400801
Email Scanned

From: Todd Plating <tplating@synterracorp.com>
Sent: Monday, November 2, 2020 5:01 PM
To: Cassidy, Greg <cassidga@dhec.sc.gov>
Cc: Powell, Richard E. <Richard.Powell2@duke-energy.com>; Andrew Brey <ABrey@Geosyntec.com>
Subject: Former Bramlette MGP Aquifer Performance Test Work Plan

Greg,

Please see the attached Aquifer Performance Test work plan for the former Bramlette MGP located in Greenville, SC. Due to file size I would appreciate confirmation of receipt. We look forward to discussing any potential questions or comments you may have regarding this scope of work.

Best Regards,

Todd Plating, P.G.*

synTerra
148 River Street, Suite 220
Greenville, South Carolina 29601
Main: 864.421.9999
Mobile: 864.420.8656
Email: tplating@synterracorp.com
www.synterracorp.com

* **Registered in SC, NC**
Connect with us: Linkedin | Facebook| Twitter

84a

400801
Email Scanned

Science & Engineering Consultants
synterracorp.com

Aquifer Performance Test Work Plan for the Former Bramlette MGP

Former Bramlette MGP Site

November 2020

Prepared For

Duke Energy Carolinas

Duke Energy Carolinas, LLC

South Carolina
SynTerra Corporation
No. C00623
Certificate of Authorization

Todd David Plating
Registered
No. 2620
South Carolina
Professional Geologist

Todd Plating, SC PG
Sr. Project Manager

Eric Hicks
Registered
No. 1171
South Carolina
Professional Geologist

Eric Hicks, SC PG
Sr. Hydrogeologist

Johnathan Ebenhack
Hydrogeologist

84a

TABLE OF CONTENTS

SECTION **PAGE**

1.0 INTRODUCTION 1-1
- 1.1 Objectives 1-1
- 1.2 Summary of the Hydrogeologic Conceptual Site Model 1-2
- 1.3 Fractured Bedrock Characteristics 1-4

2.0 FIELD DATA AND METHODS 2-1
- 2.1 Historical Data Review 2-1
- 2.2 Hydrograph Evaluation 2-2
- 2.3 Pneumatic Interference Slug Testing 2-4
- 2.4 Well Installation 2-5
- 2.5 Well Development 2-10
- 2.6 Well Surveying 2-11
- 2.7 Aquifer Performance Testing 2-11
  - 2.7.1 Static Groundwater Level Collection 2-11
  - 2.7.2 Pump Installation 2-12
  - 2.7.3 Step-Drawdown Test 2-14
  - 2.7.4 Step-Drawdown Test Recovery 2-14
  - 2.7.5 Constant Rate Pumping Test 2-15
  - 2.7.6 Constant Rate Pumping Test Recovery 2-16
  - 2.7.7 Groundwater Sampling 2-16
- 2.8 Investigation-Derived Waste Management 2-17

3.0 DATA EVALUATION 3-1
- 3.1 Hydrograph Evaluation 3-1
- 3.2 Pneumatic Interference Slug Test Evaluation 3-1
- 3.3 Static Groundwater Level Analysis Corrections 3-1
- 3.4 Step-Drawdown Test Analysis 3-2
- 3.5 Constant Rate Pump Test Analysis: Analytical Methods 3-2
- 3.6 Constant Rate Pump Test Analysis: Numerical Modeling 3-2

4.0 SCHEDULE AND REPORTING 4-1

5.0 REFERENCES 5-1

LIST OF FIGURES

Figure 1-1	USGS Topographic Map
Figure 1-2	Site Layout Map (September 2020)
Figure 1-3	Cross Section A-A′
Figure 1-4	Cross Section B-B′
Figure 1-5	Cross Section C-C′
Figure 1-6	Cross Section D-D′
Figure 1-7	Water Level Map Shallow Zone (Alluvial/Saprolite)
Figure 1-8	Water Level Map Transition Zone
Figure 1-9	Water Level Map Bedrock Zone
Figure 2-1	Alluvium/Saprolite Hydraulic Conductivity Values from Slug Tests
Figure 2-2	Transition Zone Hydraulic Conductivity Values from Slug Tests
Figure 2-3	Bedrock Zone Hydraulic Conductivity Values from Slug Tests
Figure 2-4	Proposed Pressure Transducer Locations for the Hydrograph Evaluation
Figure 2-5	Pneumatic Well Head Assembly Diagram
Figure 2-6	Bedrock Pumping Well Schematic
Figure 2-7	Potential Location for the Proposed Aquifer Performance Test Pumping Well
Figure 2-8	Shallow Observation Well Schematic
Figure 2-9	Bedrock Observation Well Schematic
Figure 2-10	Typical Flow Meter Configuration
Figure 2-11	Typical Drawdown Curve

LIST OF TABLES

Table 2-1	Summary of Hydraulic Conductivity Values from Slug Testing

LIST OF APPENDICES

Appendix A	Geophysical Logging Report: MW-02BR, MW-21BR, MW-29BR, MW-34BR, MW-35BR, MW-36BR, MW-37BR, MW-39BR, MW-42BR
Appendix B	Field Procedures for Conducting Pneumatic Interference Slug Tests

LIST OF ACRONYMS

amsl	above mean sea level
APT	Aquifer Performance Test
APT-WP	Aquifer Performance Test Work Plan
bls	below land surface
BOD	biological oxygen demand
COD	chemical oxygen demand
COI	constituent of interest
COVID-19	corona virus 2019 disease
CSM	conceptual site model
CWG	carbureted water gas
CXT	CX Transportation
FS	feasibility study
gpm	gallons per minute
HSA	hollow stem augers
ID	inner diameter
IDW	investigative derived waste
KGS	Kansas Geological Survey
MDL	method detection limit
MGP	manufactured gas plant
NAPL	non-aqueous phase liquid
NPDES	National Pollutant Discharge Elimination System
OLM	oil-like material
PAHs	polycyclic aromatic hydrocarbons
pH	potential of hydrogen
PIST	pneumatic interference slug testing
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
RI	remedial investigation
RIWP-A	Remedial Investigation Work Plan Addendum
SCDHEC	South Carolina Department of Health and Environmental Control
SM	Standard Method
SVOCs	semi-volatile organic compounds
TLM	tar-like material
USEPA	United States Environmental Protection Agency
VCC	Voluntary Cleanup Contract
VOCs	volatile organic compounds

1.0 INTRODUCTION

Duke Energy Carolinas LLC (Duke Energy) is conducting a remedial investigation (RI) at the location of the former Bramlette manufactured gas plant (MGP) (400 East Bramlette Road, Greenville, South Carolina) (**Figure 1-1**). The RI is being conducted under a Responsible Party Voluntary Cleanup Contract (VCC 16-5857-RP) with the South Carolina Department of Health and Environmental Control (SCDHEC) dated July 29, 2016. RI activities are being completed to delineate MGP related impacts resulting from the former operation of the MGP site. Results of the investigation through April 2020 were summarized in the RI Report, which was submitted to SCDHEC on June 26, 2020. The RI reports was subsequently approved on September 1, 2020.

The RI Report recommended the collection of additional data to further evaluate and delineate the extent of MGP-impacted groundwater within the fractured bedrock flow system at the Site. (Note: For the purposes of this work plan, the Site collectively refers to the location of the former MGP as well as four other contiguous parcels.) The aquifer performance test (APT) work described within this plan is proposed to gain a better understanding of the fractured bedrock system at the site, where non-aqueous phase liquid (NAPL) has been identified within discrete fracture intervals.

1.1 Objectives

The objective of the additional assessment work is to inform the Conceptual Site Model (CSM) with respect to interconnectedness of bedrock fractures below the Site and to the overlying transition zone, saprolite, and alluvium. The assessment work will also provide estimates of the magnitude and distribution of the hydraulic properties of these materials. This is particularly important in the Parcel 3 bedrock area (**Figure 1-2**), where NAPL has been detected. The NAPL contains volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and polycyclic aromatic hydrocarbons (PAHs) that potentially provide dissolved phase groundwater constituents of interest (COIs) to the groundwater within the bedrock aquifer system at the Site. The assessment work will improve overall understanding of the key geologic/hydrogeologic characteristics of the Site and help quantify hydraulic parameters. A program of additional data analysis, field characterization, and finally a large-scale aquifer pumping test are proposed to accomplish these objectives. These tasks are intended to:

- Obtain Site-specific measurements of aquifer hydraulic properties.
- Determine relative interconnectivity between wells, fractures, and the hydrostratigraphic units.

- Obtain data that could be used to support development of achievable Site-specific remedial goals prior to completing the feasibility study (FS) for the Site, specifically the bedrock aquifer system.
- Develop a sufficient and adequate data set for groundwater modeling. The model can be used to simulate exposure scenarios. Modeling may also assist with developing realistic extraction (i.e., pump and treat) and/or injection rates with which potential FS remedial scenarios can be developed and evaluated.

1.2 Summary of the Hydrogeologic Conceptual Site Model

The following is a summary hydrogeologic CSM from the RI Report (SynTerra, 2020) with conclusions from the remedial investigation assessment activities conducted through February 2020.

Topography at the Site is relatively wide, flat, and low-lying, and includes delineated wetlands. Parcels 2, 3, 4, and 5 are located within the 100-year flood plain of the Reedy River (**Figure 1-1**). The Vaughn landfill (elevation of 942 feet above mean sea level (amsl) and debris piles on Parcel 2 (946 feet amsl) are the points of highest elevation at the Site. At Parcel 1, the location of the former MGP, elevations range from approximately 932 feet amsl to 938 feet amsl.

Historical ditches provide surface water drainage southward from the floodplain area east of the elevated railroad. Stormwater drainage ditches from the former MGP parcel drain through a culvert southward under Bramlette Road to the historical drainage ditches in the floodplain. From Bramlette Road, the main floodplain drainage ditch extends approximately 2,200 feet south and drains under a railroad trestle near Willard Street to the Reedy River. There are no other known surface water drainage outlets from the Site to the river between Bramlette Road and the railroad trestle near Willard Street. A wet-weather ditch on the southern portion of Parcel 2 flows to the northwest through culverts beneath the railroad tracks and to the Reedy River during storm events.

The Site is located within the Piedmont Physiographic Province, which is generally comprised of a regolith-fractured rock system that includes regolith (unconsolidated material), a transition zone (typically consisting of saprolite and weathered rock fragments), and crystalline bedrock. Fill material is generally present to a depth of 8 feet below land surface (bls) and overlies laterally extensive alluvial deposits that have an average thickness of 11 feet. Saprolite below the alluvium is laterally extensive over the Site and ranges in thickness from approximately 1 foot to 21 feet. The transition zone tends to vary in thickness from absent (southern portion of the Site) to 30 feet. Cross-section views of lithology and stratigraphic units are presented as sections A-A′ (**Figure 1-3**), B-B′ (**Figure 1-4**), C-C′ (**Figure 1-5**), and D-D′ (**Figure 1-6**).

Stratigraphic units present at the Site are described in the following table:

Hydrostratigraphic Unit		Flow zone	Extent	Hydraulic Conductivity[1] (feet per day)
Fill		Shallow	Laterally extensive in Parcel 2 and Parcel 3 – Vaughn Landfill. Fill present from land surface to approximately 8 feet bls.	1 – 2.4 (geomean – 1.6)
Regolith	Alluvium	Shallow	Laterally extensive. Lean clay over coarse to fine sand. Alluvium present from approximately 8 feet bls to 19 feet bls.	0.7 – 35 (geomean – 5.6)
	Saprolite	Shallow	Laterally extensive. Saprolite generally present at 19–40 feet bls.	2.6 – 6.9 (geomean – 4)
	Transition Zone	Transition Zone	Transition zone present 25–50 feet bls. Diminishing thickness to absent in the southern portion of the Site.	0.06 - 100 (geomean - 0.9)
Fractured Bedrock		Bedrock	Laterally extensive. Top of bedrock encountered from 30–50 feet bls.	0.05 – 4 (geomean - 0.8)

Notes:
1. Hydraulic conductivities were estimated using single-well slug tests.

The groundwater system is characterized as an unconfined, interconnected aquifer system indicative of the Piedmont Physiographic Province. Groundwater is recharged by drainage and rainfall infiltration in the upland areas, followed by discharge to the perennial stream system. Flow in the regolith is that of porous media, while flow in bedrock is primarily within secondary porosity features (fractures).

Groundwater flow is generally to the southwest toward the Reedy River from Parcel 1 and encountered at depths of less than 1 foot to 12.5 feet bls within alluvial and unconsolidated deposits. Flow directions are similar in the shallow, transition, and bedrock hydrostratigraphic units as shown in **Figure 1-7** through **Figure 1-9**. Calculated seepage velocities for the Site range from 13 feet per year (transition zone) to 295 feet per year (fractured bedrock). The greatest seepage velocities occur within fractured bedrock because flow is confined to transmissive fractures and the effective porosity in fractured bedrock is considerably lower than that found in saprolite or transition zone. Typically, constituent migration within groundwater is slower than seepage velocity due to retardation that is influenced by advection, dispersion, adsorption and absorption, and biodegradation. Based on Site-specific estimates of groundwater flow velocity, groundwater within the shallow and transition zones would take up to approximately 85 years to travel the approximate distance to the Reedy River. While the seepage velocity may be greater in the fractured bedrock, the flow direction and travel times for groundwater (over various distances) are dependent on the interconnectedness, geometry, heterogeneities and orientation of fractures.

1.3 Fractured Bedrock Characteristics

Fractured bedrock assessment and findings are described in detail in the RI Report (SynTerra, 2020). Characteristics determined through groundwater observation well installation, borehole geophysical logging, and modeling are summarized below.

- Hydraulic conductivity values typically range from approximately 0.01 feet per day to 6 feet per day. At three well locations, measured conductivities were greater than 70 feet per day.
- The greatest hydraulic conductivity values are observed in the top 10 feet of bedrock.
- Estimated mean width/thickness of bedrock fracture apertures at the Site generally range from approximately 0.05 millimeters (mm) to 0.6 mm [50 micrometers (μm) to 600 μm], as determined via borehole geophysical logging.
- The calculated average spacing between interpreted open fractures is 8.5 feet (vertical separation).
- Fractures most frequently strike toward the west-northwest and dip moderately to the north-northeast. However, dips toward the southwest and cross-cutting fractures are also observed (as shown in the logs for MW-21BR, MW-34BR, and MW-36BR).
- The mean fracture strike direction of water bearing fractures is approximately N61W, and the mean fracture dip angle below the horizontal plane is approximately 22 degrees toward the north-northeast (**Appendix A**).

2.0 FIELD DATA AND METHODS

SynTerra will conduct multiple tasks to complete the project objectives. Prior to the aquifer pumping test, preliminary data will be collected and evaluated to plan and design the aquifer pumping test. Tasks will proceed in a specific sequence, as some tasks are intended to inform later tasks. Other tasks may run concurrently to reduce project duration. Proposed major tasks in order of implementation include the following:

- Historical data review (slug test results and hydrographs)
- Hydrograph evaluation
- Pneumatic interference slug testing (PIST) of bedrock wells
- APT bedrock pumping well installation
- APT observation well installation (if necessary)
- Static (baseline) groundwater level measurements
- Pump installation
- Step-drawdown test
- Constant rate pumping test
- Data evaluation

2.1 Historical Data Review

Prior to conducting any field work, SynTerra will review historical data to inform the field efforts. Historical data includes previous slug test results and existing hydrographs of the Site. Hydraulic conductivity values determined from slug tests previously conducted at the Site are summarized in **Table 2-1** and were plotted in plan view as shown in **Figures 2-1** through **Figure 2-3**. This information was added to the updated cross-sections to look for any discernible spatial patterns. **Figure 1-3** through **Figure 1-6** are updated cross-sections that include monitoring wells installed since the June 2020 RI report. These data can be used to inform the selection of the well locations and screen intervals that may be used as monitoring locations for the APT and to help identify potential pathways for constituent migration.

Slug test results at the site indicate that the hydraulic conductivity generally decreases with depth with the highest hydraulic conductivity values in the shallow flow zone and the lowest hydraulic conductivity values in the bedrock. Generally hydraulic conductivities measured in shallow and transition zone wells are an order of magnitude or greater than values measured in bedrock wells. Shallow zone hydraulic conductivity values range from 0.51 ft/day to 100 ft/day with a geometric mean of 5.4 ft/day (**Table 2-1**). Transition zone hydraulic conductivity values range from 0.053 ft/day to 130 ft/day with a geometric mean of 1.9 ft/day (**Table 2-1**). The highest conductivity values measured in saprolite and transition zone, 100 ft/day and 130 ft/day, appear to be atypical for the site and most hydraulic conductivity values in saprolite and transition zone are on the order of tens of feet per day or less. There appears to be no strong spatial patterns in hydraulic conductivity distributions within the shallow zone and transition zone.

