# Assessment of Drilled Shaft Capacity and QA/QC from Measuring While Drilling BED31-977-09

## GRIP Meeting


**FDOT Project Manager:**
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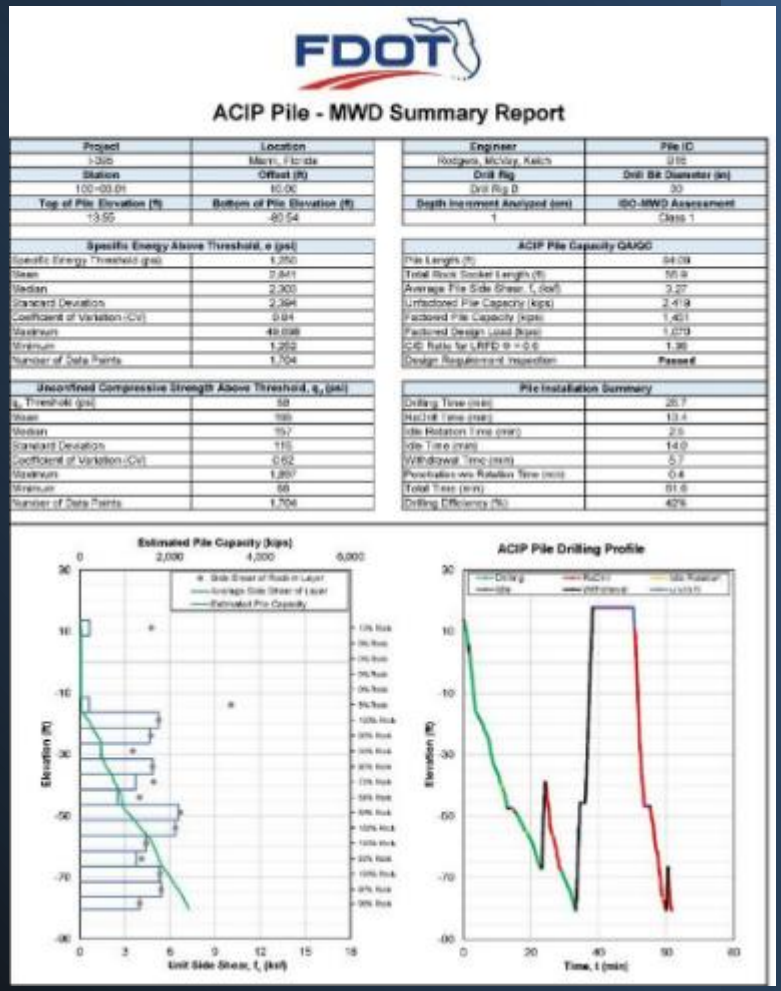
**August 15, 2024**

# Project Background

- FDOT investigated the use of MWD for Auger Cast Piles (ACP) to provide QA/QC during pile installations in Miami-Dade
  - BDV31-977-125
- A new analysis tool was developed
  - Transformed time-referenced data collected from AME to depth-referenced data that is compatible for MWD strength assessment
- For ACPs, a time-referenced data format collected from AME is most commonly used in Florida, and the ACP analysis tool was developed specifically to accommodate the data format



# Project Background

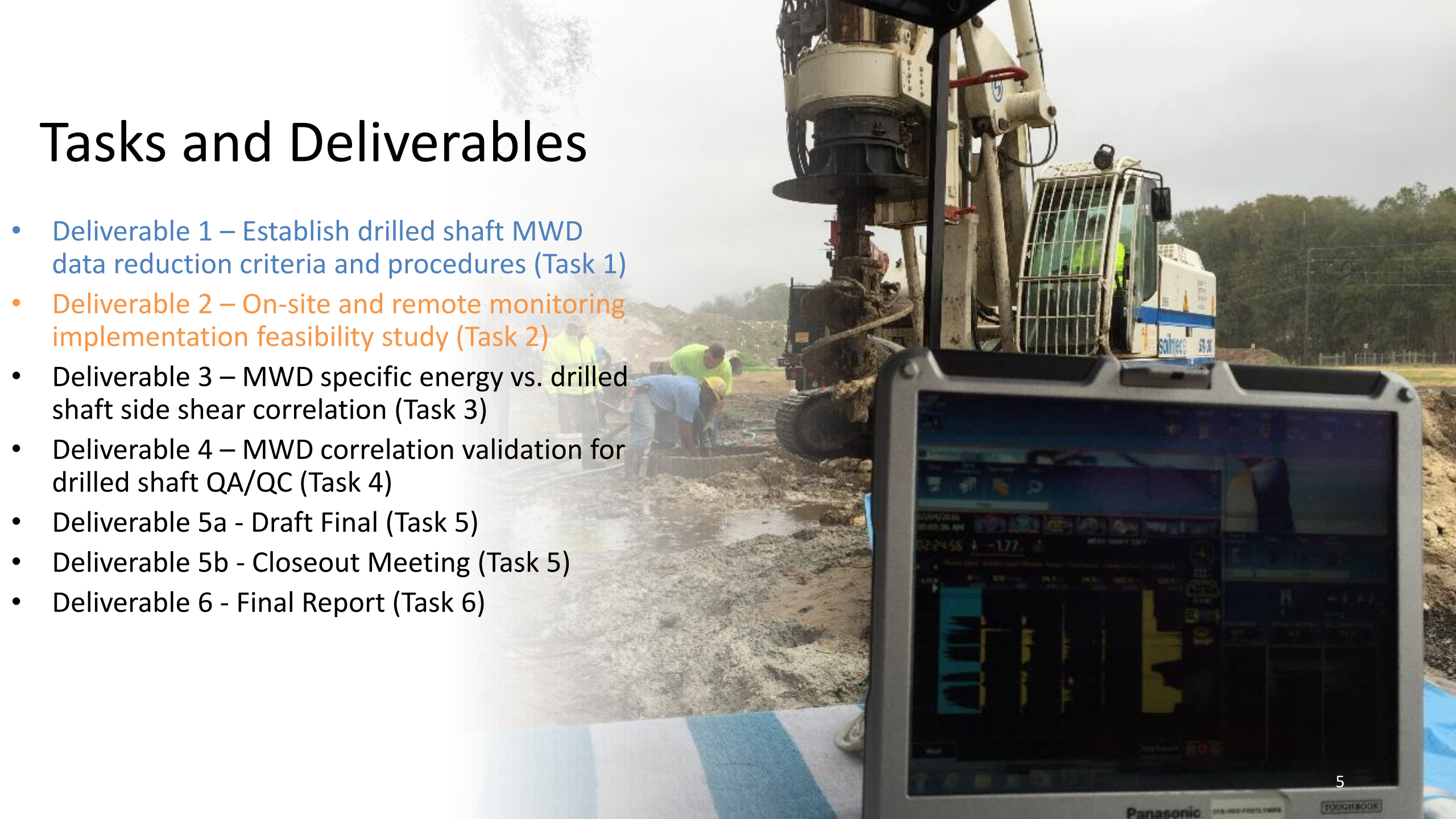
- For drilled shaft MWD…
  - Time-referenced data
  - Depth-referenced data
  - Both data formats
- A new analysis tool needed to be developed to accommodate the possible variations in raw data recording and reporting
- Provide the FDOT with a reliable method of drilled shaft QA/QC analysis, regardless of the monitoring system used
- Contractors can utilize a variety of MWD systems
  - System does not have to produce depth-referenced data
  - Current constraint for full drilled shaft MWD implementation
- On-site and remote monitoring should be explored to improve the quality control portion of the of the QA/QC tool
  - Providing real time strength assessments that can be viewed by all stakeholders

# Project Objectives

1. Using FDOT MWD criteria (FM 5-625), develop a versatile data analysis tool that will be used to provide drilled shaft MWD QA/QC
2. Conduct a feasibility study to identify the requirements of providing on-site and remote monitoring capabilities to enhance the QA/QC method
3. Monitor at least one load tested shaft and three production shafts at three independent sites to develop correlations for QA/QC purposes
4. Provide a QA/QC report for all shafts monitored during the research
5. Compare test results with previously derived correlations

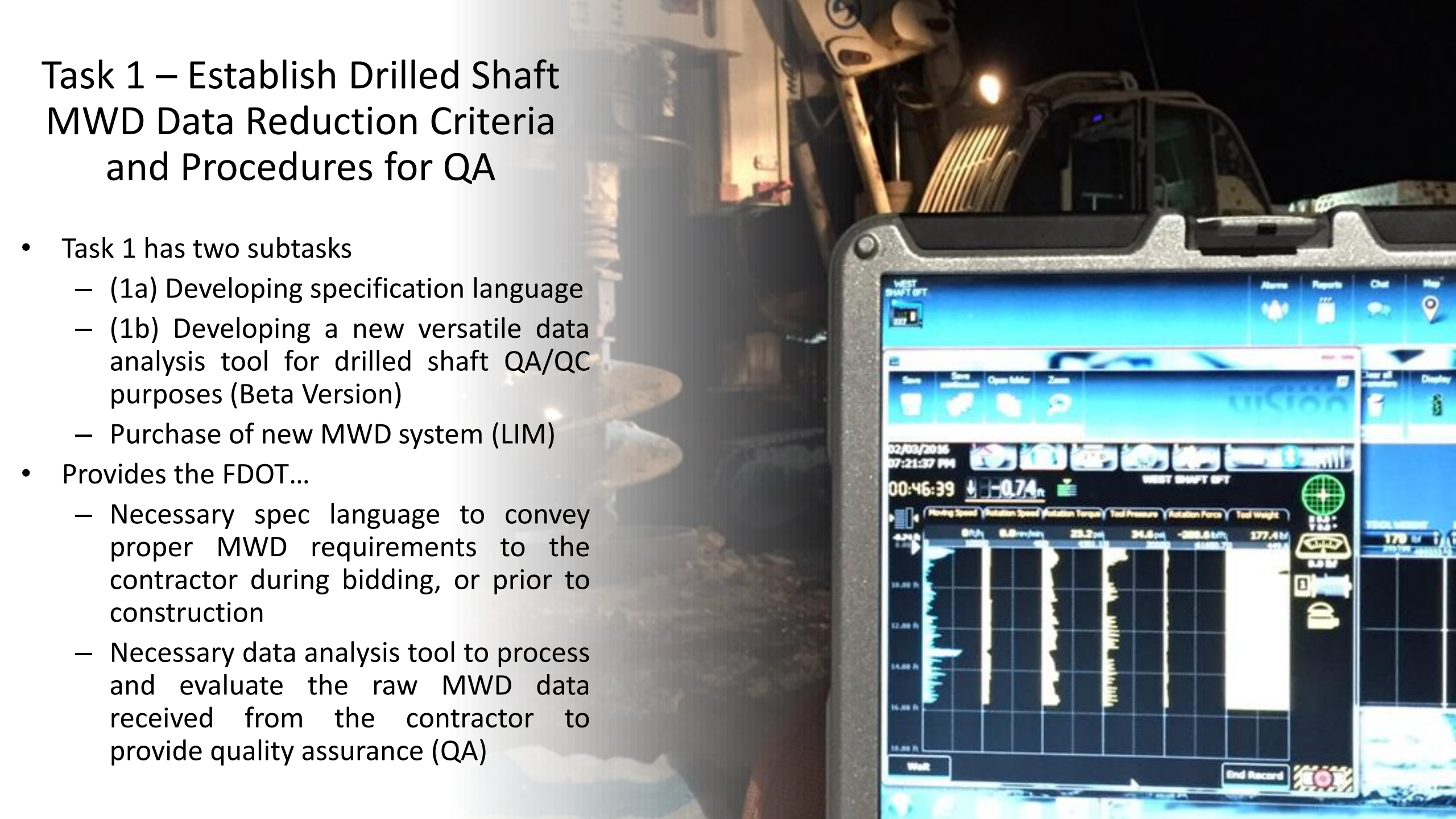
# Tasks and Deliverables

- Deliverable 1 – Establish drilled shaft MWD data reduction criteria and procedures (Task 1)
- Deliverable 2 – On-site and remote monitoring implementation feasibility study (Task 2)
- Deliverable 3 – MWD specific energy vs. drilled shaft side shear correlation (Task 3)
- Deliverable 4 – MWD correlation validation for drilled shaft QA/QC (Task 4)
- Deliverable 5a - Draft Final (Task 5)
- Deliverable 5b - Closeout Meeting (Task 5)
- Deliverable 6 - Final Report (Task 6)



# Task 1 – Establish Drilled Shaft MWD Data Reduction Criteria and Procedures for QA

- Task 1 has two subtasks
  - (1a) Developing specification language
  - (1b) Developing a new versatile data analysis tool for drilled shaft QA/QC purposes (Beta Version)
  - Purchase of new MWD system (LIM)
- Provides the FDOT…
  - Necessary spec language to convey proper MWD requirements to the contractor during bidding, or prior to construction
  - Necessary data analysis tool to process and evaluate the raw MWD data received from the contractor to provide quality assurance (QA)



# Task 1a – Development of Specification Language

- Identify MWD systems currently available
  - On-board, in-house, and commercially available systems
- Develop spec language that includes data recording and data formatting requirements
- Specification language will detail construction requirements for the contractor
  - Ensures each drill rig has the appropriate monitoring equipment installed and calibrated
  - Data logging capabilities to supply the FDOT with the necessary electronic records for drilled shaft MWD QA.

# Task 1a – Development of Specification Language

- On-board MWD Systems
  - Bauer's B-tronic System
  - Liebehrr's Litronic System
  - Soilmec's Drilling Mate System (DMS)
- Commercially Available MWD Systems
  - Jean Lutz' DIALOG MX System
  - LiM's PocketLIM System
  - Gamperl & Hatlapa's DaVis Systems
  - Pile Dynamics' Pile Installation Recorder (PIR) System
- In-house MWD Systems
  - Keller's Pile Installation Monitoring System (PIMS)
- Every system can produce time-referenced data at 1Hz
  - FM 5-625 requirement for FDOT Bored Pile Class 1

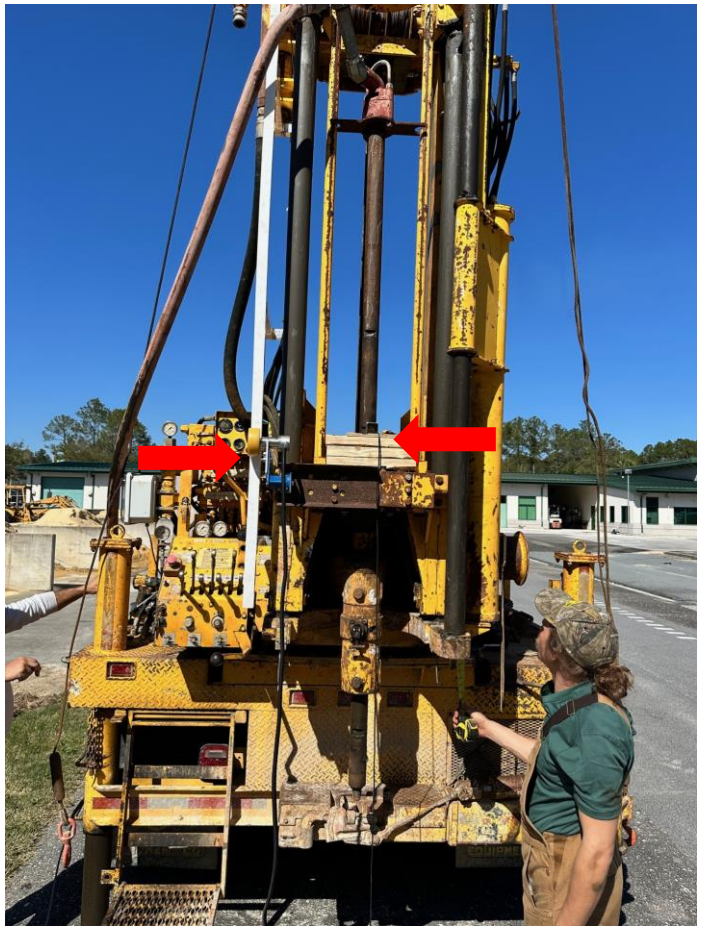
# Task 1a – Development of Specification Language

