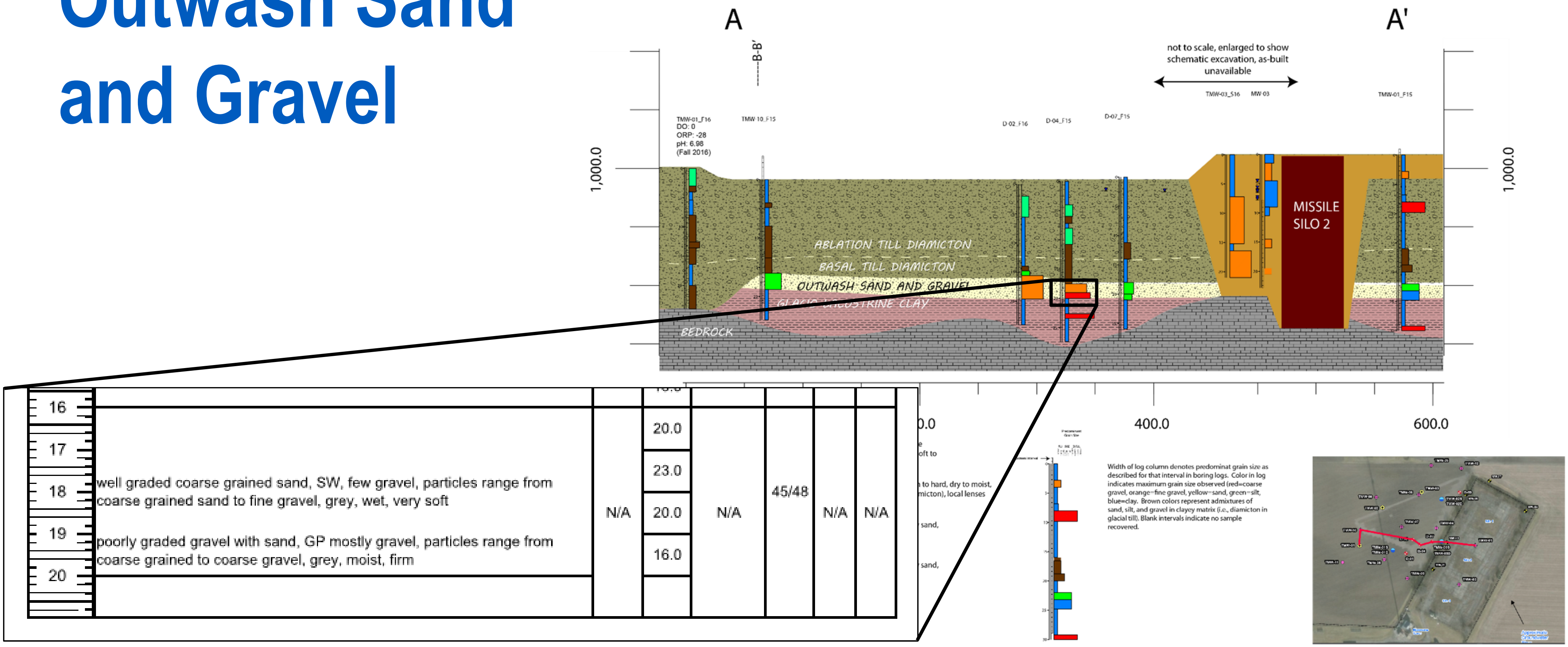
SHEET _2_ of _2_

PROJECT NAME: Nike CD-78	PROJECT NUMBER: 3359-002 DATE: 11/11/15
LOCATION: Oxford, OH	ADDRESS:
DRILLING CONTRACTOR: Envirocore	DRILLER: Jeff Shirk
DRILL RIG TYPE: Geoprobe 6620 DT	DRILLING METHOD: Direct Push Technology
DRILLING FLUID: N/A	SAMPLE METHOD: N/A
BORING 27.5 FT DIAMETER 2 INCHES	RISER INTERVAL 10.61 TO +4.39 FT BGS
WELL DEPTH 20.61 FT	SCREEN INTERVAL: 20.61 TO 10.61 FT BGS
WELL DIAMETER 0.75 IN	GEOLOGIST: Robert Koroncai

DEPTH	Geologic Description	USCS	FIELD SCREENING RESULTS (ppb), collected via	BLOW COUNT	RECOVERY	SAMPLE ID	INTERVAL
21	fat clay, CH, mostly fines, particle size is fine, brown, moist, firm	N/A	20.0	N/A	35/48	N/A	N/A
22	fat clay, CH, mostly fines, particle size is fine, dark grey, moist, firm		20.0				
23	poorly graded gravel, GP, few sand, particles range from coarse grained to coarse angular gravel, grey, moist, firm fat clay, CH, mostly fines, particle size is fine, grey, moist, firm		20.0				
24	fat clay, CH, mostly fines, particle size is fine, dark grey, moist, hard		20.0				
25		N/A	23.0	N/A	42/42	N/A	N/A
26	fat clay, CH, mostly fines, particle size is fine, dark grey, moist, hard		26.0				
27	fat clay, CH, mostly fines, particle size is fine, blue/grey, moist, hard						
	EOB @ 27.5ft BGS						



