NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar: New Era in Data Analytics for Bridge Foundation Design

October 18, 2022

2:30 – 4:00 PM

E

PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Beth Ewoldsen at TRBwebinar@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Providers Program. Credit earned on completion of this program will be reported to RCEP. A certificate of completion will be issued to participants that have registered and attended the entire session. As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.

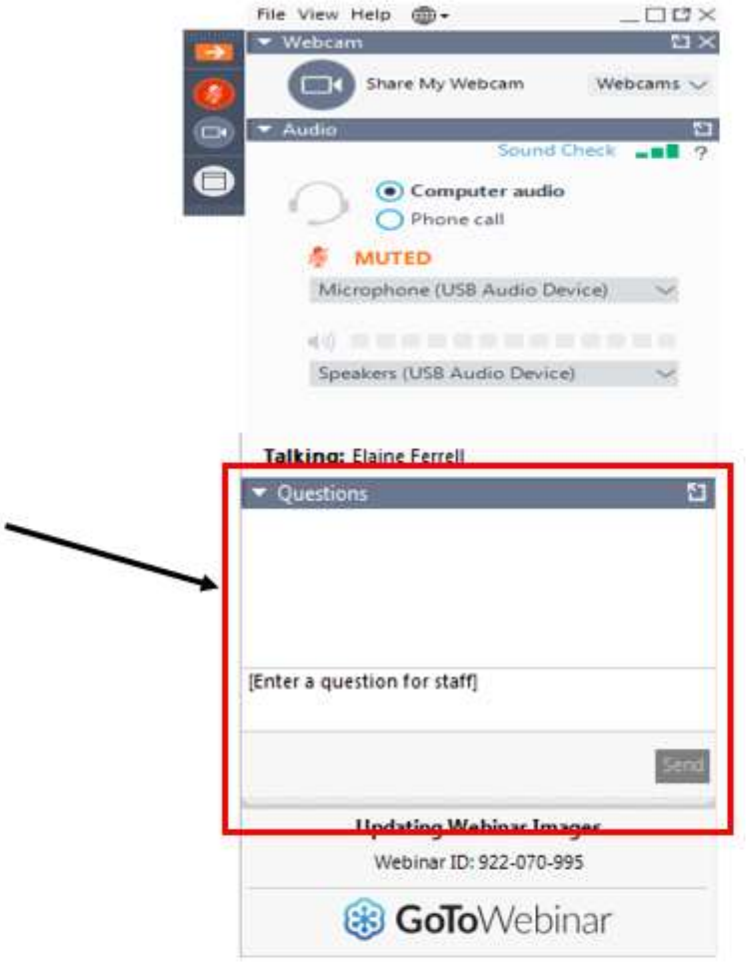
RCEP
REGISTERED CONTINUING EDUCATION PROGRAM

Learning Objectives

- Outline ways to reduce risk in bridge foundation design
- Define the role geotechnical data plays in future bridge foundation design

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's presenters

Nick Machairas
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Haley and Aldrich, Inc.

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Allen Cadden
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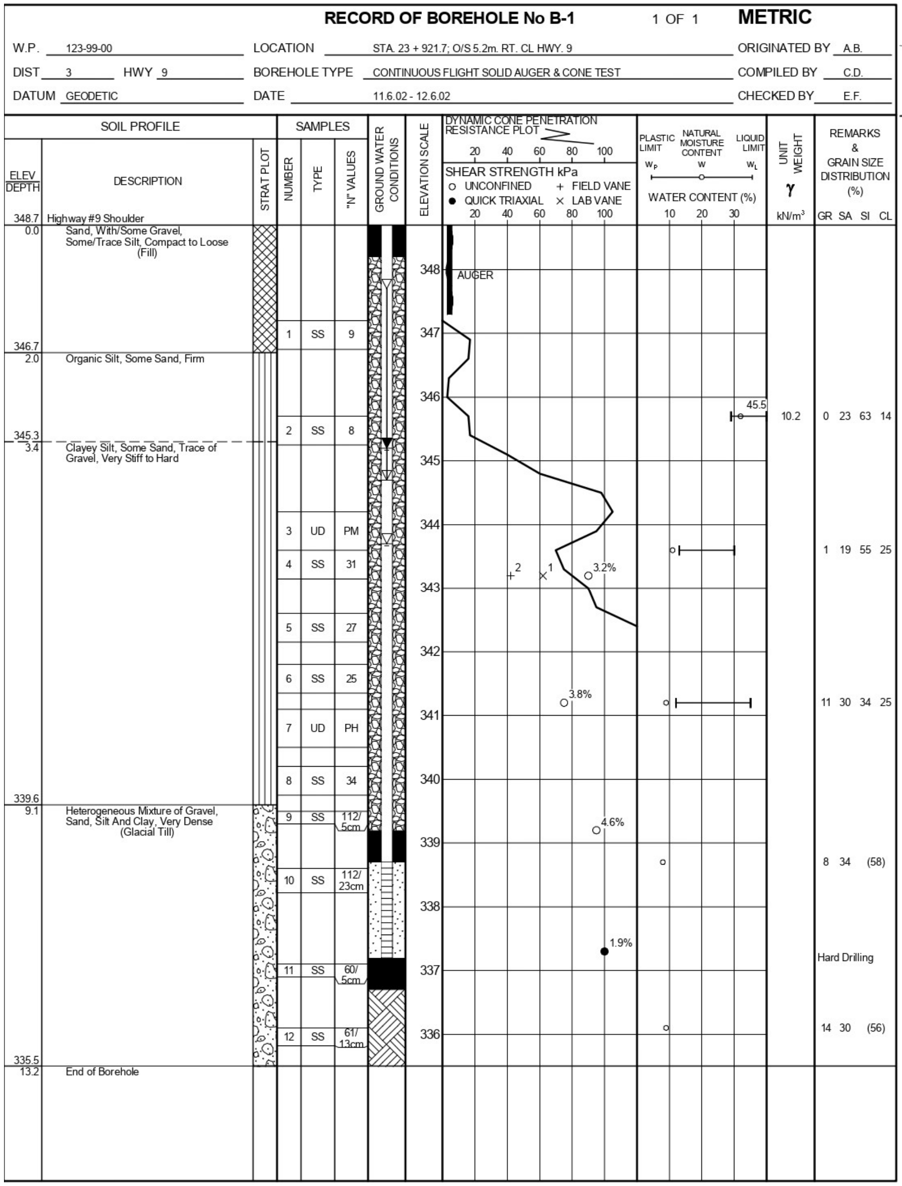
Importance of Historic Geotechnical Data for Prediction of Site Characteristics Using Machine Learning

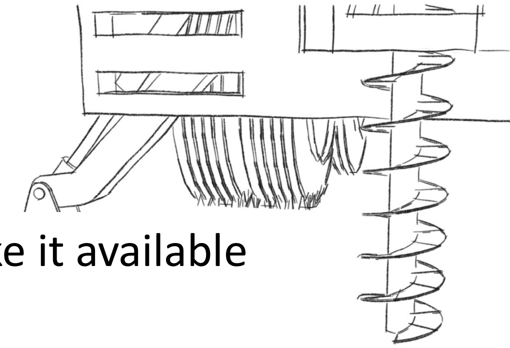
Houda Jadi, Ph.D., P.Eng

Importance of Historic and Open Data For Geotechnical Innovation

- Public transportation agencies spend millions of dollars performing geotechnical testing for projects each year.
- The results of these tests are generally stored in paper logs, pdfs, and/or single stand-alone digital files.
- These datasets are often:
  - Not GIS enabled
  - Not easily extractable or searchable
  - Onerous to use and to readily visualize

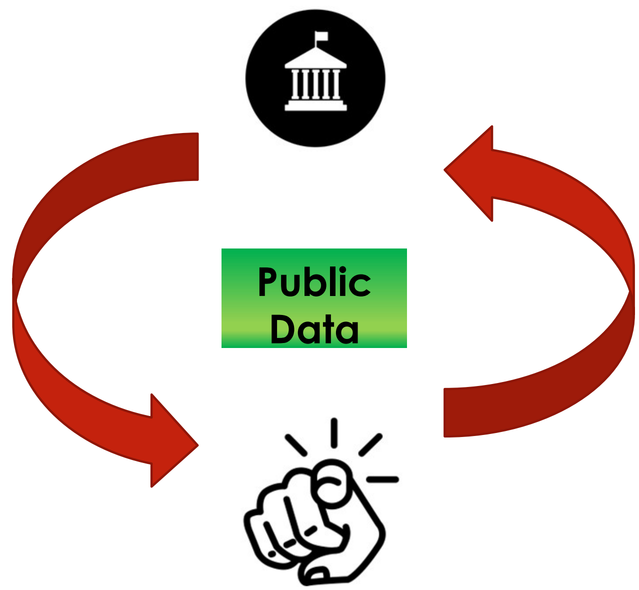


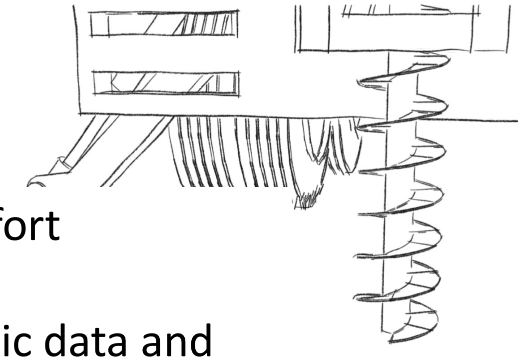
What Can We Do Better?



- We can share historic geotechnical data collected by various groups and make it available to others

- We can extract valuable information for use with new technology, such as advanced visualization tools and machine learning to generate predictive subsurface models beyond the immediate location of exploration.





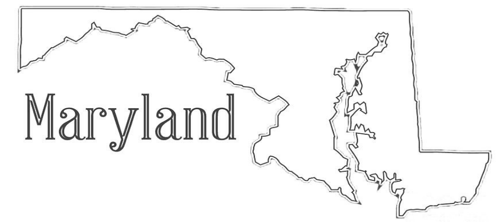
What Can We Do Better?

- There are a number of companies and products working to assist in this effort
- Look for opportunities that allow you to efficiently find and use your historic data and that of others.

Never start a new geotechnical project from scratch!

Use historic data and open resources

The Maryland DOT Experience



- Maryland DOT built a program to utilize historic data, creating a GIS subsurface data platform with a machine learning backend.

- This project resulted in an estimated MDOT SHA cost savings of nearly $1M per year.

- The project won multiple awards and was recognized as an AASHTO Research Advisory Committee “Sweet Sixteen” High-Value Research Project in 2018.

[Link to Machine Learning Report](https://roads.maryland.gov/OPR_Research/MD-21-SHAUM5-23_Machine-Learning_Report.pdf)

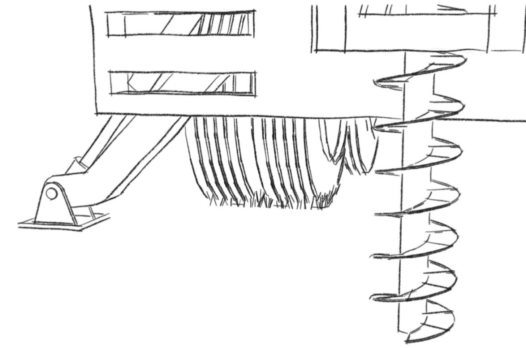
https://roads.maryland.gov/OPR_Research/MD-21-SHAUM5-23_Machine-Learning_Report.pdf

[Link to Subsurface Data platform Report](https://www.roads.maryland.gov/OPR_Research/2018_GIS-BasedBoringRequests_Published.pdf)

https://www.roads.maryland.gov/OPR_Research/2018_GIS-BasedBoringRequests_Published.pdf

System Component	Average Time taken -before-	Average Time taken -after-	Cost Savings per project ($70/hr)	Average # of projects	Cost Savings per year
Electronic Data Requests	8 hours to prepare; 8 hours to enter lab data	4 hours to prepare; 0 hours to enter lab data	$840	200	$168,000
Remote field data capture	16 hours to convert paper data to digital	0 hours to convert paper data to digital	$1,120	200	$224,000
Automated Project Tracking	24 hours a week updating and tracking projects	0 hours	$1,680 per week (by 52 weeks)		$87,360
Historic Boring Data	Conservatively estimate: eliminate 2 borings on each project with easily-retrievable historic data. Assume a cost of $1,200 per boring, the component saves $2,400 per project.			200	$480,000
TOTAL					**$959,360**

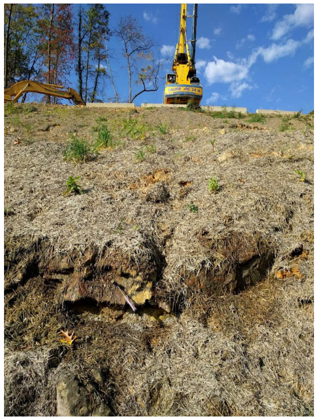
Prediction of Site Characterization Using Machine Learning