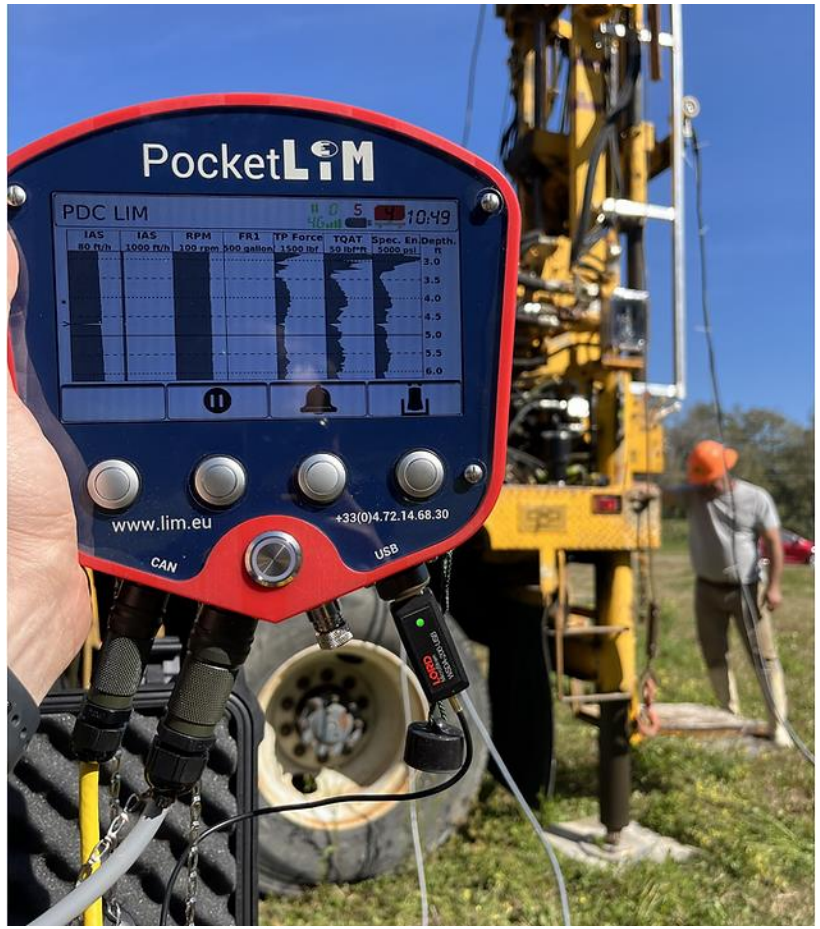
- UF Researchers submitted draft spec language for Drilled Shaft MWD:

- FDOT Standard Specifications for Road and Bridge Construction – Section 455
  - Section 455-15.1.2 – Drilled Shaft Installation Plan (DSIP)
  - Section 455-15.1.3.1 – Measuring While Drilling (MWD)
  - Section 455-15.10.5 – MWD Equipment
  - Section 455-15.10.6 – MWD Measurements

- Florida Method of Test (FM 5-625)
  - Section 3.6.1 – Minimum Accuracy of Measured Values

# Task 1b - New MWD System - LiM's PocketLiM



# Task 1b – Development of the Data Analysis Tool – Beta Version

- The monitoring systems onboard the drilled shaft drill rigs, and the format in which the drilling parameters may be recorded and reported were unknown
- New raw data processing criteria and procedures needed to be developed to accommodate the data, regardless of the format
  - Data layout
  - File type
    - e.g., .xlsx, .csv, .txt, .guh, etc.
- The research team considered:
  - Prior MWD data collected in various formats
  - Obtained sample drilling data from commercial vendors
  - Simulated large data sets (1 million rows of data)
    - 16 hrs of drilling at 20 Hz
  - Investigated multiple file types for reported data
- Allowed UF to develop initial processing criteria and a preliminary analysis tool (Beta Version)
  - 5$^{th}$ iteration of Beta version in use in S. Florida for ACPs

# Raw Data Variations Based on MWD System

| Time (s) | Depth (feet) | Penetration Rate (ft/min) | RPM (rev/min) | Torque pressure (psi) | Crowd pressure (psi) | Crowd Force (Tf) | Bottom Grout (psi) | Top Grout pressure (psi) | Grout Flow (yd3/h) | Grout Volume yd3 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.000 | 0.00 | 0.00 | 116.03 | 406.10 | 0.183 | 45.122 | 3.881091138 | 0 | 0 |
| 0.00 | 0.000 | 0.00 | 0.00 | 111.20 | 402.48 | 0.176 | 45.097 | 4.39633378 | 0 | 0 |
| 2.37 | 0.082 | 0.54 | 0.00 | 111.33 | 408.06 | 1.826 | 45.133 | 4.606430907 | 0 | 0 |
| 2.56 | 0.157 | 20.85 | 0.00 | 116.03 | 406.10 | 4.572 | 45.017 | 4.608424711 | 0 | 0 |
| 2.75 | 0.236 | 23.92 | 0.00 | 116.03 | 410.94 | 4.978 | 45.058 | 4.654531436 | 0 | 0 |
| 3.01 | 0.312 | 16.72 | 0.00 | 116.03 | 413.36 | 4.807 | 45.049 | 4.624562065 | 0 | 0 |
| 3.14 | 0.397 | 28.84 | 0.00 | 116.03 | 406.10 | 4.725 | 45.001 | 4.583066013 | 0 | 0 |
| 3.39 | 0.479 | 14.80 | 0.00 | 112.40 | 416.98 | 4.816 | 45.045 | 4.704096164 | 0 | 0 |
| 3.59 | 0.551 | 20.33 | 0.00 | 101.53 | 406.10 | 6.433 | 45.040 | 4.377891091 | 0 | 0 |
| 3.78 | 0.627 | 22.90 | 0.00 | 140.20 | 406.10 | 5.865 | 44.924 | 3.953709229 | 0 | 0 |
| 3.97 | 0.696 | 22.90 | 0.00 | 328.75 | 454.45 | 6.040 | 44.934 | 3.958319901 | 0 | 0 |
| 4.23 | 0.771 | 15.19 | 0.00 | 681.67 | 732.44 | 6.009 | 44.966 | 3.94679322 | 0 | 0 |
| 4.42 | 0.840 | 18.97 | 0.00 | 1005.59 | 1256.99 | 6.020 | 45.035 | 3.87993847 | 0 | 0 |
| 4.61 | 0.909 | 21.53 | 0.00 | 841.21 | 1165.13 | 5.836 | 45.058 | 4.290288315 | 0 | 0 |
| 4.80 | 0.988 | 22.56 | 1.10 | 836.38 | 1131.29 | 5.892 | 44.994 | 4.66375278 | 0 | 0 |
| 5.06 | 1.056 | 16.34 | 3.30 | 997.13 | 1334.34 | 5.862 | 44.987 | 4.648768095 | 0 | 0 |
| 5.25 | 1.132 | 18.63 | 3.30 | 1213.48 | 1580.90 | 5.850 | 44.984 | 4.580760677 | 0 | 0 |
| 5.38 | 1.201 | 27.94 | 3.30 | 1319.84 | 1791.21 | 5.849 | 44.987 | 4.659142108 | 0 | 0 |
| 5.83 | 1.316 | 11.75 | 3.30 | 1429.65 | 1808.82 | 5.844 | 44.980 | 4.613694051 | 0 | 0 |