Outwash Sand and Gravel

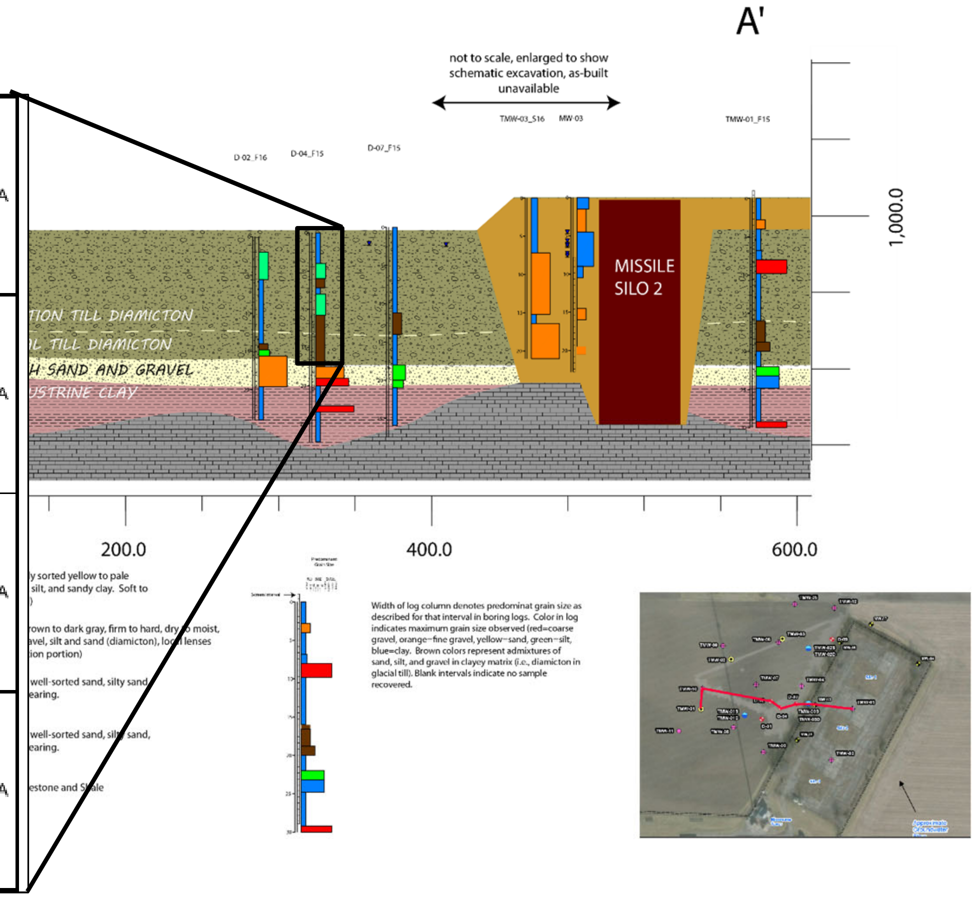


16							
17			20.0				
18	well graded coarse grained sand, SW, few gravel, particles range from coarse grained sand to fine gravel, grey, wet, very soft		23.0		45/48		
19	poorly graded gravel with sand, GP mostly gravel, particles range from coarse grained to coarse gravel, grey, moist, firm	N/A	20.0	N/A		N/A	N/A
20			16.0				

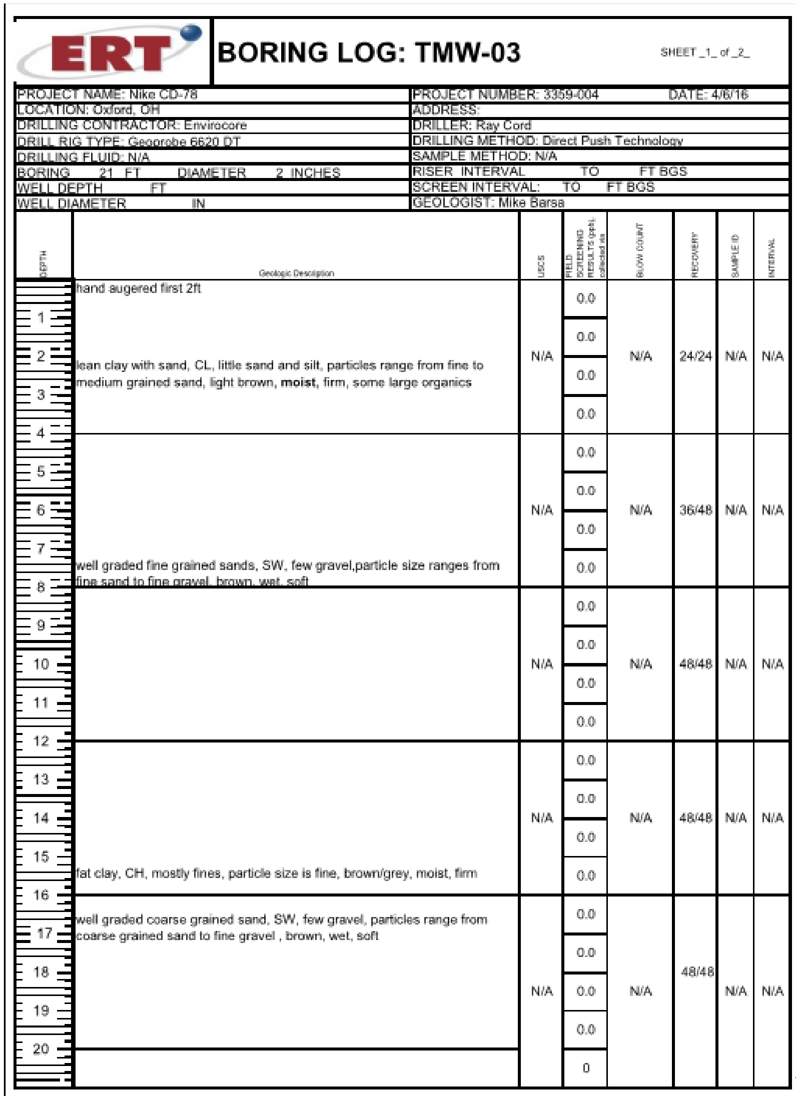
Clay Till Diamicton

A

1 2 3	hand augered first 2 ft elastic silt, MH, little clay, particles range from fine to medium grained sand, brown, dry, firm fat clay, CH, mostly fines, particle size is fine, brown, dry, firm	N/A	0.0 0.0 0.0 0.0	N/A	24/24	N/A	N/A
4 5 6 7	gravelly fat clay, CH, little gravel, particles range from fine to fine gravel, brown, dry, firm	N/A	0.0 0.0 0.0 0.0	N/A	34/48	N/A	N/A
8 9 10 11	lean clay, CL, mostly fines, vast majority of particles are fines, brown, dry, firm gravelly lean clay, CH, little gravel, particles range from fine to fine gravel, grey, dry, firm	N/A	0.0 0.0 0.0 0.0	N/A	46/48	N/A	N/A
12 13 14 15 16	fat clay, CH, mostly fines, particle size is fine,dark grey, dry, firm well graded medium grained sand, SW, little gravel, particles range from fine to fine gravel, grey, wet, soft sandy silt, ML, some sand, particles range from fine to medium sand, grey, moist, firm	N/A	0.0 0.0 0.0 0.0	N/A	48/48	N/A	N/A