Hydraulic conductivities in the bedrock ranged from 0.00088 ft/day to 4.7 ft/day with a geometric mean of 0.32 ft/day (**Table 2-1**). Higher conductivity values in bedrock appear to be clustered in the southern end of the Vaughn Landfill and in the southern portion of Parcel 1. Hydraulic conductivities in these two regions are on the order of feet per day compared to other portions of the site where bedrock hydraulic conductivity values are generally one to two orders of magnitude lower. Monitoring well MW-03BRL has an average hydraulic conductivity value of 1.08 ft/day which is approximately two orders of magnitude greater than hydraulic conductivities in surrounding wells (**Figure 2-3**).

SynTerra will examine the historical hydrographs in detail to see whether there are discernible responses in wells to external hydraulic stresses showing connectivity to boundaries or other wells. Overall patterns of hydrographs can be used to identify wells in similar flow regimes and possible connections to hydraulic boundaries. These external stresses include precipitation events, river stage, and barometric pressure change. A preliminary evaluation of the historical hydrographs indicates similar and coincident hydraulic responses to external stresses for shallow, transition zone, and bedrock wells. The similar hydrograph responses may indicate that the groundwater system behaves like an unconfined aquifer with good interconnectivity between the hydrogeologic units. The preliminary examination of the data indicates that the frequency of observations may need to be increased from four readings per day to 12 readings per hour.

2.2 Hydrograph Evaluation

New hydrographs will be developed to examine the response of water levels to external hydraulic stresses in bedrock wells, as well as in select wells completed in the shallow and transition zone hydrogeologic units. These hydrographs will be used to evaluate the connectivity between wells within similar hydrogeologic units and other monitoring wells screened within different hydrogeologic units. The hydrographs may be used to evaluate and/or establish local hydraulic boundaries. Overall patterns can be used to indicate that wells are in similar flow regimes or potentially connected to hydraulic boundaries. Establishing patterns of water level changes due to external stresses will be necessary for evaluating the aquifer pumping test data.

To acquire data for the new hydrographs, nine additional high-resolution pressure transducers will be installed in wells at the Site in addition to the six pressure transducers currently deployed. An additional two pressure transducers will be installed at staff gauge locations in the wetlands at the Site, and one pressure transducer will be installed at a staff gauge located along the Reedy River just west of the site. Proposed locations for pressure transducers in monitoring wells and surface water monitoring locations are shown in **Figure 2-4**. Water level variations can range more than several feet at the Site and up to 10 feet in some wells. Therefore, pressure transducers will be installed to depths of approximately 5 feet to 10 feet below the average water level of the well so that the pressure transducers remain fully submerged during data collection.

Pressure transducers will be marked prior to deployment with depth increments of at least 0.1 feet. Depth increments will be used during installation so that the transducers are installed to the appropriate depth. The date, time, and depth of installation (measured from the pre-marked transducer cable) will be recorded in a field notebook. Manual depth to water measurements will be collected prior to and after installation of all pressure transducers. Depth to water level measurements will be made to the nearest 0.01 feet. All measurements will be recorded in a field notebook with well ID, depth to water, and date and time of measurement.

Existing data appear to have been collected at a frequency of one measurement per 6 hours. For this hydrograph evaluation, a shorter measurement collection interval of 5 minutes is proposed (12 readings per hour). The transducers will be deployed for a period long enough to capture significant precipitation and barometric pressure changes. It is anticipated that the required period of data collection will be two to three weeks, but this may vary depending on the occurrence of precipitation events and atmospheric conditions. Water levels collected during this evaluation will be plotted with precipitation, river stage, wetland water levels, and barometric pressure to evaluate the effects of external hydrologic and atmospheric stresses on the potentiometric surfaces within each of the hydrogeologic units at the Site.

Results from the hydrograph evaluation will be used to inform the selection of test and observation wells during the pneumatic interference slug tests (PISTs) and aquifer pumping test portions of the field investigation.

2.3 Pneumatic Interference Slug Testing

PISTs will be performed on wells at the Site to evaluate the potential interconnectivity of monitoring wells and hydraulic properties. PISTs are a good initial method of evaluating the hydrogeologic conditions at the Site because they generally cost less per test and take less time to complete than traditional pumping tests. Also, with PISTs, multiple tests can be performed on a single well to achieve repeatability of the results, and they do not produce formation water for which off-Site disposal would be required. Information obtained from the PISTs will be used to plan the large-scale aquifer pumping test. Results from both the PISTs and the aquifer pumping test will be used to estimate the magnitudes and distribution of hydraulic properties at the site.

PISTs involve applying a “slug” of air or nitrogen to a test well and measuring the response in the hydraulic head in the test well and in surrounding observation wells. This method is similar to that described by Novakowski (1989), Spane (1996), and Spane et al (1996). Traditional single well slug tests affect a limited volume of formation in the immediate vicinity around the test well and therefore provide hydraulic property estimates that are limited in scale (Ferris et al 1962). Interference slug tests increase the volume of formation evaluated and can provide estimates of average hydraulic parameters over larger scales because the response in observation wells reflects formation properties between the test well and the observation wells (Spane 1996). Furthermore, interference slug tests can provide a qualitative method for determining whether monitoring wells are hydraulically interconnected by evaluating the type and magnitude of observed signals in observation wells caused by an applied stress in the test well. PISTs are performed using a wellhead assembly that allows the head space within the test well to be sealed off from the atmosphere and pressurized. The PIST wellhead assembly will be constructed from PVC and designed to fit a 2-inch diameter monitoring well. A generalized diagram of the basic features of the PIST wellhead assembly is shown in **Figure 2-5**.

Approximately two to three weeks prior to conducting PISTs at the Site, high-resolution pressure transducers will be installed in several existing wells for the hydrograph evaluation. Proposed wells for the hydrograph evaluation are identified on **Figure 2-4**. The hydrograph evaluation will include several wells that will be used as test and observation wells during the PISTs. Potential short-term trends that might affect measured water level responses during the PISTs will be identified and evaluated using the data from the hydrograph evaluation. The time period required to conduct a PISTs on a single well is likely to be a maximum of a few hours or less depending on aquifer properties, as opposed to the timeframes required for effectively monitoring external hydrologic and atmospheric changes that affect groundwater elevations. Therefore, it is anticipated that trends in groundwater elevations caused by external hydrologic or atmospheric processes will not have significant effects on groundwater elevation measurements during the PISTs.

The number and location of PIST test wells and observation wells will be selected based on findings from the initial historical data review and hydrograph evaluation. It is anticipated that approximately three to four bedrock wells will be used as test wells and as many as 14 wells will be used as observation wells. Observation wells will include wells screened within the bedrock, transition zone, and the shallow hydrostratigraphic units.

After test and observation wells are identified, PISTs will be conducted using the basic steps described in **Appendix B**. A minimum of at least three slug tests will be performed at each well.

Data from the test and observation well pressure transducers will be downloaded daily for qualitative preliminary data evaluation. After completion of the PIST field work, a full quantitative evaluation of the data will be performed.

2.4 Well Installation

Well installation is anticipated to include installation of a pumping well for the aquifer tests and potentially additional observation wells. Additional observation wells will be installed only if the current monitoring system is deemed insufficient for collecting the required observation data for the aquifer tests.

Pumping Well Installation

The current monitoring wells at the Bramlette site are constructed with 2-inch diameter PVC screens and riser pipe. A 6-inch diameter well will be installed for use as the pumping well for the APT. A 6-inch pumping well can improve the ease of pump installation and allow for a downhole riser pipe for the pumping well pressure transducer. The riser pipe can reduce the chance of downhole entanglement of instrumentation cables and improve the ease of collecting manual water level measurements during the pump test. A larger diameter well can also make it possible to implement shielding for the transducer cable if significant electrical interference is observed when the pump is operating. The 6-inch pumping well will be completed as an open borehole well to promote good communication with any bedrock fractures.

Additionally, open borehole construction will allow for inflatable packer installation if specific zones are isolated for testing. A double-cased well is proposed to provide a good annular seal and mitigate the migration of sediments or contaminants from the bedrock/ transition zone into the borehole.

Subsurface utility locating, marking and verification will be conducted prior to drilling activities. Drillers will clear each boring location to 5 feet bls using a hand auger. Oversight of drilling operations will include documentation of field observations associated with well drilling, well installation, and well development activities conducted by a licensed South Carolina water well contractor.

A decontamination pad will be constructed in an area designated by SynTerra. The drill rig and all downhole equipment will be decontaminated by steam cleaning and inspected by a SynTerra geologist prior to mobilization to each boring location. Downhole equipment will also be decontaminated between each boring location.

The pumping well will be approved prior to installation in accordance with SCDHEC regulation R.61-71 H (SCDHEC, 2016). All wells will be drilled, constructed, and abandoned by a South Carolina certified water well contractor per S.C. Code Section 40-23-10 et seq. Typical bedrock pumping well construction details for stickup completion are shown in **Figure 2-6**.

The use of hollow stem auger (HSA) in combination with air rotary drilling techniques (commonly referred to as a "pneumatic air hammer") is recommended for installation of the pumping well. HSA will be used to advance the borehole through unconsolidated material to set an outer casing. Cutting returns will be logged at a minimum of 5-foot intervals while drilling with HSA. Once the outer surface casing has been set, air rotary drilling can be employed to advance the borehole through rock. Air rotary drilling is a standard drilling technique and will allow efficient well installation to facilitate completion within the schedule timeframe.

The location of the proposed pumping well will be selected based on results from the historical data evaluation, hydrograph evaluation, and PISTs. The pumping well is likely to be located on Parcel 3 in proximity to bedrock wells where discrete NAPL impacts have been observed in fractures. The potential location for the proposed pumping well is shown in **Figure 2-7**. It is anticipated that a single boring will be drilled for the pumping well installation. However, the location and depth of the pumping well may vary depending on field observations, and more than a single boring may be required. Field conditions that would warrant the drilling of additional borings for the pumping well include a non-producing or very low-producing bedrock boring or a boring that is not strongly connected to the monitoring well network.

The pumping well will be double cased with a 10-inch schedule 80 PVC outer surface casing and a 6-inch inner surface casing. The initial boring diameter will be sufficiently wide to allow the installation of the 10-inch outer casing fitted with a grout shoe to be seated into the top of rock and tremie-grouted into place. The casing will be filled with water (as it is set to help it sink in the borehole) to help offset the pressure of the grout and to reduce heat generated during the grout cure reaction. Any casings that exceed 100 feet will be grouted in at least two lifts; the maximum lift of grout will not exceed 80 feet. Grout mixture should be approximately 5.2 to 5.75 gallons of water to each 94-pound bag of Portland Type cement powder with 1 percent to 2 percent bentonite powder added to the mixture.

After a minimum 24-hour grout cure period, a nominal 6-inch boring will be advanced to a depth of 15 to 20 feet below the top of bedrock. At the target depth a secondary 6-inch schedule 80 PVC inner casing with a grout shoe would be grouted into bedrock. Similar to the outer casing, the inner casing will be filled with water before grouting. After the grout has set for 24 hours, a 6-inch air hammer will be used to advance the boring to the desired depth. A surface pad and protective casing will be installed at the surface. The surface pad and casing may not be installed until after the aquifer tests are completed due to time constraints to complete the field work.

A geophysical logging suite will be performed on the open borehole portion of the pumping well after the boring is advanced to the total depth. The geophysical logging suite will include acoustic televiewer, optical televiewer, 3-arm caliper, fluid temperature, fluid conductivity, single point resistance (SPR), spontaneous potential (SP), and heat pulse flowmeter (HPF). The geophysical logs will be used to fully characterize the borehole and identify potential fractures or fracture zones within the borehole. This information will be used when assessing whether the borehole can be used as a viable pumping well during the APT.

Observations during air hammer drilling can yield important information about the presence of fractures and the amount of water they may produce. A sudden increase in the rate at which the hammer advances can indicate fractures or a fracture zone. The amount of water produced during drilling can also be an indication of the productivity of the well and fractures. While drilling the open borehole pumping test well, water levels in nearby wells will be monitored to look for influence from the drilling process. While these methods provide qualitative data, they will give an indication of the suitability of the well for use as a pumping well during aquifer testing, along with the data collected during the historical data review, PISTs, and geophysical logs.

Following the completion of the APT the 6-inch open borehole well will be left in place. Water bearing fractures within the open borehole will be isolated from one another using K-packers to prevent cross-communication between the fractures. Depending on the findings from this work and potentially future work the 6-inch open borehole well will either be converted into a 4-inch monitoring well or a 4-inch extraction well.

Specific Capacity/Packer Testing Fracture Zones

Specific capacity tests will be performed in the open borehole after it is completed using a straddle packer system with a pump. The specific capacity tests will be conducted to confirm that fractures/fracture zones identified during drilling and from geophysical logs are sufficiently productive to use the borehole to conduct the APT and to collect depth discrete groundwater samples in the pumping well borehole. The geophysical logs and observations from drilling will be used to identify intervals in the borehole for specific capacity testing.

Once the test intervals are selected the straddle packer system will be installed in the borehole at the lowest interval, the packers will be inflated to isolate the interval, the pump and pressure transducer will be installed through the straddle packer riser pipe, and water levels in the isolated interval will be allowed to reach equilibrium or near equilibrium. Once equilibrium or near equilibrium is reached, the interval will be pumped. The flowrates used during specific capacity tests will be based on field observations during testing and are expected to be low (less than 5 gpm). During specific capacity tests the flow rate will be held constant and the water level in the isolated portion of the borehole will be monitored with a pressure transducer. The flowrate will be measured every three to five minutes during the test to ensure that the flowrate is constant and the pressure transducer will, at a minimum, be set to collect one measurement every 30 seconds. Water quality parameters including temperature, pH, and specific conductivity will be measured during the specific capacity tests at least every five minutes and a water quality sample will be collected at the end of each test. Turbidity may be measured during the tests depending on the presence of suspended solids due to drilling. If turbidity is too great due to disturbance during drilling it will not be measured.

Once the specific capacity test is completed at the lowest identified fractured interval, the straddle packer system will be raised to the next selected interval and the processes described above will be repeated. During specific capacity testing, water levels in surrounding wells will be monitored with pressure transducers to measure any potential water levels changes that may occur due to specific capacity testing in the pumping well.

Observation Well Installation

Water level changes in the monitoring wells due to pumping must be greater than the background variations. Small well diameter and close proximity to the pumping well generally favor a stronger signal in the monitoring well. Review of the historical data, the PIST data, and the installation of the pumping well may indicate that the existing monitoring well network is not adequate for the aquifer test and that additional observation points might be needed. To reduce the number of mobilizations, the HSA/pneumatic air hammer rig used to install the pumping well could also be used to install the observation wells. Although not expected, the processes for installing shallow wells or bedrock observation wells are outlined below.

If needed, alluvial, saprolite, or transition zone wells will be installed using HSA methods. Shallow observation wells will be installed through the HSA auger stem. Cutting returns will be logged at a minimum of 5-foot intervals while drilling borings for the shallow wells. Split spoon sampling through the auger stem will be used to verify the lithology where any shallow observation well is installed. Once the desired depth for the well is reached, the 2-inch diameter PVC observation well will be installed through the center of the auger stem. Threaded PVC pipe with a machine-slotted screen will be used. A sand pack will be installed via a tremie pipe around the well screen as the augers are slowly removed from the boring. The sand pack will extend at least 2 feet above the top of the screen. A hydrated bentonite seal at least 2 feet thick will be placed on top of the sand pack. A cement bentonite grout annular seal will be placed above the hydrated bentonite seal. A surface pad and protective casing will be installed at the surface. The surface pad and casing may not be installed until after the aquifer tests are completed due to time constraints to complete the field work. Typical shallow observation well construction details for stickup completion are shown in **Figure 2-8**.

Bedrock observation wells, if necessary, will be installed using the air hammer techniques described above. A 2-inch diameter PVC casing and well screen will be installed in the 6-inch borehole. Once the desired depth for the well is reached within bedrock, the 2-inch diameter PVC observation well will be installed through the center of the 6-inch borehole. Threaded PVC pipe with a machine-slotted screen will be used. The 2-inch PVC well will be hung approximately 1 foot off the bottom of the boring, and a sand pack will be installed via a tremie pipe. The sand pack will extend at least 2 feet above the top of the screen. A hydrated bentonite seal at least 2 feet thick will be placed on top of the sand pack. A cement bentonite grout annular seal will be placed above the hydrated bentonite seal. The hydrated bentonite seal will be installed in lifts of no more than 80 feet to control the amount of heat generated through the heat of hydration process. A surface pad and protective casing will be installed at the surface. The surface pad and casing may not be installed until after the aquifer tests are completed due to time constraints to complete the field work. Typical bedrock observation well construction details for stick-up completion are shown in **Figure 2-9**.

2.5 Well Development

The pumping well will be developed no sooner than 24 hours after installation of the inner surface casing to allow for grout cure time. Development will be conducted by the drilling contractor. Well development will be performed using a portable submersible pump. Well development will consist of pumping the well at the greatest sustainable rate while moving the pump up and down within the open borehole portion of the well. Well development will continue until the turbidity is 10 nephelometric turbidity units (NTUs) or less and water quality parameters — including temperature, pH, and specific conductance — have stabilized. Water quality parameters will be considered stable when five consecutive measurements collected every 10 minutes are within ±10 percent of one another. If any drilling fluids are used during drilling, development will continue until the estimated volume of drilling fluids has been removed and the above criteria are met. If sediment persists in the well or the parameters do not stabilize within 6 hours, alternative development techniques such as using a surge block or the air lift method will be evaluated.