DATA SOURCES

Auger Boring

Standard Penetration Testing



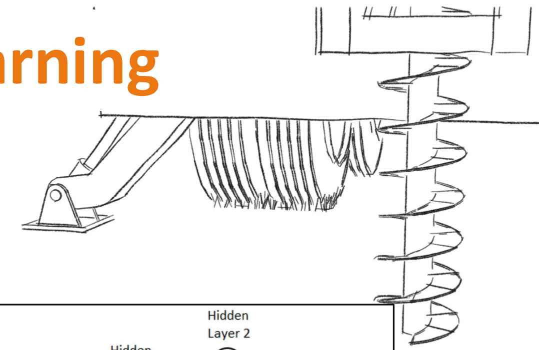
Foundation Installation

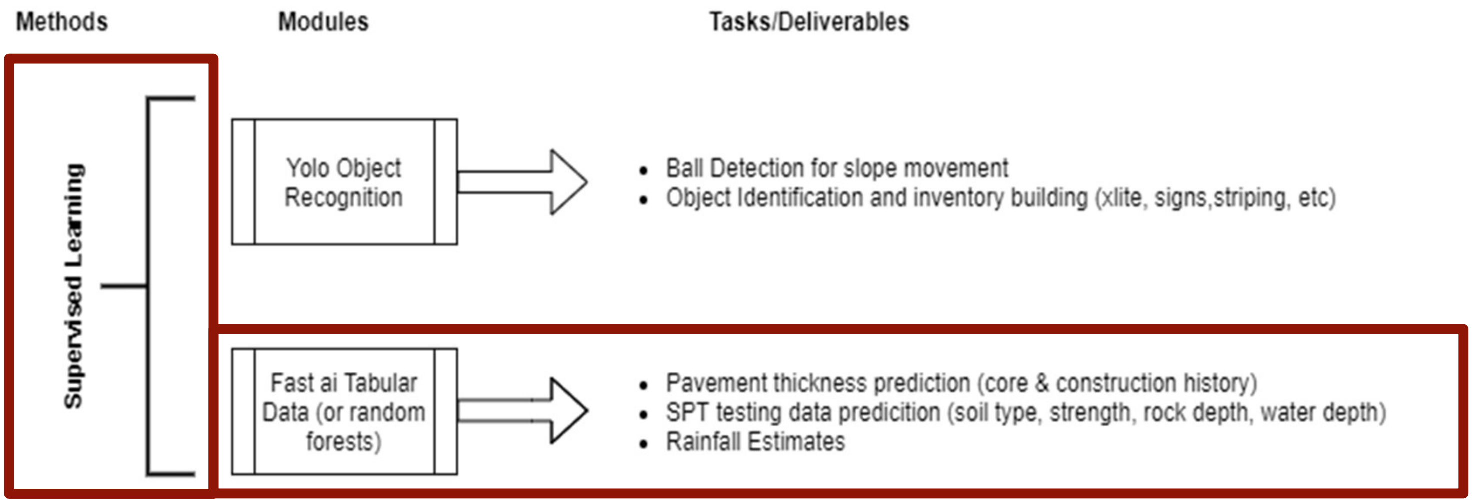
=

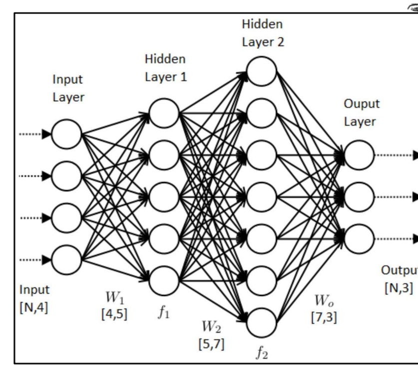
DATA EXAMPLES

- Soil Strength
- Groundwater Level
- Depth to Rock
- Soil Classification
- Rock Classification
- Rock Quality

Prediction of Site Characterization Using Machine Learning







Neural Net Based

Supervised Learning

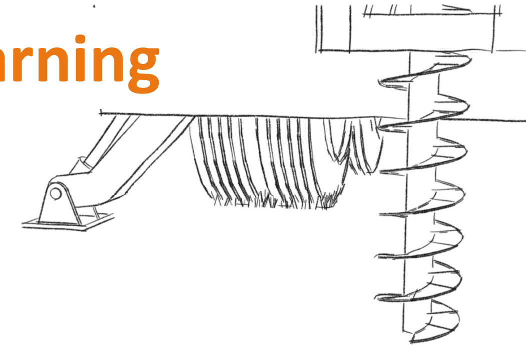
Pros:

- After training you can immediately quantify the accuracy
- Model is ready to go right after training
- You can turn discrete data sets into continuous data

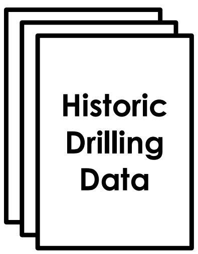
Cons:

- Requires very large training sets (transfer learning can help for specific data sets))
- Most of the development time is spent finding and cleaning historic data
- Requires retraining on a routine basis resulting in static models between training sessions

Prediction of Site Characterization Using Machine Learning

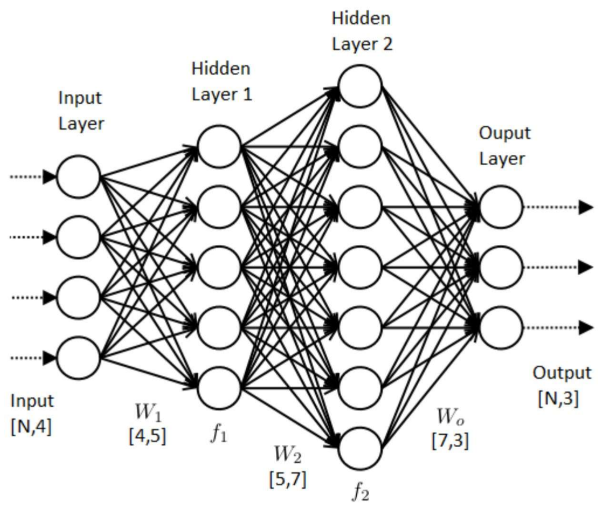


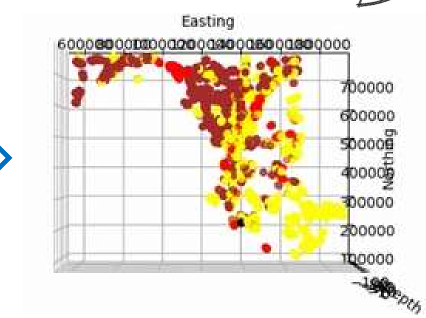
Training Neural Networks



Variables

- Northing
- Easting
- Elevation
- SPT N
- Infiltration
- Grainsize





<u>1. Collect Historic Drilling</u>

<u>2. Extract meaningful variables</u>

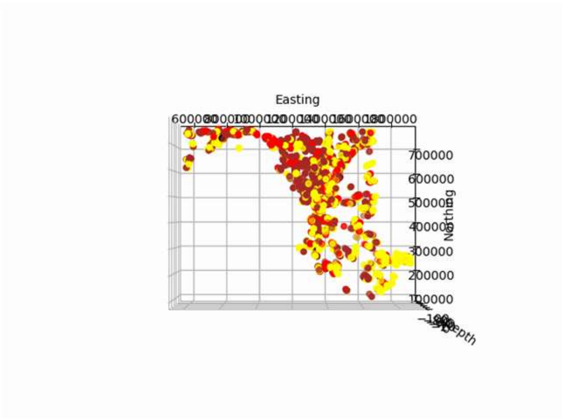
<u>3. Process variables through a Neural Network*</u>

<u>4. Build tools that utilize the calculated Numerical Model(s)</u>

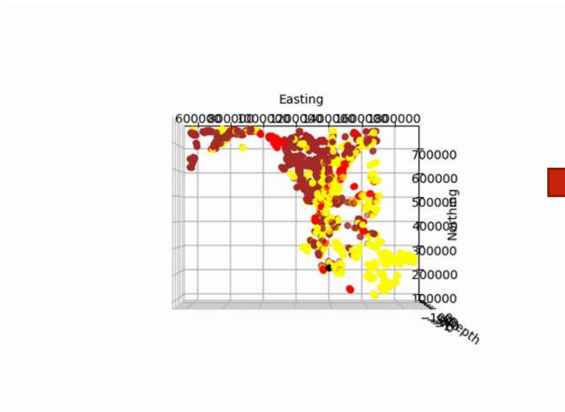
** Step 3 is a recursive process where the network geometry is optimized/derived for the dataset.*

Prediction of Site Characterization Using Machine Learning

Actual data

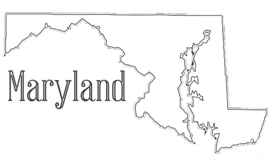


Model data

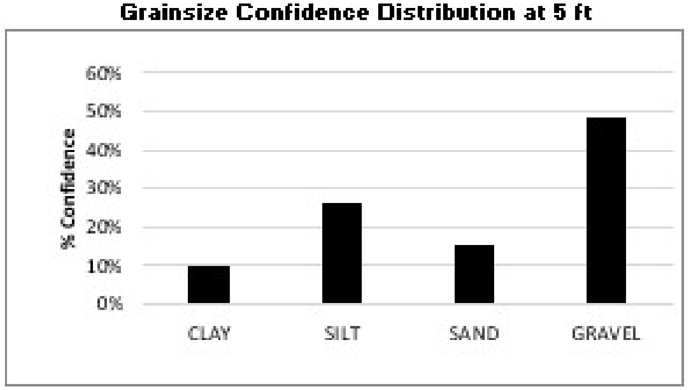


Grainsize

- Clay
- SAND
- SILT
- GRAVEL



Grainsize Confidence Distribution at 5 ft



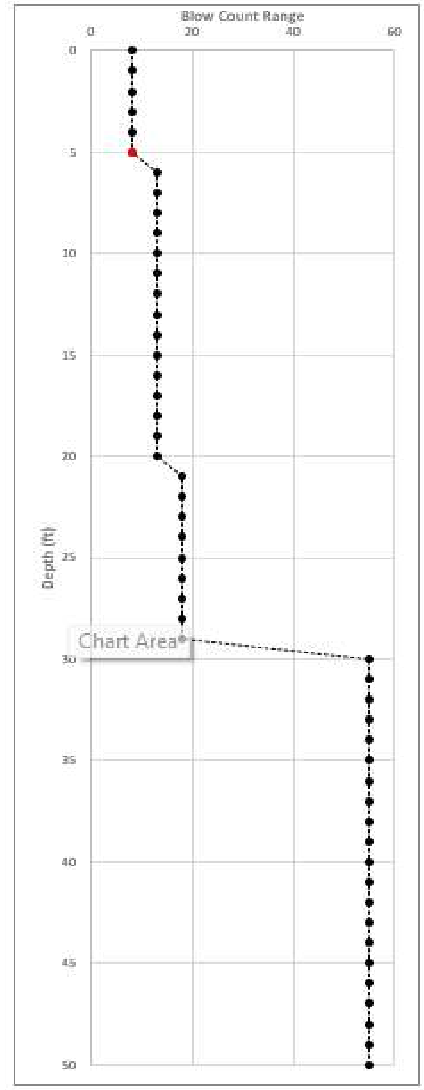
Change Depths Here

Select Depth 5

Rock Depth* Range (ft) 11-20

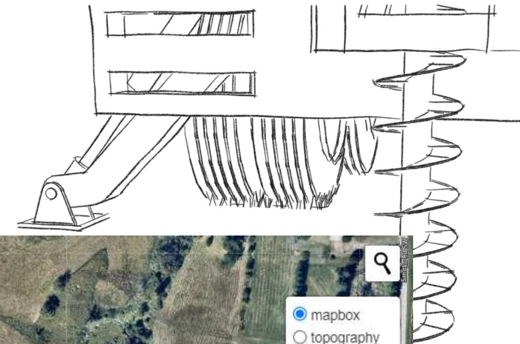
Depth (ft)	Elevation (ft)	Grainsize	N Range
0	1017	GRAVEL	6-10
1	1016	GRAVEL	6-10
2	1015	GRAVEL	6-10
3	1014	GRAVEL	6-10
4	1013	GRAVEL	6-10
5	1012	GRAVEL	6-10
6	1011	GRAVEL	11-15
7	1010	GRAVEL	11-15
8	1009	GRAVEL	11-15
9	1008	GRAVEL	11-15
10	1007	GRAVEL	11-15
11	1006	GRAVEL	11-15
12	1005	GRAVEL	11-15
13	1004	GRAVEL	11-15
14	1003	GRAVEL	11-15
15	1002	GRAVEL	11-15
16	1001	GRAVEL	11-15
17	1000	GRAVEL	11-15
18	999	GRAVEL	11-15
19	998	GRAVEL	11-15
20	997	GRAVEL	11-15
21	996	GRAVEL	16-20
22	995	GRAVEL	16-20
23	994	GRAVEL	16-20
24	993	GRAVEL	16-20
25	992	GRAVEL	16-20
26	991	GRAVEL	16-20
27	990	GRAVEL	16-20
28	989	GRAVEL	16-20
29	988	GRAVEL	16-20
30	987	Refusal	50+
31	986	Refusal	50+
32	985	Refusal	50+
33	984	Refusal	50+
34	983	Refusal	50+
35	982	Refusal	50+
36	981	Refusal	50+
37	980	Refusal	50+
38	979	Refusal	50+
39	978	Refusal	50+
40	977	Refusal	50+
41	976	Refusal	50+
42	975	Refusal	50+
43	974	Refusal	50+
44	973	Refusal	50+
45	972	Refusal	50+
46	971	Refusal	50+
47	970	Refusal	50+
48	969	Refusal	50+
49	968	Refusal	50+
50	967	Refusal	50+