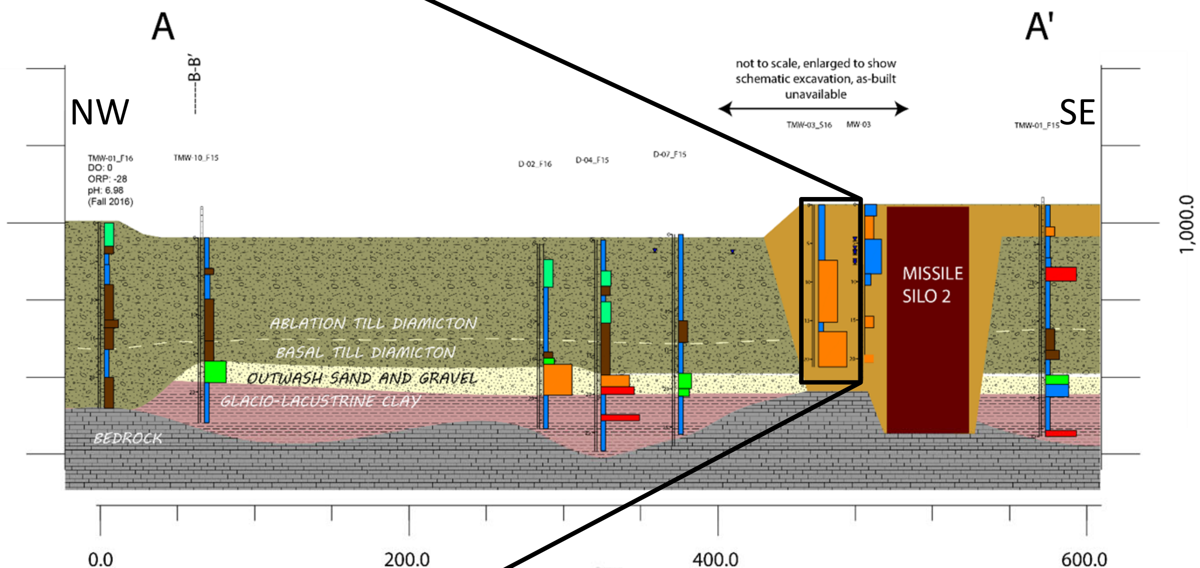
Backfill Related to Silo Construction



ERT — BORING LOG: TMW-03 SHEET _1_ of _2_

PROJECT NAME: Nike CD-78	PROJECT NUMBER: 3359-004 DATE: 4/6/16
LOCATION: Oxford, OH	ADDRESS:
DRILLING CONTRACTOR: Envirocore	DRILLER: Ray Cord
DRILL RIG TYPE: Geoprobe 6620 DT	DRILLING METHOD: Direct Push Technology
DRILLING FLUID: N/A	SAMPLE METHOD: N/A
BORING 21 FT DIAMETER 2 INCHES	RISER INTERVAL TO FT BGS
WELL DEPTH FT	SCREEN INTERVAL: TO FT BGS
WELL DIAMETER IN	GEOLOGIST: Mike Barsa

DEPTH	Geologic Description	USCS	FIELD SCREENING RESULTS (ppb) collected via	BLOW COUNT	RECOVERY	SAMPLE ID	INTERVAL
0–4	hand augered first 2ft lean clay with sand, CL, little sand and silt, particles range from fine to medium grained sand, light brown, **moist**, firm, some large organics	N/A	0.0 / 0.0 / 0.0 / 0.0	N/A	24/24	N/A	N/A
4–8	well graded fine grained sands, SW, few gravel,particle size ranges from fine sand to fine gravel, brown, wet, soft	N/A	0.0 / 0.0 / 0.0 / 0.0	N/A	36/48	N/A	N/A
8–12		N/A	0.0 / 0.0 / 0.0 / 0.0	N/A	48/48	N/A	N/A
12–16	fat clay, CH, mostly fines, particle size is fine, brown/grey, moist, firm	N/A	0.0 / 0.0 / 0.0 / 0.0	N/A	48/48	N/A	N/A
16–20	well graded coarse grained sand, SW, few gravel, particles range from coarse grained sand to fine gravel , brown, wet, soft	N/A	0.0 / 0.0 / 0.0 / 0.0	N/A	48/48	N/A	N/A
20–			0				



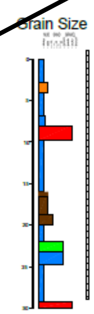
Excavation backfill: poorly sorted yellow to pale brown sand, clayey sand, silt, and sandy clay. Soft to firm (boundaries inferred).

Till: poorly sorted dark brown to dark gray, firm to hard dry to moist clay with interspersed gravel, silt, and sand (diamicton), local lenses of silt and gravel (in ablation portion)

Outwash: moderately to well-sorted sand, silty sand, and gravel. Soft and water-bearing.

Glaciolacustrine clay. Firm to hard, moist to dry

Bedrock: Ordovician Limestone and Shale



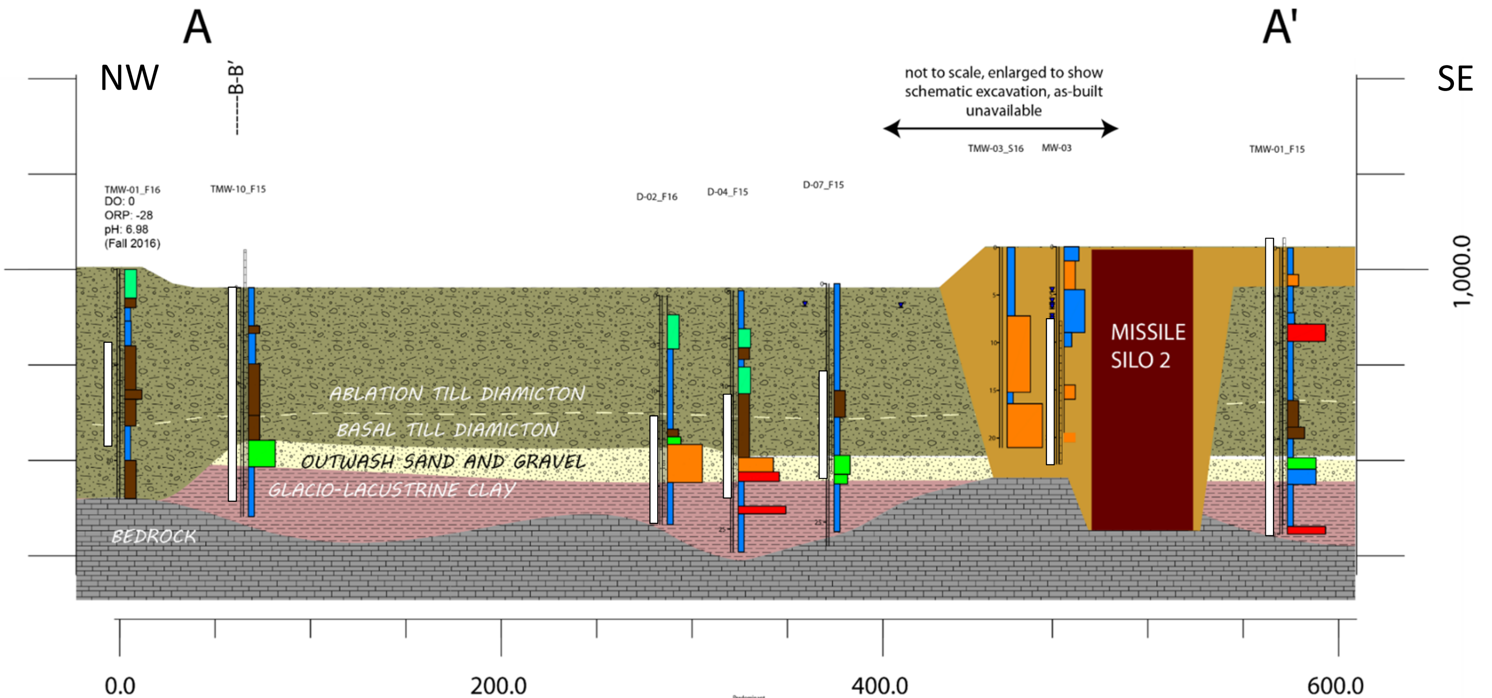
Width of log column denotes predominat grain size as described for that interval in boring logs. Color in log indicates maximum grain size observed (red=coarse gravel, orange=fine gravel, yellow=sand, green=silt, blue=clay. Brown colors represent admixtures of sand, silt, and gravel in clayey matrix (i.e., diamicton in glacial till). Blank intervals indicate no sample recovered.