| Time | Duration (min) | Gear Box RPM | Penetration Rate (ft/min) | Penetration Rate | Depth (ft) | Gear Box Pres | Torque (ft-lbs) | Crowd Pressu | Thrust (lb |
|---|---|---|---|---|---|---|---|---|---|
| 6/10/2020 7:29:31 AM | 0 | -81.89 | -46.9488204 | 3.048 | 0 | 639.0361062 | 0 | 221.0374548 | 3426.96 |
| 6/10/2020 7:29:32 AM | 0.02 | -82.5 | -49.1469832 | 3.048 | 0 | 66.2822289 | 0 | 201.8924784 | 3130.14 |
| 6/10/2020 7:29:33 AM | 0.03 | -84.45 | -51.2467208 | 3.048 | 0.0656168 | 0 | 0 | 44.8166493 | 694.837 |
| 6/10/2020 7:29:34 AM | 0.05 | -88.47 | -53.0183744 | 3.048 | 0.0656168 | 664.9978545 | 0 | 213.0603813 | 3303.29 |
| 6/10/2020 7:29:35 AM | 0.07 | -80.52 | -48.4908152 | 3.048 | 0.0656168 | 589.4332128 | 0 | 224.2282842 | 3476.44 |
| 6/10/2020 7:29:36 AM | 0.08 | 11.97 | 1.0498688 | 0.9525 | 0.0984252 | 584.0668179 | 0 | 213.4954944 | 3310.03 |
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| 6/10/2020 7:29:38 AM | 0.12 | 14.51 | 1.8372704 | 0.544285714 | 0.1968504 | 691.1046405 | 0 | 253.2358242 | 3926.17 |
| 6/10/2020 7:29:39 AM | 0.13 | 18.86 | 1.804462 | 0.554181818 | 0.2624672 | 653.5398762 | 0 | 256.4266536 | 3975.64 |
| 6/10/2020 7:29:40 AM | 0.15 | 21.26 | 2.3950132 | 0.417534247 | 0.2952756 | 661.5169497 | 0 | 250.915221 | 3890.19 |
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| 6/10/2020 7:29:43 AM | 0.2 | 23.07 | 2.952756 | 0.338666667 | 0.4593176 | 691.9748667 | 0 | 259.1823699 | 4018.36 |
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| 6/10/2020 7:29:47 AM | 0.27 | 24.06 | 2.9855644 | 0.334945055 | 0.6233596 | 678.776436 | 0 | 255.4113897 | 3959.9 |
| 6/10/2020 7:29:48 AM | 0.28 | 24.24 | 2.8871392 | 0.346363636 | 0.6889764 | 694.5855453 | 0 | 254.8312389 | 3950.9 |
| 6/10/2020 7:29:49 AM | 0.3 | 24.38 | 2.8543308 | 0.350344828 | 0.7217848 | 679.3565868 | 0 | 252.8007111 | 3919.42 |

```
[PARAMETER]
Date;Depth;P-Grout;P-Rotary Head;P-Crowd;Rotation;Torque;Speed;X-Axis;Y-Axis;Grout
0;m;bar;bar;bar;RPM;kNm;cm/min;°;°;l/min;L;%;-;-;-;%;l/min

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```
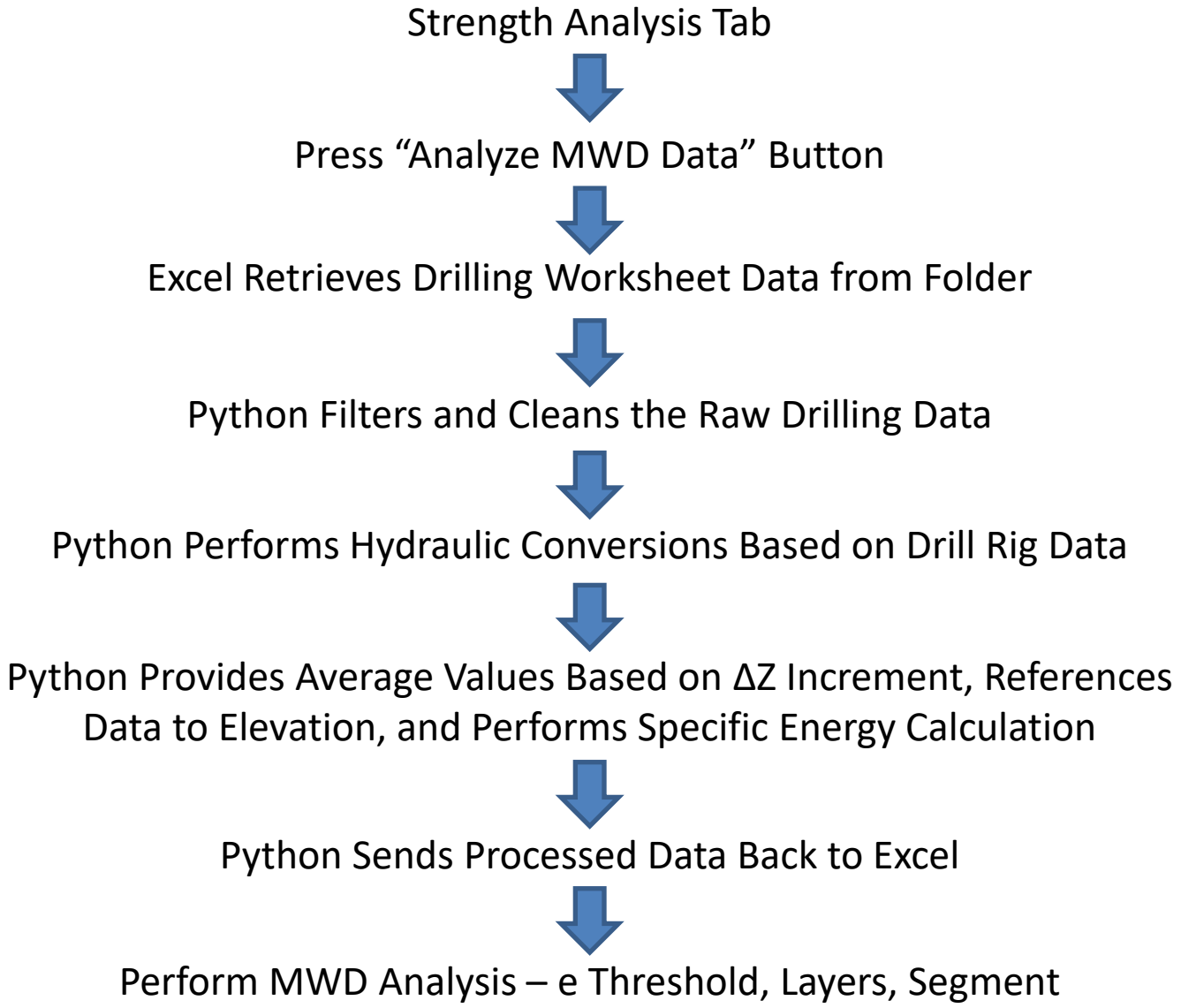

# FLMWD Analysis Tool Workflow

- New MWD analysis tool utilizes python to perform the background calculations
  - No longer have to copy and paste data or files into analysis tool
    - Imports all data and files from folders
    - Never have to open a single drilling file to analyze your MWD data
  - Much smaller file sizes
    - > 3MB compared to 40 to 50 MB
  - Easier to track changes during upgrades and modifications
- Provides a similar user interface (UI) to ACIP analysis tool
  - Specific energy threshold and layers can be adjusted without triggering the program to reanalyze the data



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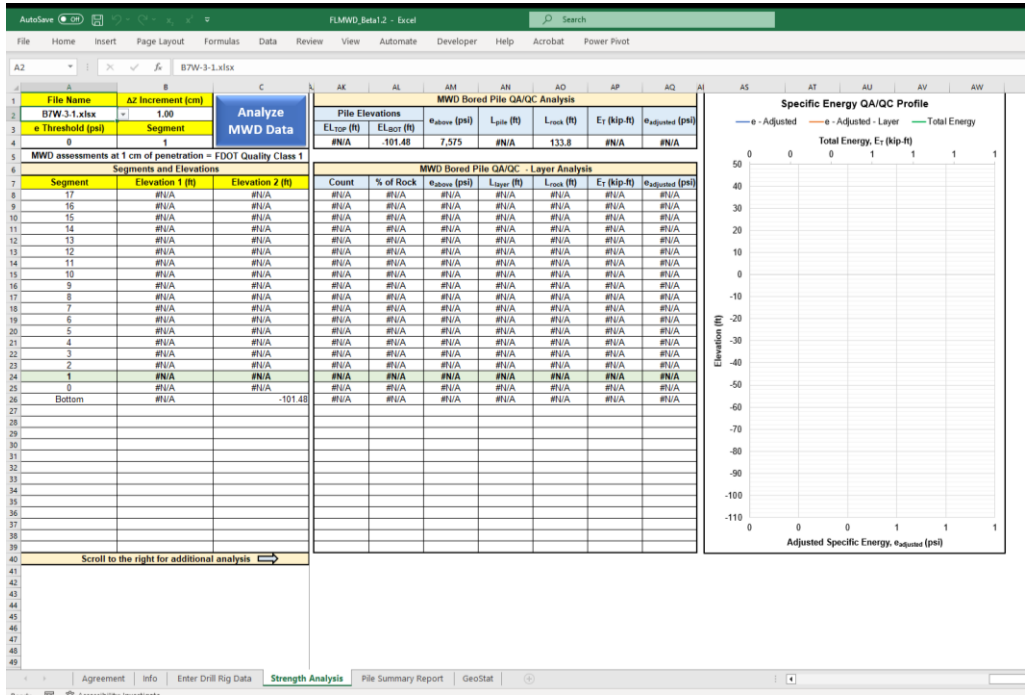
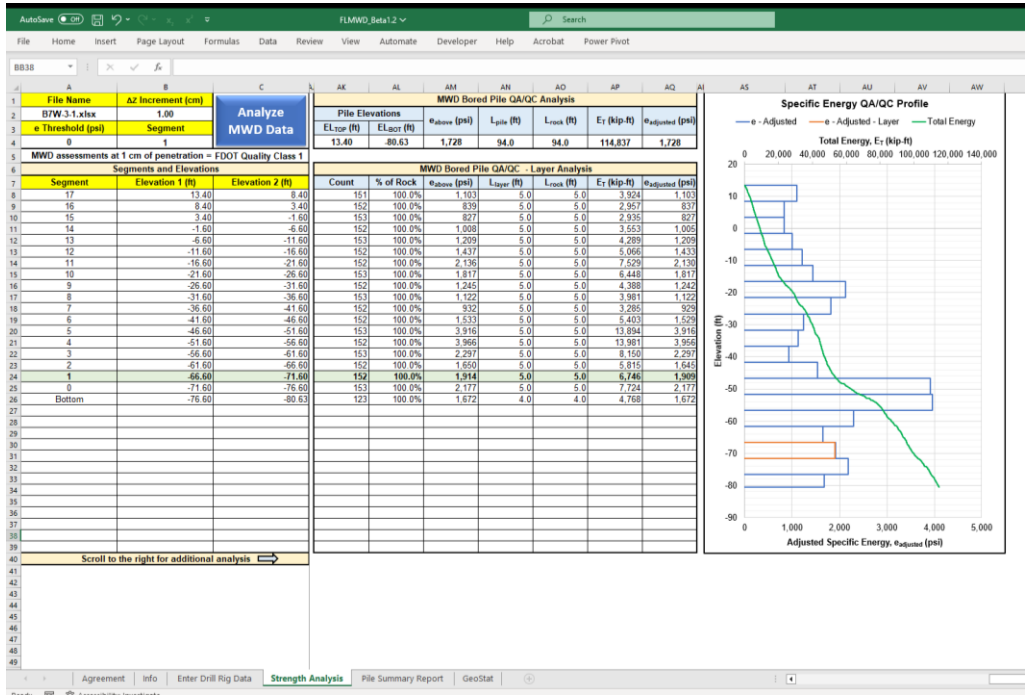
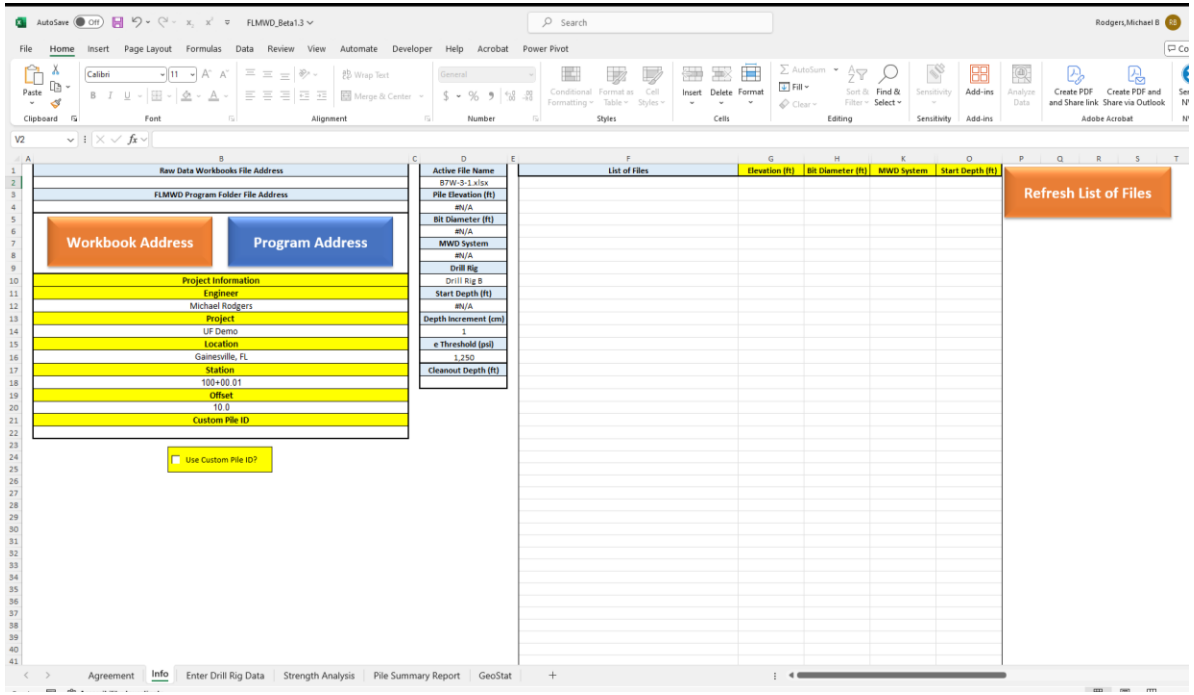


# Info Sheet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FLMWD Program Folder File Address
Workbook Address
Program Address
Project Information
Engineer
Michael Rodgers
Project
UF Demo
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Gainesville, FL
Station
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Offset
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Custom Pile ID
Use Custom Pile ID?
Active File Name
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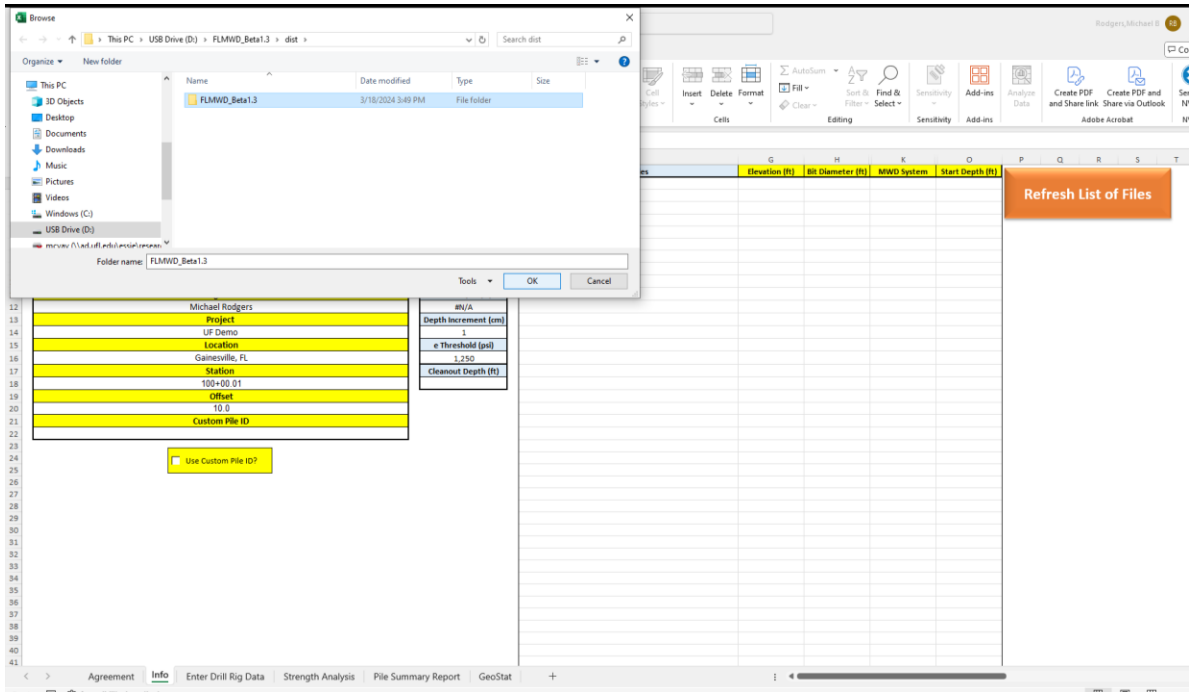
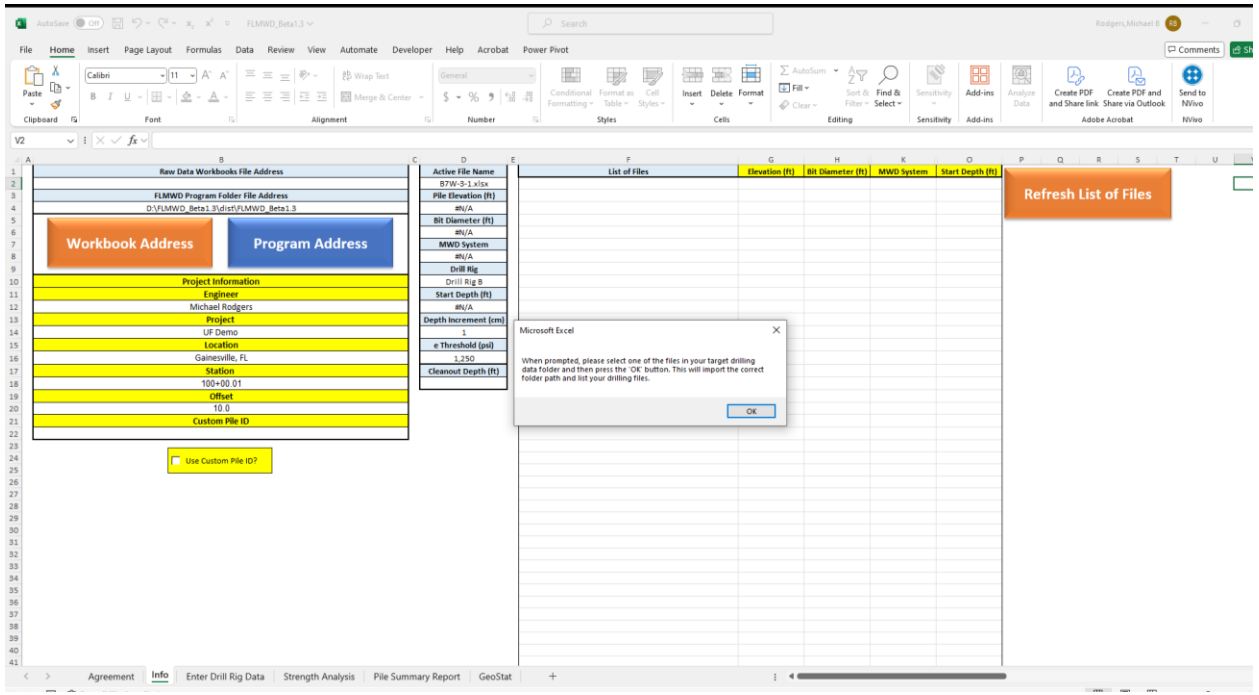
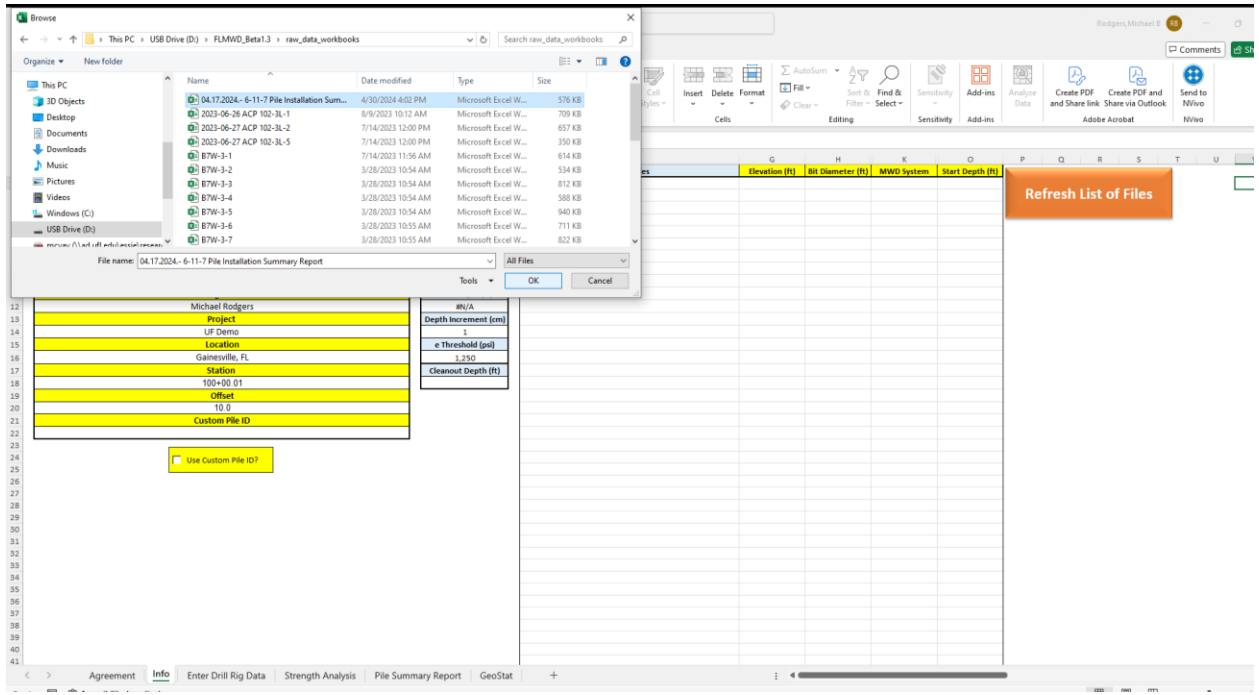
#N/A
Bit Diameter (ft)
#N/A
MWD System
#N/A
Drill Rig
Drill Rig B
Start Depth (ft)
#N/A
Depth Increment (cm)
1
e Threshold (psi)
1,250
Cleanout Depth (ft)
List of Files
Elevation (ft)
Bit Diameter (ft)
MWD System
Start Depth (ft)
Refresh List of Files
Agreement
Info
Enter Drill Rig Data
Strength Analysis
Pile Summary Report
GeoStat

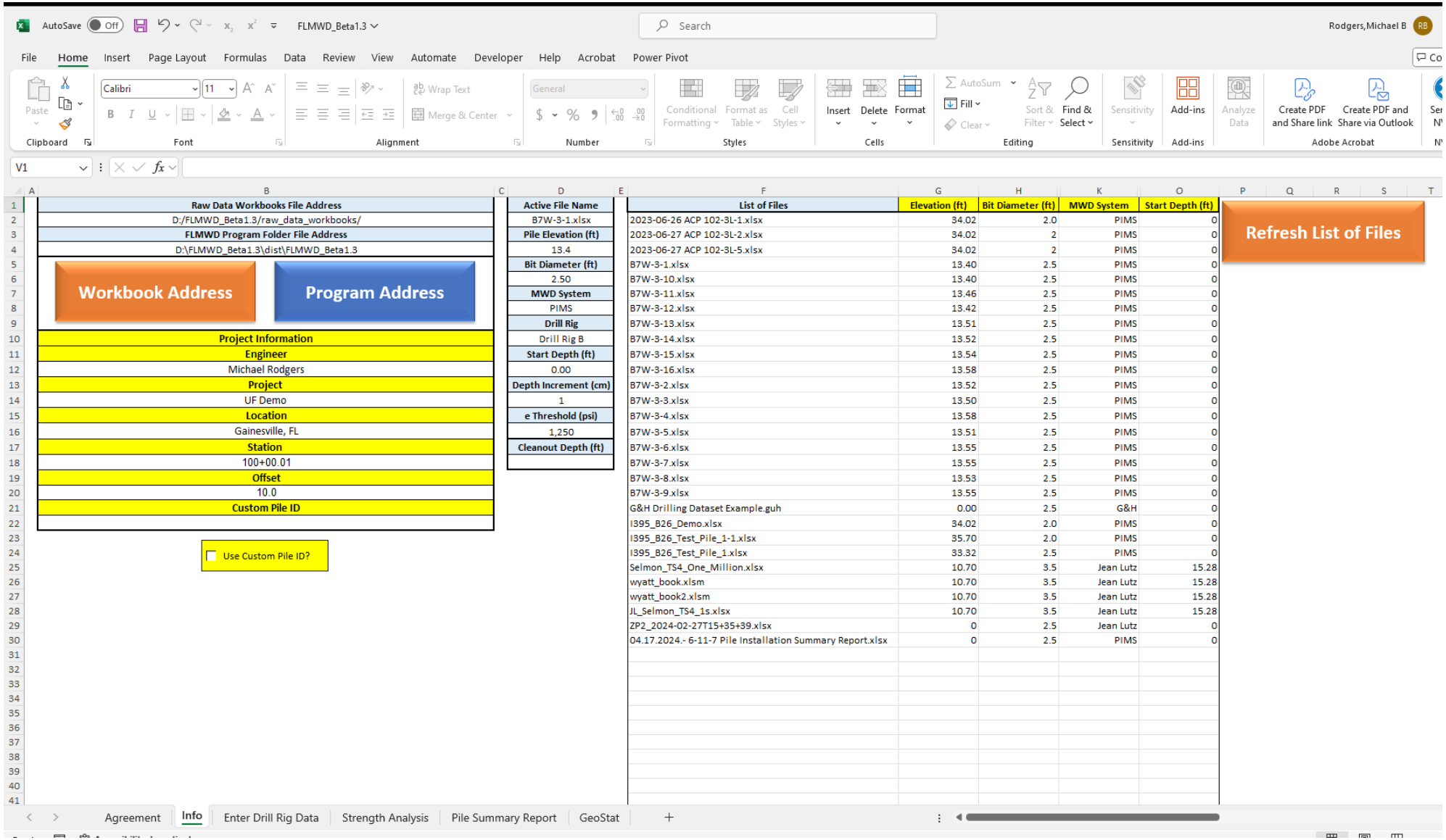

Browse
FLMWD_Beta1.3
Folder name: FLMWD_Beta1.3
OK
Cancel
Refresh List of Files
Agreement
Info
Enter Drill Rig Data