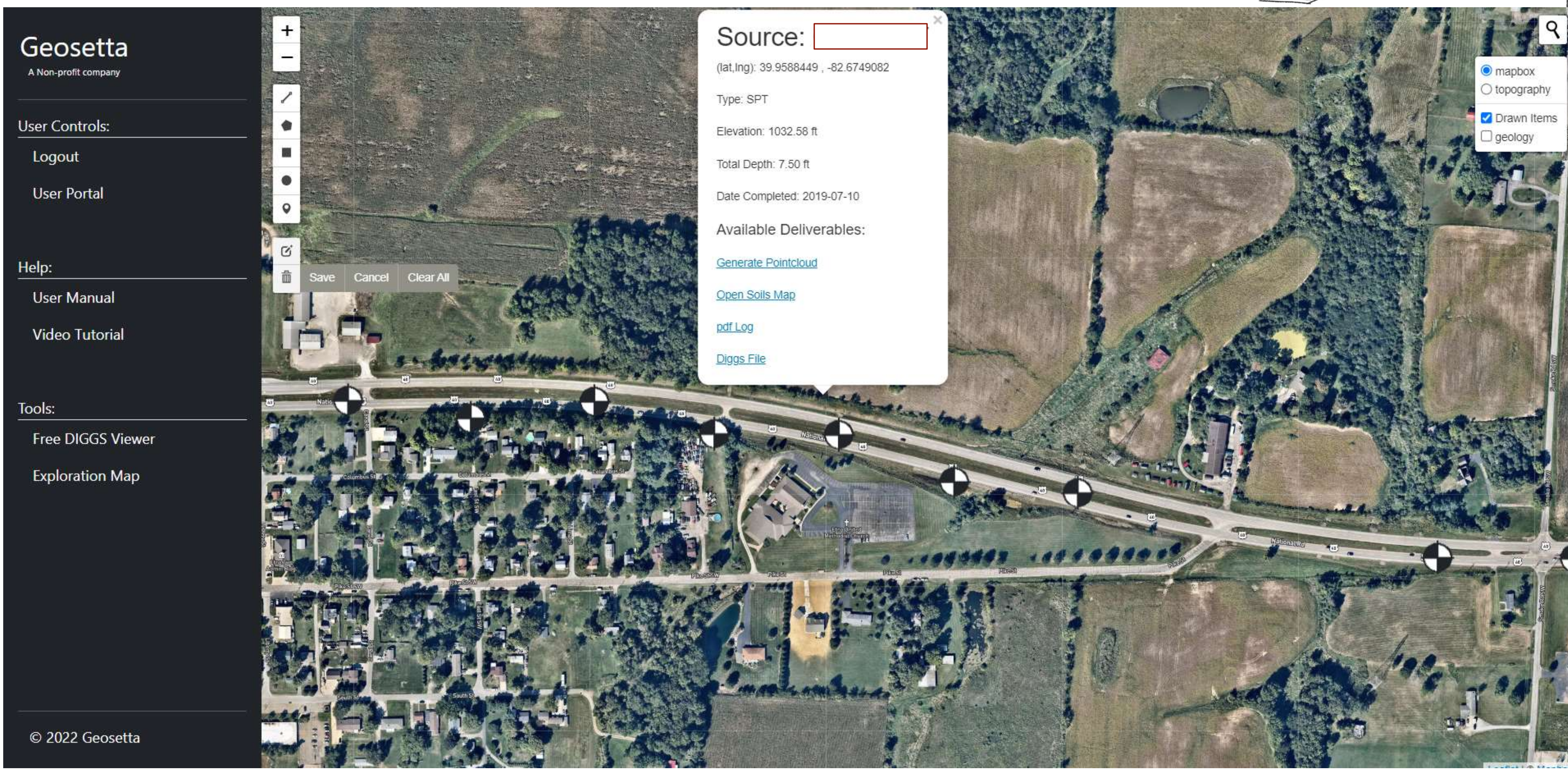
Predicted SPT Blow Count Log



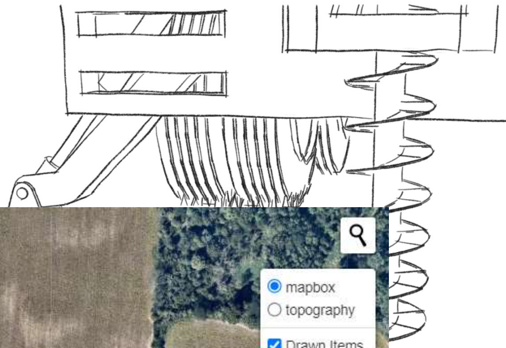
Example Machine Learning Application

Accessing Historic Data Points

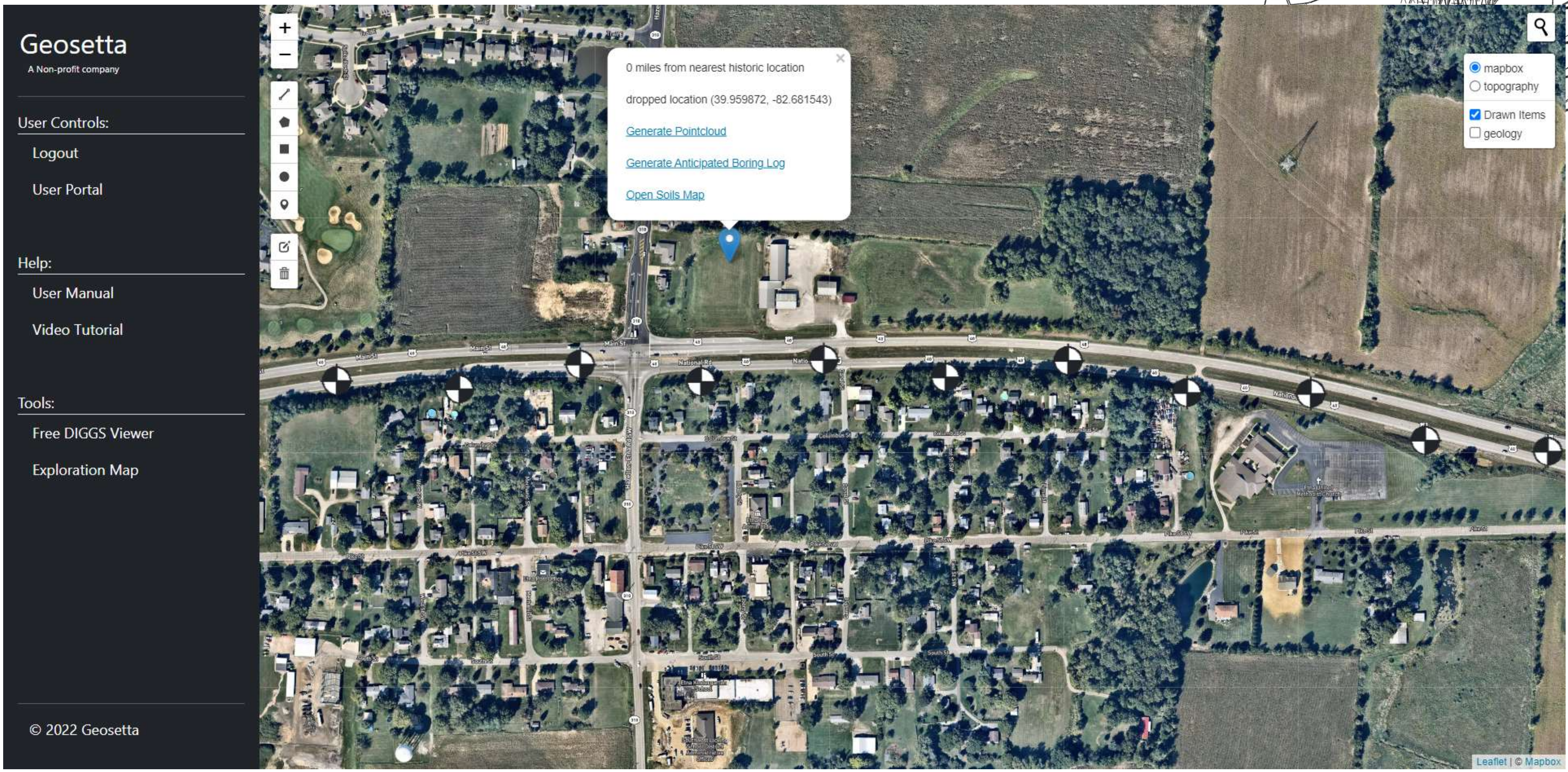




Example Machine Learning Application

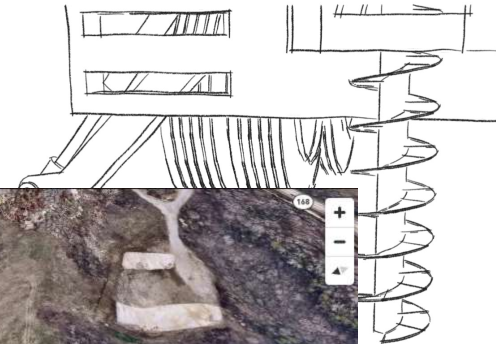


User-Selected Points to Obtain Anticipated Data

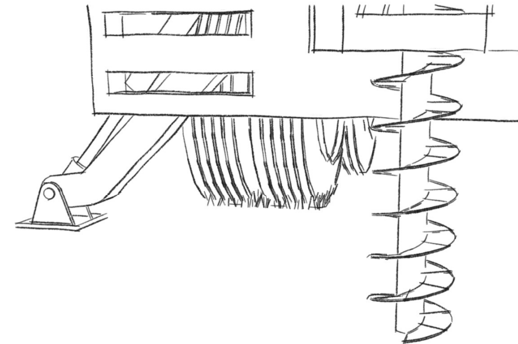


Example Machine Learning Application

Soil Profile with Predicted Rock Surface Depths

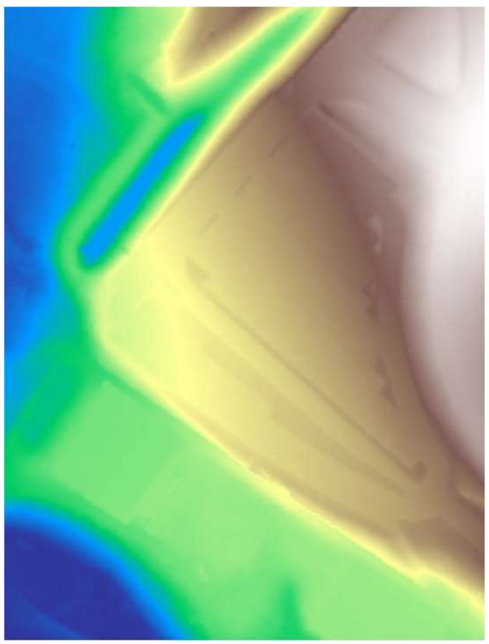


Example Visualization Features

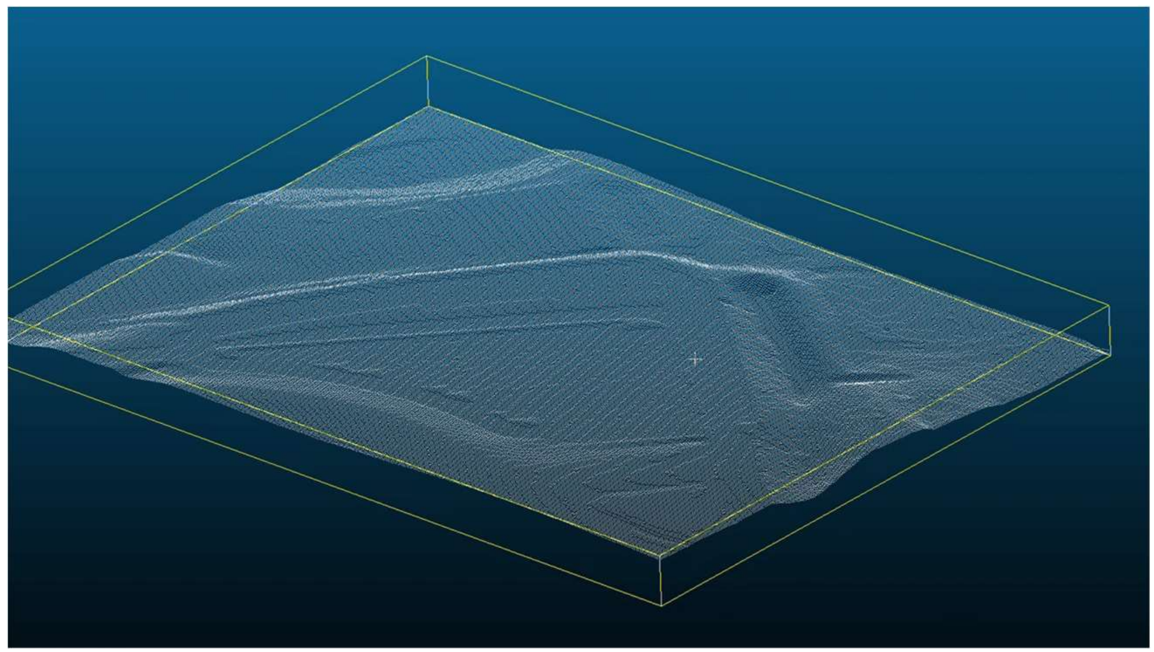


- Automatically generate point clouds from State DEM data and Satellite Imagery that include machine learning based predictions

xyz (DEM)

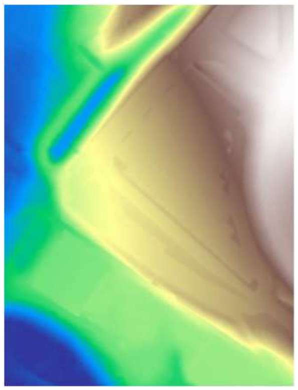


xyrgb (satellite Imagery)

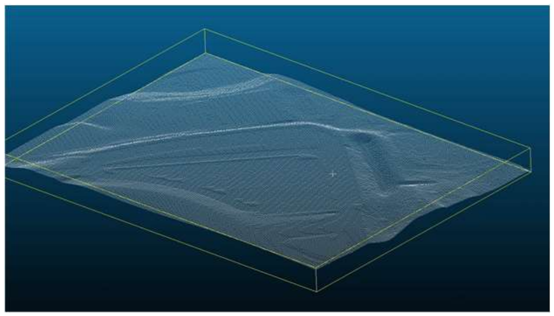


Example Visualization Features

xyz (DEM)

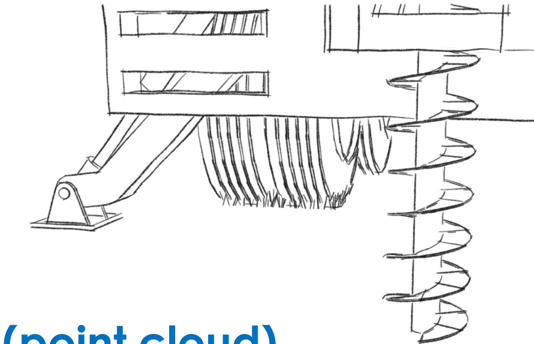


xyz (point cloud)

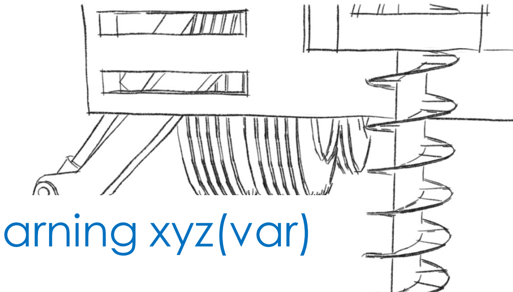