Likely one full glacial cycle

Coarse backfill adjacent to fine till and coarse outwash

GSLs “Flagged” unnatural stratigraphic signature of backfill

Outwash Is the primary Hydro-Stratigraphic Unit (HSU)



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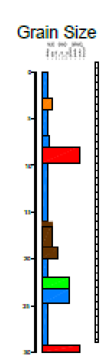

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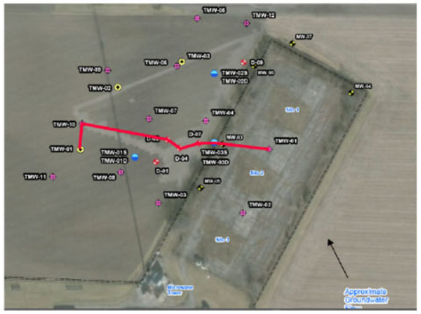
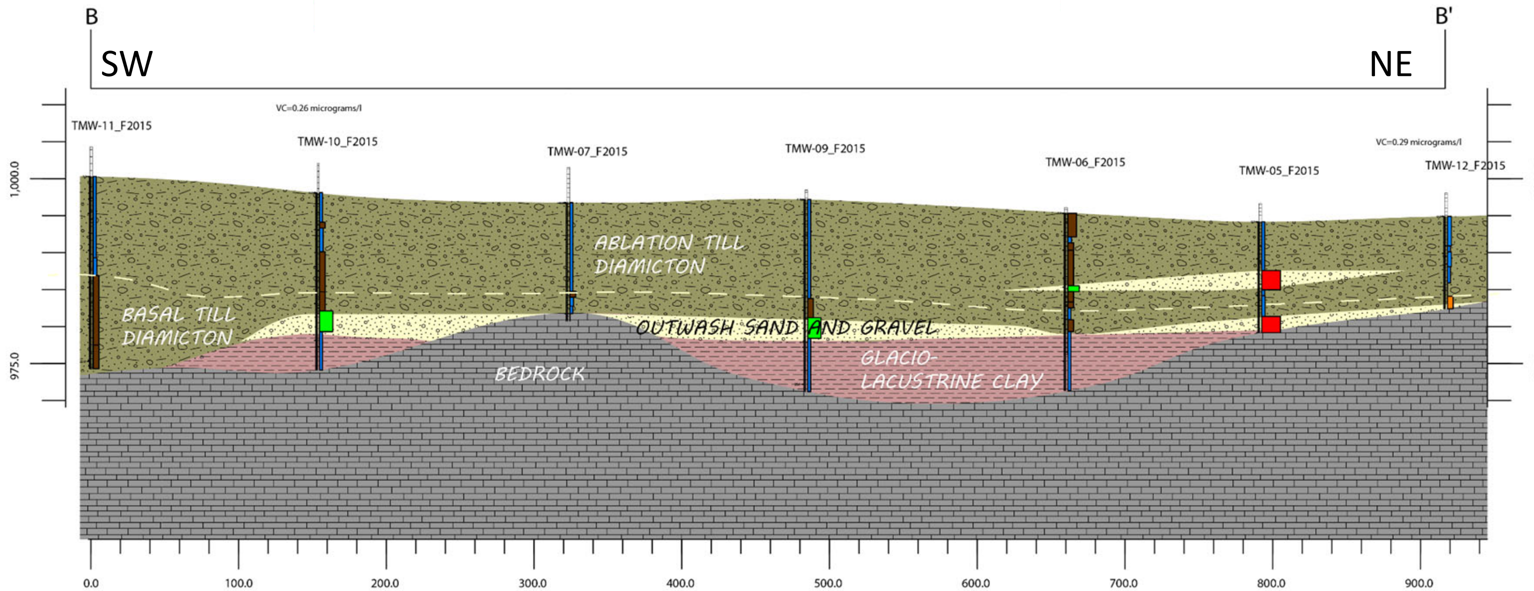


Native Till Section shows nature of outwash sand.

Outwash sand pinches out onto bedrock highs, and is truncated to the south by the basal till diamicton.



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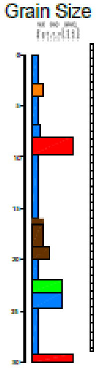
Outwash: moderately to well-sorted sand, silty sand, and gravel. Soft and water-bearing.