Strength Analysis
Pile Summary Report
GeoStat

# Info Sheet


Raw Data Workbooks File Address
FLMWD Program Folder File Address
D:\FLMWD_Beta1.3\dist\FLMWD_Beta1.3
Workbook Address
Program Address
Project Information
Engineer
Michael Rodgers
Project
UF Demo
Location
Gainesville, FL
Station
100+00.01
Offset
10.0
Custom Pile ID
Use Custom Pile ID?
Active File Name
B7W-3-1.xlsx
Pile Elevation (ft)
#N/A
Bit Diameter (ft)
#N/A
MWD System
#N/A
Drill Rig
Drill Rig B
Start Depth (ft)
#N/A
Depth Increment (cm)
1
e Threshold (psi)
1,250
Cleanout Depth (ft)
List of Files
Elevation (ft)
Bit Diameter (ft)
MWD System
Start Depth (ft)
Refresh List of Files
Microsoft Excel
When prompted, please select one of the files in your target drilling data folder and then press the 'OK' button. This will import the correct folder path and list your drilling files.
OK
Agreement
Info
Enter Drill Rig Data
Strength Analysis
Pile Summary Report
GeoStat


Browse
raw_data_workbooks
04.17.2024 - 6-11-7 Pile Installation Summary Report
2023-06-26 ACP 102-3L-1
2023-06-27 ACP 102-3L-2
2023-06-27 ACP 102-3L-5
B7W-3-1
B7W-3-2
B7W-3-3
B7W-3-4
B7W-3-5
B7W-3-6
B7W-3-7
File name: 04.17.2024 - 6-11-7 Pile Installation Summary Report
All Files
Tools
OK
Cancel
Michael Rodgers
Project
UF Demo
Location
Gainesville, FL
Station
100+00.01
Offset
10.0
Custom Pile ID
Use Custom Pile ID?
Depth Increment (cm)
1
e Threshold (psi)
1,250
Cleanout Depth (ft)
Elevation (ft)
Bit Diameter (ft)
MWD System
Start Depth (ft)
Refresh List of Files
Agreement
Info
Enter Drill Rig Data
Strength Analysis
Pile Summary Report
GeoStat

# Info Sheet



| Raw Data Workbooks File Address |
|---|
| D:/FLMWD_Beta1.3/raw_data_workbooks/ |
| FLMWD Program Folder File Address |
| D:\FLMWD_Beta1.3\dist\FLMWD_Beta1.3 |

Workbook Address | Program Address

| Project Information |
|---|
| Engineer |
| Michael Rodgers |
| Project |
| UF Demo |
| Location |
| Gainesville, FL |
| Station |
| 100+00.01 |
| Offset |
| 10.0 |
| Custom Pile ID |

Use Custom Pile ID?

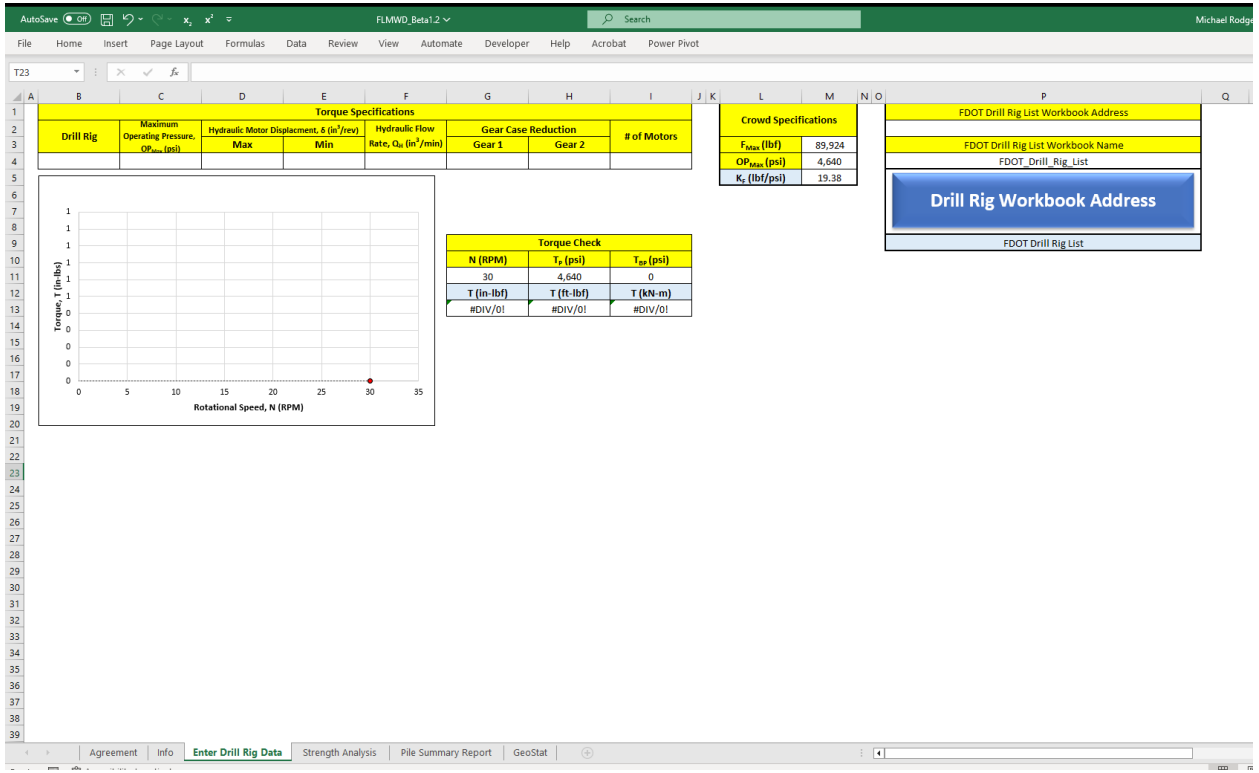
| Active File Name |
|---|
| B7W-3-1.xlsx |
| Pile Elevation (ft) |
| 13.4 |
| Bit Diameter (ft) |
| 2.50 |
| MWD System |
| PIMS |
| Drill Rig |
| Drill Rig B |
| Start Depth (ft) |
| 0.00 |
| Depth Increment (cm) |
| 1 |
| e Threshold (psi) |
| 1,250 |
| Cleanout Depth (ft) |

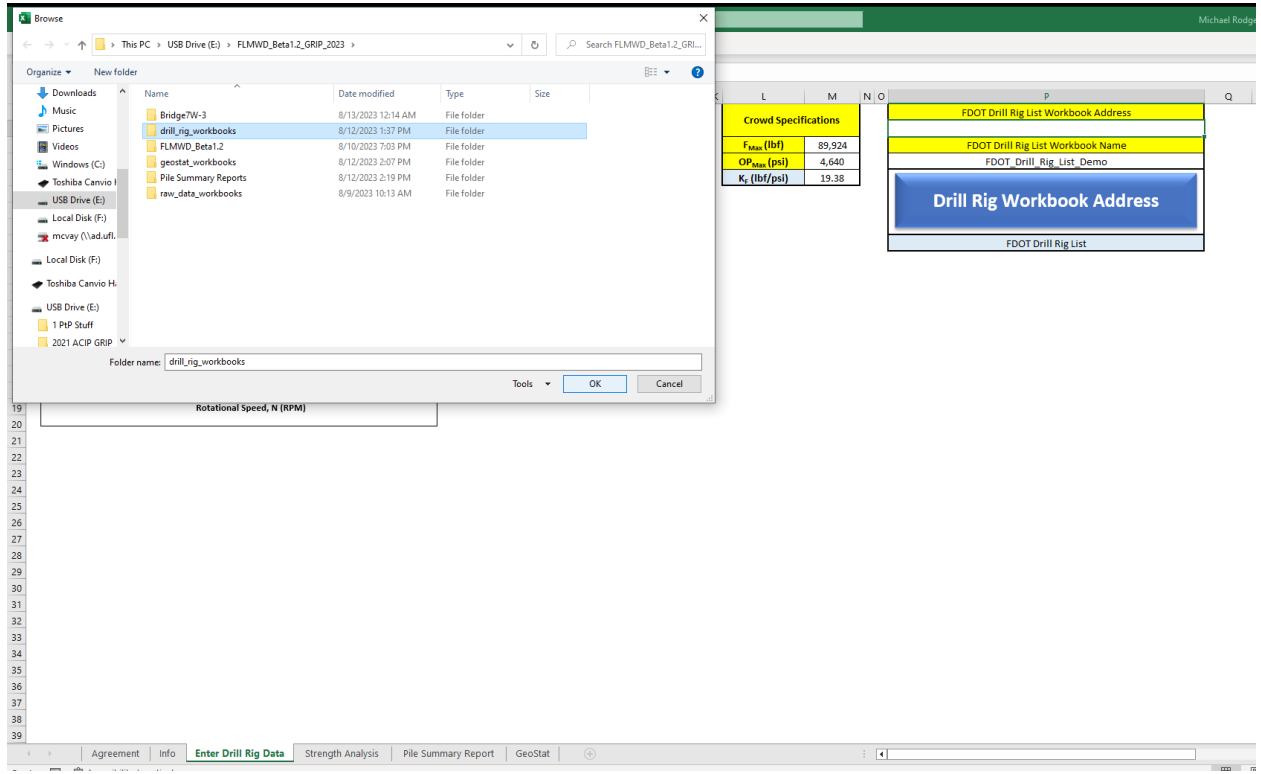
Refresh List of Files

| List of Files | Elevation (ft) | Bit Diameter (ft) | MWD System | Start Depth (ft) |
|---|---|---|---|---|
| 2023-06-26 ACP 102-3L-1.xlsx | 34.02 | 2.0 | PIMS | 0 |
| 2023-06-27 ACP 102-3L-2.xlsx | 34.02 | 2 | PIMS | 0 |
| 2023-06-27 ACP 102-3L-5.xlsx | 34.02 | 2 | PIMS | 0 |
| B7W-3-1.xlsx | 13.40 | 2.5 | PIMS | 0 |
| B7W-3-10.xlsx | 13.40 | 2.5 | PIMS | 0 |
| B7W-3-11.xlsx | 13.46 | 2.5 | PIMS | 0 |
| B7W-3-12.xlsx | 13.42 | 2.5 | PIMS | 0 |
| B7W-3-13.xlsx | 13.51 | 2.5 | PIMS | 0 |
| B7W-3-14.xlsx | 13.52 | 2.5 | PIMS | 0 |
| B7W-3-15.xlsx | 13.54 | 2.5 | PIMS | 0 |
| B7W-3-16.xlsx | 13.58 | 2.5 | PIMS | 0 |
| B7W-3-2.xlsx | 13.52 | 2.5 | PIMS | 0 |
| B7W-3-3.xlsx | 13.50 | 2.5 | PIMS | 0 |
| B7W-3-4.xlsx | 13.58 | 2.5 | PIMS | 0 |
| B7W-3-5.xlsx | 13.51 | 2.5 | PIMS | 0 |
| B7W-3-6.xlsx | 13.55 | 2.5 | PIMS | 0 |
| B7W-3-7.xlsx | 13.55 | 2.5 | PIMS | 0 |
| B7W-3-8.xlsx | 13.53 | 2.5 | PIMS | 0 |
| B7W-3-9.xlsx | 13.55 | 2.5 | PIMS | 0 |
| G&H Drilling Dataset Example.guh | 0.00 | 2.5 | G&H | 0 |
| I395_B26_Demo.xlsx | 34.02 | 2.0 | PIMS | 0 |
| I395_B26_Test_Pile_1-1.xlsx | 35.70 | 2.0 | PIMS | 0 |
| I395_B26_Test_Pile_1.xlsx | 33.32 | 2.5 | PIMS | 0 |
| Selmon_TS4_One_Million.xlsx | 10.70 | 3.5 | Jean Lutz | 15.28 |
| wyatt_book.xlsm | 10.70 | 3.5 | Jean Lutz | 15.28 |
| wyatt_book2.xlsm | 10.70 | 3.5 | Jean Lutz | 15.28 |
| JL_Selmon_TS4_1s.xlsx | 10.70 | 3.5 | Jean Lutz | 15.28 |
| ZP2_2024-02-27T15+35+39.xlsx | 0 | 2.5 | Jean Lutz | 0 |
| 04.17.2024.- 6-11-7 Pile Installation Summary Report.xlsx | 0 | 2.5 | PIMS | 0 |

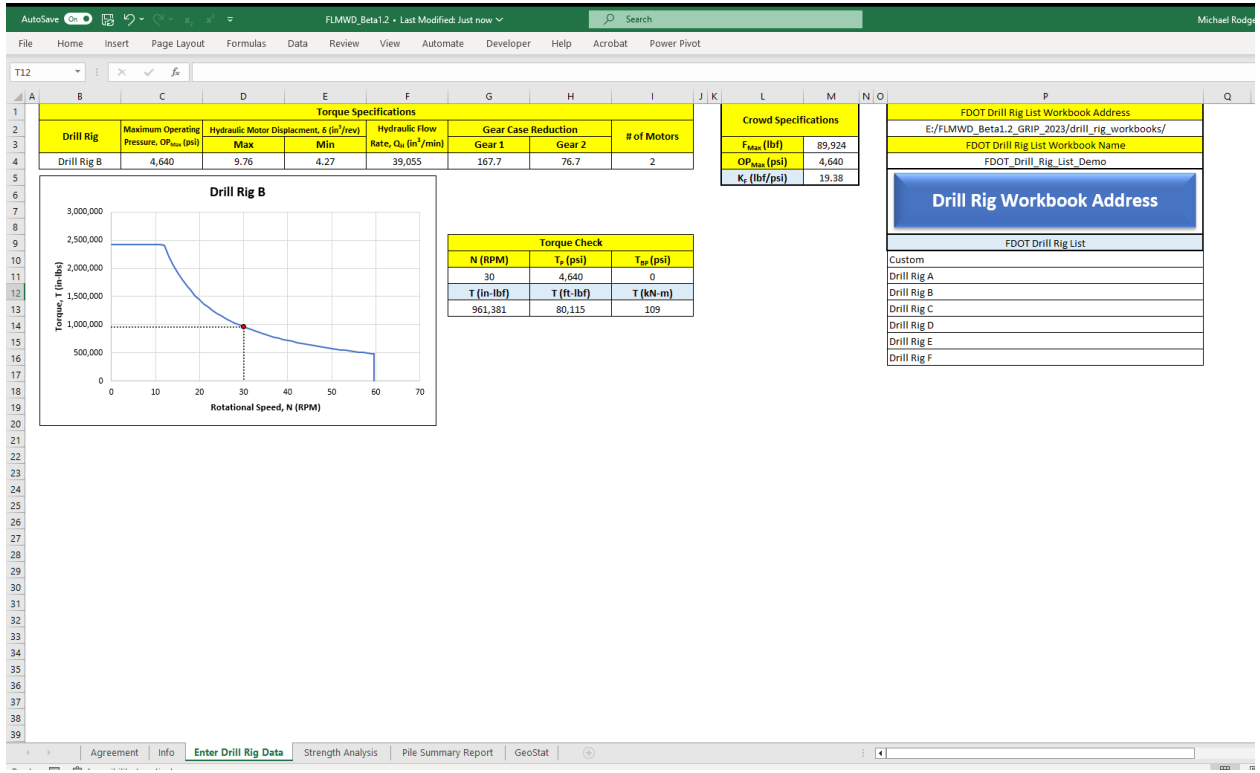