After development, the bottom of the well will be tagged to establish a “hard” (sediment-free) bottom. Development records will be prepared under the direction of SynTerra and will include all pertinent information related to well development, including at a minimum the following:

- Development method(s)
- Volume of water removed over time
- Total volume of water removed at the end of development
- Field measurements of temperature, pH, specific conductivity, and turbidity with date and time of measurements.

2.6 Well Surveying

After installation of the proposed pumping well and any observation wells deemed necessary, the wells will be surveyed by a surveyor licensed in the state of South Carolina. The survey will consist of well location, ground surface elevation, and the vertical elevation of the top of casing, following final construction of surface completions at each well. Wells will be surveyed in state plane coordinates using the North American Datum of 1983. Vertical elevations will be surveyed to within a hundredth of a foot using the North American Vertical Datum of 1988.

2.7 Aquifer Performance Testing

2.7.1 Static Groundwater Level Collection

Two sets of static (baseline) groundwater level readings will be collected. The first set of baseline groundwater levels will be collected prior to pump installation, and the second set of baseline groundwater levels will be collected after the step-drawdown test and before the constant rate pumping test. Baseline groundwater levels will be used to determine long-term groundwater level trends or potential interferences from other pumping/discharge source(s) that might influence the test results. Baseline groundwater level data will be used to adjust measurements collected during aquifer testing to correct for any long-term trends or potential interfering signals. Water levels will be monitored in selected wells near the pumping well using pressure transducers. Approximately 15 wells will be monitored with transducers, including the pumped well, selected monitoring wells, and one background well. In addition, groundwater levels will also be measured in the Reedy River and at two locations within the wetland. A barometric pressure probe will also be installed at the Site.

Before installing/moving the pressure transducers that will be used for the aquifer tests, an initial round of water levels will be manually collected from all Site wells or as many which can be gauged in a day. All measurements will be recorded in a field notebook with well ID, depth to water, and date and time of measurement. Pressure transducers installed in monitoring wells selected for the pump test that were previously installed for the water level study and PISTs will be left in place for the aquifer tests. The frequency of water level measurements for these pressure transducers will be set to one measurement every 5 minutes. Pressure transducers will be installed in the additional wells selected for monitoring, and the frequency of the measurements will be set to one measurement every 5 minutes. Depth to water measurements will be taken any time a pressure transducer is moved to a new location, the frequency of measurement is changed, or any other activity occurs that might impact transducer placement in the well. All measurements will be recorded in a field notebook with well ID, depth to water, and date and time of measurement.

Initial static (baseline) groundwater level collection in the pumping well and monitoring wells may commence once the pumping well and any new observation wells have been installed, developed, and allowed to equilibrate. It is anticipated that approximately three to five days should be given for the system to reach equilibrium following any well development or well installation activities, but this time may vary based on field observations of measured groundwater levels. Baseline groundwater levels prior to the pump installation and the subsequent step-drawdown test should be collected for at least 24 hours prior to installing the pump, but this time may vary based on field observations. Prior to pump installation and the step-drawdown test, pressure transducer data from the initial baseline groundwater level collection event will be downloaded and reviewed.

Static groundwater levels will be collected before the constant rate pumping test and after groundwater levels have been given time to equilibrate following the step-drawdown test. Static groundwater levels will be collected for at least 72 hours before the constant rate pumping test begins, but this time may be extended based on field conditions and observations. Pressure transducers will be programmed to collect groundwater level data at a frequency of one measurement per minute. Before beginning the constant rate pumping test, pressure transducer data from the baseline groundwater level collection event will be downloaded and reviewed.

2.7.2 Pump Installation

Once baseline groundwater levels have been established, a submersible pump assembly and riser pipe will be installed in the pumping well. Pump size will be selected based on estimated sustainable flowrates determined from earlier Site investigations and observations. The stand pipe for the pump will be sized based on estimated flowrates and it is expected that a 1-inch stand pipe will be used. The pump will be set to the maximum depth possible to allow for the greatest drawdown and head above the pump.

The drilling subcontractor performing the aquifer testing will be responsible for providing, installing, and operating all pump equipment, piping, riser pipe, cable ties, flow meters, discharge lines and other relevant equipment required to complete aquifer testing. All equipment must be decontaminated prior to being installed in the pumping well.

The subcontractor will be responsible for providing a flow meter capable of continuously logging discharge rates and total flow in-line with the pump discharge line and that can read to an accuracy at least 0.01 gpm. The flow meter must be installed in such a way that no head space is present in the flow meter and along the discharge line along which the flow meter is installed. At least a 6-inch drop in the discharge line prior to the flow meter and a subsequent 6-inch rise in the discharge line past the flow meter will be installed along the discharge line to minimize any headspace. Straight pipe at least 1 foot in length will be installed before the flow meter and after the flow meter to maintain laminar flow through the flow meter. Two ball valves will be installed in the discharge line. One will be located prior to the drop in the pipe and one located past the rise in the pipe. A photograph showing the general proposed configuration for the flow meter is presented on **Figure 2-10**. A small diameter sampling port will be installed along the discharge line so field water quality measurements and samples can be collected.

Riser pipe, installed along with the pump equipment, will contain the pressure transducer during testing and will be used to collect depth-to-water measurements. The riser pipe will be installed in one of two methods. The method of riser pipe installation will depend on whether electrical interference is observed in the pumping well transducer when the pump is activated. The first and preferred method is to directly secure the riser pipe to the drop pipe for the pumping equipment and lower the riser piper in conjunction with the pump equipment. If excessive electrical interference is encountered, the riser pipe will be re-installed separately from the pump equipment with rubber spacers along the riser pipe to insure separation between the pump electrical cable and the riser pipe. If the second method is necessary, the riser pipe will be secured at the surface using pipe holders and safety cable connected to the well stick up casing. It is anticipated that the pump electrical cable will be insulated and that the pump voltage will be small compared to large flowrate pumps that typically cause interference, and therefore significant electrical interference will not be encountered compared to the signal magnitude during testing. The riser pipe will be installed to approximately 10 to 15 feet below the required depth of the pressure transducer.

After the pump equipment and riser pipe are installed, the well will be allowed to equilibrate until static conditions are reached based on pressure transducer readings. Water levels will be measured in the well after equilibrium is reached to confirm that the pressure transducer is reading water levels accurately.

2.7.3 Step-Drawdown Test

Once static conditions are reached after installing the pump equipment and riser pipe, a step-drawdown test will be conducted. Pressure transducers measurements will be recorded at a frequency of one measurement a minute during the step-drawdown test. A step-drawdown test (or step test) is a single-well pumping test designed to investigate the performance of a pumping well under controlled variable discharge conditions. During the step-drawdown test, an initial rate of 0.25 gallons per minute (gpm) will be used, this initial flow rate may vary depending on information obtained during previous portions of this investigation. The discharge rate would be increased approximately 0.25 gpm per step period (subject to change based on field observations). Each step would be approximately 2 hours (subject to change based on field observations). This duration should allow wellbore storage effects to dissipate. This process would continue until the well can no longer sustain the selected flow rate (curve does not flatten out) or a maximum of 20 gpm flow rate is reached. Typical (idealized) drawdown curves for an aquifer performance test from well development, step-drawdown test, constant rate test and recovery are presented in **Figure 2-11**. After completion of the step-drawdown test, the pumping well will be allowed to return to static conditions based on pressure transducer readings.

Data from the step-drawdown test will be used to determine an appropriate pumping rate (Q_{max}) for the constant rate pumping test. At the end of the test, the flow will be adjusted to the selected Q_{max} using one of the ball valves prior to shutting down the pump and this configuration will not be changed until the constant rate pumping test is completed. As the pump is shut down, the remaining ball valve would be closed to prevent the discharge line from draining into the well (which would affect recovery data).

2.7.4 Step-Drawdown Test Recovery

Once the step-drawdown test is complete, the pump would be shut off and the flow meter would be isolated (using ball valves upstream and downstream of the flow meter). The well will be allowed to fully recover. It is anticipated that recovery would take less than 12 hours. Water levels will continue to be monitored at the same frequency during recovery.

Once recovery is complete, pressure transducer groundwater level data will be downloaded and evaluated.

2.7.5 Constant Rate Pumping Test

The constant rate pumping test will be conducted after static water levels are collected following the step-drawdown test. Prior to the start of the constant rate test, a round of water levels will be measured manually from selected monitored wells. Pressure transducer measurements will be recorded at a frequency of one measurement a minute during the constant rate pumping test. All measurements will be recorded in a field notebook with well ID, depth to water, and date and time of measurement.

A constant-rate pumping test involves a pumping well that is pumped at a constant rate while water-level response (drawdown) is measured in the pumping well and in one or more surrounding observation wells. The goal of a constant-rate pumping test is to estimate hydraulic properties of a saturated porous media, including the transmissivity (T), hydraulic conductivity (K), and the aquifer storage coefficient (S). Additionally, a constant rate pumping test can be used to identify potential hydraulic boundary conditions that may interact with the aquifer.

The discharge rate will be monitored approximately every 5 to 10 minutes during the initial portion of the test (first 4 hours) and adjusted to maintain a constant flow rate. If the discharge rate is stable, flow readings will be monitored hourly for the remainder of the test and adjusted as needed to maintain a constant flow rate. Pressure transducers will be set to record measurements every minute for the duration of the 72-hour test and recovery period and every 5 minutes at outlying observation points. Discharge water will be stored in on-Site containers prior to disposal. Potential disposal options are discussed in **Section 2.8**.

Once pumping has started, the test will run uninterrupted for up to 72 hours. During this period, water levels will be continuously monitored with data logging pressure transducers and flow measurements continuously recorded (24 hours per day) with an electronic flow meter that averages measurements at 5-minute intervals. Manual water-level readings will be collected every 2 hours at the pumping well and selected observation wells during active pumping to provide confirmation and backup for pressure transducer measurements. Manual water-level readings will be collected twice daily at all other observation wells.

2.7.6 Constant Rate Pumping Test Recovery

Once the constant rate test is completed, the pump will be stopped, and the ball valves will be closed to prevent backflow into the well from the pump discharge line. Backflow is prevented as to not affect the early time recovery data. Pressure transducers will remain in place after the test is completed and will continue to collect data for at least 72 hours after pumping has stopped or until groundwater levels in the pumping well have returned to at least 90 percent of the pre-pumping static groundwater level.

2.7.7 Groundwater Sampling

To help identify the potential geochemical and COI concentration changes due to pumping, groundwater quality parameters will be measured at regular intervals in the pumped well and groundwater samples will be collected. The water-quality parameters to be measured in the field are pH, specific conductance, temperature, dissolved oxygen, oxidation reduction potential, and turbidity. A YSI Pro Plus water-quality meter will be connected to the sampling port line to measure these parameters. Changes in water-quality parameters or temperature may indicate groundwater from a different source area so these parameters will be measured every 2 hours during the test. All measurements during the test will be recorded in a field notebook with the pertinent water-quality parameter information and the date and time the measurements were taken.

Groundwater samples from the pumped well will be collected and submitted for laboratory analysis:

- After well development
- Before step-drawdown test
- Once per day during the constant rate test

Groundwater sampling will follow the procedures outlined in the Quality Assurance Project Plan (QAPP): Former Bramlette MGP Site (SynTerra, 2018). The sample ID, date, and time of sample collection will be recorded in a field notebook. The analytical samples will be collected after a set of water-quality parameters are measured and recorded from a sampling port connected to the discharge line. The water will be collected in laboratory-prepared sample bottles and immediately placed on ice under strict chain-of-custody. The groundwater samples collected from the pumping well will be analyzed for the following:

Analysis	Analysis Method
VOCs	USEPA 8260B
SVOCs	USEPA 8270E
Calcium and Magnesium	USEPA 6010/6020
Total Iron and Manganese	USEPA 6010
Total Hardness	SM 2340B
Total Alkalinity	SM 2320B
Total Suspended Solids	SM 2540D
Total Dissolved Solids	SM 2450C
Total Organic Carbon	USEPA 9060
5-Day Biochemical Oxygen Demand (BOD)	USEPA SM 5210B
Chemical Oxygen Demand (COD)	USEPA 410.4

Notes:
1. VOCs = Volatile Organic Compounds
2. SVOCs = Semi-volatile Organic Compounds
3. PAHs = Polycyclic Aromatic Hydrocarbons

Samples will be properly preserved and shipped to a South Carolina certified laboratory for analysis. All samples will be shipped in coolers containing ice and managed under chain-of-custody protocol.

2.8 Investigation-Derived Waste Management

Solid and liquid investigation derived waste (IDW) will be generated during collection of soil or rock cores, well installation and development, and environmental media sampling. Reusable equipment can be decontaminated using Liquinox (or similar) and water or by steam cleaning methods were appropriate between all sampling events and locations. Decontamination fluids will be collected and disposed of with IDW. Solids and liquids will be contained as appropriate in 55-gallon barrels, lined roll-off containers, or similarly acceptable waste receptacles. Solid and liquid IDWs will be disposed of in accordance with existing waste profiles or sampled for waste characterization purposes as necessary before disposal.

Based on cost and ease of implementation, water generated during the pumping tests will be temporarily stored in frac tanks onsite and hauled by vacuum truck for disposal at a Duke Energy approved and permitted facility. Adequate and suitable space for placement of two 21,000-gallon frac tanks has been identified within Parcel 3 at the Site. Pumped water will be sampled throughout the test to verify the IDW is consistent with existing waste profiles.

Other liquid IDW generated during the test will be managed in the same manner as water produced during the aquifer pumping test. Solids will be transported to an approved disposal facility in a timely manner.

3.0 DATA EVALUATION

Aquifer pumping test data — including data about water levels, flow rates, barometric pressure, and precipitation data — will be analyzed using standard analytical methods and graphical methods. It is recommended that numerical modeling methods also be used to estimate the spatial distribution of hydraulic properties.

3.1 Hydrograph Evaluation

The analysis will be mostly qualitative by graphing groundwater elevations and the various external factors, which could affect water-level elevations. Water levels and the external factors will be graphed on the y axis and time will be graphed on the x axis. These external factors include barometric pressure, precipitation, river stage, and wetland stage. Historical hydrographs show a strong correlation between precipitation, river stage, and groundwater elevations. However, with the greater frequency of measurement planned, lag times for responses and barometric pressure effects might become discernible. The historical and new hydrographs will be examined for correlations between groundwater elevations and these external factors. Strong correlation of groundwater elevation changes to external changes may show a hydraulic connection. In addition, water levels from the wells will be compared. Wells with water levels that track together may be an indication of hydraulic connection.

3.2 Pneumatic Interference Slug Test Evaluation

The PIST data will be evaluated using the Kansas Geologic Survey (KGS) model in AQTESOLV® Version 4.5 or with another industry accepted analytical solution. The KGS model is a semi-analytical solution for unconfined and non-leaky confined aquifers developed by the Kansas Geological Survey (Hyder *et al* 1994). Due to time constraints for conducting field work at the Site, quantitative results might not be fully completed prior to the aquifer pumping test.

3.3 Static Groundwater Level Analysis Corrections

Groundwater elevations recorded between the step-drawdown test and the constant rate test will be evaluated for any long-term trends in water levels or other external influences on Site water levels. These could be pumping, precipitation, barometric pressure changes, or changes in surface water elevations. Groundwater elevations, precipitation, barometric pressure, and surface water elevations will be plotted against elapsed time to look for patterns and interactions. Corrections for barometric pressure changes will be applied if needed. If long-term data trends and/or diurnal fluctuations are observed, the baseline data will be used to adjust the pumping test drawdown data to compensate for the observed trends.

3.4 Step-Drawdown Test Analysis

The step-drawdown data analysis will be conducted using AQTESOLV® Version 4.5 (Duffield, 2007). Initial step test analysis will be conducted in the field or shortly after the test ends. The Theis (1935) step-drawdown procedure will be used to analyze data. Additional analytical methods (Dougherty-Babu, 1984; Hantush-Jacob, 1955; Theis, 1935; and Hantush, 1961) may be used depending on the step-drawdown test data.

Step-drawdown test results will be used to calculate a flow rate for an expected drawdown of no more than approximately 25 percent of the saturated thickness after 72 hours of pumping.

3.5 Constant Rate Pump Test Analysis: Analytical Methods

Multiple methods of analyses from AQTESOLV® will also be used to analyze drawdown and recovery data from the constant rate test. These include methods that assume a porous media and methods that incorporate fracture systems. The final method or methods will be dependent on actual results of the test. An initial review of the hydrographs indicates possible unconfined conditions. If drawdown is observed only in the pumping well, the data will be analyzed as a single-well pumping test. If data indicate drawdown in one or more observation wells, the test will be analyzed as a multiple-well pump test. Suggested analytical methodologies for data analysis of both single-well and multiple-well pump tests are outlined in the Technical Guidance Manual for Hydrogeologic Investigations and Groundwater Monitoring, Chapter 4 (revised February 2018), Slug and Pumping Test, Table 4.2 (single-well pump test) and Table 4.7 (multiple-well pump test) at https://epa.ohio.gov/Portals/28/documents/TGM-04.pdf (Ohio EPA, 2018).