Glaciolacustrine clay. Firm to hard, moist to dry

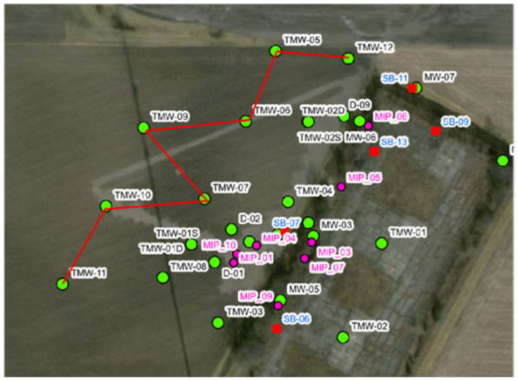
Bedrock: Ordovician Limestone and Shale

Grain Size



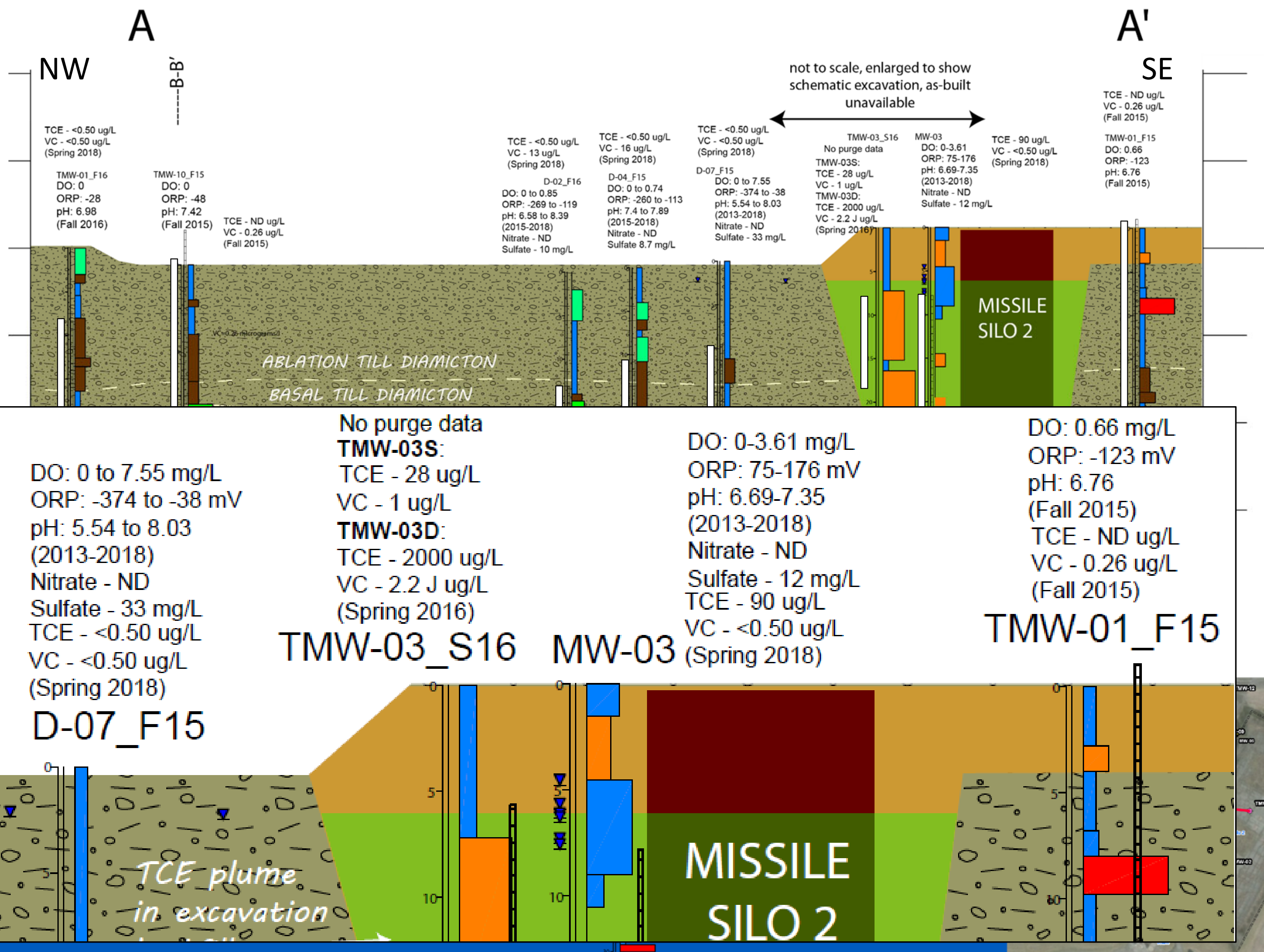
Screen Interval

Width of log column denotes predominat grain size as described for that interval in boring logs. Color in log indicates maximum grain size observed (red=coarse gravel, orange=fine gravel, yellow=sand, green=silt, blue=clay. Brown colors represent admixtures of sand, silt, and gravel in clayey matrix (i.e., diamicton in glacial till). Blank intervals indicate no sample recovered.