Agreement | Info | Enter Drill Rig Data | Strength Analysis | Pile Summary Report | GeoStat

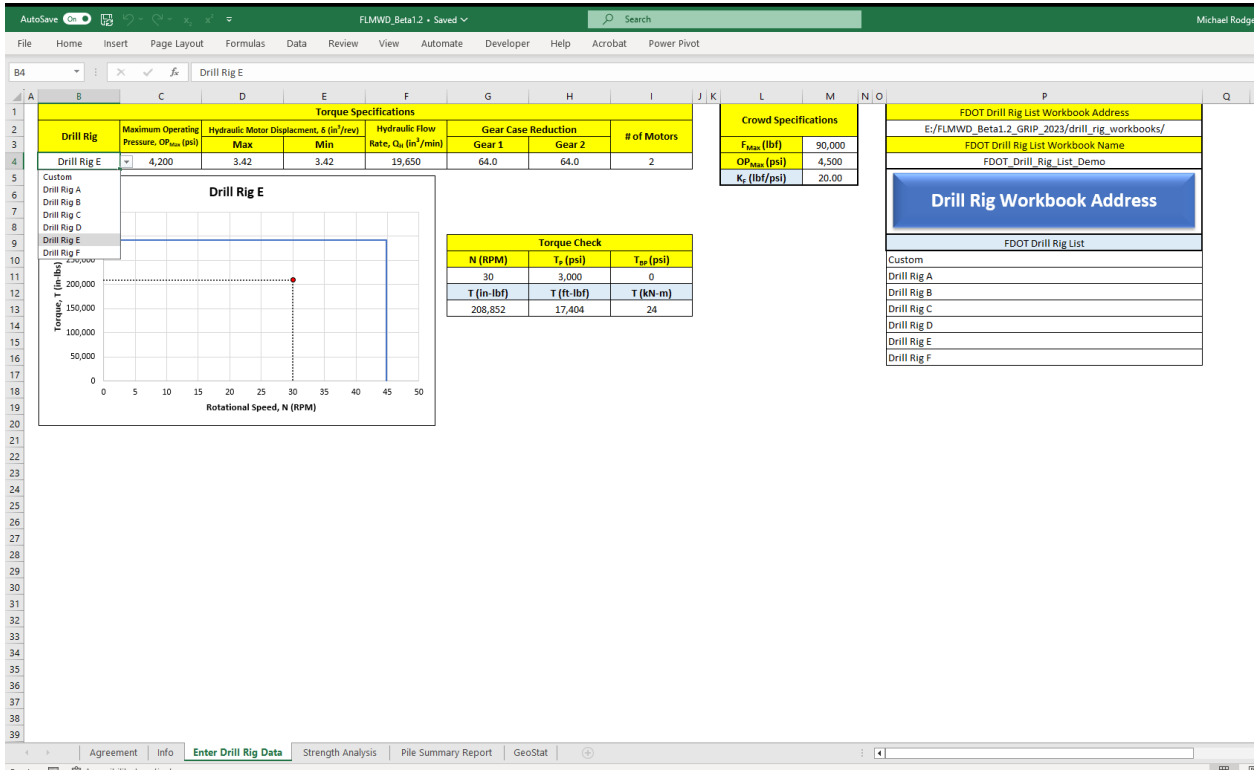
# Enter Drill Rig Data



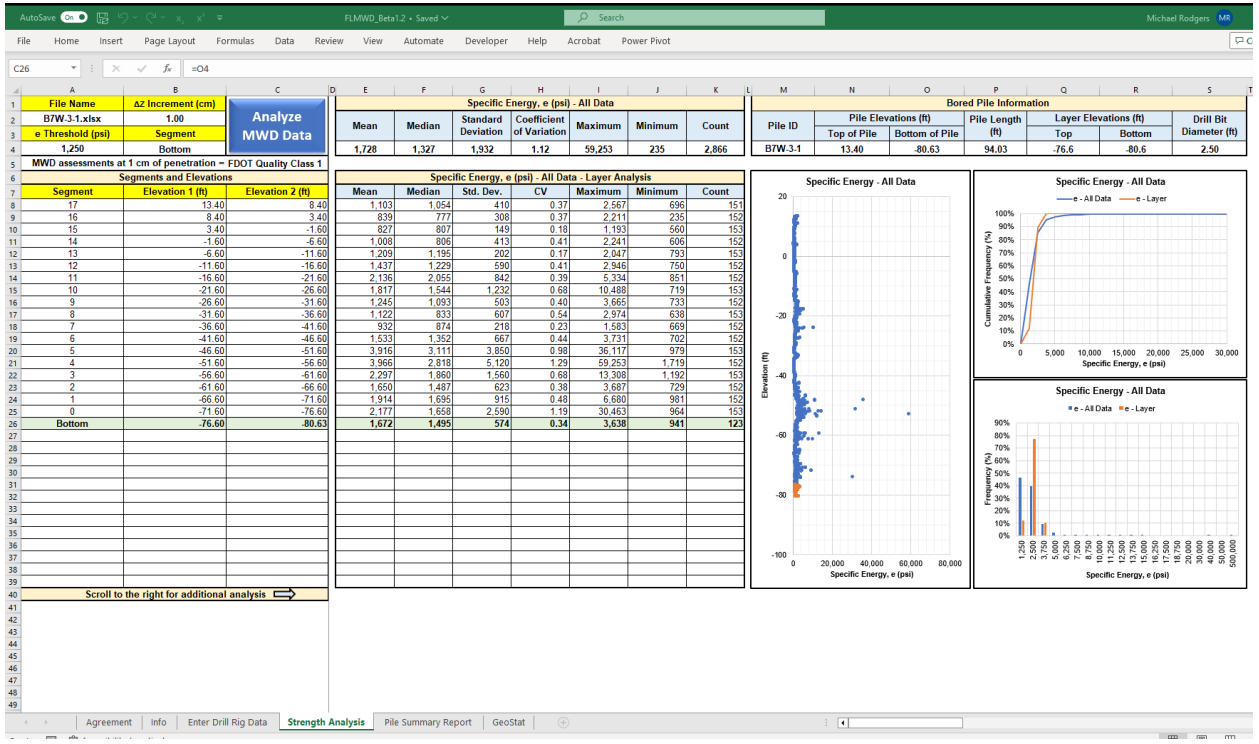



# Enter Drill Rig Data



# Strength Analysis



| File Name | Δz Increment (cm) | Analyze MWD Data |
|---|---|---|
| B7W-3-1.xlsx | 1.00 | |
| e Threshold (psi) | Segment | |
| 1,250 | Bottom | |

MWD assessments at 1 cm of penetration – FDOT Quality Class 1

Segments and Elevations

| Segment | Elevation 1 (ft) | Elevation 2 (ft) |
|---|---|---|
| 17 | 13.40 | 8.40 |
| 16 | 8.40 | 3.40 |
| 15 | 3.40 | -1.60 |
| 14 | -1.60 | -6.60 |
| 13 | -6.60 | -11.60 |
| 12 | -11.60 | -16.60 |
| 11 | -16.60 | -21.60 |
| 10 | -21.60 | -26.60 |
| 9 | -26.60 | -31.60 |
| 8 | -31.60 | -36.60 |
| 7 | -36.60 | -41.60 |
| 6 | -41.60 | -46.60 |
| 5 | -46.60 | -51.60 |
| 4 | -51.60 | -56.60 |
| 3 | -56.60 | -61.60 |
| 2 | -61.60 | -66.60 |
| 1 | -66.60 | -71.60 |
| 0 | -71.60 | -76.60 |
| Bottom | -76.60 | -80.63 |

Scroll to the right for additional analysis

Specific Energy, e (psi) - All Data

| Mean | Median | Standard Deviation | Coefficient of Variation | Maximum | Minimum | Count |
|---|---|---|---|---|---|---|
| 1,728 | 1,327 | 1,932 | 1.12 | 59,253 | 235 | 2,866 |

Specific Energy, e (psi) - All Data - Layer Analysis

| Segment | Mean | Median | Std. Dev. | CV | Maximum | Minimum | Count |
|---|---|---|---|---|---|---|---|
| 17 | 1,103 | 1,054 | 410 | 0.37 | 2,567 | 696 | 151 |
| 16 | 839 | 777 | 308 | 0.37 | 2,211 | 235 | 152 |
| 15 | 827 | 807 | 149 | 0.18 | 1,193 | 560 | 153 |
| 14 | 1,008 | 806 | 413 | 0.41 | 2,241 | 606 | 152 |
| 13 | 1,209 | 1,195 | 202 | 0.17 | 2,047 | 793 | 153 |
| 12 | 1,437 | 1,229 | 590 | 0.41 | 2,946 | 750 | 152 |
| 11 | 2,136 | 2,055 | 842 | 0.39 | 5,334 | 851 | 152 |
| 10 | 1,817 | 1,544 | 1,232 | 0.68 | 10,488 | 719 | 153 |
| 9 | 1,245 | 1,093 | 503 | 0.40 | 3,665 | 733 | 152 |
| 8 | 1,122 | 833 | 607 | 0.54 | 2,974 | 638 | 153 |
| 7 | 932 | 874 | 218 | 0.23 | 1,583 | 669 | 152 |
| 6 | 1,533 | 1,352 | 667 | 0.44 | 3,731 | 702 | 152 |
| 5 | 3,916 | 3,111 | 3,850 | 0.98 | 36,117 | 979 | 153 |
| 4 | 3,966 | 2,818 | 5,120 | 1.29 | 59,253 | 1,719 | 152 |
| 3 | 2,297 | 1,860 | 1,560 | 0.68 | 13,308 | 1,192 | 153 |
| 2 | 1,650 | 1,487 | 623 | 0.38 | 3,687 | 729 | 152 |
| 1 | 1,914 | 1,695 | 915 | 0.48 | 6,680 | 981 | 152 |
| 0 | 2,177 | 1,658 | 2,590 | 1.19 | 30,463 | 964 | 153 |
| Bottom | 1,672 | 1,495 | 574 | 0.34 | 3,638 | 941 | 123 |

Bored Pile Information

| Pile ID | Pile Elevations (ft) | | Pile Length (ft) | Layer Elevations (ft) | | Drill Bit Diameter (ft) |
|---|---|---|---|---|---|---|
| | Top of Pile | Bottom of Pile | | Top | Bottom | |
| B7W-3-1 | 13.40 | -80.63 | 94.03 | -76.6 | -80.6 | 2.50 |

Specific Energy - All Data

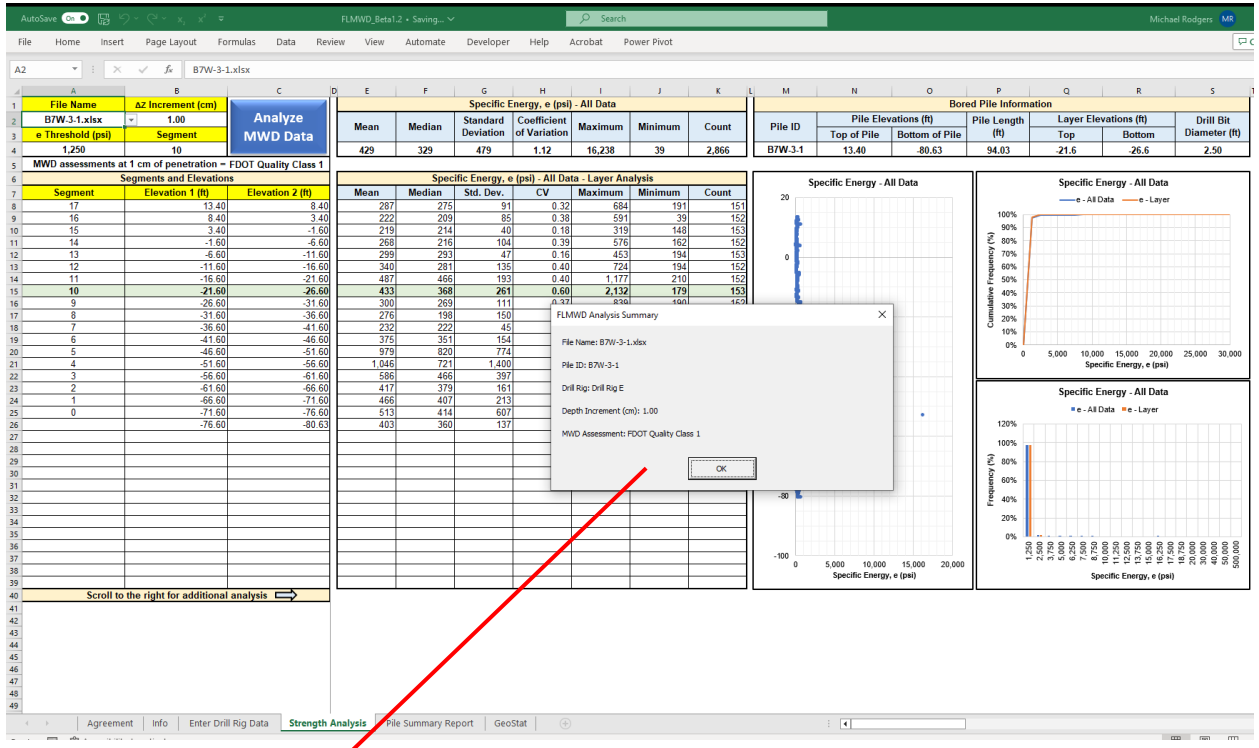



Specific Energy - All Data




Specific Energy - All Data



| File Name | Δz Increment (cm) | Analyze MWD Data |
|---|---|---|
| B7W-3-1.xlsx | 1.00 | |
| e Threshold (psi) | Segment | |
| 1,250 | 10 | |

MWD assessments at 1 cm of penetration – FDOT Quality Class 1

Segments and Elevations

| Segment | Elevation 1 (ft) | Elevation 2 (ft) |
|---|---|---|
| 17 | 13.40 | 8.40 |
| 16 | 8.40 | 3.40 |
| 15 | 3.40 | -1.60 |
| 14 | -1.60 | -6.60 |
| 13 | -6.60 | -11.60 |
| 12 | -11.60 | -16.60 |
| 11 | -16.60 | -21.60 |
| 10 | -21.60 | -26.60 |
| 9 | -26.60 | -31.60 |
| 8 | -31.60 | -36.60 |
| 7 | -36.60 | -41.60 |
| 6 | -41.60 | -46.60 |
| 5 | -46.60 | -51.60 |
| 4 | -51.60 | -56.60 |
| 3 | -56.60 | -61.60 |
| 2 | -61.60 | -66.60 |
| 1 | -66.60 | -71.60 |
| 0 | -71.60 | -76.60 |
| | -76.60 | -80.63 |

Scroll to the right for additional analysis

Specific Energy, e (psi) - All Data

| Mean | Median | Standard Deviation | Coefficient of Variation | Maximum | Minimum | Count |
|---|---|---|---|---|---|---|
| 429 | 329 | 479 | 1.12 | 16,238 | 39 | 2,866 |

Specific Energy, e (psi) - All Data - Layer Analysis

| Segment | Mean | Median | Std. Dev. | CV | Maximum | Minimum | Count |