3.6 Constant Rate Pump Test Analysis: Numerical Modeling

Fractured bedrock environments are very likely to not exhibit the simple geometry assumed by some of the standard pumping test analytical methods. As such, SynTerra recommends that a numerical model also be used to analyze the results of the constant rate pumping test. Numerical modeling is particularly useful for estimating complex heterogeneous hydraulic conductivity structures common to Piedmont aquifer systems like those expected at the Site. Numerical models would be developed using MODFLOW (McDonald and Harbaugh, 1988), a three-dimensional (3D) finite difference groundwater model created by the USGS. Inputs to the numerical model would include findings and data from past and current field investigations. Initial estimates of hydraulic parameters for the model would be obtained from analytical evaluations of field data from the PISTs and aquifer tests described in this scope of work. The model geometry (*i.e.* hydrostratigraphic layers) would be based on the most current understanding of the Site hydrogeology and use findings from the field investigation conducted as part of this scope of work. The model geometry would also utilize data obtained from borehole geophysical logging previously conducted at the site during the RI. The numerical model would be calibrated to observed heads, drawdown observations, and flowrates.

4.0 SCHEDULE AND REPORTING

After completion of the field work and data analysis, a technical report documenting all field work, sampling, data collection, and analysis will be prepared. The report will be divided into two sections. The first will document Field Activities and Observations. The second will document Data Analysis and Results and will include how the data was analyzed and the results were reached.

The report will include a description of activities undertaken at the Site, results of the groundwater sample analysis, and results of the analysis with respect to connectedness of the fracture systems and aquifer characteristics. The report will include plots from the water-level study and the pumping tests. Data tables summarizing test results for the PISTs and aquifer tests will be included. The numerical model, if deemed necessary, will be provided as an addendum to the technical report that will be submitted after the report due to the time required to build and calibrate the model.

The following preliminary schedule is proposed. The schedule is dependent on SCDHEC's written approval of the Aquifer Performance Test Work Plan (APT-WP), obtaining the necessary property access agreements, and field conditions encountered during field activities. Upon approval of the APT-WP by SCDHEC, an updated project schedule will be developed. The current preliminary schedule is detailed below:

Activity(s)	Approximate Date(s)
APT-WP submittal to SCDHEC	November 2, 2020
Site instrumentation and hydrograph data collection	November 4, 2020 – November 23, 2020
Pneumatic well testing	November 23, 2020 – December 2, 2020
Well installation, geophysical logging, specific capacity testing/packer testing, and well development and surveying	December 4, 2020 - December 14, 2020
Initial static water level collection, pump installation, and step-drawdown tests	December 14, 2020 - December 28, 2020
Static water level collection and Constant rate pumping test	January 4th, 2021 - January 11, 2021
Final data evaluation	January 11, 2021 – March 1, 2021
Incorporate APT data evaluation into RI Report Addendum	March 1, 2021 – April 5, 2021

5.0 REFERENCES

Dougherty, D.E and D.K. Babu, 1984. “Flow to a partially penetrating well in a double porosity reservoir,” Water Resources Research, vol. 20, no. 8, pp. 1116-1122.

Duffield, G.M., 2007, AQTESOLV for Windows, V4.5, HydroSOLVE, Inc.

Ferris, J.G., D.B. Knowles, R.H. Brown, and R.W. Stallman, 1962. “Theory of aquifer tests.” U.S. Geological Survey Water-Supply Paper 1536-E.

Hantush, M.S. and C.E. Jacob, 1955. “Non-steady radial flow in an infinite leaky aquifer,” Am. Geophys. Union Trans., vol. 36, pp. 95-100.

Hantush, M.S., 1961. “Aquifer tests on partially penetrating wells,” Jour. of the Hyd. Div., Proc. of the Am. Soc. of Civil Eng., vol. 87, no. HY5, pp. 171-194.

Hyder, Z., J.J. Butler, Jr., C.D. McElwee and W. Liu, 1994. “Slug tests in partially penetrating wells,” Water Resources Research, vol. 30, no. 11, pp. 2945-2957

McDonald, M.G. and A.W. Harbaugh, 1988. “A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model,” U.S. Geological Survey Techniques of Water Resources Investigations, book 6, 586 p.

Novakowski, K.S., 1989. “Analysis of pulse interference tests.” Water Resources Research, vol. 25, no. 11.

Ohio EPA, 2018. Technical Guidance Manual for Ground Water Investigations, Chapter 4, Pumping and Slug Tests, December 2006, Revision 1.

South Carolina Department of Health and Environmental Control. 2016. “Regulation 61-71 Well Standards.”

Spane, F.A., 1996. "Applicability of slug interference tests for hydraulic characterization of unconfined aquifers: (1) analytical assessment." Ground Water, vol. 34, no. 1.

Spane, F.A., P.D. Thorne, and L.C. Swanson, 1996. "Applicability of slug interference tests for hydraulic characterization of unconfined aquifers: (2) field test examples." Ground Water, vol. 34, no. 5.

SynTerra Corporation. 2018. “Quality Assurance Project Plan (QAPP): Former Bramlette MGP Site.”

SynTerra Corporation. 2019. "Remedial Investigation Work Plan Addendum: Former Bramlette MGP Site."

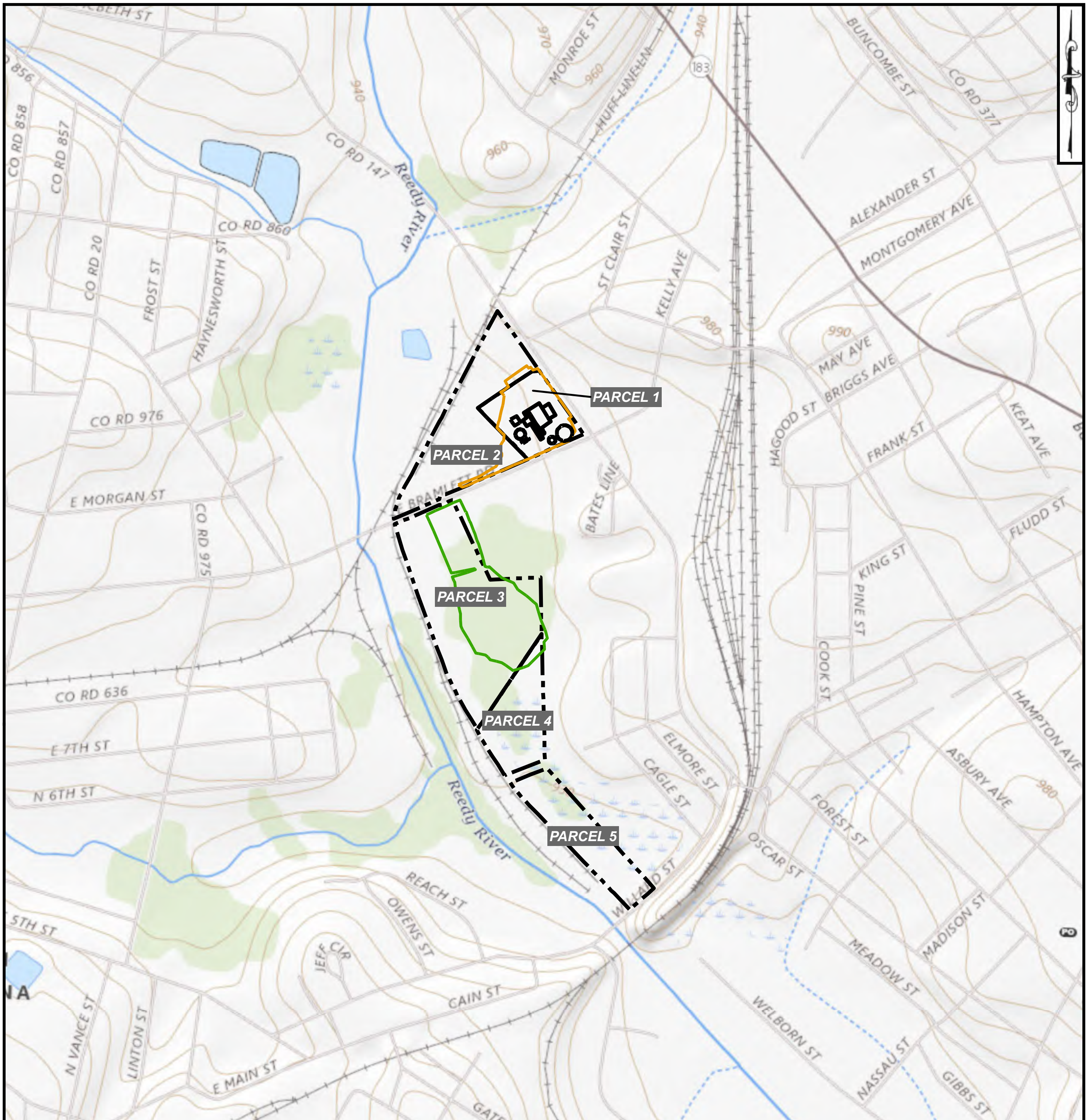
SynTerra Corporation. 2020. "Remedial Investigation Report: Former Bramlette MGPS Site."

Theis, C.V., 1935. "The relation between the lowering of the piezometer surface and the rate and duration of a discharge well using ground water storage", Am. Geophys. Union Trans., vol. 16, pp. 519-524.

FIGURES

synTerra

Science & Engineering Consultants



Legend

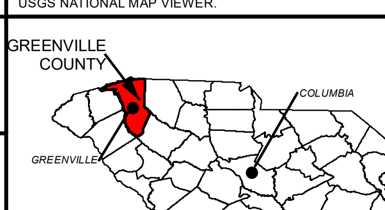
- FORMER MGP FOOTPRINT
- EXCAVATION AREA (2001-2002)
- VAUGHN LANDFILL
- PARCEL BOUNDARIES

NOTES:

1. EXCAVATION AREA AND VAUGHN LANDFILL BOUNDARY ARE FROM ERM WORK PLAN ADDENDUM, APRIL 13, 2018. THESE LAYERS ARE GEOREFERENCED AND APPROXIMATE.
2. PROPERTY BOUNDARIES SOURCED FROM GREENVILLE COUNTY.
3. DRAWING HAS BEEN SET WITH A PROJECTION OF SOUTH CAROLINA STATE PLANE COORDINATE SYSTEM FIPS 3900 (NAD83 INTERNATIONAL FEET).
4. 2020 USGS TOPOGRAPHIC MAP OBTAINED FROM THE USGS NATIONAL MAP VIEWER.

DUKE ENERGY CAROLINAS

synTerra



www.synterracorp.com

FIGURE 1-1
USGS TOPOGRAPHIC MAP
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA

DRAWN BY: C. DAVIS	DATE: 05/02/2019
REVISED BY: R.	DATE: 09/28/2020
CHECKED BY: T. PLATING	DATE: 09/28/2020
APPROVED BY: T. PLATING	DATE: 09/28/2020
PROJECT MANAGER: T. PLATING	

GRAPHIC SCALE
400 0 400 800
(IN FEET)

NOTES:

1. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM 88 (NAVD 88).

2. SURFACE WATER LOCATIONS, FORMER DRAINAGE DITCHES, EXCAVATION AREA, AND VAUGHN LANDFILL BOUNDARY FROM ERM GROUNDWATER REMEDIAL INVESTIGATION WORK PLAN ADDENDUM, APRIL 13, 2018. THESE LAYERS ARE GEOREFERENCED AND APPROXIMATE.

3. MONITORING WELL LOCATIONS AND ELEVATIONS SURVEYED BY A SOUTH CAROLINA LICENSED PROFESSIONAL LAND SURVEYOR

4. TOPOGRAPHIC CONTOURS FOR GREENVILLE COUNTY FROM SC DNR (2013).

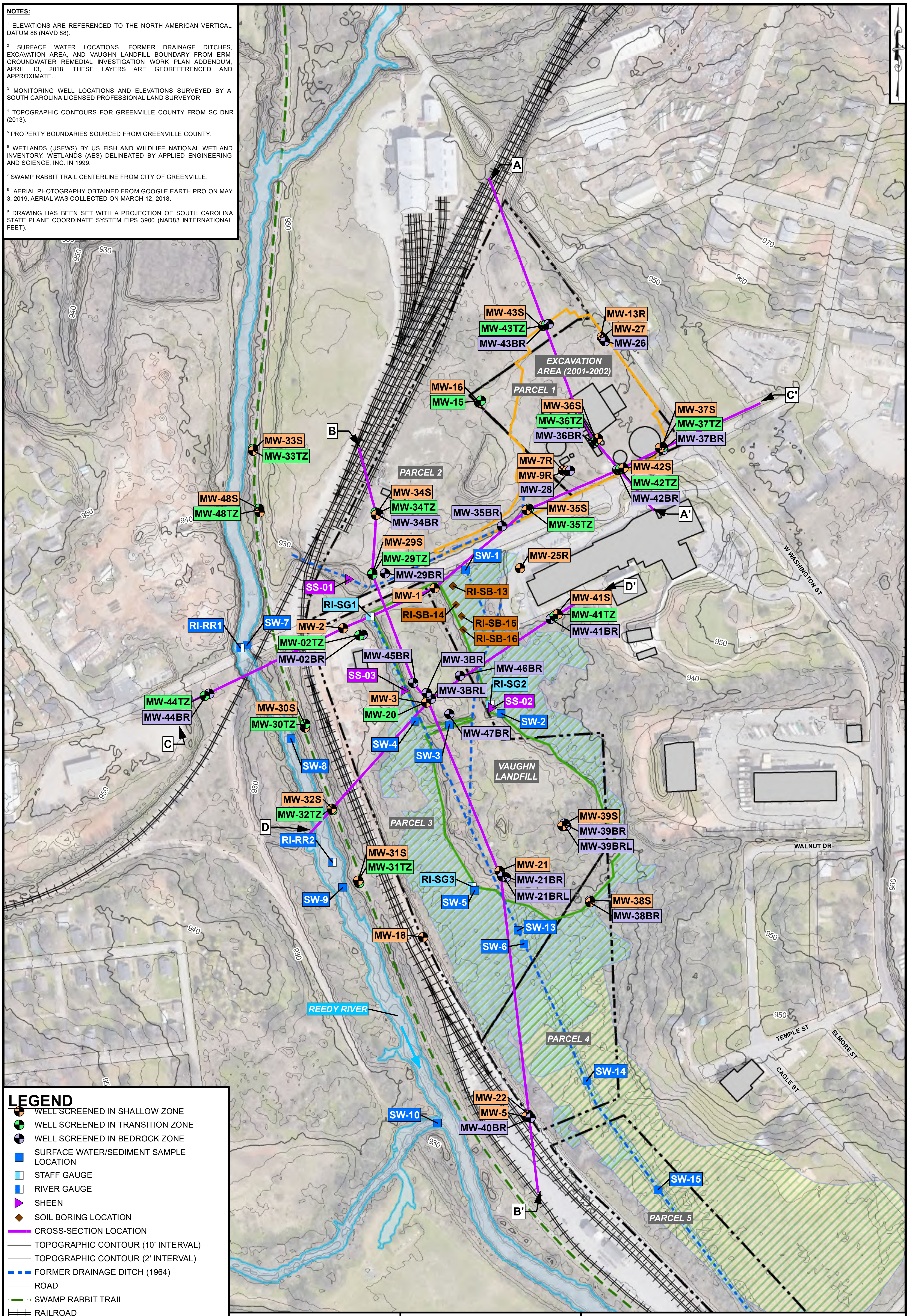
5. PROPERTY BOUNDARIES SOURCED FROM GREENVILLE COUNTY.

6. WETLANDS (USFWS) BY US FISH AND WILDLIFE NATIONAL WETLAND INVENTORY. WETLANDS (AES) DELINEATED BY APPLIED ENGINEERING AND SCIENCE, INC. IN 1999.

7. SWAMP RABBIT TRAIL CENTERLINE FROM CITY OF GREENVILLE.

8. AERIAL PHOTOGRAPHY OBTAINED FROM GOOGLE EARTH PRO ON MAY 3, 2019. AERIAL WAS COLLECTED ON MARCH 12, 2018.

9. DRAWING HAS BEEN SET WITH A PROJECTION OF SOUTH CAROLINA STATE PLANE COORDINATE SYSTEM FIPS 3900 (NAD83 INTERNATIONAL FEET).