xyrgb (satellite Imagery)

xyzrgb (point cloud)

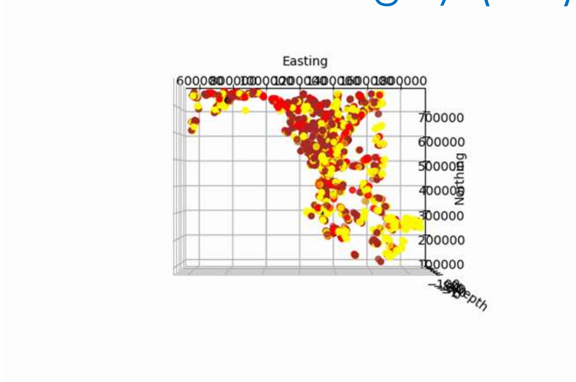


Example Visualization Features



xyzrgb (point cloud)

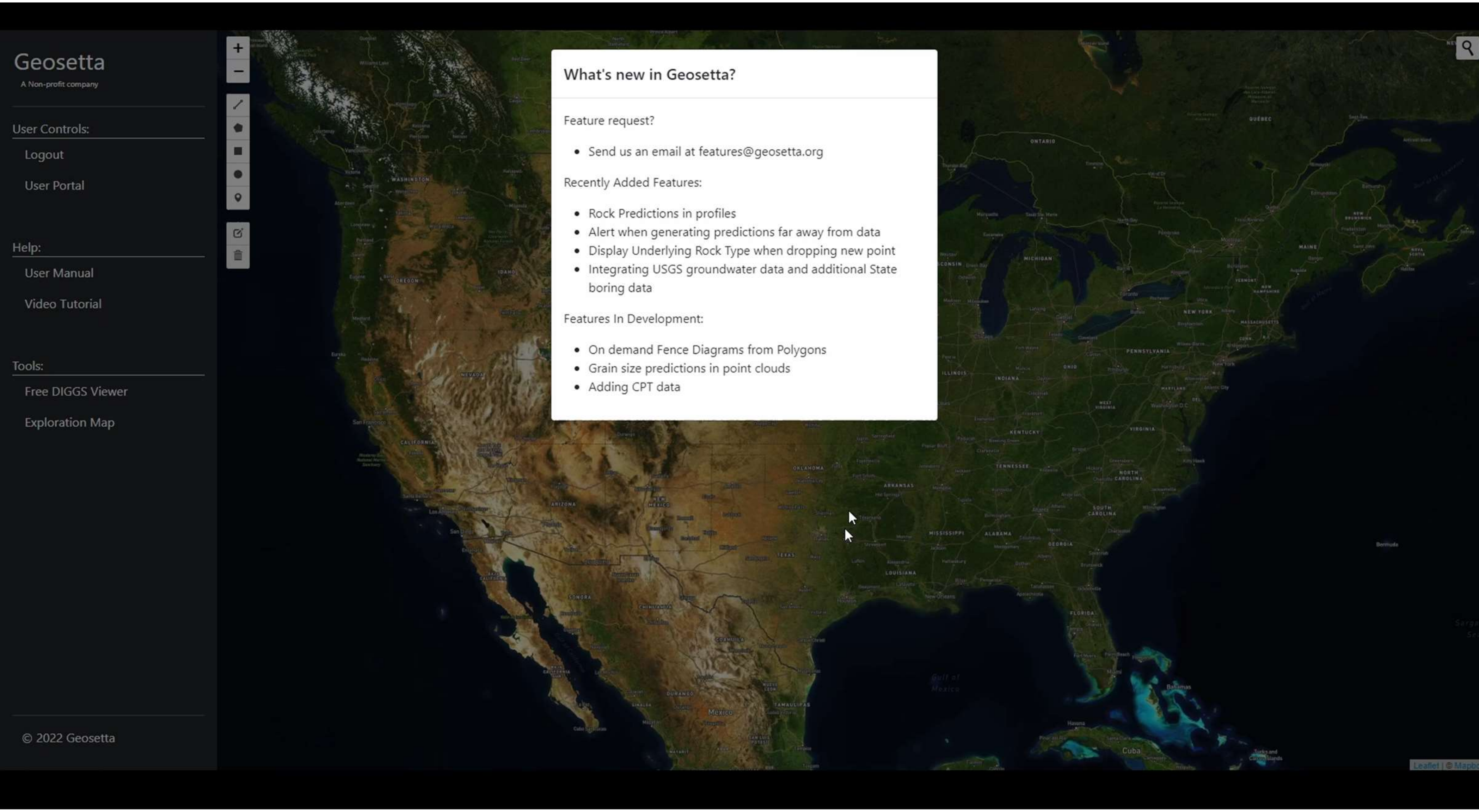
Machine Learning xyz(var)

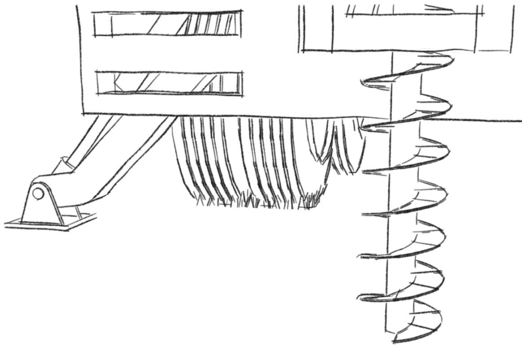


Xyzrgb+Machine Learning xyz(var)

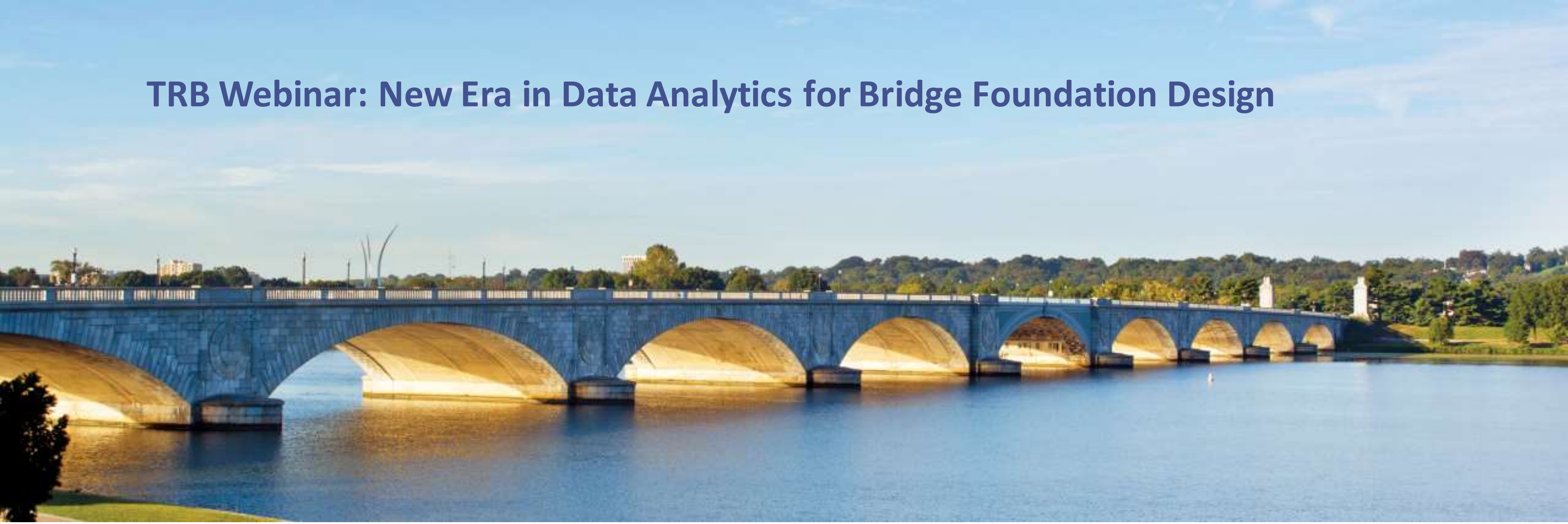
Depth to Refusal

Blow Counts Low to High


Geosetta
A Non-profit company
User Controls:
Logout
User Portal
Help:
User Manual
Video Tutorial
Tools:
Free DIGGS Viewer
Exploration Map
© 2022 Geosetta
What's new in Geosetta?
Feature request?
Send us an email at features@geosetta.org
Recently Added Features:
Rock Predictions in profiles
Alert when generating predictions far away from data
Display Underlying Rock Type when dropping new point
Integrating USGS groundwater data and additional State boring data
Features In Development:
On demand Fence Diagrams from Polygons
Grain size predictions in point clouds
Adding CPT data



Thank you!