|---|---|---|---|---|---|---|---|
| 17 | 287 | 275 | 91 | 0.32 | 684 | 191 | 151 |
| 16 | 222 | 209 | 85 | 0.38 | 591 | 39 | 152 |
| 15 | 219 | 214 | 40 | 0.18 | 319 | 148 | 153 |
| 14 | 268 | 216 | 104 | 0.39 | 576 | 162 | 152 |
| 13 | 299 | 293 | 47 | 0.16 | 453 | 194 | 153 |
| 12 | 340 | 281 | 135 | 0.40 | 724 | 194 | 152 |
| 11 | 487 | 466 | 193 | 0.40 | 1,177 | 210 | 152 |
| 10 | 433 | 368 | 261 | 0.60 | 2,132 | 179 | 153 |
| 9 | 300 | 269 | 111 | 0.37 | 839 | 190 | 152 |
| 8 | 276 | 198 | 150 | | | | |
| 7 | 232 | 222 | 45 | | | | |
| 6 | 375 | 351 | 154 | | | | |
| 5 | 979 | 820 | 774 | | | | |
| 4 | 1,046 | 721 | 1,400 | | | | |
| 3 | 586 | 466 | 397 | | | | |
| 2 | 417 | 379 | 161 | | | | |
| 1 | 466 | 407 | 213 | | | | |
| 0 | 513 | 414 | 607 | | | | |
| | 403 | 360 | 137 | | | | |

Bored Pile Information

| Pile ID | Pile Elevations (ft) | | Pile Length (ft) | Layer Elevations (ft) | | Drill Bit Diameter (ft) |
|---|---|---|---|---|---|---|
| | Top of Pile | Bottom of Pile | | Top | Bottom | |
| B7W-3-1 | 13.40 | -80.63 | 94.03 | -21.6 | -26.6 | 2.50 |



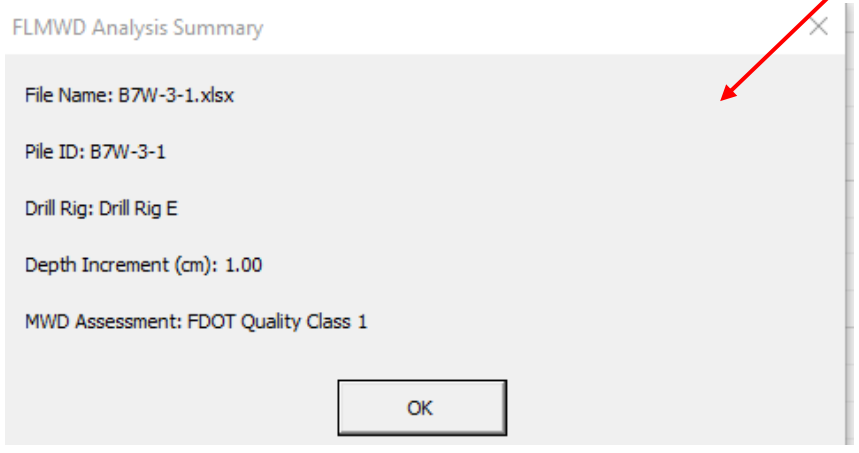






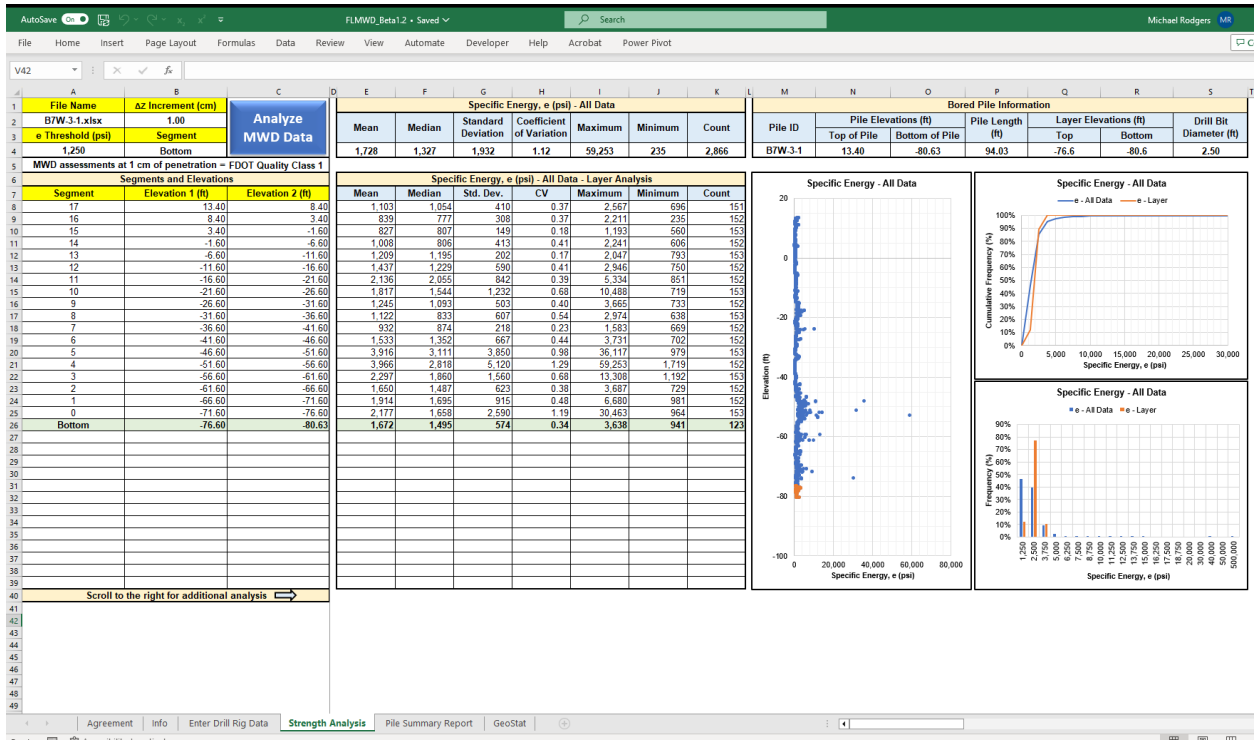






# Strength Analysis – Specific Energy Threshold

## All Specific Energy Data



| File Name | Δz Increment (cm) | Analyze MWD Data |
|---|---|---|
| B7W-3-1.xlsx | 1.00 | |
| e Threshold (psi) | Segment | |
| 1,250 | Bottom | |

MWD assessments at 1 cm of penetration = FDOT Quality Class 1

**Segments and Elevations**

| Segment | Elevation 1 (ft) | Elevation 2 (ft) |
|---|---|---|
| 17 | 13.40 | 8.40 |
| 16 | 8.40 | 3.40 |
| 15 | 3.40 | -1.60 |
| 14 | -1.60 | -6.60 |
| 13 | -6.60 | -11.60 |
| 12 | -11.60 | -16.60 |
| 11 | -16.60 | -21.60 |
| 10 | -21.60 | -26.60 |
| 9 | -26.60 | -31.60 |
| 8 | -31.60 | -36.60 |
| 7 | -36.60 | -41.60 |
| 6 | -41.60 | -46.60 |
| 5 | -46.60 | -51.60 |
| 4 | -51.60 | -56.60 |
| 3 | -56.60 | -61.60 |
| 2 | -61.60 | -66.60 |
| 1 | -66.60 | -71.60 |
| 0 | -71.60 | -76.60 |
| Bottom | -76.60 | -80.63 |

Scroll to the right for additional analysis

**Specific Energy, e (psi) - All Data**

| Mean | Median | Standard Deviation | Coefficient of Variation | Maximum | Minimum | Count |
|---|---|---|---|---|---|---|
| 1,728 | 1,327 | 1,932 | 1.12 | 59,253 | 235 | 2,866 |

**Specific Energy, e (psi) - All Data - Layer Analysis**

| Mean | Median | Std. Dev. | CV | Maximum | Minimum | Count |
|---|---|---|---|---|---|---|
| 1,103 | 1,054 | 410 | 0.37 | 2,567 | 696 | 151 |
| 839 | 777 | 308 | 0.37 | 2,211 | 235 | 152 |
| 827 | 807 | 149 | 0.18 | 1,193 | 560 | 153 |
| 1,008 | 806 | 413 | 0.41 | 2,241 | 606 | 152 |
| 1,209 | 1,195 | 202 | 0.17 | 2,047 | 793 | 153 |
| 1,437 | 1,229 | 590 | 0.41 | 2,946 | 750 | 152 |
| 2,136 | 2,055 | 842 | 0.39 | 5,334 | 851 | 152 |
| 1,817 | 1,544 | 1,232 | 0.68 | 10,488 | 719 | 153 |
| 1,245 | 1,093 | 503 | 0.40 | 3,665 | 733 | 152 |
| 1,122 | 833 | 607 | 0.54 | 2,974 | 638 | 153 |
| 932 | 874 | 218 | 0.23 | 1,583 | 669 | 152 |
| 1,533 | 1,352 | 667 | 0.44 | 3,731 | 702 | 152 |
| 3,916 | 3,111 | 3,850 | 0.98 | 36,117 | 979 | 153 |
| 3,966 | 2,818 | 5,120 | 1.29 | 59,253 | 1,719 | 152 |
| 2,297 | 1,860 | 1,560 | 0.68 | 13,308 | 1,192 | 153 |
| 1,650 | 1,487 | 623 | 0.38 | 3,687 | 729 | 152 |
| 1,914 | 1,695 | 915 | 0.48 | 6,680 | 981 | 152 |
| 2,177 | 1,658 | 2,590 | 1.19 | 30,463 | 964 | 153 |
| 1,672 | 1,495 | 574 | 0.34 | 3,638 | 941 | 123 |

**Bored Pile Information**

| Pile ID | Pile Elevations (ft) | | Pile Length (ft) | Layer Elevations (ft) | | Drill Bit Diameter (ft) |
|---|---|---|---|---|---|---|
| | Top of Pile | Bottom of Pile | | Top | Bottom | |
| B7W-3-1 | 13.40 | -80.63 | 94.03 | -76.6 | -80.6 | 2.50 |

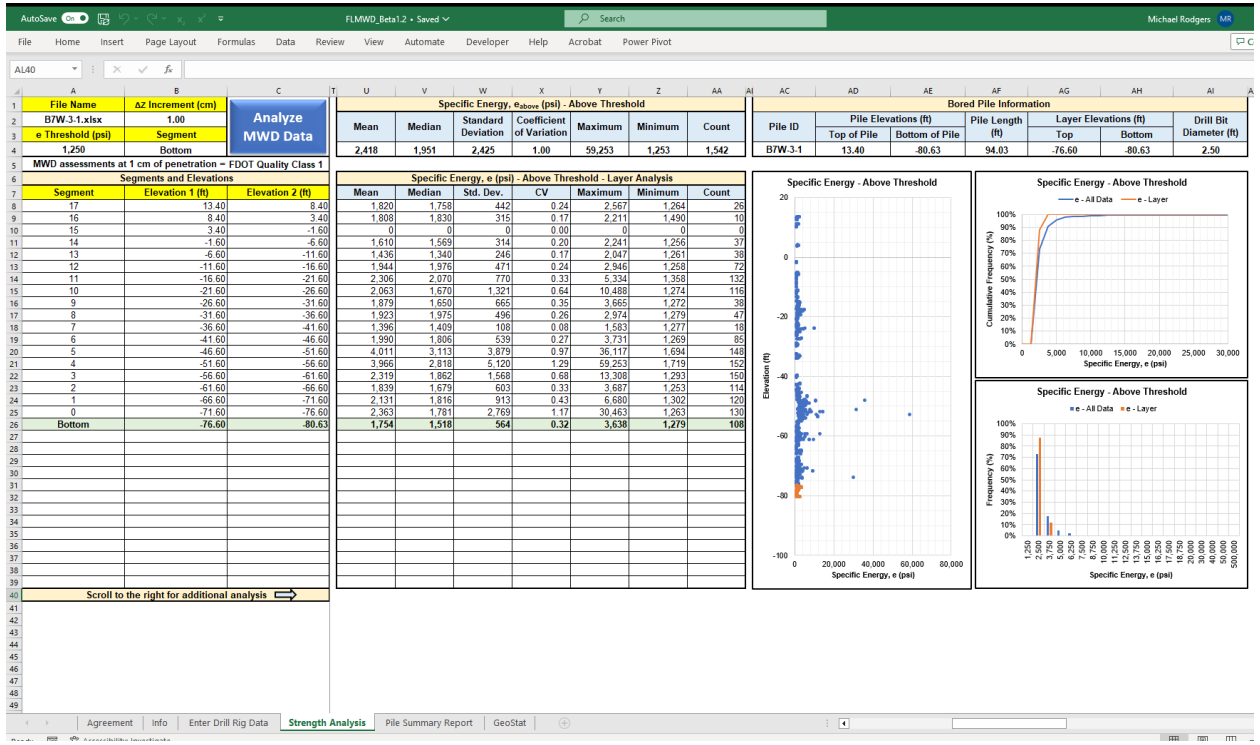






Agreement | Info | Enter Drill Rig Data | Strength Analysis | Pile Summary Report | GeoStat

## Only Specific Energy Data Above Threshold



| File Name | Δz Increment (cm) | Analyze MWD Data |
|---|---|---|
| B7W-3-1.xlsx | 1.00 | |
| e Threshold (psi) | Segment | |