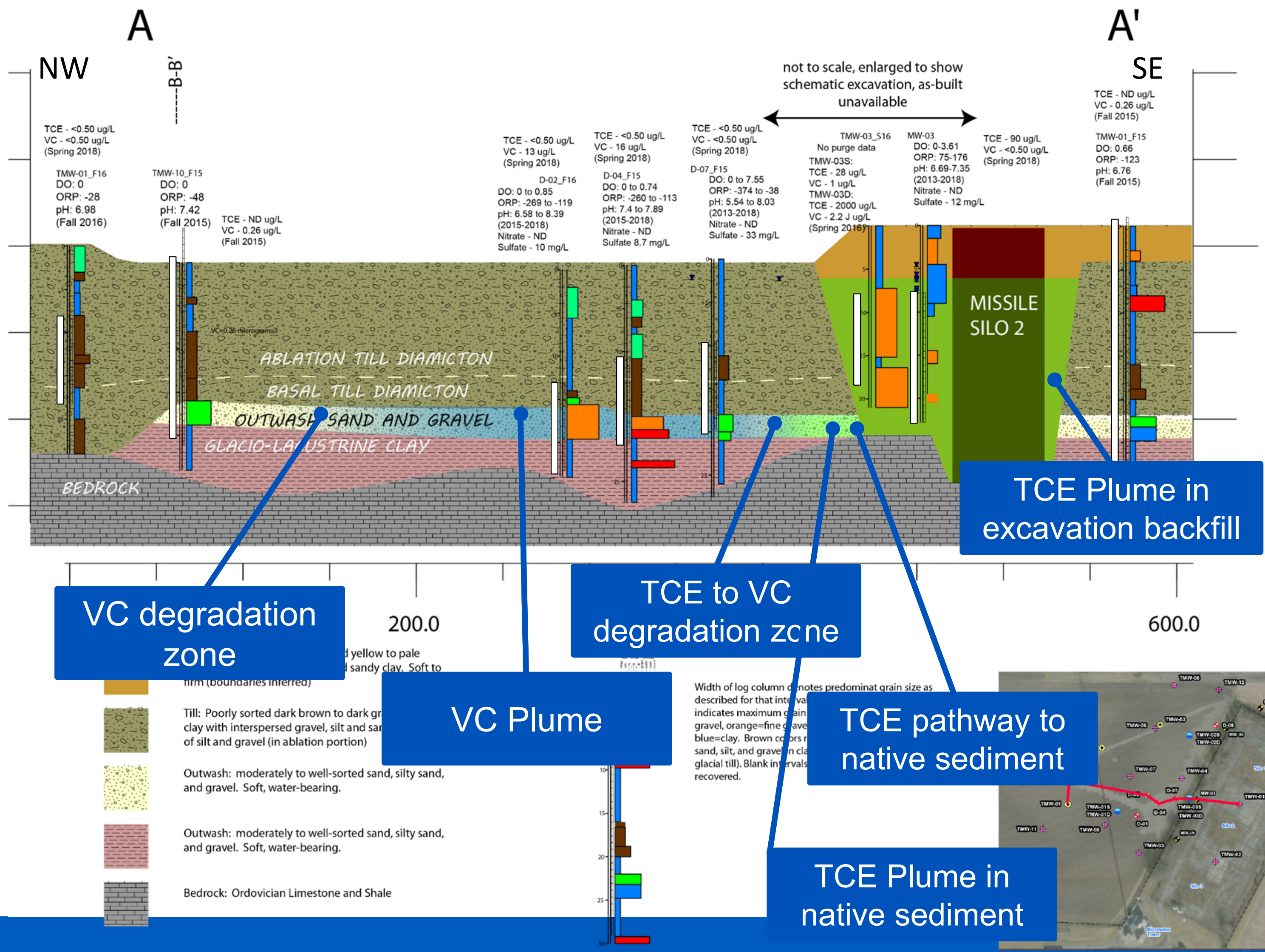
CSM for Contaminant F&T

- Expulsion of contaminated water from backfill (winter/ spring rainfall) into semi-conf sand
- Different s properties organics? sand lead
- Rapid deg in outwasl
- Outwash s distributio



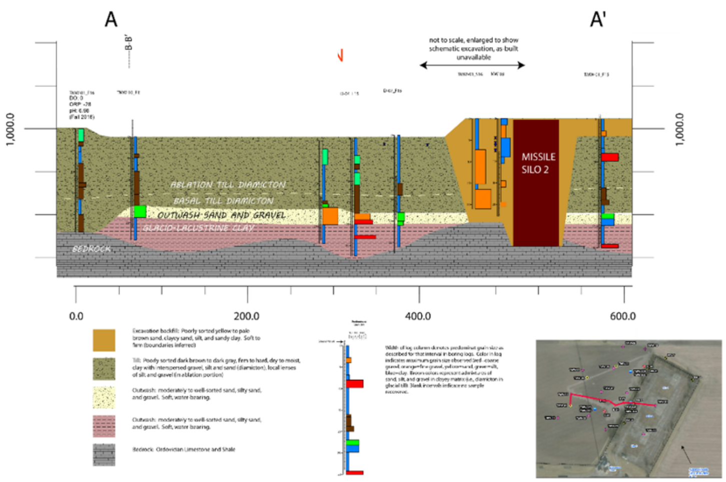
CSM for Contaminant F&T

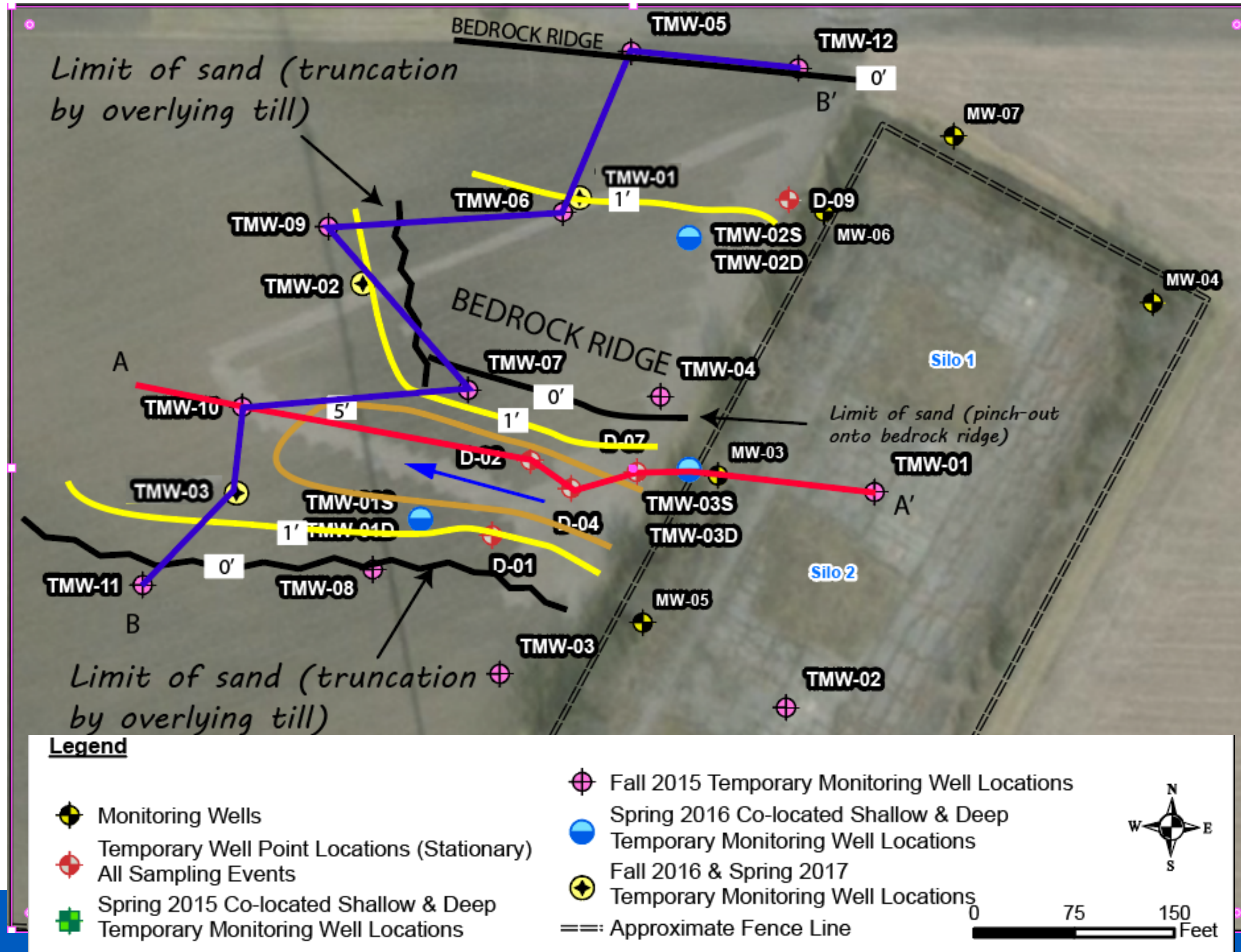
- Expulsion of contaminated water from backfill (winter/ spring rainfall) into semi-confined outwash sand
- Different sediment properties (increased organics?) in outwash sand leads too…
- Rapid degradation once in outwash sand
- Outwash sand distribution limited