Lifetime of Geotechnical Data in Bridge Projects

Allen Cadden, PE D.GE
acadden@schnabel-eng.com

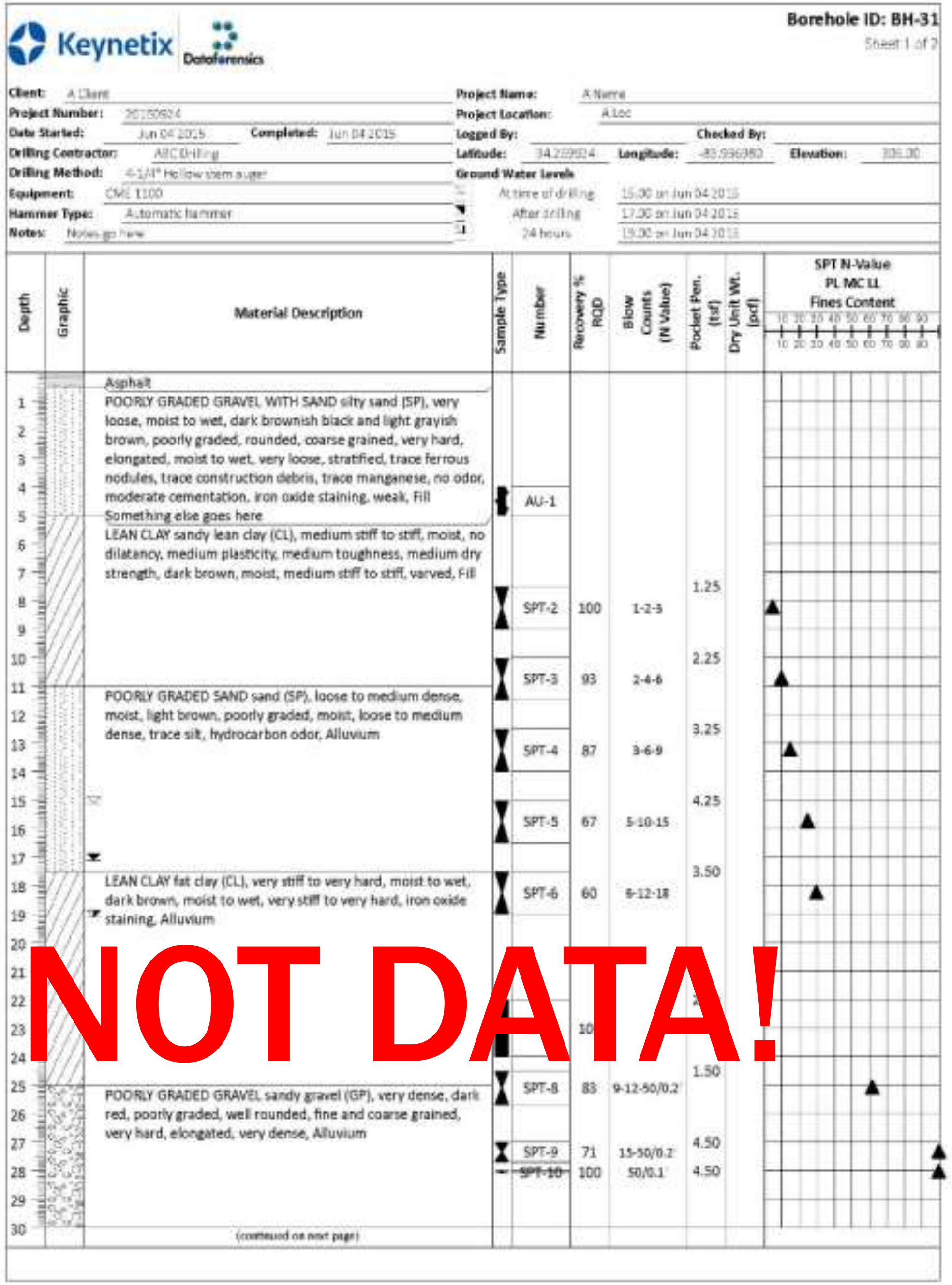
3 Rules of Data

- Capture it at the source.
- Only enter it once. (Never touch the data again)
- Get someone else to do it.

Single Source of Truth (Data Storage)


Where are we now?
NOT DATA!

PDF borehole log



Keynetix | Datoforensics

Borehole ID: BH-31
Sheet 1 of 2

Client: A Client
Project Number: 20150924
Date Started: Jun 04 2015 Completed: Jun 04 2015
Drilling Contractor: ABC Drilling
Drilling Method: 4-1/4" Hollow stem auger
Equipment: CME 1100
Hammer Type: Automatic hammer
Notes: Notes go here

Project Name: A Name
Project Location: A Loc
Logged By: Checked By:
Latitude: 34.239924 Longitude: -83.936980 Elevation: 306.00
Ground Water Levels
At time of drilling 15.00 on Jun 04 2015
After drilling 17.00 on Jun 04 2015
24 hours 19.00 on Jun 04 2015

Depth | Graphic | Material Description | Sample Type | Number | Recovery % RQD | Blow Counts (N Value) | Pocket Pen. (tsf) | Dry Unit Wt. (pcf) | SPT N-Value PL MC LL Fines Content

Asphalt

POORLY GRADED GRAVEL WITH SAND silty sand (SP), very loose, moist to wet, dark brownish black and light grayish brown, poorly graded, rounded, coarse grained, very hard, elongated, moist to wet, very loose, stratified, trace ferrous nodules, trace construction debris, trace manganese, no odor, moderate cementation, iron oxide staining, weak, Fill

Something else goes here

LEAN CLAY sandy lean clay (CL), medium stiff to stiff, moist, no dilatancy, medium plasticity, medium toughness, medium dry strength, dark brown, moist, medium stiff to stiff, varved, Fill

POORLY GRADED SAND sand (SP), loose to medium dense, moist, light brown, poorly graded, moist, loose to medium dense, trace silt, hydrocarbon odor, Alluvium

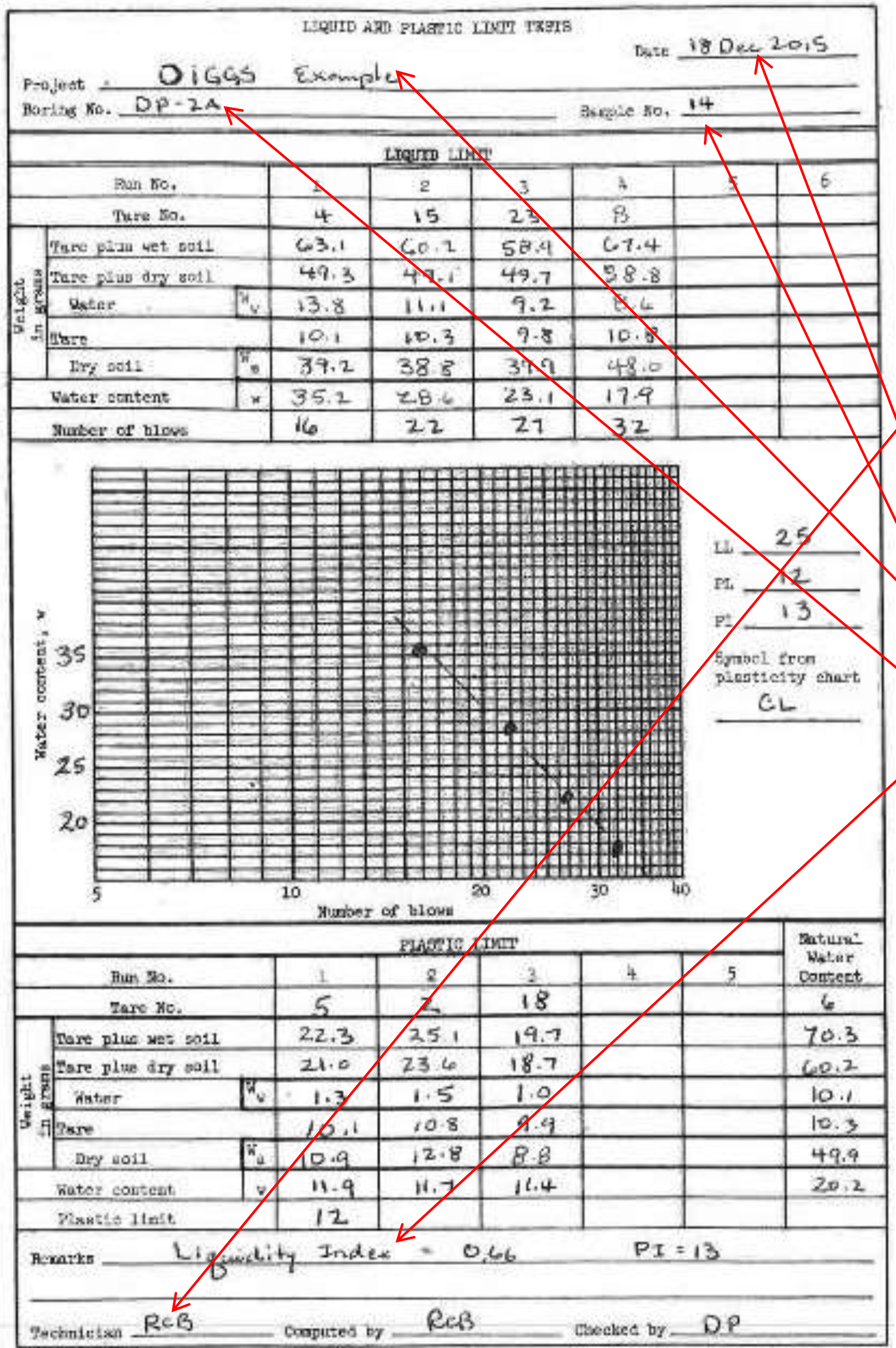
LEAN CLAY fat clay (CL), very stiff to very hard, moist to wet, dark brown, moist to wet, very stiff to very hard, iron oxide staining, Alluvium

POORLY GRADED GRAVEL sandy gravel (GP), very dense, dark red, poorly graded, well rounded, fine and coarse grained, very hard, elongated, very dense, Alluvium

Number	Recovery % RQD	Blow Counts (N Value)	Pocket Pen. (tsf)
AU-1			
SPT-2	100	1-2-3	1.25
SPT-3	93	2-4-6	2.25
SPT-4	87	3-6-9	3.25
SPT-5	67	5-10-15	4.25
SPT-6	60	6-12-18	3.50
SPT-8	83	9-12-50/0.2'	1.50
SPT-9	71	15-50/0.2'	4.50
SPT-10	100	50/0.1'	4.50

(continued on next page)

NOT DATA!



LIQUID AND PLASTIC LIMIT TESTS

Date 18 Dec 2015

Project DIGGS Example

Boring No. DP-2A   Sample No. 14

LIQUID LIMIT

Run No.	1	2	3	4	5	6
Tare No.	4	15	23	8		
Tare plus wet soil	63.1	60.2	58.9	67.4		
Tare plus dry soil	49.3	49.1	49.7	58.8		
Water W_w	13.8	11.1	9.2	8.6		
Tare	10.1	10.3	9.8	10.8		
Dry soil W_s	39.2	38.8	39.9	48.0		
Water content w	35.2	28.6	23.1	17.9		
Number of blows	16	22	27	32		

(Weight in grams)

LL 25

PL 12

PI 13

Symbol from plasticity chart CL

PLASTIC LIMIT

Run No.	1	2	3	4	5	Natural Water Content
Tare No.	5	2	18			6
Tare plus wet soil	22.3	25.1	19.7			70.3
Tare plus dry soil	21.0	23.6	18.7			60.2
Water W_w	1.3	1.5	1.0			10.1
Tare	10.1	10.8	9.9			10.3
Dry soil W_s	10.9	12.8	8.8			49.9
Water content w	11.9	11.7	11.4			20.2
Plastic limit	12					

(Weight in grams)