| 1,250 | Bottom | |

MWD assessments at 1 cm of penetration = FDOT Quality Class 1

**Segments and Elevations**

| Segment | Elevation 1 (ft) | Elevation 2 (ft) |
|---|---|---|
| 17 | 13.40 | 8.40 |
| 16 | 8.40 | 3.40 |
| 15 | 3.40 | -1.60 |
| 14 | -1.60 | -6.60 |
| 13 | -6.60 | -11.60 |
| 12 | -11.60 | -16.60 |
| 11 | -16.60 | -21.60 |
| 10 | -21.60 | -26.60 |
| 9 | -26.60 | -31.60 |
| 8 | -31.60 | -36.60 |
| 7 | -36.60 | -41.60 |
| 6 | -41.60 | -46.60 |
| 5 | -46.60 | -51.60 |
| 4 | -51.60 | -56.60 |
| 3 | -56.60 | -61.60 |
| 2 | -61.60 | -66.60 |
| 1 | -66.60 | -71.60 |
| 0 | -71.60 | -76.60 |
| Bottom | -76.60 | -80.63 |

Scroll to the right for additional analysis

**Specific Energy, $e_{above}$ (psi) - Above Threshold**

| Mean | Median | Standard Deviation | Coefficient of Variation | Maximum | Minimum | Count |
|---|---|---|---|---|---|---|
| 2,418 | 1,951 | 2,425 | 1.00 | 59,253 | 1,253 | 1,542 |

**Specific Energy, e (psi) - Above Threshold - Layer Analysis**

| Mean | Median | Std. Dev. | CV | Maximum | Minimum | Count |
|---|---|---|---|---|---|---|
| 1,820 | 1,758 | 442 | 0.24 | 2,567 | 1,264 | 26 |
| 1,808 | 1,830 | 315 | 0.17 | 2,211 | 1,490 | 10 |
| 0 | 0 | 0 | 0.00 | 0 | 0 | 0 |
| 1,610 | 1,569 | 314 | 0.20 | 2,241 | 1,256 | 37 |
| 1,436 | 1,340 | 246 | 0.17 | 2,047 | 1,261 | 38 |
| 1,944 | 1,976 | 471 | 0.24 | 2,946 | 1,258 | 72 |
| 2,306 | 2,070 | 770 | 0.33 | 5,334 | 1,358 | 132 |
| 2,063 | 1,670 | 1,321 | 0.64 | 10,488 | 1,274 | 116 |
| 1,879 | 1,650 | 665 | 0.35 | 3,665 | 1,272 | 38 |
| 1,923 | 1,975 | 496 | 0.26 | 2,974 | 1,279 | 47 |
| 1,396 | 1,409 | 108 | 0.08 | 1,583 | 1,277 | 18 |
| 1,990 | 1,806 | 539 | 0.27 | 3,731 | 1,269 | 85 |
| 4,011 | 3,113 | 3,879 | 0.97 | 36,117 | 1,694 | 148 |
| 3,966 | 2,818 | 5,120 | 1.29 | 59,253 | 1,719 | 152 |
| 2,319 | 1,862 | 1,568 | 0.68 | 13,308 | 1,293 | 150 |
| 1,839 | 1,679 | 603 | 0.33 | 3,687 | 1,253 | 114 |
| 2,131 | 1,816 | 913 | 0.43 | 6,680 | 1,302 | 120 |
| 2,363 | 1,781 | 2,769 | 1.17 | 30,463 | 1,263 | 130 |
| 1,754 | 1,518 | 564 | 0.32 | 3,638 | 1,279 | 108 |

**Bored Pile Information**

| Pile ID | Pile Elevations (ft) | | Pile Length (ft) | Layer Elevations (ft) | | Drill Bit Diameter (ft) |
|---|---|---|---|---|---|---|
| | Top of Pile | Bottom of Pile | | Top | Bottom | |
| B7W-3-1 | 13.40 | -80.63 | 94.03 | -76.60 | -80.63 | 2.50 |



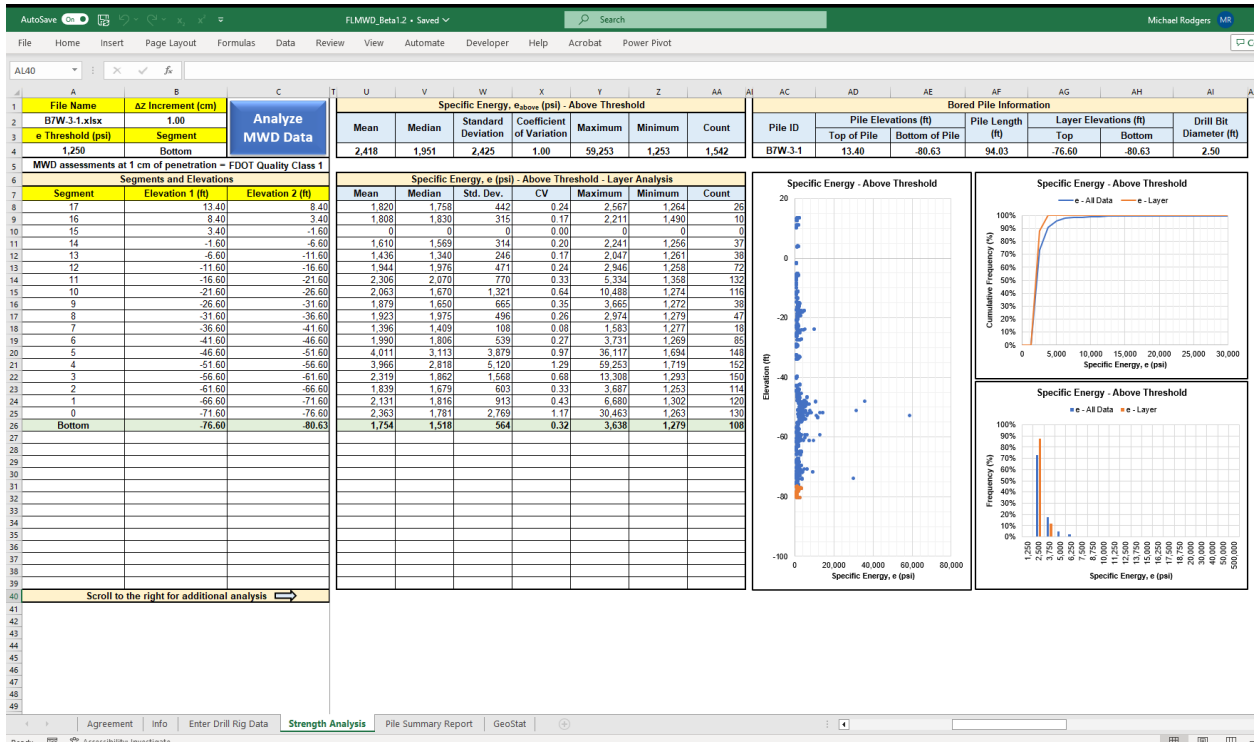




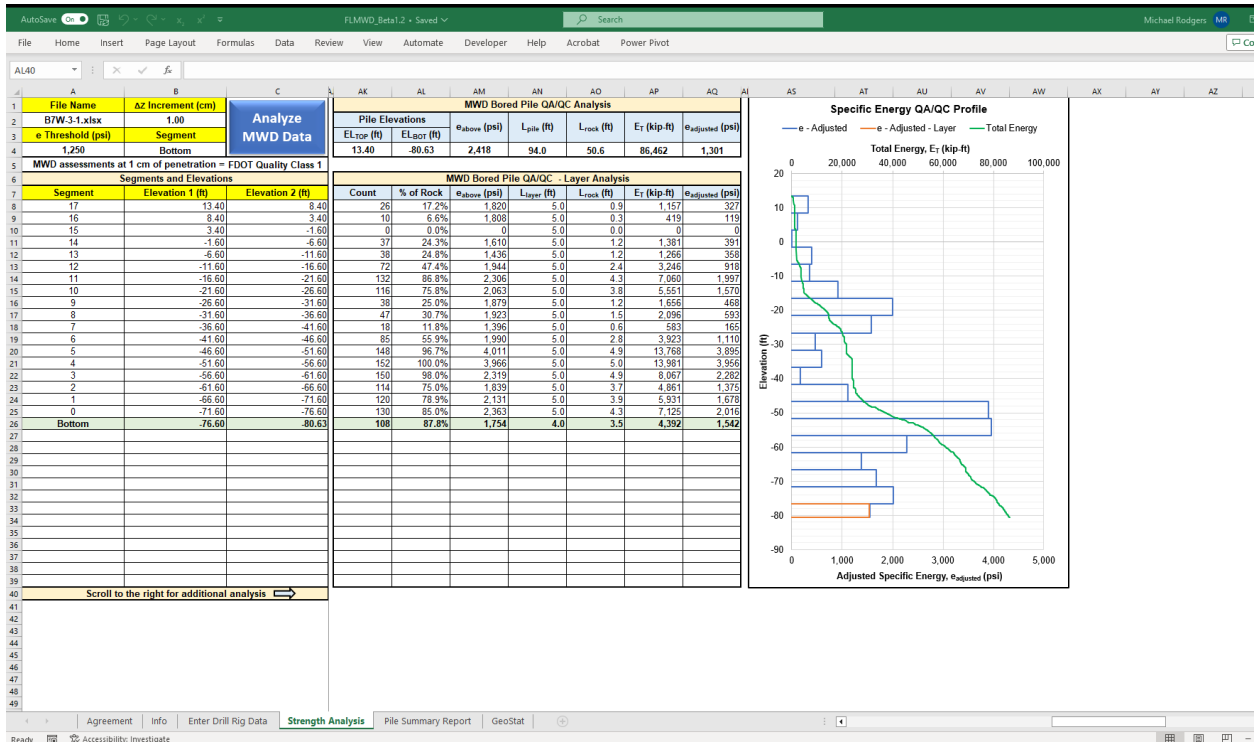
Agreement | Info | Enter Drill Rig Data | Strength Analysis | Pile Summary Report | GeoStat

# Strength Analysis – Specific Energy Threshold

Only Specific Energy Data Above Threshold



Bored Pile QA/QC Analysis



# Pile Summary Report

## MWD Summary Report

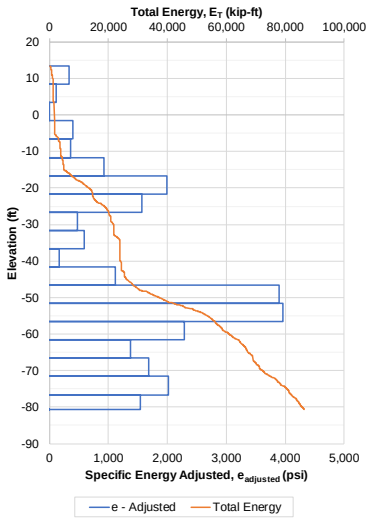
| Engineer | Pile ID | Drill Rig | Drill Bit Diameter (in) |
|---|---|---|---|
| Michael Rodgers | 7W-3-1 | Drill Rig B | 30 |
| **Project** | **Location** | **Top of Pile Elevation (ft)** | **Bottom of Pile Elevation (ft)** |
| UF Demo | Gainesville, FL | 13.40 | -80.63 |
| **Station** | **Offset (ft)** | **Depth Increment Analyzed (cm)** | **MWD Assessment** |
| 100+00.01 | 10.00 | 1.00 | FDOT Quality Class 1 |

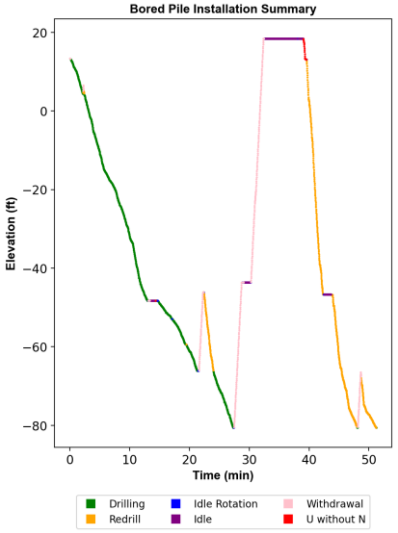
| Specific Energy, e (psi) - All Data | |
|---|---|
| Mean | 1,728 |
| Median | 1,327 |
| Standard Deviation | 1,932 |
| Coefficient of Variation (CV) | 1.12 |
| Maximum | 59,253 |
| Minimum | 235 |
| Number of Data Points | 2,866 |

| ACIP Pile QA/QC - Rock Socket Assessment | |
|---|---|
| Pile Length (ft) | 94.03 |
| Total Rock Socket Length (ft) | 50.59 |
| Pile Pecentage of Rock (%) | 54% |
| Specific Energy Threshold (psi) | 1,250 |
| Specific Energy, $e_{above}$ (psi) | 2,418 |
| Specific Energy, $e_{adjusted}$ (psi) | 1,301 |
| Total Energy, $E_T$ (kip-ft) | 86,469 |

| Specific Energy, $e_{above}$ (psi) - Above Threshold | |
|---|---|
| Mean | 2,418 |
| Median | 1,951 |
| Standard Deviation | 2,425 |
| Coefficient of Variation (CV) | 1.00 |
| Maximum | 59,253 |