LEGEND

- WELL SCREENED IN SHALLOW ZONE
- WELL SCREENED IN TRANSITION ZONE
- WELL SCREENED IN BEDROCK ZONE
- SURFACE WATER/SEDIMENT SAMPLE LOCATION
- STAFF GAUGE
- RIVER GAUGE
- SHEEN
- SOIL BORING LOCATION
- CROSS-SECTION LOCATION
- TOPOGRAPHIC CONTOUR (10' INTERVAL)
- TOPOGRAPHIC CONTOUR (2' INTERVAL)
- FORMER DRAINAGE DITCH (1964)
- ROAD
- SWAMP RABBIT TRAIL
- RAILROAD
- BUILDING
- EXCAVATED AREA (2001-2002)
- VAUGHN LANDFILL BOUNDARY
- HYDROLOGY
- PARCEL BOUNDARY
- WETLANDS (AES)
- WETLANDS (USFWS)

DUKE ENERGY. CAROLINAS

synTerra

GRAPHIC SCALE

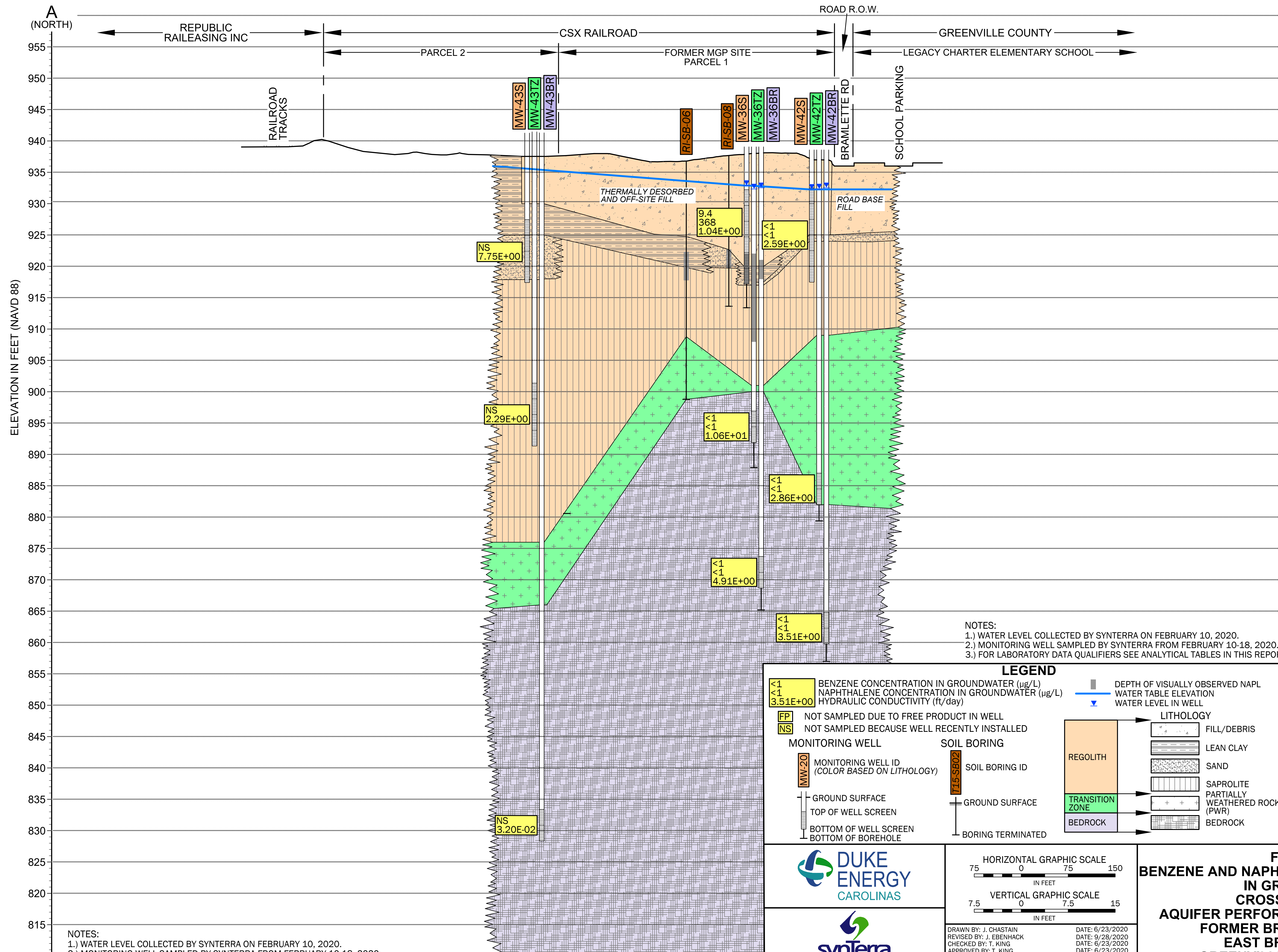
125 0 125 250

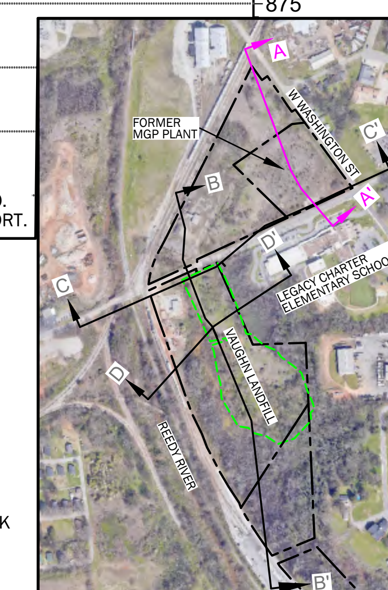
(IN FEET)

DRAWN BY: T. KING	DATE: 05/21/2019
REVISED BY: R. KIEKHAEFER	DATE: 09/28/2020
CHECKED BY: E. HICKS	DATE: 09/28/2020
APPROVED BY: T. PLATING	DATE: 09/28/2020
PROJECT MANAGER: T. PLATING	

www.synterracorp.com

FIGURE 1-2
SITE LAYOUT MAP (SEPTEMBER 2020)
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA





NOTES:
1.) WATER LEVEL COLLECTED BY SYNTERRA ON FEBRUARY 10, 2020.
2.) MONITORING WELL SAMPLED BY SYNTERRA FROM FEBRUARY 10-18, 2020.
3.) FOR LABORATORY DATA QUALIFIERS SEE ANALYTICAL TABLES IN THIS REPORT.

LEGEND

<1 / <1 / 3.51E+00 — BENZENE CONCENTRATION IN GROUNDWATER (µg/L); NAPHTHALENE CONCENTRATION IN GROUNDWATER (µg/L); HYDRAULIC CONDUCTIVITY (ft/day)

FP — NOT SAMPLED DUE TO FREE PRODUCT IN WELL

NS — NOT SAMPLED BECAUSE WELL RECENTLY INSTALLED

DEPTH OF VISUALLY OBSERVED NAPL

WATER TABLE ELEVATION

WATER LEVEL IN WELL

MONITORING WELL
- MW-20 — MONITORING WELL ID *(COLOR BASED ON LITHOLOGY)*
- GROUND SURFACE
- TOP OF WELL SCREEN
- BOTTOM OF WELL SCREEN
- BOTTOM OF BOREHOLE

SOIL BORING
- T15-SB02 — SOIL BORING ID
- GROUND SURFACE
- BORING TERMINATED

LITHOLOGY
- REGOLITH: FILL/DEBRIS; LEAN CLAY; SAND; SAPROLITE
- TRANSITION ZONE: PARTIALLY WEATHERED ROCK (PWR)
- BEDROCK: BEDROCK

NOTES:
1.) WATER LEVEL COLLECTED BY SYNTERRA ON FEBRUARY 10, 2020.
2.) MONITORING WELL SAMPLED BY SYNTERRA FROM FEBRUARY 10-18, 2020.

DUKE ENERGY CAROLINAS

synTerra

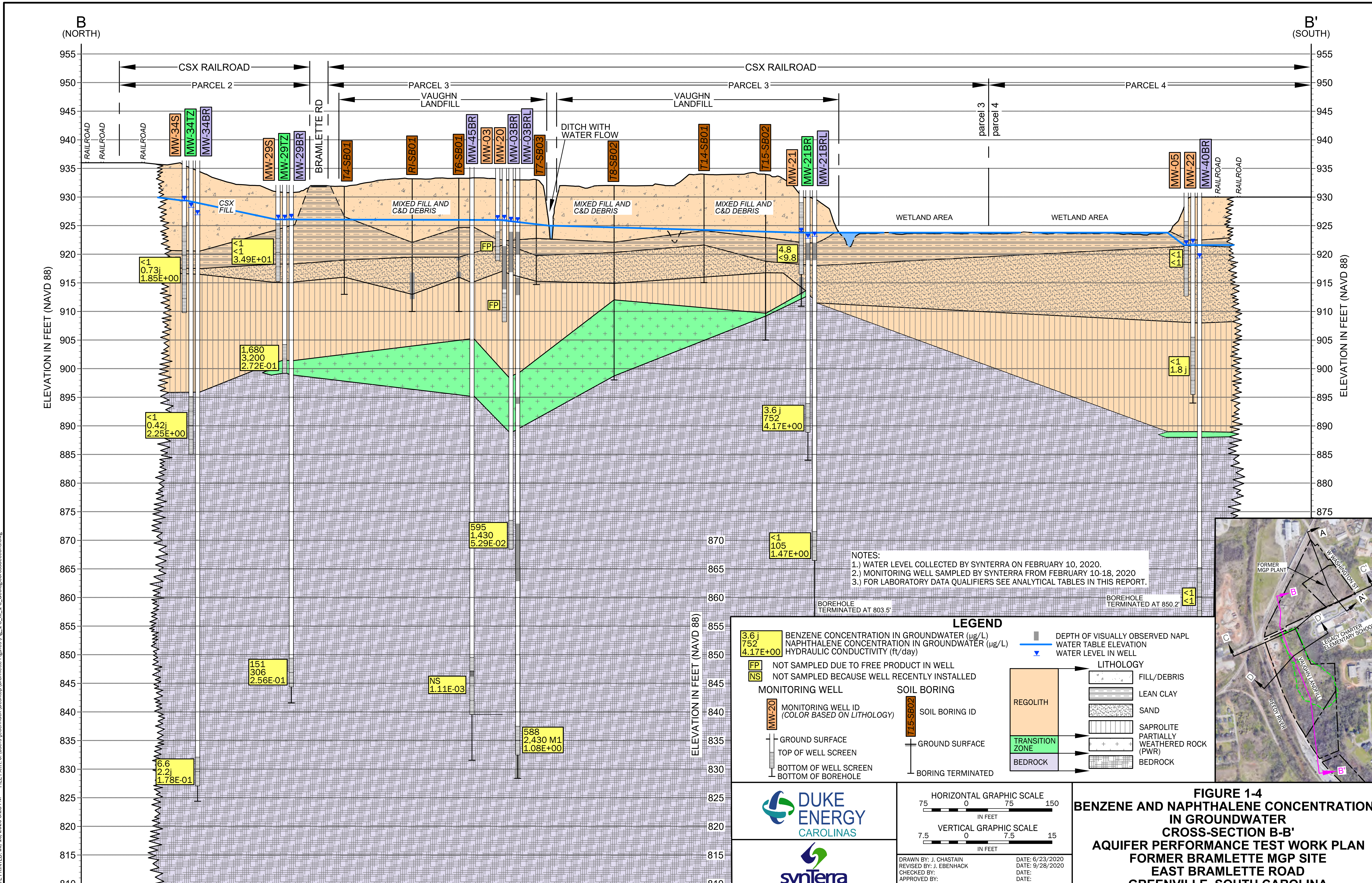
HORIZONTAL GRAPHIC SCALE
75 0 75 150
IN FEET

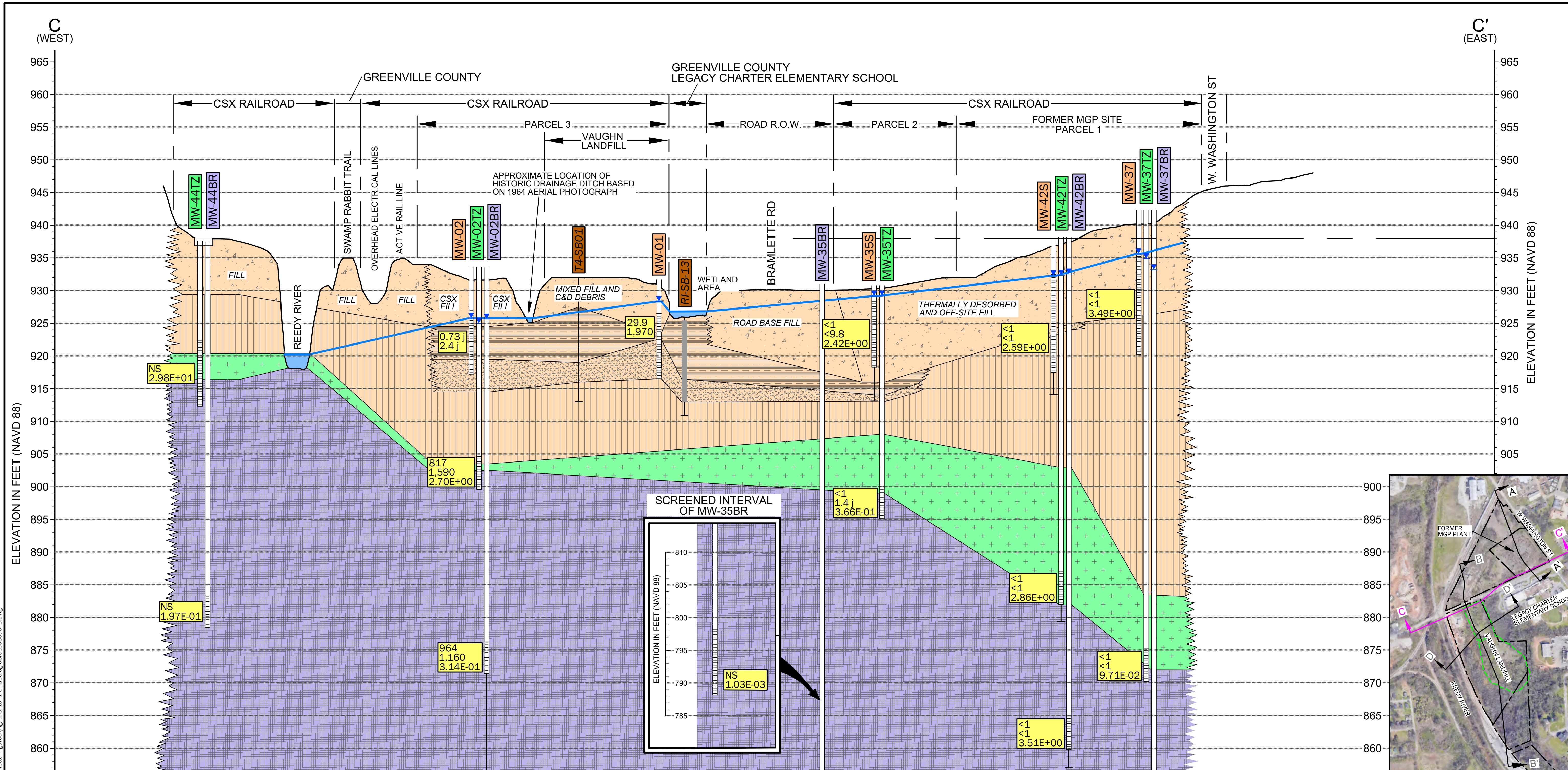
VERTICAL GRAPHIC SCALE
7.5 0 7.5 15
IN FEET

DRAWN BY: J. CHASTAIN	DATE: 6/23/2020
REVISED BY: J. EBENHACK	DATE: 9/28/2020
CHECKED BY: T. KING	DATE: 6/23/2020
APPROVED BY: T. KING	DATE: 6/23/2020
PROJECT MANAGER: T. PLATING	

FIGURE 1-3
BENZENE AND NAPHTHALENE CONCENTRATIONS IN GROUNDWATER CROSS-SECTION A-A'
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA

DATE PRINTED: 10/16/2020 3:27 PM FILE PATH: C:\Users\jebenhack\Desktop\Bramlette Figures\Fig_1-3_to_1-6_GeologicCrossSections.dwg