Remarks Liquidity Index = 0,66   PI = 13

Technician RcB   Computed by RcB   Checked by DP

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<gml:name>Atterberg Limits Test</gml:name>
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<Role>
<rolePerformed>Technician</rolePerformed>
<businessAssociate>RCB</businessAssociate>
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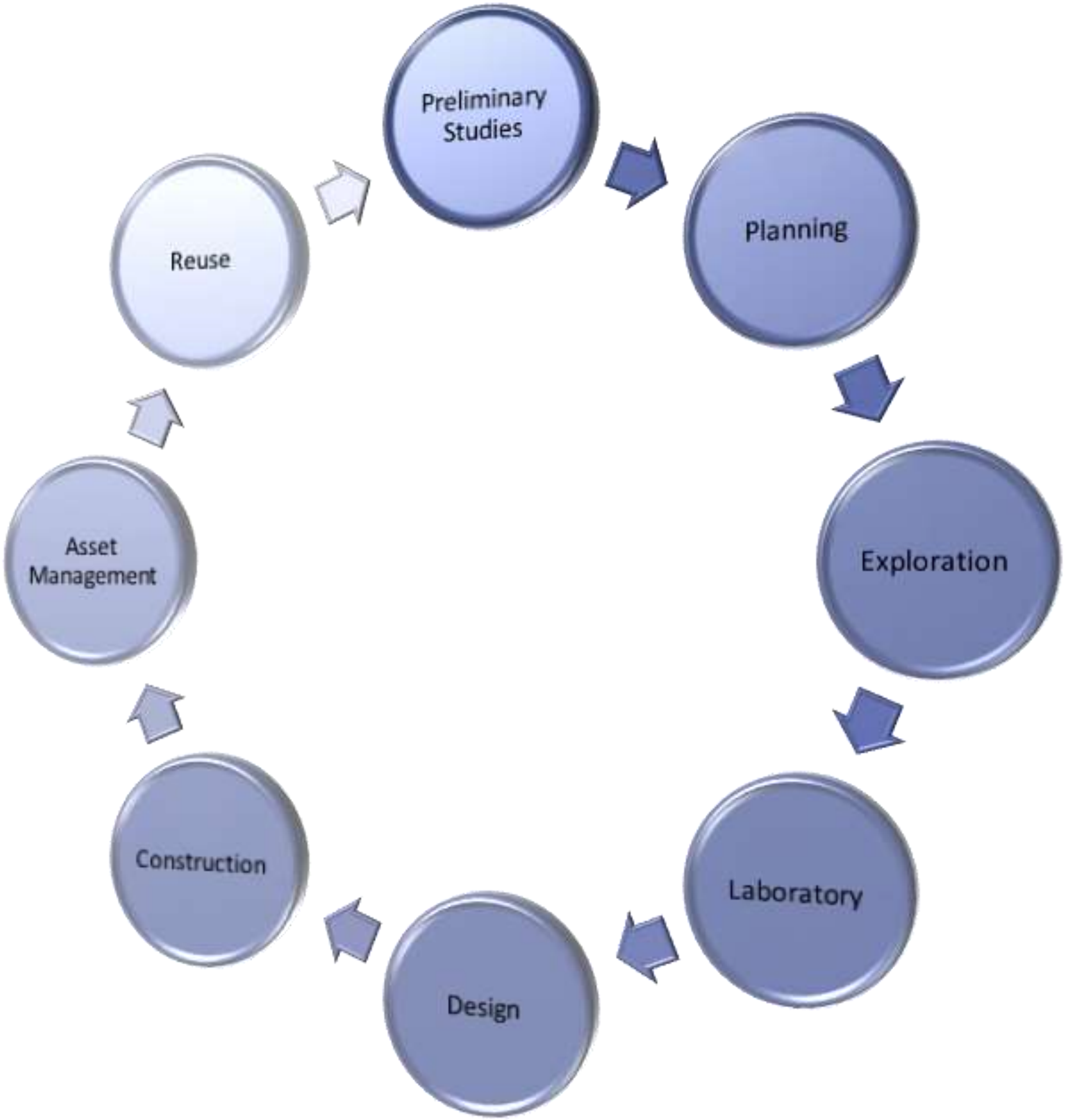
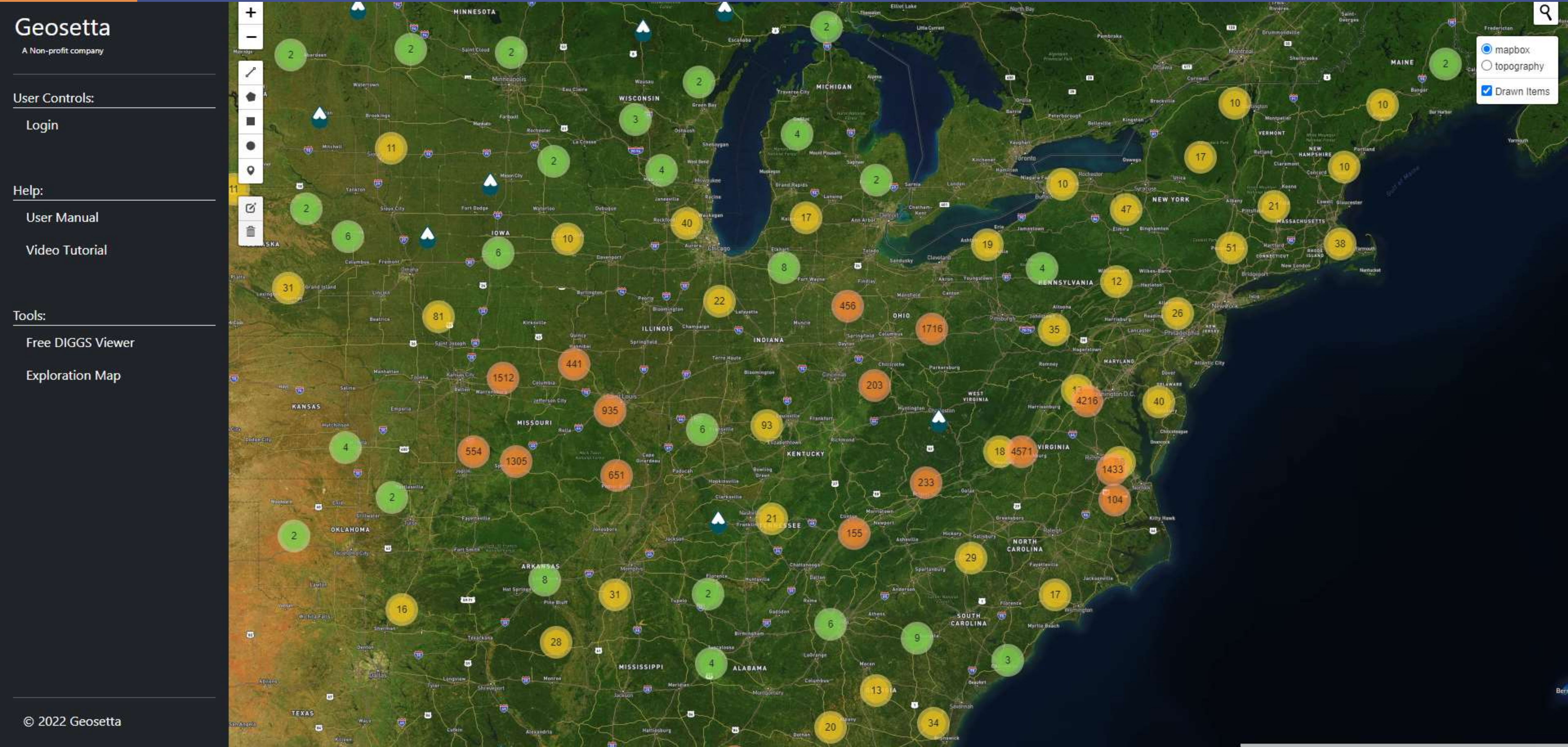
</TimeInterval>
</resultTime>
<outcome>

The Life Cycle of A Bridge



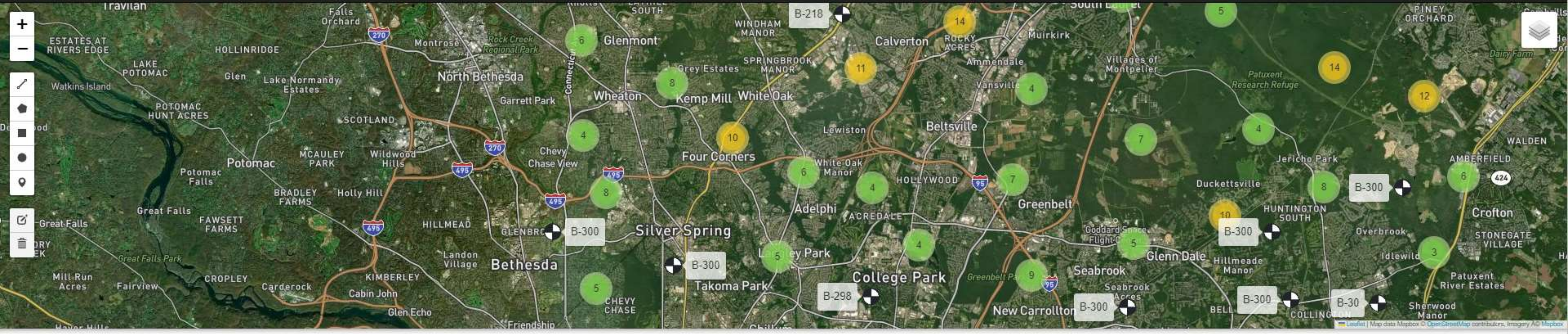
Preliminary Studies – Start with Available Data



Planning for Data Collection

Planning Dashboard Zoom To Data | Charts | Split View | Log Out

GEO MORTAR



Filter Data | Export Data | 190 visible features | Search

Action	Boring Ident	Elevation (ft)	Structure	Total Boring Depth (ft)	Rock Boring Depth (ft)	infiltration check	Traffic Control Check	Private Property Check	Date Released for Survey	Date Staked	Date U
	B-94										
	B-91										
	B-90										
	B-84										
	B-76										
	B-73										
	B-66										
	B-65										
	B-61										

Field Data Capture

- Digital data collection
- Reduce transcription errors
- Automatic quality checks of the data entered
- Near real time review
- No more rain soaked forms