| Minimum | 1,253 |
| Number of Data Points | 1,542 |

| Bored Pile Installation Summary - Time (min) | |
|---|---|
| Drilling | 23.33 |
| Redrill | 11.43 |
| Idle Rotation | 1.55 |
| Idle | 9.10 |
| Withdraw | 5.33 |
| Penetration without Rotation | 0.52 |
| Total | 51.27 |




**Notes:**

Enter notes here.

**Date of Analysis:** 8/12/2024

Create PDF

MWD Summary Report PDF Address

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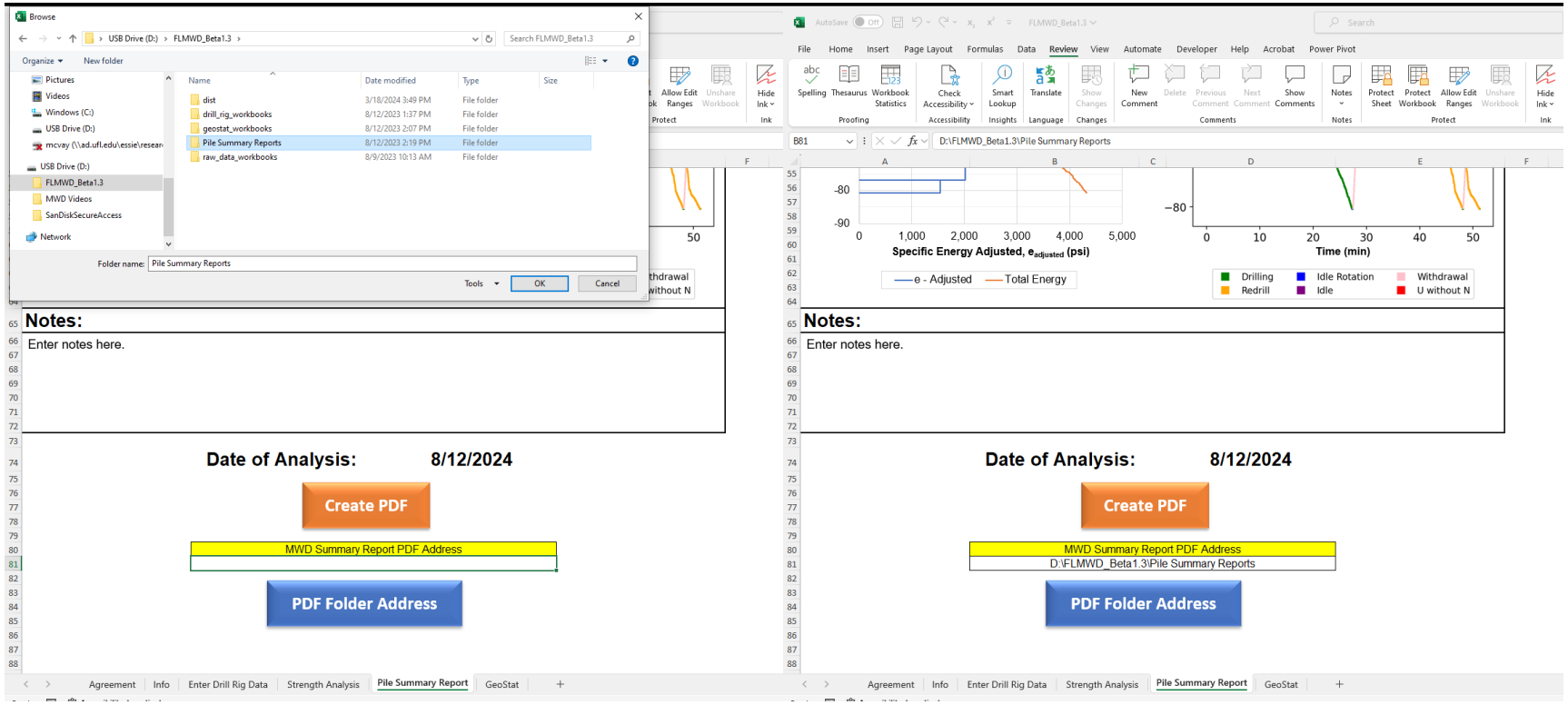
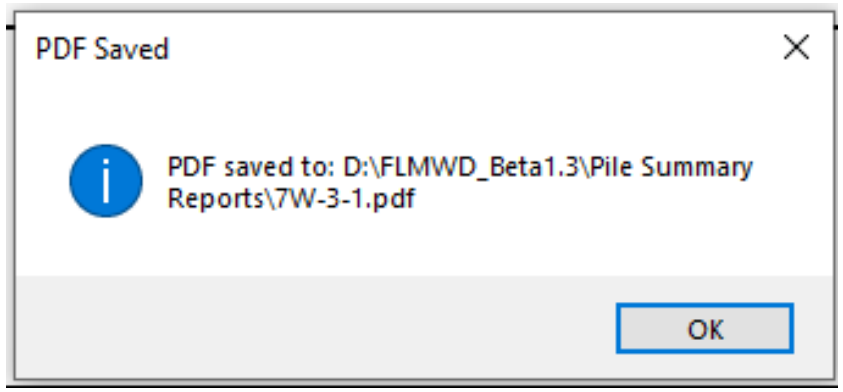
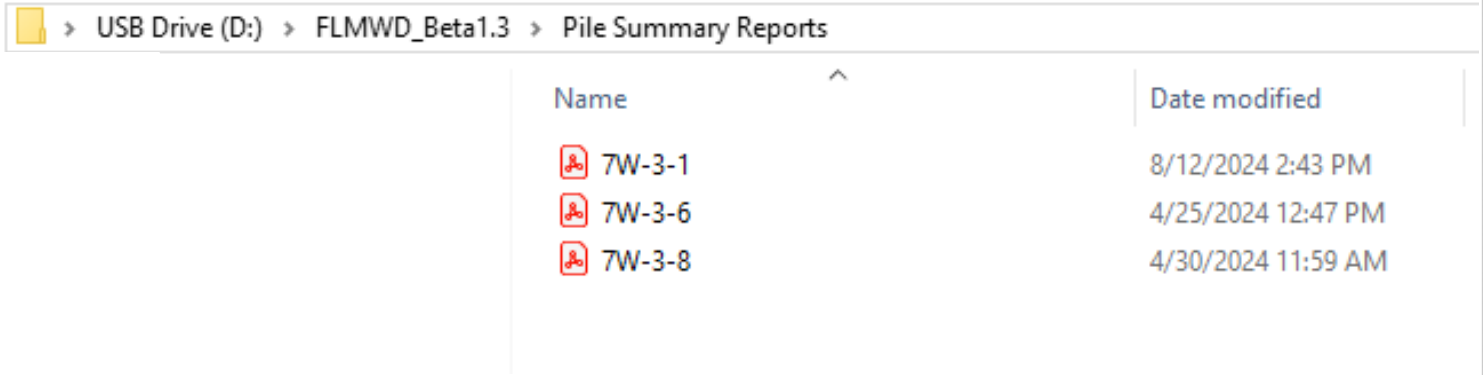
PDF Folder Address



# Pile Summary Report




FDOT

## MWD Summary Report

| Engineer | Pile ID | Drill Rig | Drill Bit Diameter (in) |
|---|---|---|---|
| Michael Rodgers | 7W-3-1 | Drill Rig B | 30 |
| **Project** | **Location** | **Top of Pile Elevation (ft)** | **Bottom of Pile Elevation (ft)** |
| UF Demo | Gainesville, FL | 13.40 | -80.63 |
| **Station** | **Offset (ft)** | **Depth Increment Analyzed (cm)** | **MWD Assessment** |
| 100+00.01 | 10.00 | 1.00 | FDOT Quality Class 1 |

| Specific Energy, e (psi) - All Data | |
|---|---|
| Mean | 1,728 |
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| Standard Deviation | 1,932 |
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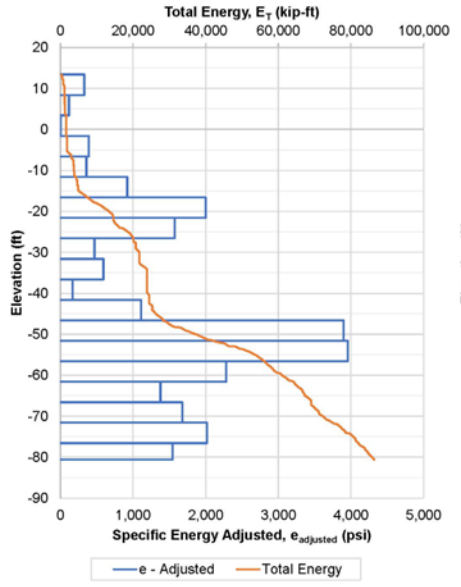


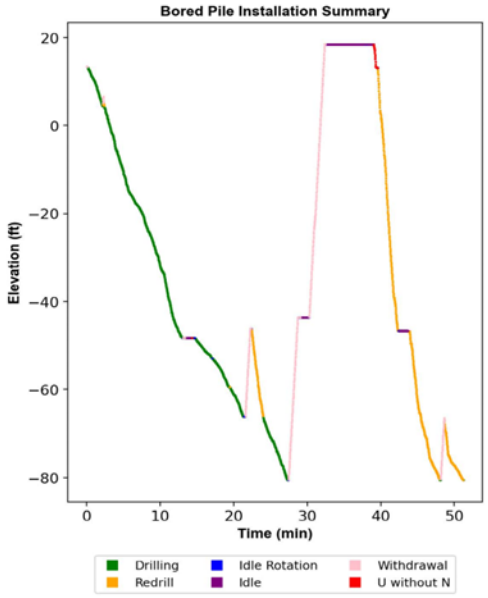


**Notes:**

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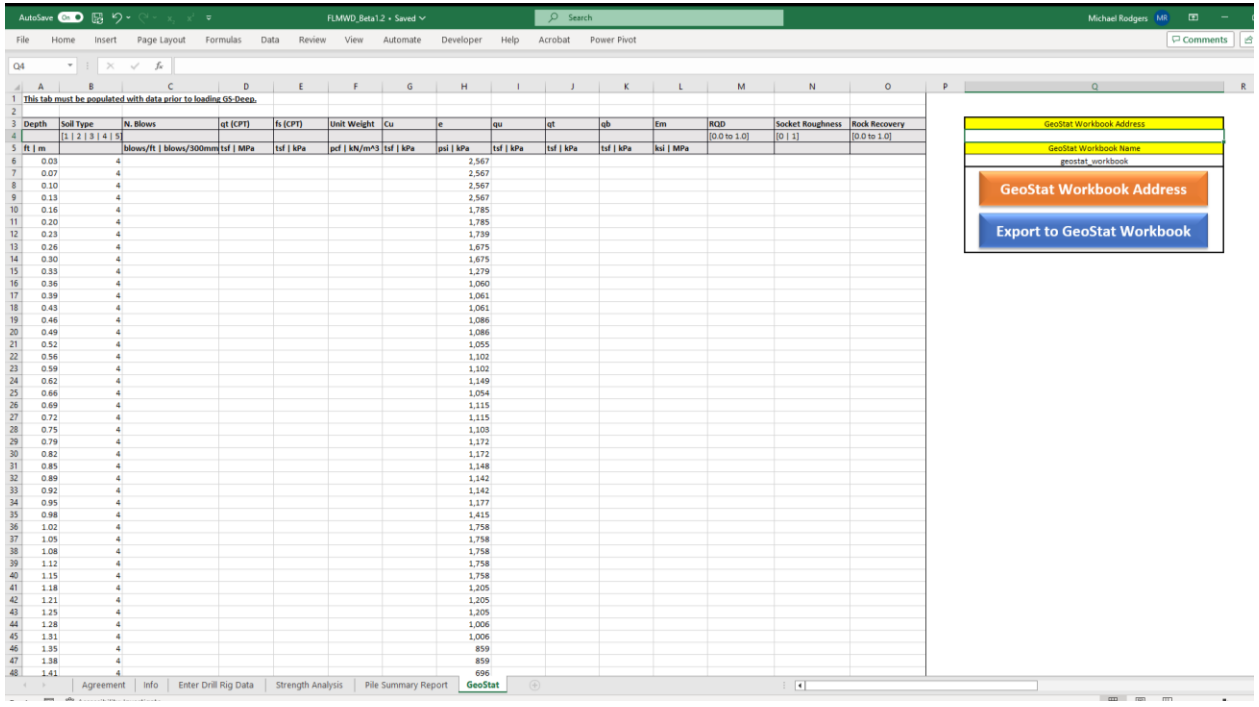
**Date of Analysis:** **8/12/2024**

# GeoStat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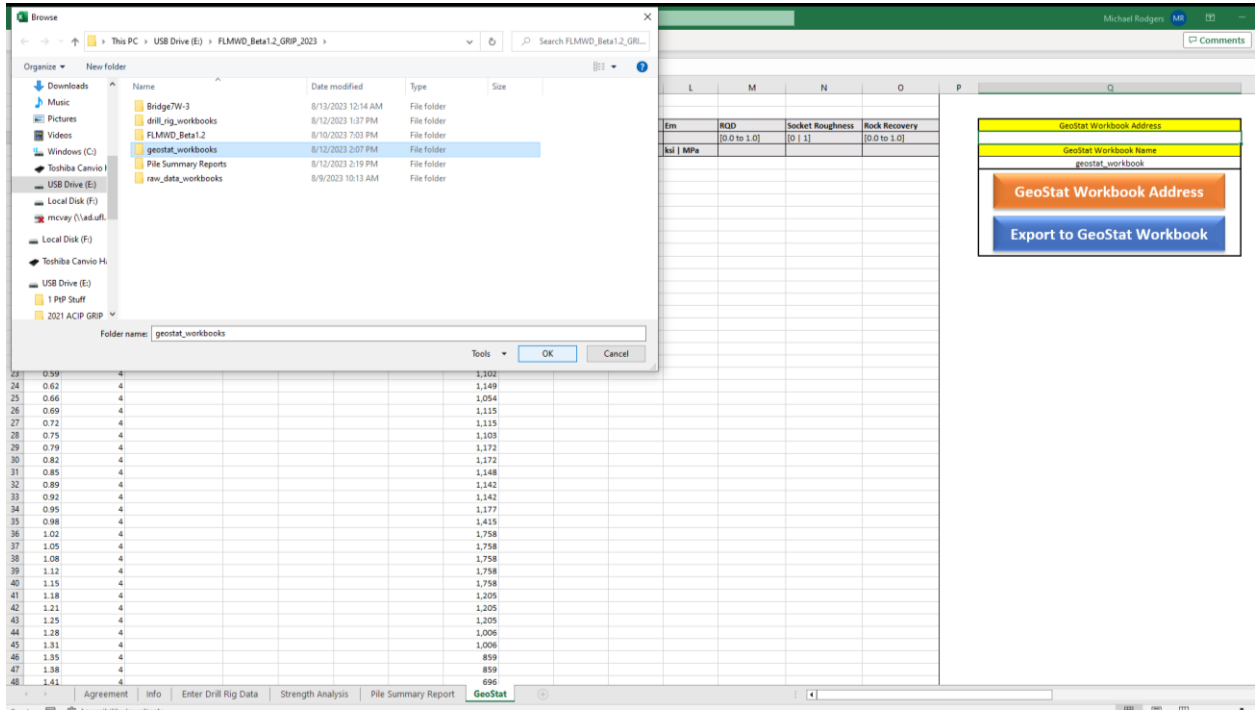
Strength Analysis
Pile Summary Report
GeoStat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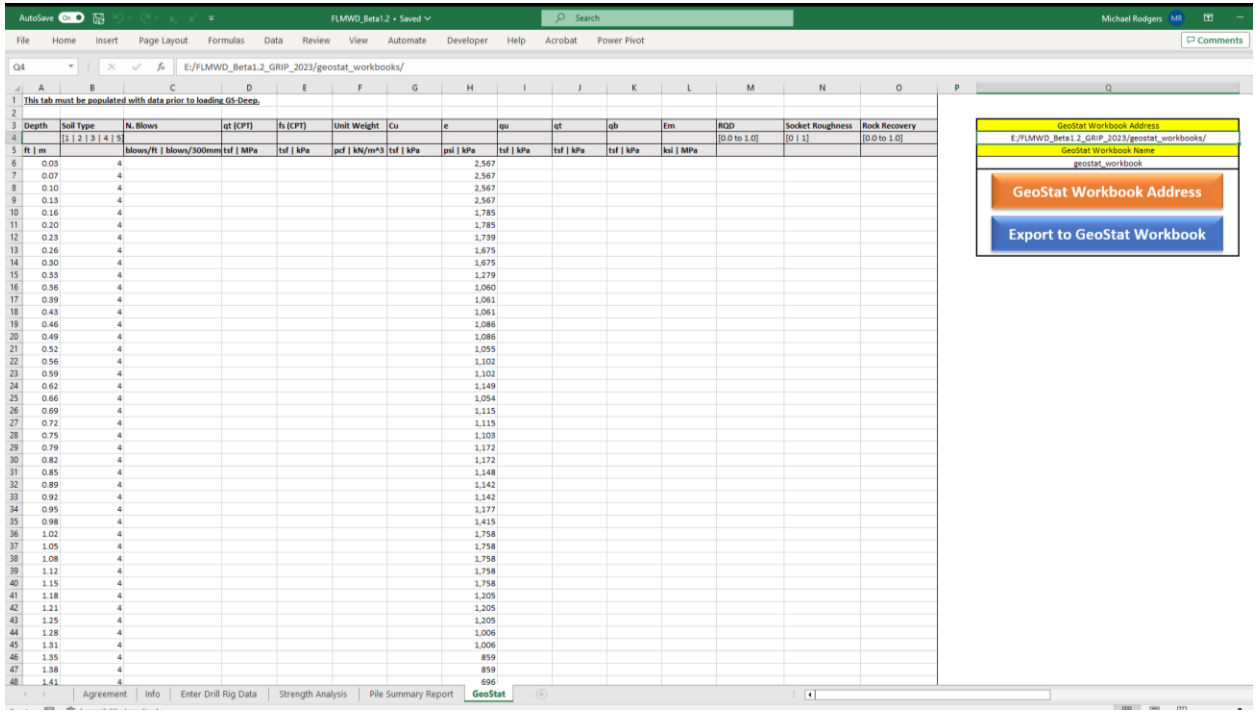
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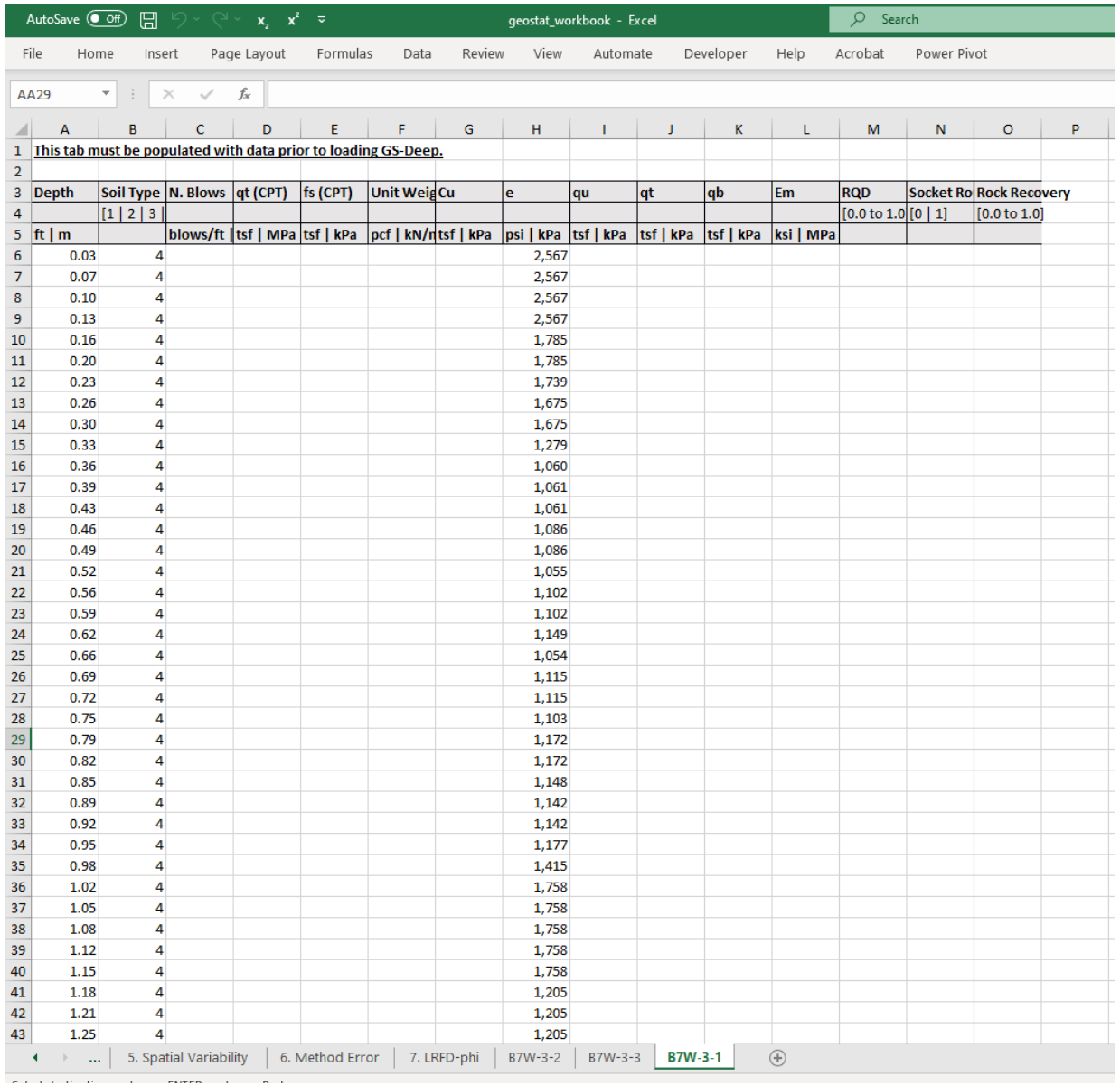
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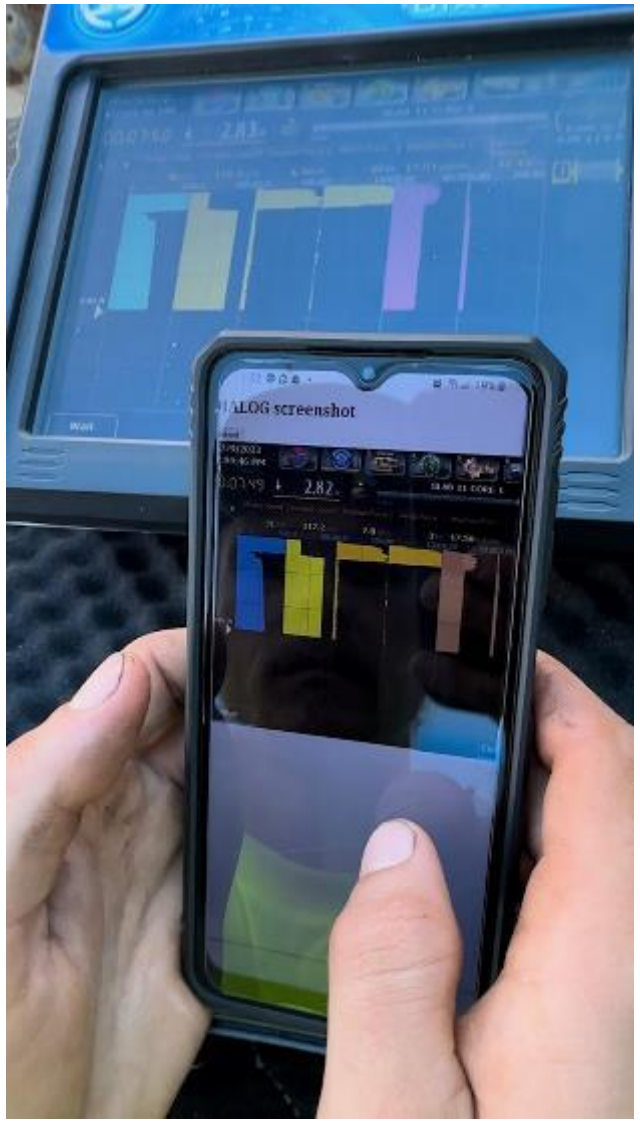
B7W-3-2
B7W-3-3
B7W-3-1

# Task 2 – Real Time, On-site and Remote QC Monitoring Implementation Feasibility Study

- The new data analysis tool will greatly improve drilled shaft QA/QC as the quality and lengths of rock sockets can be verified through specific energy obtained from MWD
- When MWD-load test correlations can be established for a site or region, the QA portion of the procedure is improved by allowing the shaft's axial capacity to be estimated to ensure it meets design criteria, directly
- However, the quality control (QC) portion of the procedure could be further improved by providing real-time measurements of specific energy, total energy, and side shear axial shaft capacity during the drilling process

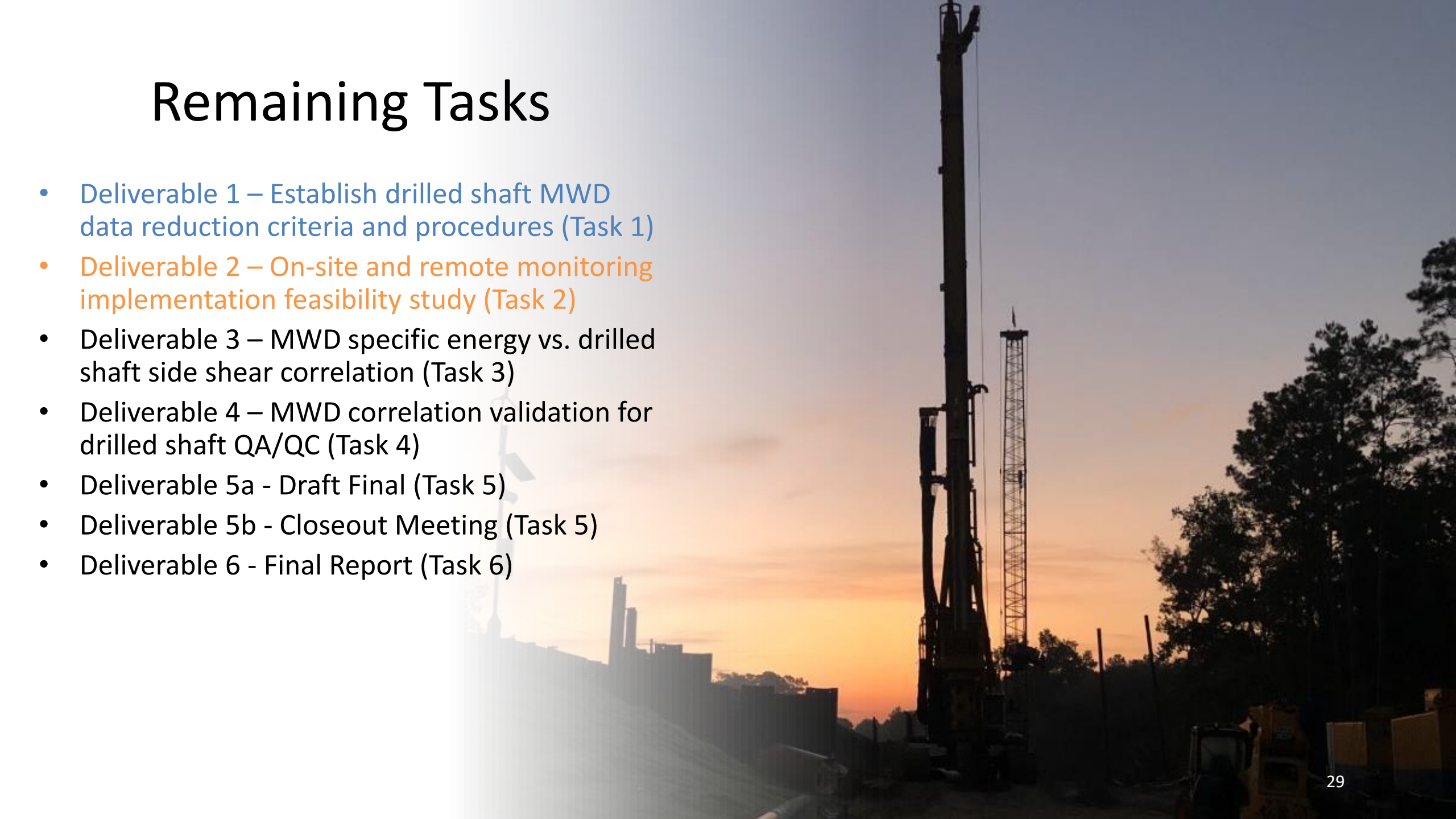
# Task 2 – Real Time, On-site and Remote QC Monitoring Implementation Feasibility Study

- Can currently view drilling parameters live
- Need to develop a robust method that can transmit MWD data that is applicable to all monitoring systems
  - Likely through CAN bus integration
  - Will be tested during BED31-977-03 in a controlled setting
  - SBC module can transmit actual data on-site and to remote locations via CAN and Modem hats added in
- Moving in the direction of remote monitoring being demonstrated during this project
  - Live data is sent to a satellite server that can be accessed via the FLMWD Excel UI, filtered, cleaned, and analyzed in the office
    - Creates a viable path forward for remote monitoring and live analysis in the office
    - Will be tested with the Jean Lutz system very soon



# Remaining Tasks

- Deliverable 1 – Establish drilled shaft MWD data reduction criteria and procedures (Task 1)
- Deliverable 2 – On-site and remote monitoring implementation feasibility study (Task 2)
- Deliverable 3 – MWD specific energy vs. drilled shaft side shear correlation (Task 3)
- Deliverable 4 – MWD correlation validation for drilled shaft QA/QC (Task 4)
- Deliverable 5a - Draft Final (Task 5)
- Deliverable 5b - Closeout Meeting (Task 5)
- Deliverable 6 - Final Report (Task 6)



# Questions?