B
(NORTH)
B'
(SOUTH)
CSX RAILROAD
PARCEL 2
PARCEL 3
PARCEL 4
VAUGHN LANDFILL
BRAMLETTE RD
DITCH WITH WATER FLOW
parcel 3
parcel 4
RAILROAD
MW-34S
MW-34TZ
MW-34BR
MW-29S
MW-29TZ
MW-29BR
T4-SB01
RI-SB01
T6-SB01
MW-45BR
MW-03
MW-20
MW-03BR
MW-03BRL
T7-SB03
T8-SB02
T14-SB01
T15-SB02
MW-21
MW-21BR
MW-21BRL
MW-05
MW-22
MW-40BR
CSX FILL
MIXED FILL AND C&D DEBRIS
WETLAND AREA
ELEVATION IN FEET (NAVD 88)
<1
<1
3.49E+01
<1
0.73j
1.85E+00
FP
FP
4.8
<9.8
<1
<1
1,680
3,200
2.72E-01
<1
0.42j
2.25E+00
3.6 j
752
4.17E+00
<1
1.8 j
595
1,430
5.29E-02
<1
105
1.47E+00
<1
<1
151
306
2.56E-01
NS
1.11E-03
588
2,430 M1
1.08E+00
6.6
2.2j
1.78E-01
BOREHOLE TERMINATED AT 803.5'
BOREHOLE TERMINATED AT 850.2'
NOTES:
1.) WATER LEVEL COLLECTED BY SYNTERRA ON FEBRUARY 10, 2020.
2.) MONITORING WELL SAMPLED BY SYNTERRA FROM FEBRUARY 10-18, 2020
3.) FOR LABORATORY DATA QUALIFIERS SEE ANALYTICAL TABLES IN THIS REPORT.
LEGEND
3.6 j BENZENE CONCENTRATION IN GROUNDWATER (µg/L)
752 NAPHTHALENE CONCENTRATION IN GROUNDWATER (µg/L)
4.17E+00 HYDRAULIC CONDUCTIVITY (ft/day)
FP NOT SAMPLED DUE TO FREE PRODUCT IN WELL
NS NOT SAMPLED BECAUSE WELL RECENTLY INSTALLED
DEPTH OF VISUALLY OBSERVED NAPL
WATER TABLE ELEVATION
WATER LEVEL IN WELL
MONITORING WELL
MW-20 MONITORING WELL ID (COLOR BASED ON LITHOLOGY)
GROUND SURFACE
TOP OF WELL SCREEN
BOTTOM OF WELL SCREEN
BOTTOM OF BOREHOLE
SOIL BORING
T15-SB02 SOIL BORING ID
GROUND SURFACE
BORING TERMINATED
LITHOLOGY
REGOLITH
TRANSITION ZONE
BEDROCK
FILL/DEBRIS
LEAN CLAY
SAND
SAPROLITE
PARTIALLY WEATHERED ROCK (PWR)
BEDROCK
FORMER MGP PLANT
W WASHINGTON ST
LEGACY CHARTER ELEMENTARY SCHOOL
VAUGHN LANDFILL
REEDY RIVER
DUKE ENERGY CAROLINAS
synTerra
HORIZONTAL GRAPHIC SCALE
75 0 75 150
IN FEET
VERTICAL GRAPHIC SCALE
7.5 0 7.5 15
IN FEET
DRAWN BY: J. CHASTAIN DATE: 6/23/2020
REVISED BY: J. EBENHACK DATE: 9/28/2020
CHECKED BY: DATE:
APPROVED BY: DATE:
PROJECT MANAGER: T. PLATING
FIGURE 1-4
BENZENE AND NAPHTHALENE CONCENTRATIONS IN GROUNDWATER
CROSS-SECTION B-B'
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA
DATE PRINTED: 10/16/2020 3:28 PM
FILE PATH: C:\Users\jebenhack\Desktop\Bramlette Figures\Fig_1-3_to_1-6_GeologicCrossSections.dwg



NOTES:
1.) WATER LEVEL COLLECTED BY SYNTERRA ON FEBRUARY 10, 2020.
2.) MONITORING WELL SAMPLED BY SYNTERRA FROM FEBRUARY 10-18, 2020.
3.) FOR LABORATORY DATA QUALIFIERS SEE ANALYTICAL TABLES IN THIS REPORT.

LEGEND

964 / 1,160 / 3.14E-01 — BENZENE CONCENTRATION IN GROUNDWATER (µg/L); NAPHTHALENE CONCENTRATION IN GROUNDWATER (µg/L); HYDRAULIC CONDUCTIVITY (ft/day)

FP — NOT SAMPLED DUE TO FREE PRODUCT IN WELL

NS — NOT SAMPLED BECAUSE WELL RECENTLY INSTALLED

DEPTH OF VISUALLY OBSERVED NAPL

WATER TABLE ELEVATION

WATER LEVEL IN WELL

MONITORING WELL

MW-20 — MONITORING WELL ID (*COLOR BASED ON LITHOLOGY*)

GROUND SURFACE

TOP OF WELL SCREEN

BOTTOM OF WELL SCREEN

BOTTOM OF BOREHOLE

SOIL BORING

T15-SB02 — SOIL BORING ID

GROUND SURFACE

BORING TERMINATED

LITHOLOGY

REGOLITH: FILL/DEBRIS; LEAN CLAY; SAND; SAPROLITE

TRANSITION ZONE: PARTIALLY WEATHERED ROCK (PWR)

BEDROCK: BEDROCK

DUKE ENERGY CAROLINAS

synTerra

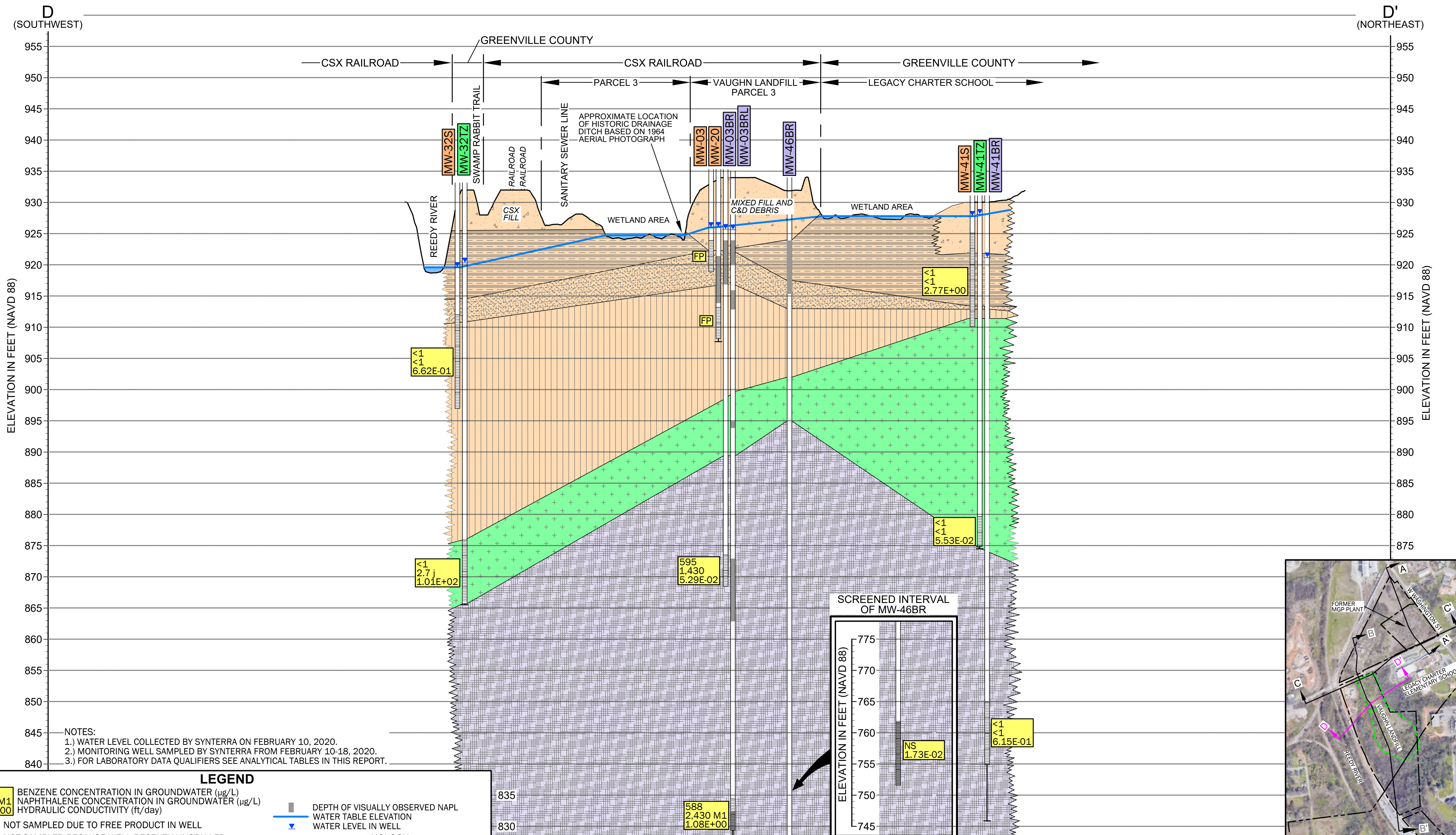
HORIZONTAL GRAPHIC SCALE: 75 0 75 150 IN FEET

VERTICAL GRAPHIC SCALE: 7.5 0 7.5 15 IN FEET

DRAWN BY: J. CHASTAIN — DATE: 6/23/2020
REVISED BY: J. EBENHACK — DATE: 9/28/2020
CHECKED BY: T. KING — DATE: 6/23/2020
APPROVED BY: T. KING — DATE: 6/23/2020
PROJECT MANAGER: T. PLATING

FIGURE 1-5
BENZENE AND NAPHTHALENE CONCENTRATIONS IN GROUNDWATER CROSS-SECTION C-C'
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA

DATE PRINTED: 10/16/2020 3:29 PM FILE PATH: C:\Users\jebenhack\Desktop\Bramlette Figures\Fig_1-3_to_1-6_GeologicCrossSections.dwg



NOTES:
1.) WATER LEVEL COLLECTED BY SYNTERRA ON FEBRUARY 10, 2020.
2.) MONITORING WELL SAMPLED BY SYNTERRA FROM FEBRUARY 10-18, 2020.
3.) FOR LABORATORY DATA QUALIFIERS SEE ANALYTICAL TABLES IN THIS REPORT.

LEGEND

588 — BENZENE CONCENTRATION IN GROUNDWATER (µg/L)
2,430 M1 — NAPHTHALENE CONCENTRATION IN GROUNDWATER (µg/L)
1.08E+00 — HYDRAULIC CONDUCTIVITY (ft/day)

FP — NOT SAMPLED DUE TO FREE PRODUCT IN WELL
NS — NOT SAMPLED BECAUSE WELL RECENTLY INSTALLED

DEPTH OF VISUALLY OBSERVED NAPL
WATER TABLE ELEVATION
WATER LEVEL IN WELL

MONITORING WELL
MW-20 MONITORING WELL ID *(COLOR BASED ON LITHOLOGY)*
GROUND SURFACE
TOP OF WELL SCREEN
BOTTOM OF WELL SCREEN
BOTTOM OF BOREHOLE

SOIL BORING
715-SB02 SOIL BORING ID
GROUND SURFACE
BORING TERMINATED

LITHOLOGY
REGOLITH: FILL/DEBRIS; LEAN CLAY; SAND; SAPROLITE
TRANSITION ZONE: PARTIALLY WEATHERED ROCK (PWR)
BEDROCK: BEDROCK

DUKE ENERGY CAROLINAS

synTerra

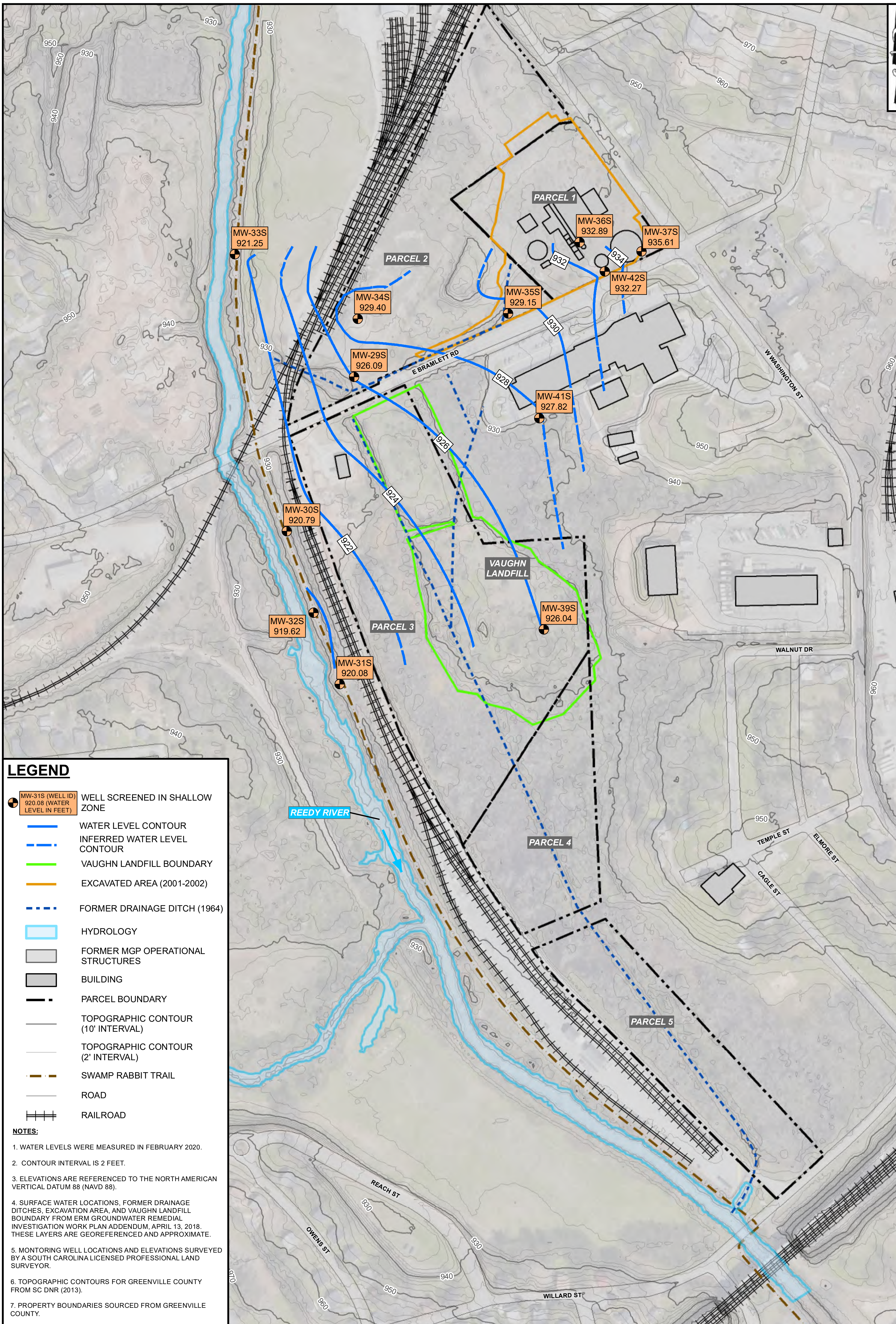
HORIZONTAL GRAPHIC SCALE
75 0 75 150
IN FEET

VERTICAL GRAPHIC SCALE
7.5 0 7.5 15
IN FEET

DRAWN BY: J. CHASTAIN DATE: 6/23/2020
REVISED BY: J. EBENHACK DATE: 9/28/2020
CHECKED BY: DATE:
APPROVED BY: DATE:
PROJECT MANAGER: T. PLATING

FIGURE 1-6
BENZENE AND NAPHTHALENE CONCENTRATIONS IN GROUNDWATER
CROSS-SECTION D-D'
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA

DATE PRINTED: 10/16/2020 3:30 PM FILE PATH: C:\Users\jebenhack\Desktop\Bramlette Figures\Fig_1-3_to_1-6_GeologicCrossSections.dwg



LEGEND

MW-31S (WELL ID) 920.08 (WATER LEVEL IN FEET)	WELL SCREENED IN SHALLOW ZONE
	WATER LEVEL CONTOUR
	INFERRED WATER LEVEL CONTOUR
	VAUGHN LANDFILL BOUNDARY
	EXCAVATED AREA (2001-2002)
	FORMER DRAINAGE DITCH (1964)
	HYDROLOGY
	FORMER MGP OPERATIONAL STRUCTURES
	BUILDING
	PARCEL BOUNDARY
	TOPOGRAPHIC CONTOUR (10' INTERVAL)
	TOPOGRAPHIC CONTOUR (2' INTERVAL)
	SWAMP RABBIT TRAIL
	ROAD
	RAILROAD

NOTES:

1. WATER LEVELS WERE MEASURED IN FEBRUARY 2020.
2. CONTOUR INTERVAL IS 2 FEET.
3. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM 88 (NAVD 88).
4. SURFACE WATER LOCATIONS, FORMER DRAINAGE DITCHES, EXCAVATION AREA, AND VAUGHN LANDFILL BOUNDARY FROM ERM GROUNDWATER REMEDIAL INVESTIGATION WORK PLAN ADDENDUM, APRIL 13, 2018. THESE LAYERS ARE GEOREFERENCED AND APPROXIMATE.
5. MONTORING WELL LOCATIONS AND ELEVATIONS SURVEYED BY A SOUTH CAROLINA LICENSED PROFESSIONAL LAND SURVEYOR.
6. TOPOGRAPHIC CONTOURS FOR GREENVILLE COUNTY FROM SC DNR (2013).
7. PROPERTY BOUNDARIES SOURCED FROM GREENVILLE COUNTY.
8. WETLANDS BY US FISH AND WILDLIFE NATIONAL WETLAND INVENTORY.
9. SWAMP RABBIT TRAIL CENTERLINE FROM CITY OF GREENVILLE.
10. AERIAL PHOTOGRAPHY OBTAINED FROM GOOGLE EARTH PRO ON MAY 3, 2019. AERIAL WAS COLLECTED ON MARCH 12, 2018.
11. DRAWING HAS BEEN SET WITH A PROJECTION OF SOUTH CAROLINA STATE PLANE COORDINATE SYSTEM FIPS 3900 (NAD83 INTERNATIONAL FEET).