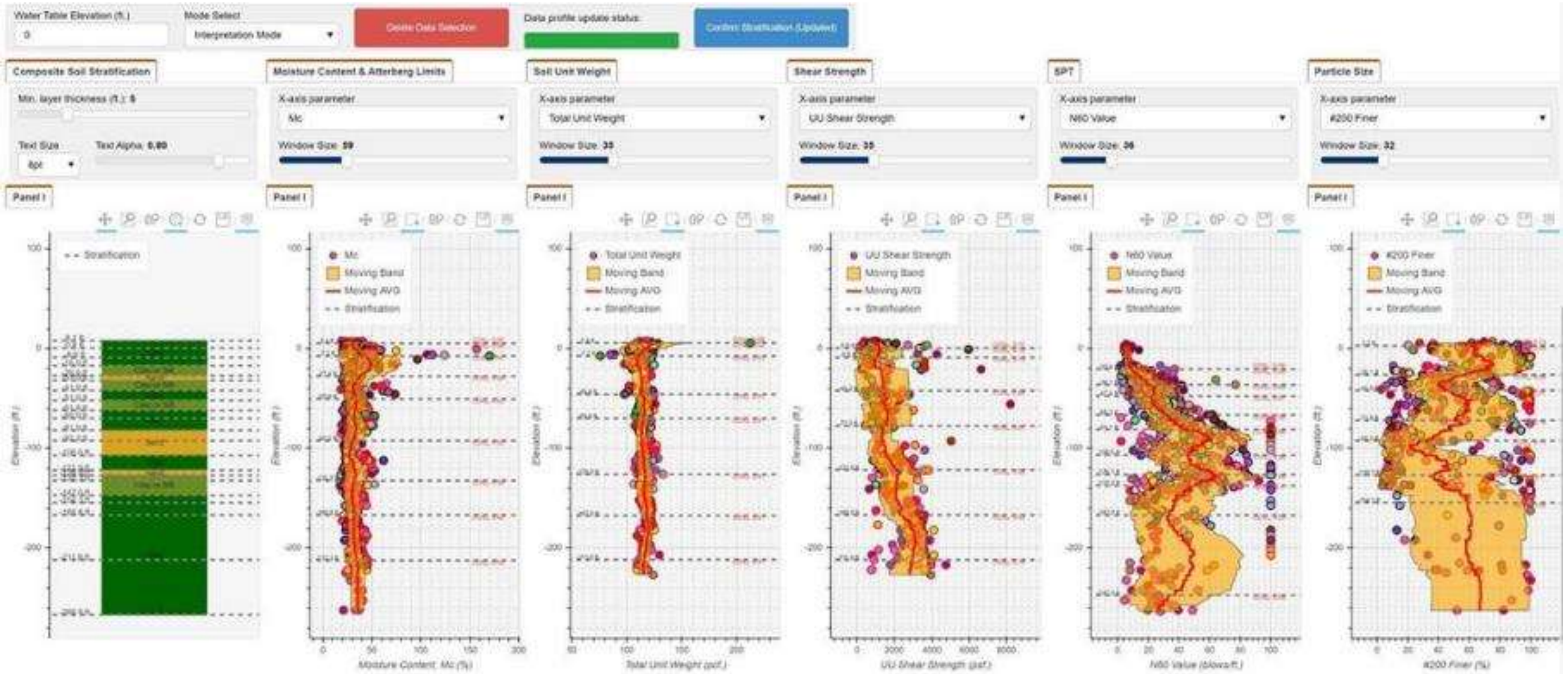
Integrating Laboratory Data

Digital capture is spreading in laboratories

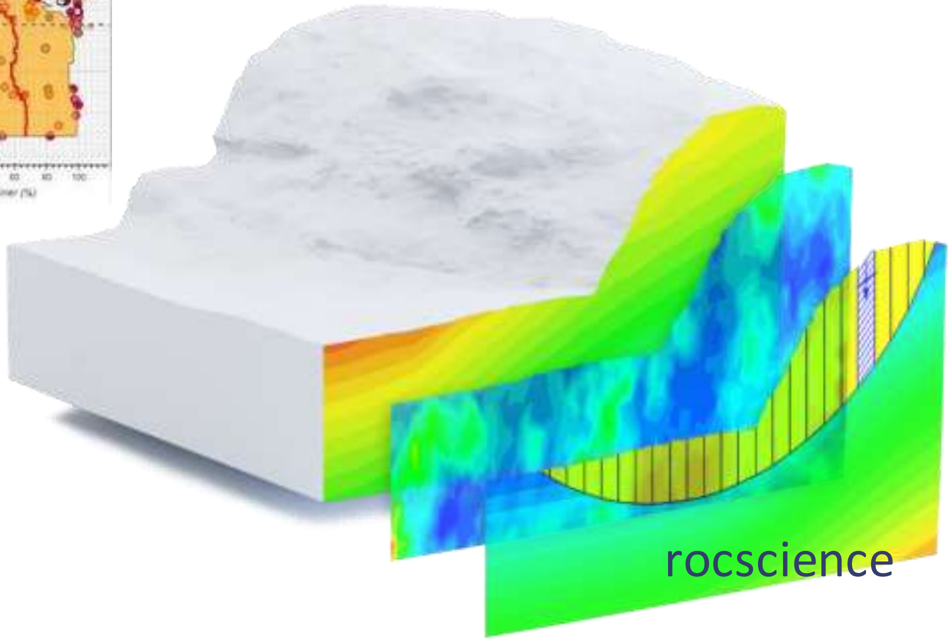
Many still use spreadsheets and misc. forms to collect the data and do basic calculations and plotting

Transferring that data to the project record is critical

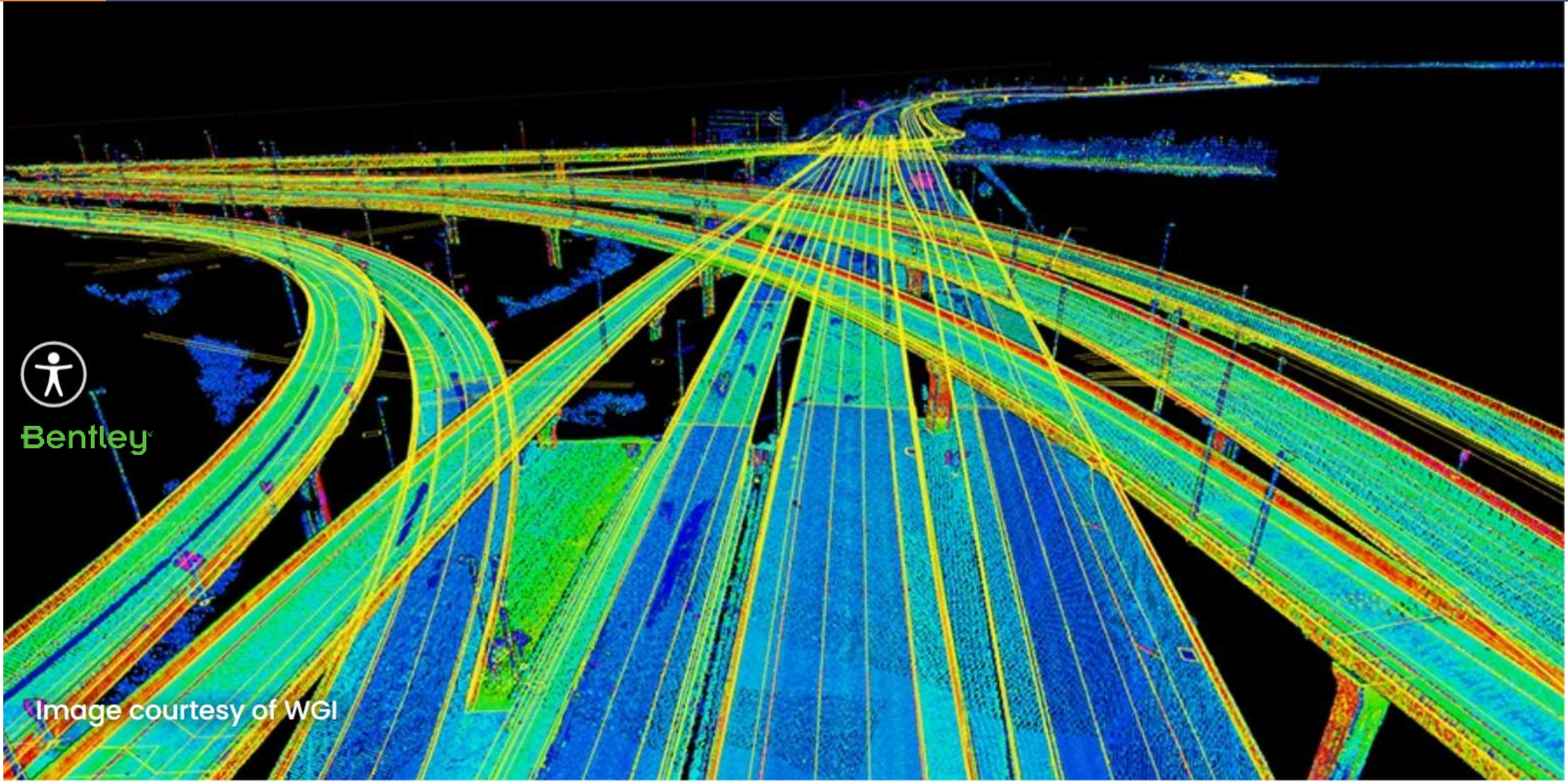
Connection with Analysis Tools



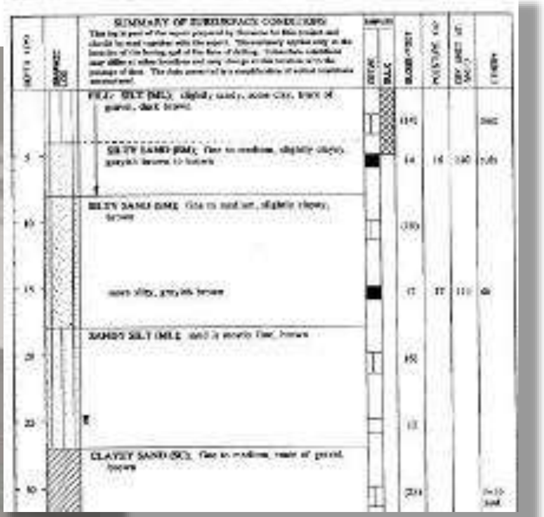
Xin Peng, Ardaman and Jesse Rauser, LADOT