Isopach Map of Outwash Sand

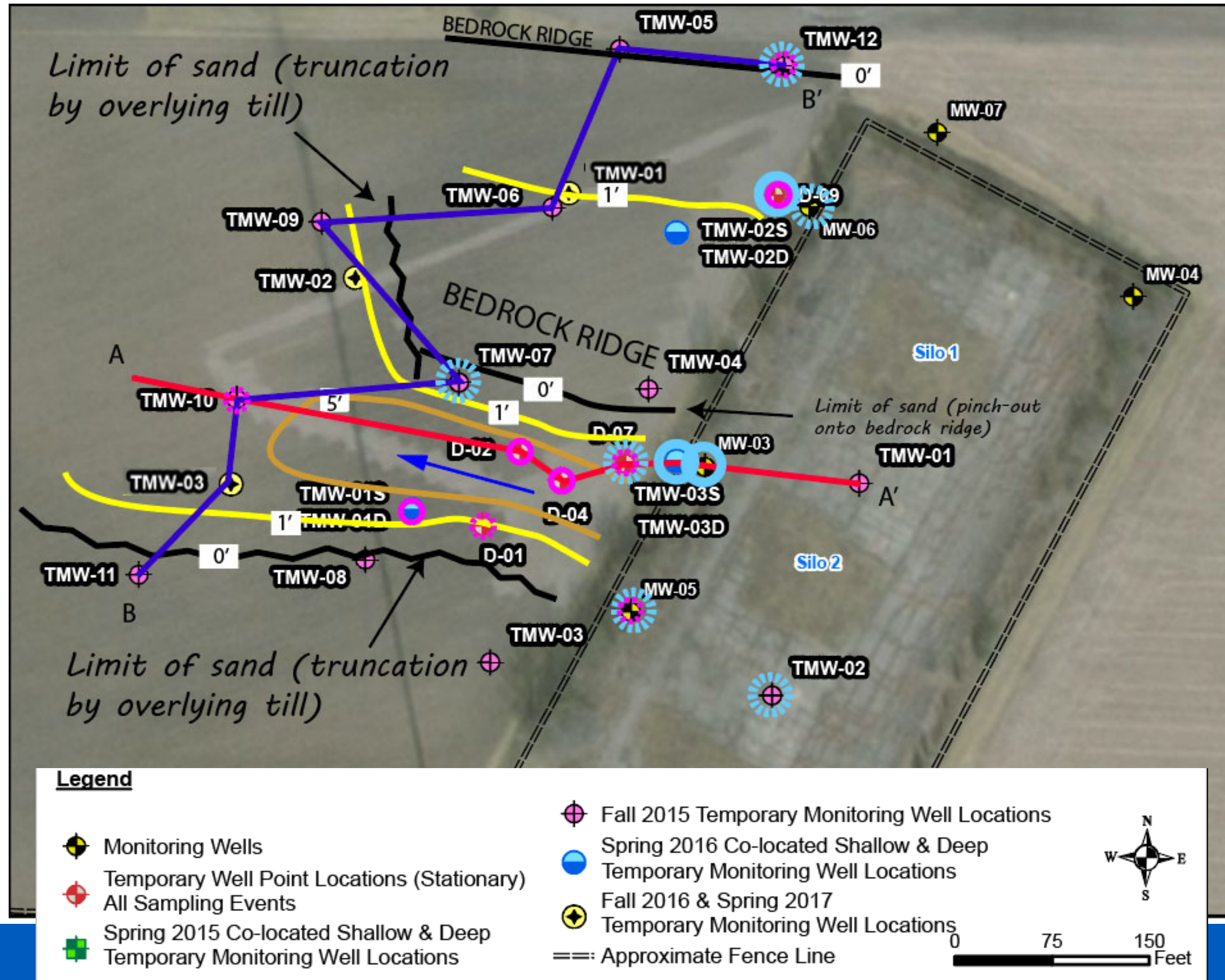
- Bedrock ridge devoid of outwash sand
- Pinch-out of outwash sand to north
- Transport limited to outwash sand pathway





Analytical Data and Geologic Pathway Map

- Thickness of Glaciofluvial outwash sand deposit (single hydrostratigraphic unit and groundwater preferential pathway) — 0′
- TCE above 5 micrograms/liter any sampling period 2015-2017
- TCE detected below 5 micrograms/liter any sampling period 2015-2017
- VC above 5 micrograms/liter any sampling period 2015-2017
- VC detected below 5 micrograms/liter any sampling period 2015-2017
- TCE Plume (5 micrograms/liter, Spring 2016)
- VC Plume (5 micrograms/liter, Spring 2016)