DUKE ENERGY CAROLINAS

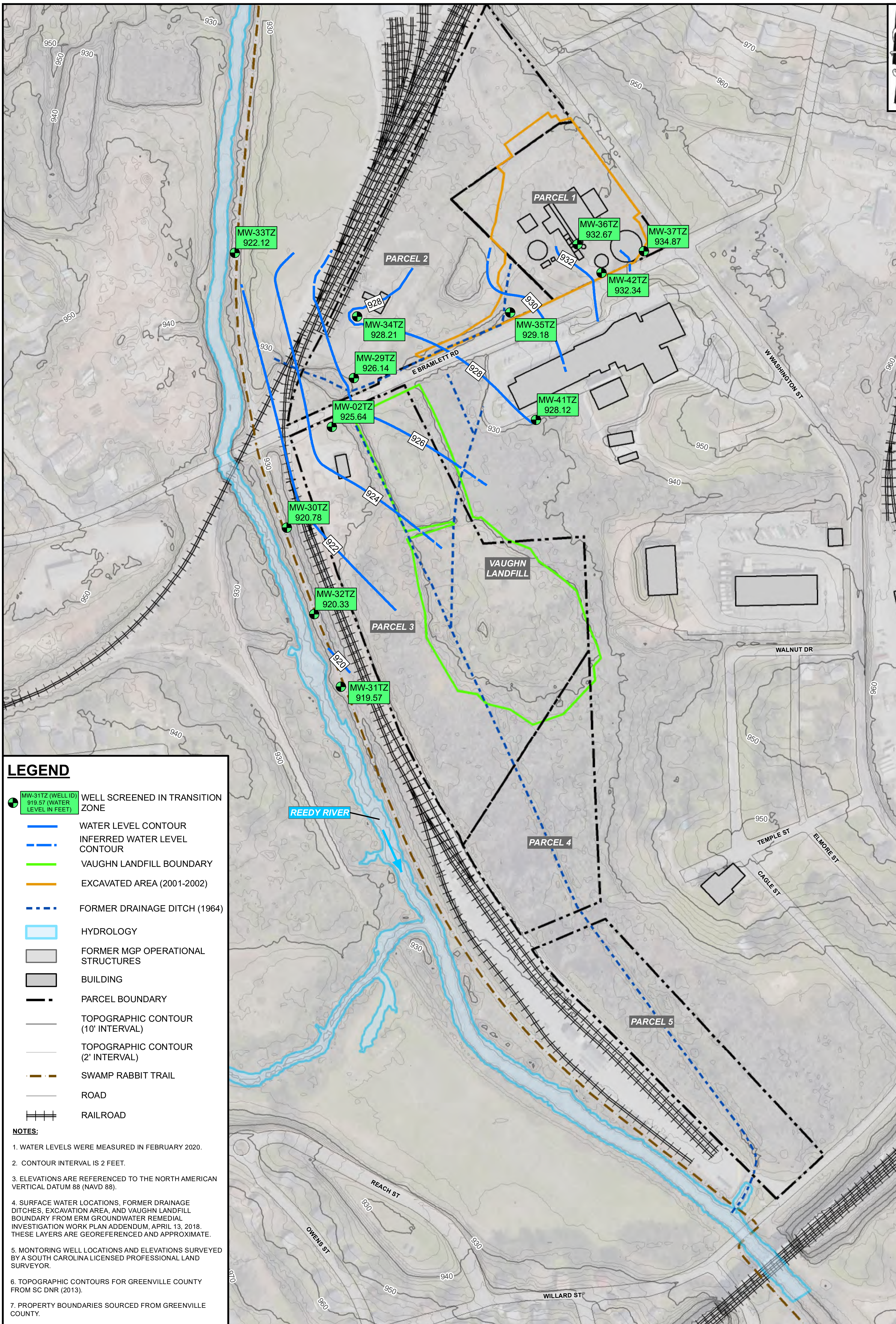
synTerra

GRAPHIC SCALE
125 0 125 250
(IN FEET)

DRAWN BY: R. KIEKHAEFER DATE: 09/17/2020
REVISED BY: R. KIEKHAEFER DATE: 09/28/2020
CHECKED BY: E. HICKS DATE: 09/28/2020
APPROVED BY: T. PLATING DATE: 09/28/2020
PROJECT MANAGER: T. PLATING

www.synterracorp.com

FIGURE 1-7
WATER LEVEL MAP (FEBRUARY 2020)
SHALLOW ZONE (ALLUVIAL/SAPROLITE)
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE ROAD MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA



LEGEND

MW-31TZ (WELL ID) 919.57 (WATER LEVEL IN FEET)	WELL SCREENED IN TRANSITION ZONE
	WATER LEVEL CONTOUR
	INFERRED WATER LEVEL CONTOUR
	VAUGHN LANDFILL BOUNDARY
	EXCAVATED AREA (2001-2002)
	FORMER DRAINAGE DITCH (1964)
	HYDROLOGY
	FORMER MGP OPERATIONAL STRUCTURES
	BUILDING
	PARCEL BOUNDARY
	TOPOGRAPHIC CONTOUR (10' INTERVAL)
	TOPOGRAPHIC CONTOUR (2' INTERVAL)
	SWAMP RABBIT TRAIL
	ROAD
	RAILROAD

NOTES:

1. WATER LEVELS WERE MEASURED IN FEBRUARY 2020.
2. CONTOUR INTERVAL IS 2 FEET.
3. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM 88 (NAVD 88).
4. SURFACE WATER LOCATIONS, FORMER DRAINAGE DITCHES, EXCAVATION AREA, AND VAUGHN LANDFILL BOUNDARY FROM ERM GROUNDWATER REMEDIAL INVESTIGATION WORK PLAN ADDENDUM, APRIL 13, 2018. THESE LAYERS ARE GEOREFERENCED AND APPROXIMATE.
5. MONTORING WELL LOCATIONS AND ELEVATIONS SURVEYED BY A SOUTH CAROLINA LICENSED PROFESSIONAL LAND SURVEYOR.
6. TOPOGRAPHIC CONTOURS FOR GREENVILLE COUNTY FROM SC DNR (2013).
7. PROPERTY BOUNDARIES SOURCED FROM GREENVILLE COUNTY.
8. WETLANDS BY US FISH AND WILDLIFE NATIONAL WETLAND INVENTORY.
9. SWAMP RABBIT TRAIL CENTERLINE FROM CITY OF GREENVILLE.
10. AERIAL PHOTOGRAPHY OBTAINED FROM GOOGLE EARTH PRO ON MAY 3, 2019. AERIAL WAS COLLECTED ON MARCH 12, 2018.
11. DRAWING HAS BEEN SET WITH A PROJECTION OF SOUTH CAROLINA STATE PLANE COORDINATE SYSTEM FIPS 3900 (NAD83 INTERNATIONAL FEET).

DUKE ENERGY. CAROLINAS

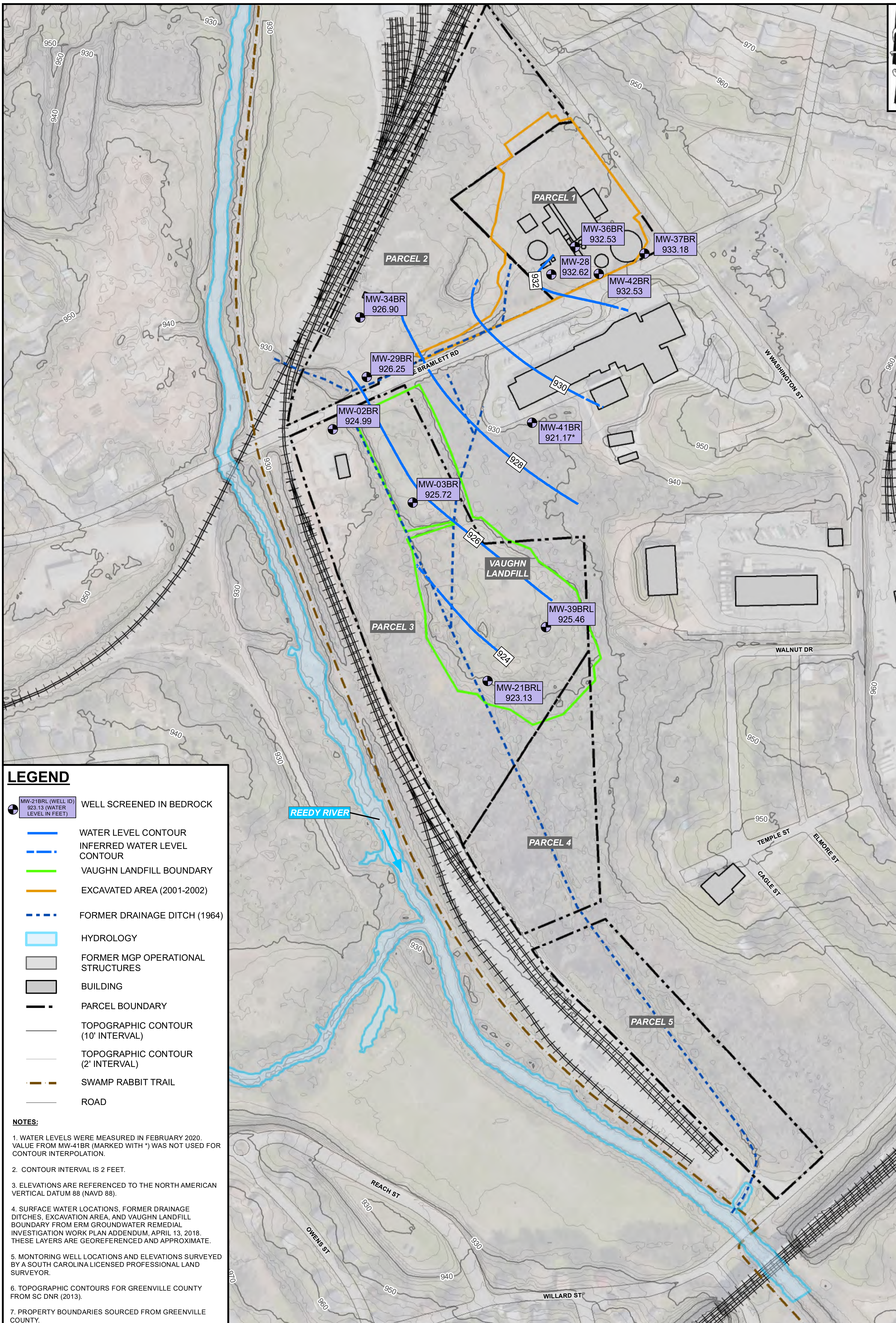
synTerra

GRAPHIC SCALE
125 0 125 250
(IN FEET)

DRAWN BY: R. KIEKHAEFER DATE: 09/17/2020
REVISED BY: R. KIEKHAEFER DATE: 09/28/2020
CHECKED BY: E. HICKS DATE: 09/28/2020
APPROVED BY: T. PLATING DATE: 09/28/2020
PROJECT MANAGER: T. PLATING

www.synterracorp.com

FIGURE 1-8
WATER LEVEL MAP (FEBRUARY 2020)
TRANSITION ZONE
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE ROAD MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA



LEGEND

MW-21BRL (WELL ID) 923.13 (WATER LEVEL IN FEET) — WELL SCREENED IN BEDROCK

WATER LEVEL CONTOUR

INFERRED WATER LEVEL CONTOUR

VAUGHN LANDFILL BOUNDARY

EXCAVATED AREA (2001-2002)

FORMER DRAINAGE DITCH (1964)

HYDROLOGY

FORMER MGP OPERATIONAL STRUCTURES

BUILDING

PARCEL BOUNDARY

TOPOGRAPHIC CONTOUR (10' INTERVAL)

TOPOGRAPHIC CONTOUR (2' INTERVAL)

SWAMP RABBIT TRAIL

ROAD

NOTES:

1. WATER LEVELS WERE MEASURED IN FEBRUARY 2020. VALUE FROM MW-41BR (MARKED WITH *) WAS NOT USED FOR CONTOUR INTERPOLATION.
2. CONTOUR INTERVAL IS 2 FEET.
3. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM 88 (NAVD 88).
4. SURFACE WATER LOCATIONS, FORMER DRAINAGE DITCHES, EXCAVATION AREA, AND VAUGHN LANDFILL BOUNDARY FROM ERM GROUNDWATER REMEDIAL INVESTIGATION WORK PLAN ADDENDUM, APRIL 13, 2018. THESE LAYERS ARE GEOREFERENCED AND APPROXIMATE.
5. MONITORING WELL LOCATIONS AND ELEVATIONS SURVEYED BY A SOUTH CAROLINA LICENSED PROFESSIONAL LAND SURVEYOR.
6. TOPOGRAPHIC CONTOURS FOR GREENVILLE COUNTY FROM SC DNR (2013).
7. PROPERTY BOUNDARIES SOURCED FROM GREENVILLE COUNTY.
8. WETLANDS BY US FISH AND WILDLIFE NATIONAL WETLAND INVENTORY.
9. SWAMP RABBIT TRAIL CENTERLINE FROM CITY OF GREENVILLE.
10. AERIAL PHOTOGRAPHY OBTAINED FROM GOOGLE EARTH PRO ON MAY 3, 2019. AERIAL WAS COLLECTED ON MARCH 12, 2018.
11. DRAWING HAS BEEN SET WITH A PROJECTION OF SOUTH CAROLINA STATE PLANE COORDINATE SYSTEM FIPS 3900 (NAD83 INTERNATIONAL FEET).

DUKE ENERGY CAROLINAS

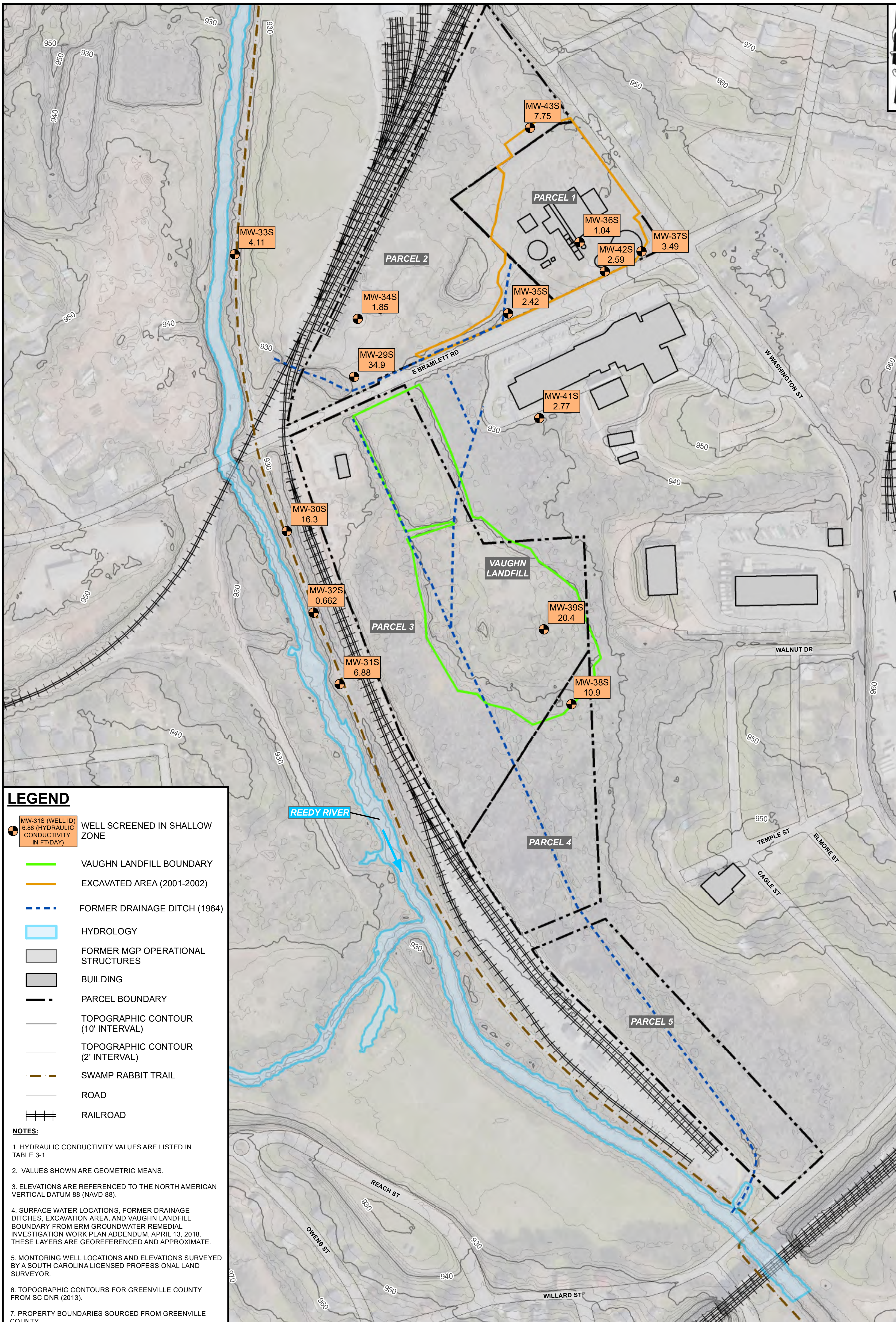
synTerra

GRAPHIC SCALE
125 0 125 250
(IN FEET)

DRAWN BY: R. KIEKHAEFER DATE: 09/17/2020
REVISED BY: R. KIEKHAEFER DATE: 10/05/2020
CHECKED BY: E. HICKS DATE: 10/05/2020
APPROVED BY: T. PLATING DATE: 10/05/2020
PROJECT MANAGER: T. PLATING

www.synterracorp.com

FIGURE 1-9
WATER LEVEL MAP (FEBRUARY 2020)
BEDROCK ZONE
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE ROAD MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA



NOTES:

1. HYDRAULIC CONDUCTIVITY VALUES ARE LISTED IN TABLE 3-1.

2. VALUES SHOWN ARE GEOMETRIC MEANS.

3. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM 88 (NAVD 88).