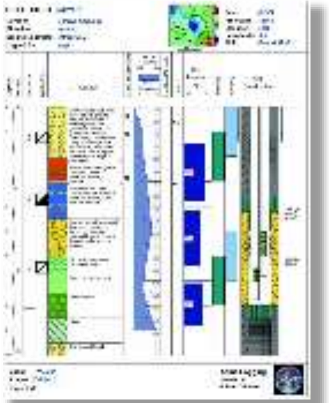


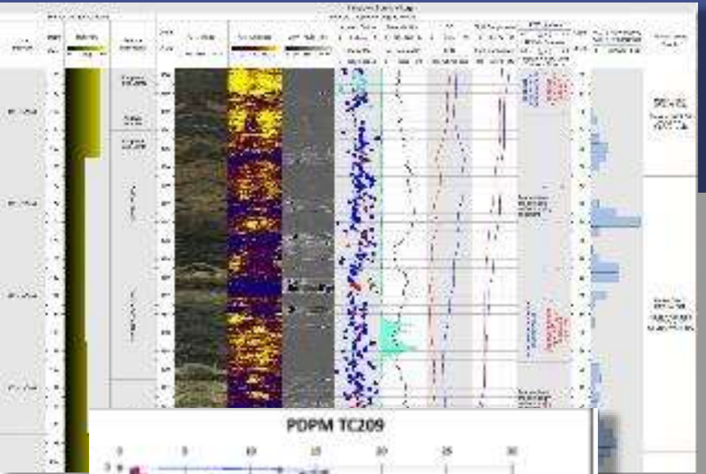
Development of BIM Model

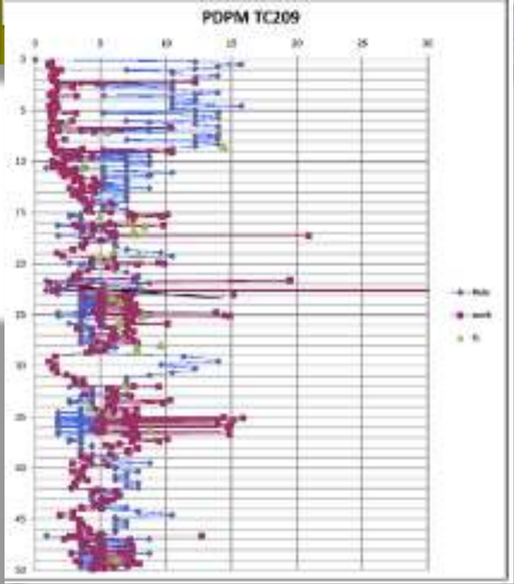


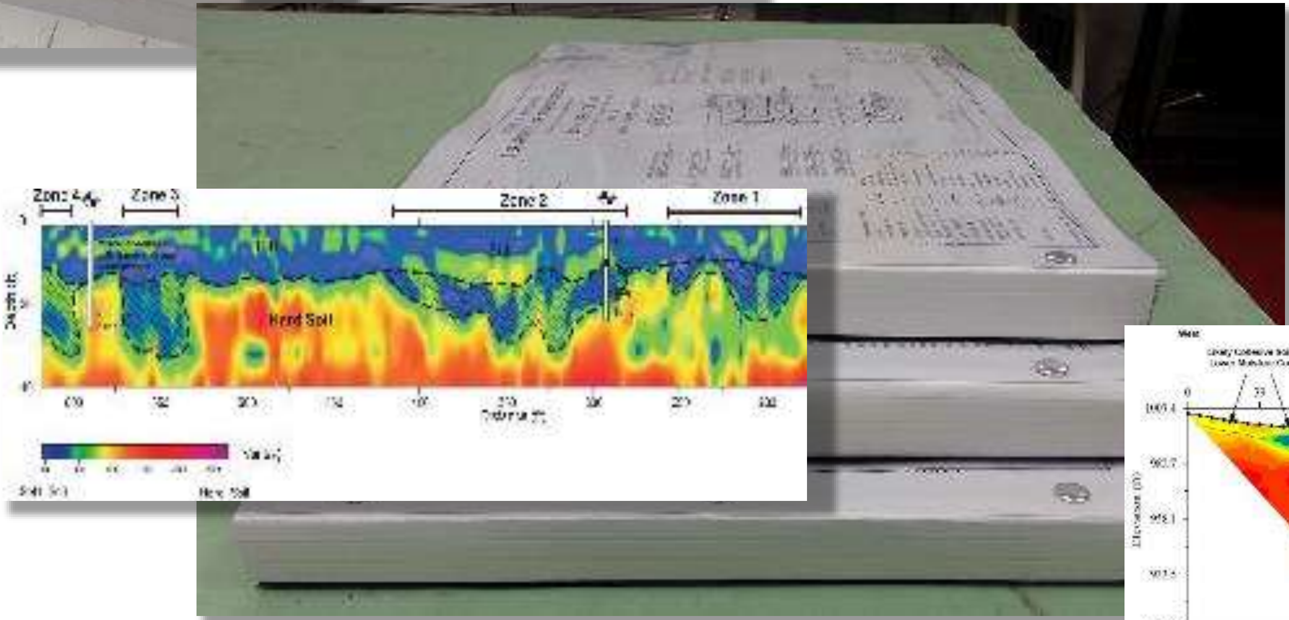
Sharing “Data” with Contractors

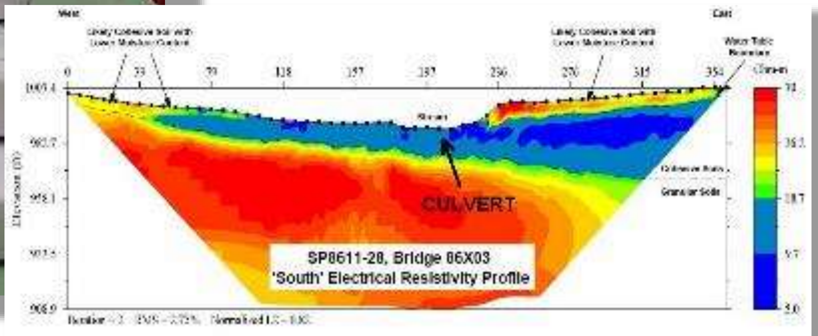






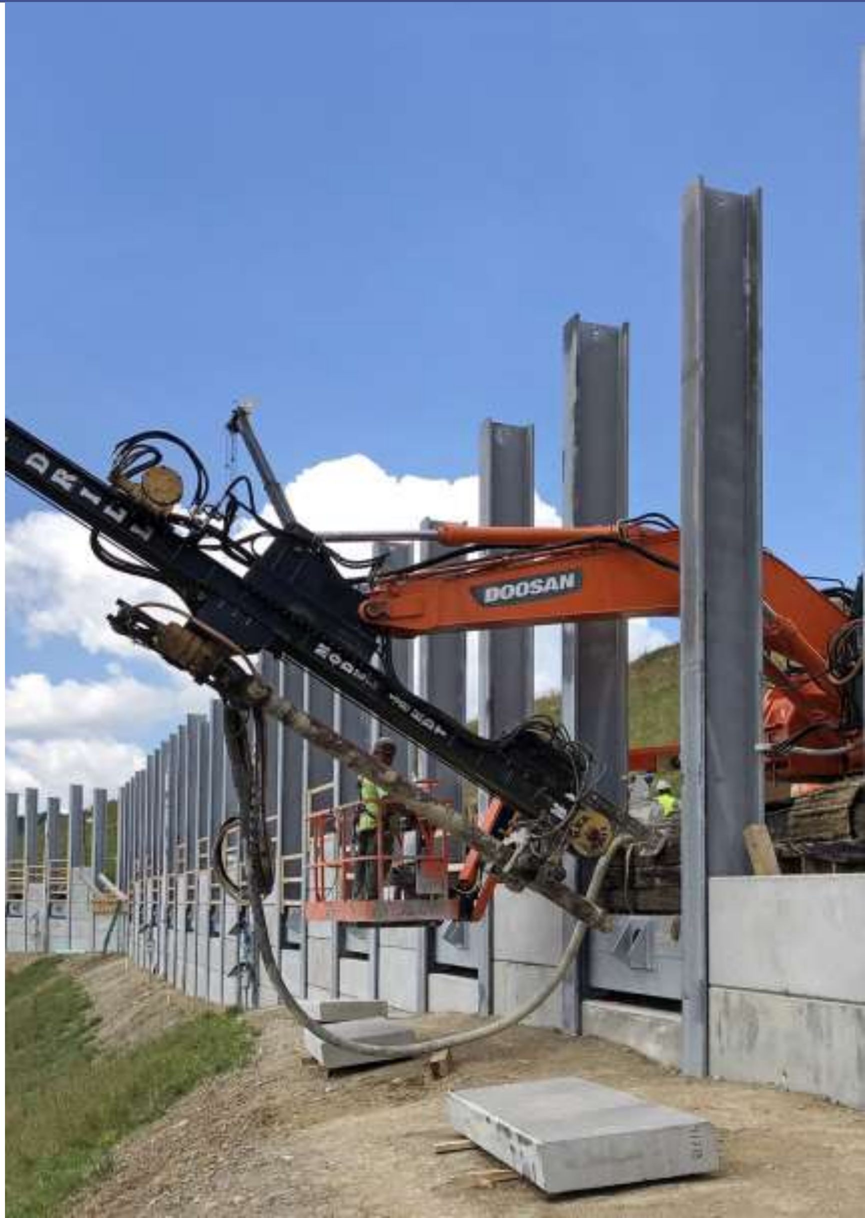






Collecting Construction Records

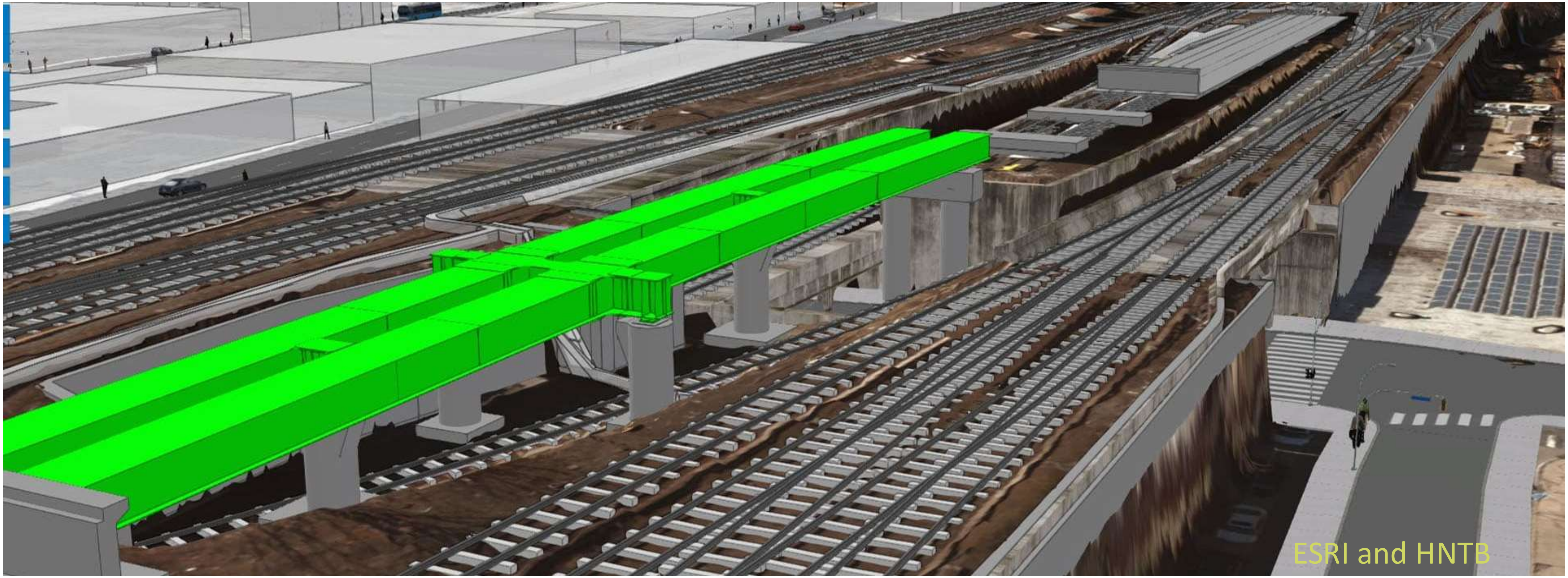
- Wealth of data that allows us to refine the subsurface understanding even further
- And document the conditions and elements installed



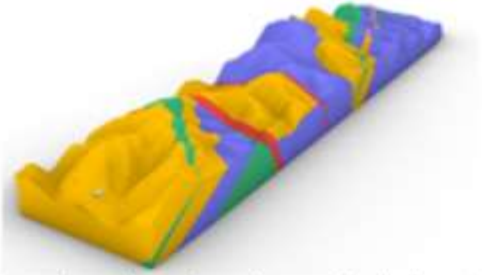
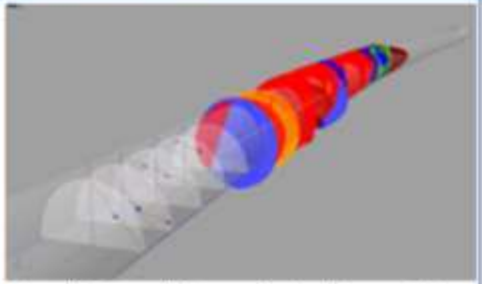
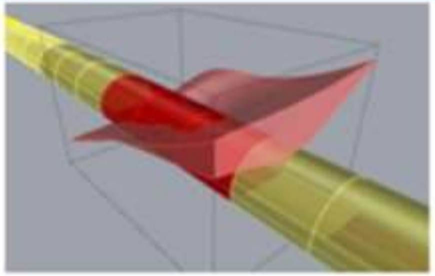
Monitoring Data

Asset Management

Reuse of Data



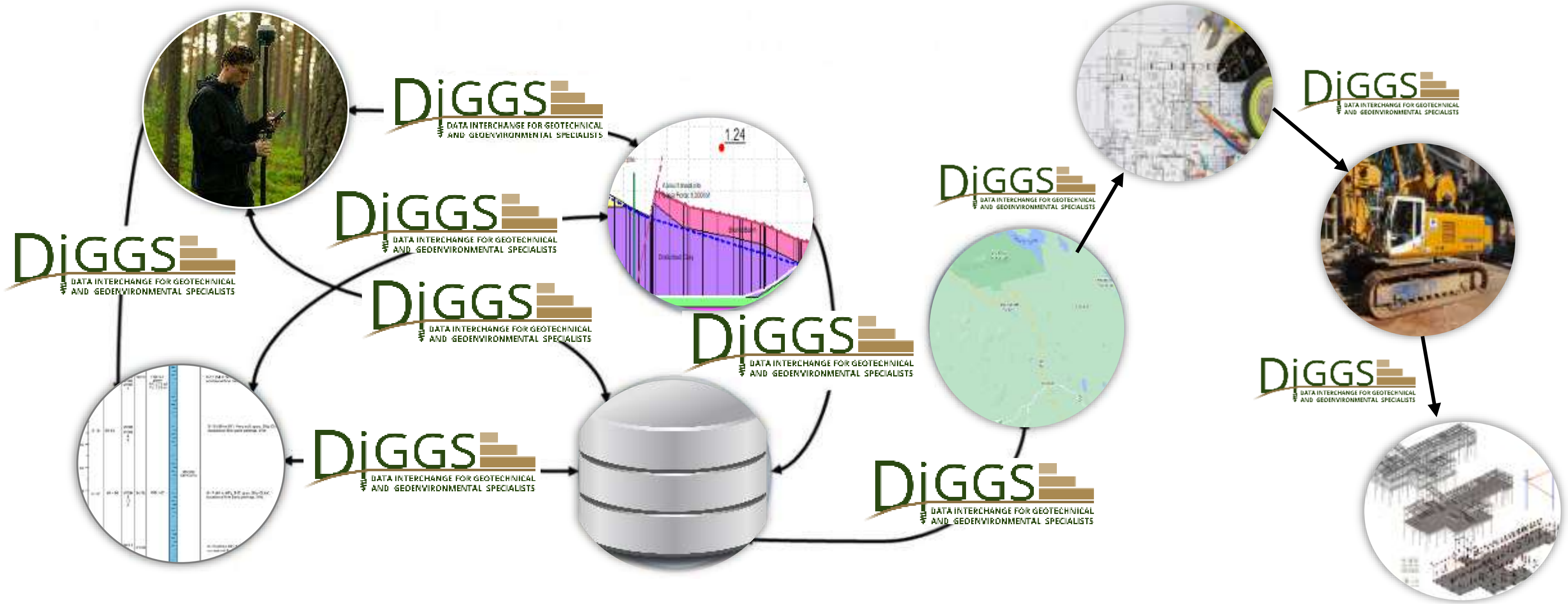
Industry Foundation Classes (IFC)-Tunnel Project Report WP2: Requirements analysis report (RAR)

Lifecycle stage	Plan & Investigation	Investigation & Design	Construction	Maintenance
Primary objective of modeling	Tunnel routes / alignment studies (UC 2a)	Tunnel Design (UC 2b, 12b)	Construction management (UC 15b, 2c, 12b)	Measures to deformation and damage (2C)
Model example	 Regional-scale engineering-geological model	 Tunnel-scale engineering-geological model	 Geol. Tunnel Docu. /as-built model	 As-built model for specific area
Modeling area	Relatively wide area including potential tunnel routes	Around the tunnel corridor	Around the tunnel excavation	Selection of previous models around zones of interest
Approx. resolution required to the model	>10m mesh	<10m mesh	Down to 0.1m mesh	Down to 0.1m mesh

Data Transfer for Life

DIGGS is the tool for exchanging the geotechnical data throughout the life cycle of a transportation asset.

We (the DIGGS team) are currently working with buildingSMART to integrate DIGGS as a schema for geotechnical data transfer in their tunneling model.



ASCE GI Web Site: www.DIGGSML.org or https://github.com/DIGGSml

Lifetime of Geotechnical Data in Bridge Projects

Allen Cadden, PE D.GE

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ASCE GI Web Site: www.DIGGSML.org
or https://github.com/DIGGSml

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November 10

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https://www.nationalacademies.org/trb/events

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