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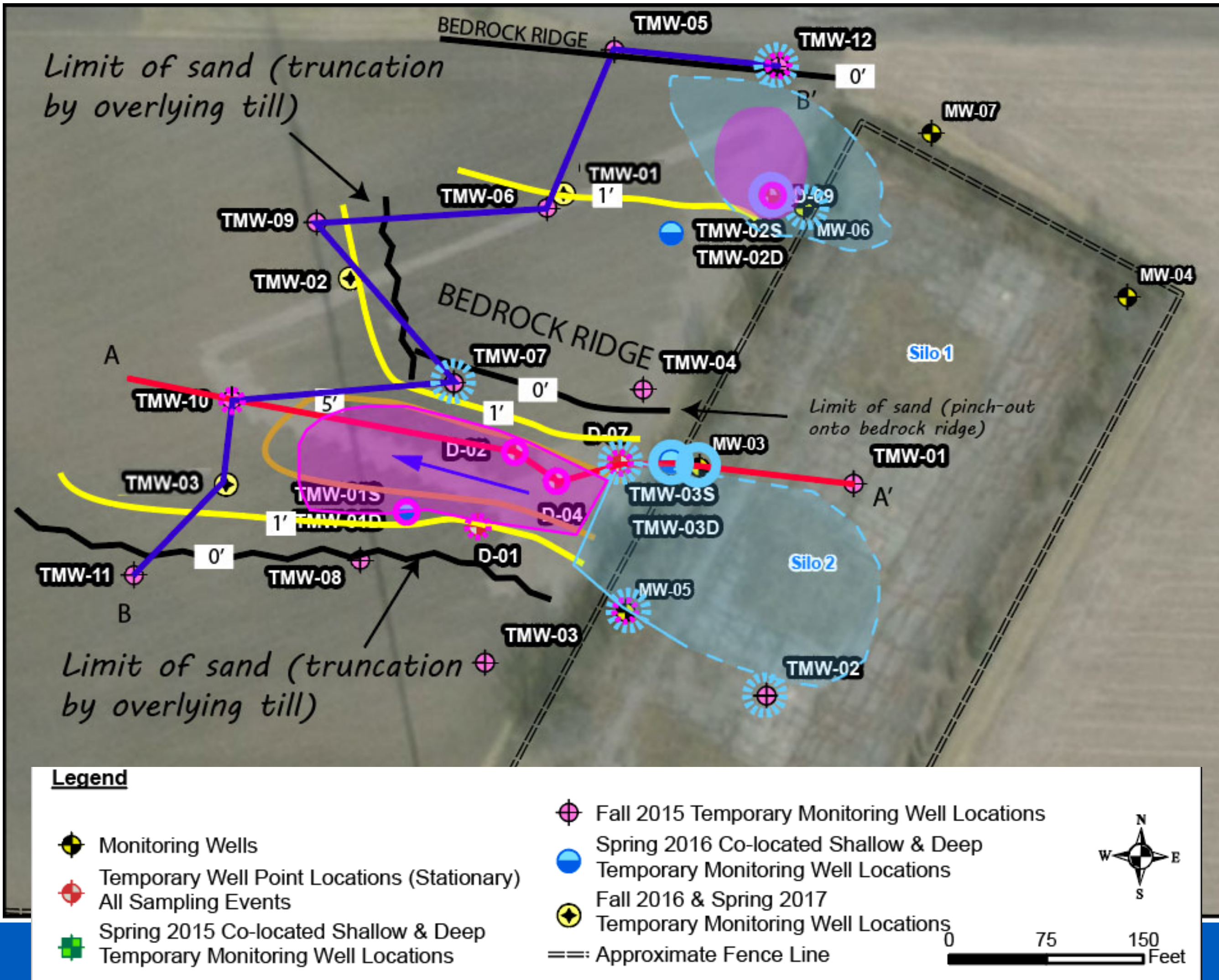
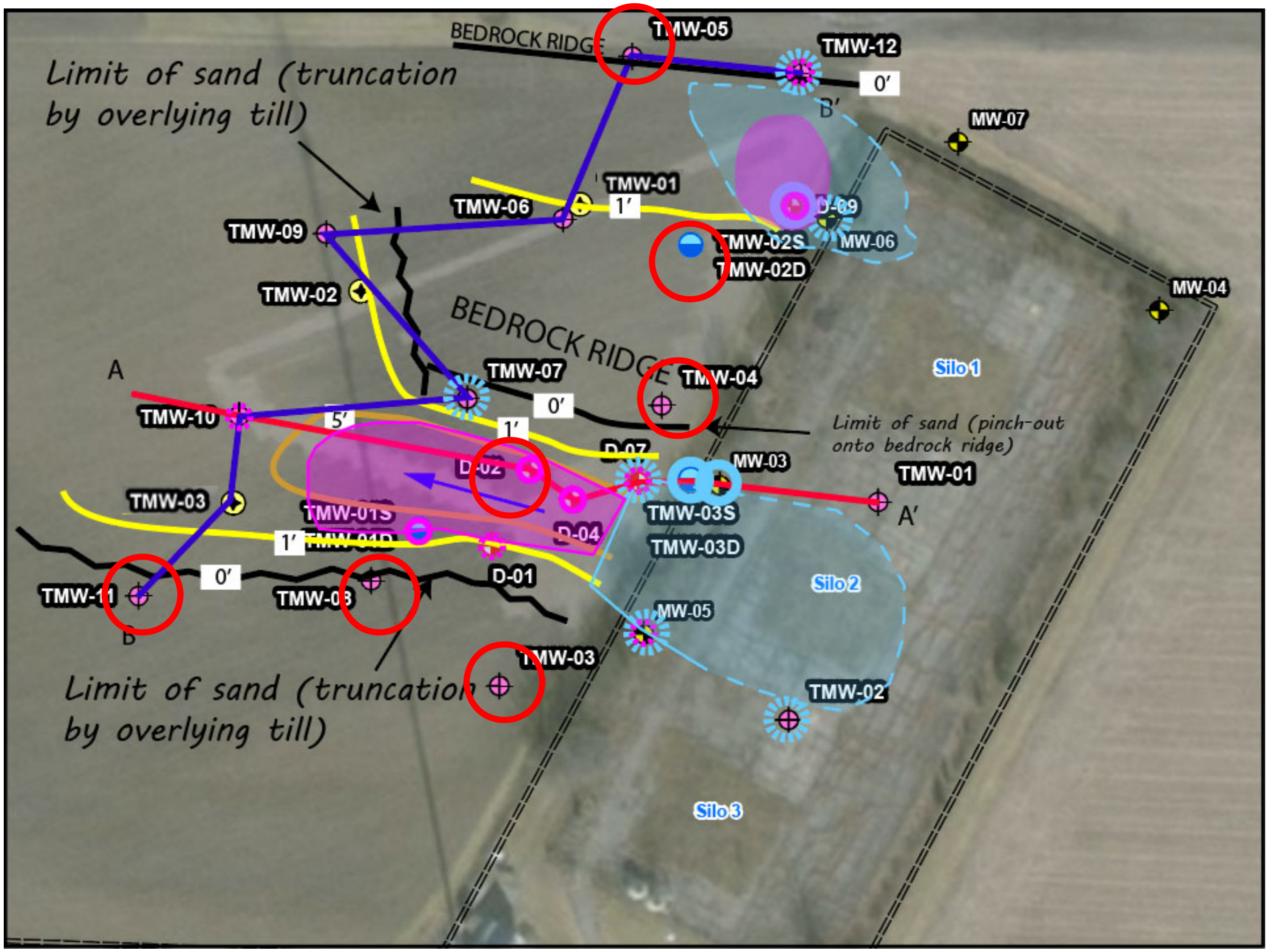


Conclusions

- Discrete Contaminant Pathways Mapped
- Once in native sediments rapid degradation occurs
- Evidence supports complete reductive dichlorination pathway
- New opportunity to optimize monitoring activities and eliminate redundant monitoring points



CREATE AMAZING.