4. SURFACE WATER LOCATIONS, FORMER DRAINAGE DITCHES, EXCAVATION AREA, AND VAUGHN LANDFILL BOUNDARY FROM ERM GROUNDWATER REMEDIAL INVESTIGATION WORK PLAN ADDENDUM, APRIL 13, 2018. THESE LAYERS ARE GEOREFERENCED AND APPROXIMATE.

5. MONITORING WELL LOCATIONS AND ELEVATIONS SURVEYED BY A SOUTH CAROLINA LICENSED PROFESSIONAL LAND SURVEYOR.

6. TOPOGRAPHIC CONTOURS FOR GREENVILLE COUNTY FROM SC DNR (2013).

7. PROPERTY BOUNDARIES SOURCED FROM GREENVILLE COUNTY.

8. WETLANDS BY US FISH AND WILDLIFE NATIONAL WETLAND INVENTORY.

9. SWAMP RABBIT TRAIL CENTERLINE FROM CITY OF GREENVILLE.

10. AERIAL PHOTOGRAPHY OBTAINED FROM GOOGLE EARTH PRO ON MAY 3, 2019. AERIAL WAS COLLECTED ON MARCH 12, 2018.

11. DRAWING HAS BEEN SET WITH A PROJECTION OF SOUTH CAROLINA STATE PLANE COORDINATE SYSTEM FIPS 3900 (NAD83 INTERNATIONAL FEET).

DUKE ENERGY CAROLINAS

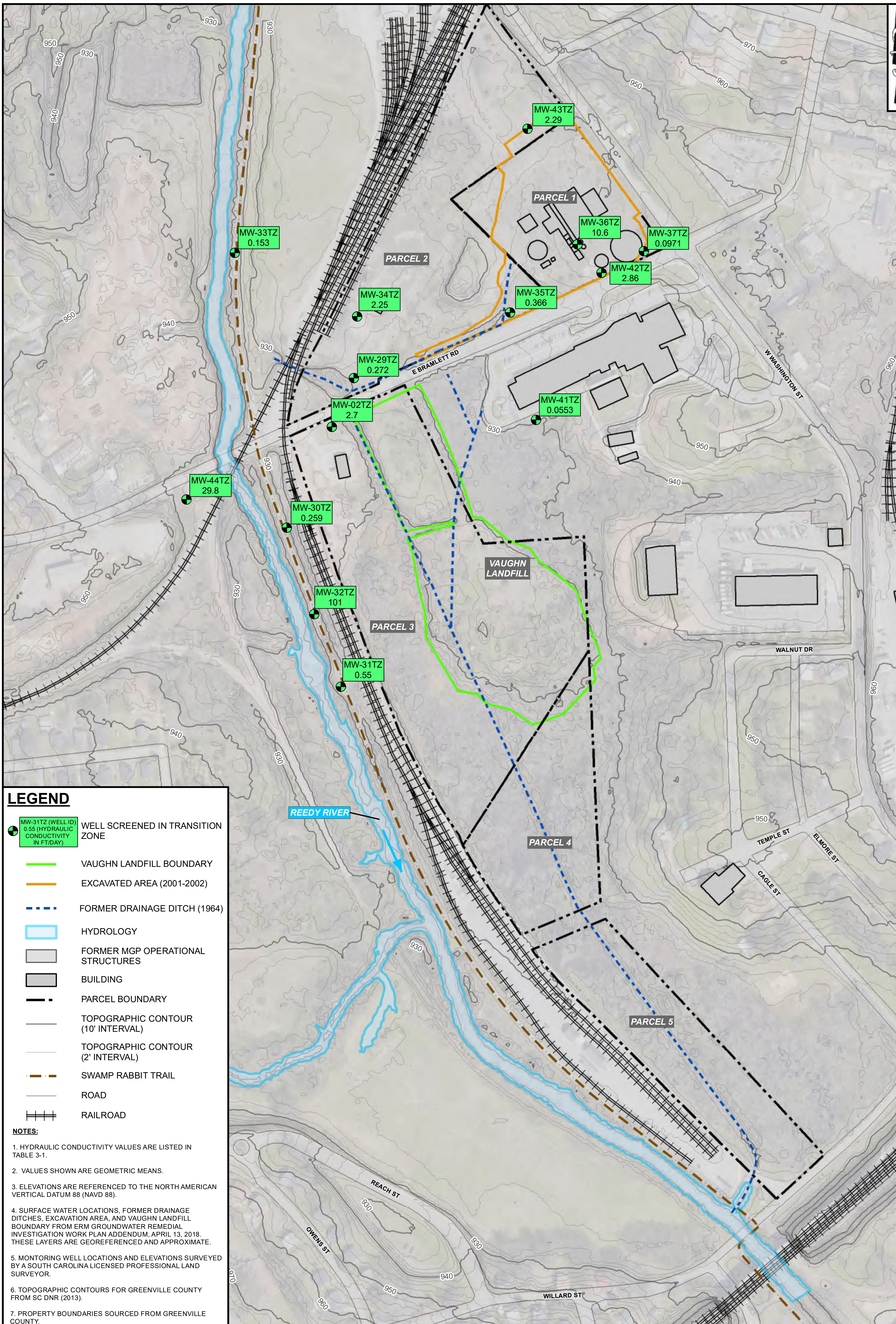
synTerra

GRAPHIC SCALE
125 0 125 250
(IN FEET)

DRAWN BY: R. KIEKHAEFER DATE: 09/17/2020
REVISED BY: R. KIEKHAEFER DATE: 09/28/2020
CHECKED BY: E. HICKS DATE: 09/28/2020
APPROVED BY: T. PLATING DATE: 09/28/2020
PROJECT MANAGER: T. PLATING

www.synterracorp.com

FIGURE 2-1
ALLUVIAL/SAPROLITE HYDRAULIC CONDUCTIVITY VALUES FROM SLUG TESTS
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE ROAD MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA



LEGEND

- MW-31TZ (WELL ID) 0.55 (HYDRAULIC CONDUCTIVITY IN FT/DAY) — WELL SCREENED IN TRANSITION ZONE
- VAUGHN LANDFILL BOUNDARY
- EXCAVATED AREA (2001-2002)
- FORMER DRAINAGE DITCH (1964)
- HYDROLOGY
- FORMER MGP OPERATIONAL STRUCTURES
- BUILDING
- PARCEL BOUNDARY
- TOPOGRAPHIC CONTOUR (10' INTERVAL)
- TOPOGRAPHIC CONTOUR (2' INTERVAL)
- SWAMP RABBIT TRAIL
- ROAD
- RAILROAD

NOTES:

1. HYDRAULIC CONDUCTIVITY VALUES ARE LISTED IN TABLE 3-1.
2. VALUES SHOWN ARE GEOMETRIC MEANS.
3. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM 88 (NAVD 88).
4. SURFACE WATER LOCATIONS, FORMER DRAINAGE DITCHES, EXCAVATION AREA, AND VAUGHN LANDFILL BOUNDARY FROM ERM GROUNDWATER REMEDIAL INVESTIGATION WORK PLAN ADDENDUM, APRIL 13, 2018. THESE LAYERS ARE GEOREFERENCED AND APPROXIMATE.
5. MONITORING WELL LOCATIONS AND ELEVATIONS SURVEYED BY A SOUTH CAROLINA LICENSED PROFESSIONAL LAND SURVEYOR.
6. TOPOGRAPHIC CONTOURS FOR GREENVILLE COUNTY FROM SC DNR (2013).
7. PROPERTY BOUNDARIES SOURCED FROM GREENVILLE COUNTY.
8. WETLANDS BY US FISH AND WILDLIFE NATIONAL WETLAND INVENTORY.
9. SWAMP RABBIT TRAIL CENTERLINE FROM CITY OF GREENVILLE.
10. AERIAL PHOTOGRAPHY OBTAINED FROM GOOGLE EARTH PRO ON MAY 3, 2019. AERIAL WAS COLLECTED ON MARCH 12, 2018.
11. DRAWING HAS BEEN SET WITH A PROJECTION OF SOUTH CAROLINA STATE PLANE COORDINATE SYSTEM FIPS 3900 (NAD83 INTERNATIONAL FEET).

DUKE ENERGY CAROLINAS

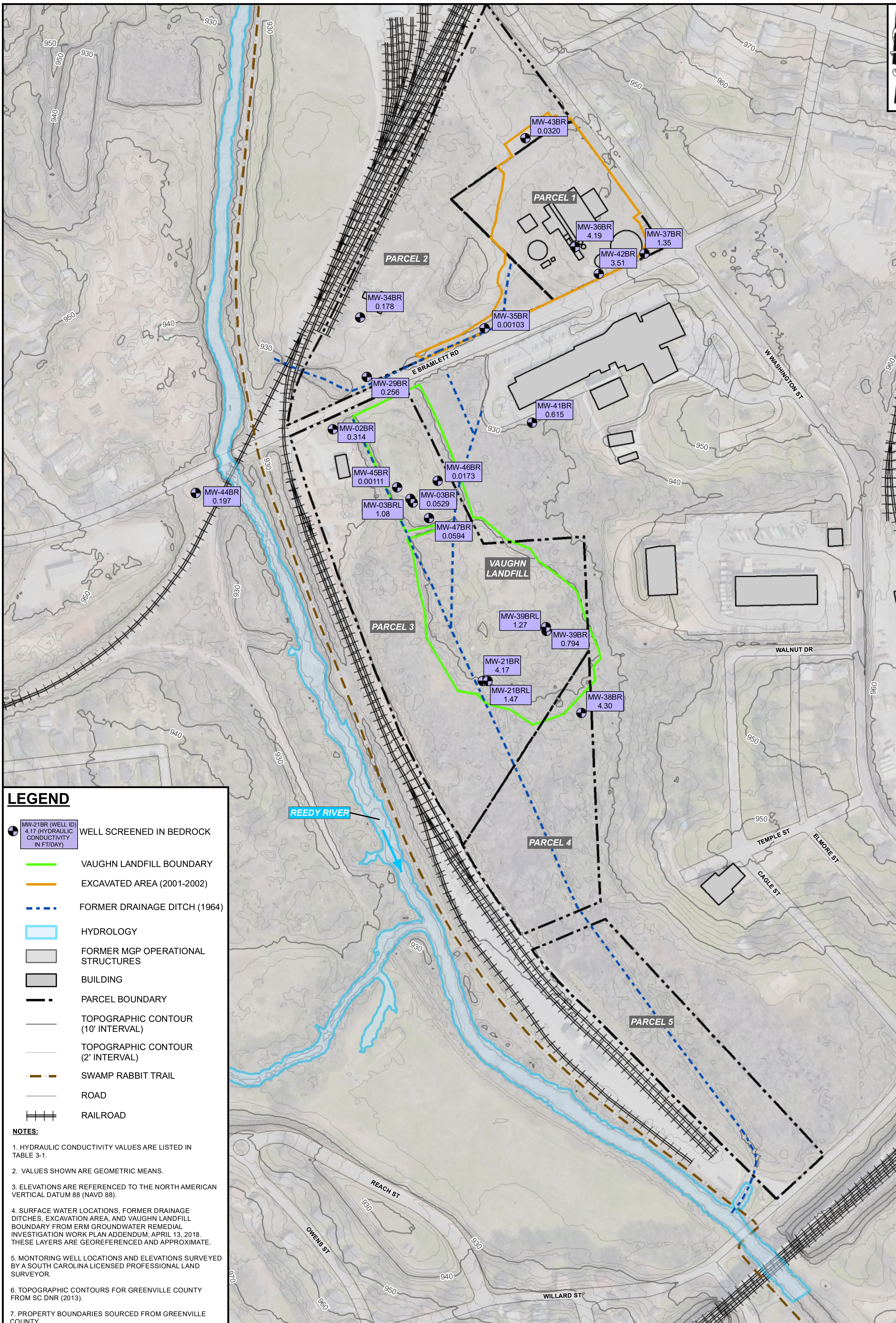
synTerra

GRAPHIC SCALE
125 0 125 250
(IN FEET)

DRAWN BY: R. KIEKHAEFER	DATE: 09/17/2020
REVISED BY: R. KIEKHAEFER	DATE: 09/28/2020
CHECKED BY: E. HICKS	DATE: 09/28/2020
APPROVED BY: T. PLATING	DATE: 09/28/2020
PROJECT MANAGER: T. PLATING	

www.synterracorp.com

FIGURE 2-2
TRANSITION ZONE HYDRAULIC CONDUCTIVITY VALUES FROM SLUG TESTS
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE ROAD MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA



LEGEND

MW-21BR (WELL ID) 4.17 (HYDRAULIC CONDUCTIVITY IN FT/DAY)	WELL SCREENED IN BEDROCK
	VAUGHN LANDFILL BOUNDARY
	EXCAVATED AREA (2001-2002)
	FORMER DRAINAGE DITCH (1964)
	HYDROLOGY
	FORMER MGP OPERATIONAL STRUCTURES
	BUILDING
	PARCEL BOUNDARY
	TOPOGRAPHIC CONTOUR (10' INTERVAL)
	TOPOGRAPHIC CONTOUR (2' INTERVAL)
	SWAMP RABBIT TRAIL
	ROAD
	RAILROAD

NOTES:

1. HYDRAULIC CONDUCTIVITY VALUES ARE LISTED IN TABLE 3-1.
2. VALUES SHOWN ARE GEOMETRIC MEANS.
3. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM 88 (NAVD 88).
4. SURFACE WATER LOCATIONS, FORMER DRAINAGE DITCHES, EXCAVATION AREA, AND VAUGHN LANDFILL BOUNDARY FROM ERM GROUNDWATER REMEDIAL INVESTIGATION WORK PLAN ADDENDUM, APRIL 13, 2018. THESE LAYERS ARE GEOREFERENCED AND APPROXIMATE.
5. MONTORING WELL LOCATIONS AND ELEVATIONS SURVEYED BY A SOUTH CAROLINA LICENSED PROFESSIONAL LAND SURVEYOR.
6. TOPOGRAPHIC CONTOURS FOR GREENVILLE COUNTY FROM SC DNR (2013).
7. PROPERTY BOUNDARIES SOURCED FROM GREENVILLE COUNTY.
8. WETLANDS BY US FISH AND WILDLIFE NATIONAL WETLAND INVENTORY.
9. SWAMP RABBIT TRAIL CENTERLINE FROM CITY OF GREENVILLE.
10. AERIAL PHOTOGRAPHY OBTAINED FROM GOOGLE EARTH PRO ON MAY 3, 2019. AERIAL WAS COLLECTED ON MARCH 12, 2018.
11. DRAWING HAS BEEN SET WITH A PROJECTION OF SOUTH CAROLINA STATE PLANE COORDINATE SYSTEM FIPS 3900 (NAD83 INTERNATIONAL FEET).

DUKE ENERGY. CAROLINAS

synTerra

GRAPHIC SCALE
125 0 125 250
(IN FEET)

DRAWN BY: R. KIEKHAEFER DATE: 09/17/2020
REVISED BY: R. KIEKHAEFER DATE: 10/05/2020
CHECKED BY: E. HICKS DATE: 10/05/2020
APPROVED BY: T. PLATING DATE: 10/05/2020
PROJECT MANAGER: T. PLATING

www.synterracorp.com

FIGURE 2-3
BEDROCK HYDRAULIC CONDUCTIVITY VALUES FROM SLUG TESTS
AQUIFER PERFORMANCE TEST PLAN
FORMER BRAMLETTE ROAD MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA

NOTES:

1. MONITORING WELL LOCATIONS WITH EXISTING TRANSDUCERS ARE NOTED IN ITALICS AND WITH AN ASTERISK (*) AFTER THE WELL ID.

2. PROPOSED HYDROGRAPH MONITORING WELLS ARE NOTED IN ITALICS AND WITH TWO ASTERISKS (**) AFTER THE WELL ID.

3. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM 88 (NAVD 88).

4. SURFACE WATER LOCATIONS, FORMER DRAINAGE DITCHES, EXCAVATION AREA, AND VAUGHN LANDFILL BOUNDARY FROM ERM GROUNDWATER REMEDIAL INVESTIGATION WORK PLAN ADDENDUM, APRIL 13, 2018. THESE LAYERS ARE GEOREFERENCED AND APPROXIMATE.

5. MONITORING WELL LOCATIONS AND ELEVATIONS SURVEYED BY A SOUTH CAROLINA LICENSED PROFESSIONAL LAND SURVEYOR

6. TOPOGRAPHIC CONTOURS FOR GREENVILLE COUNTY FROM SC DNR (2013).

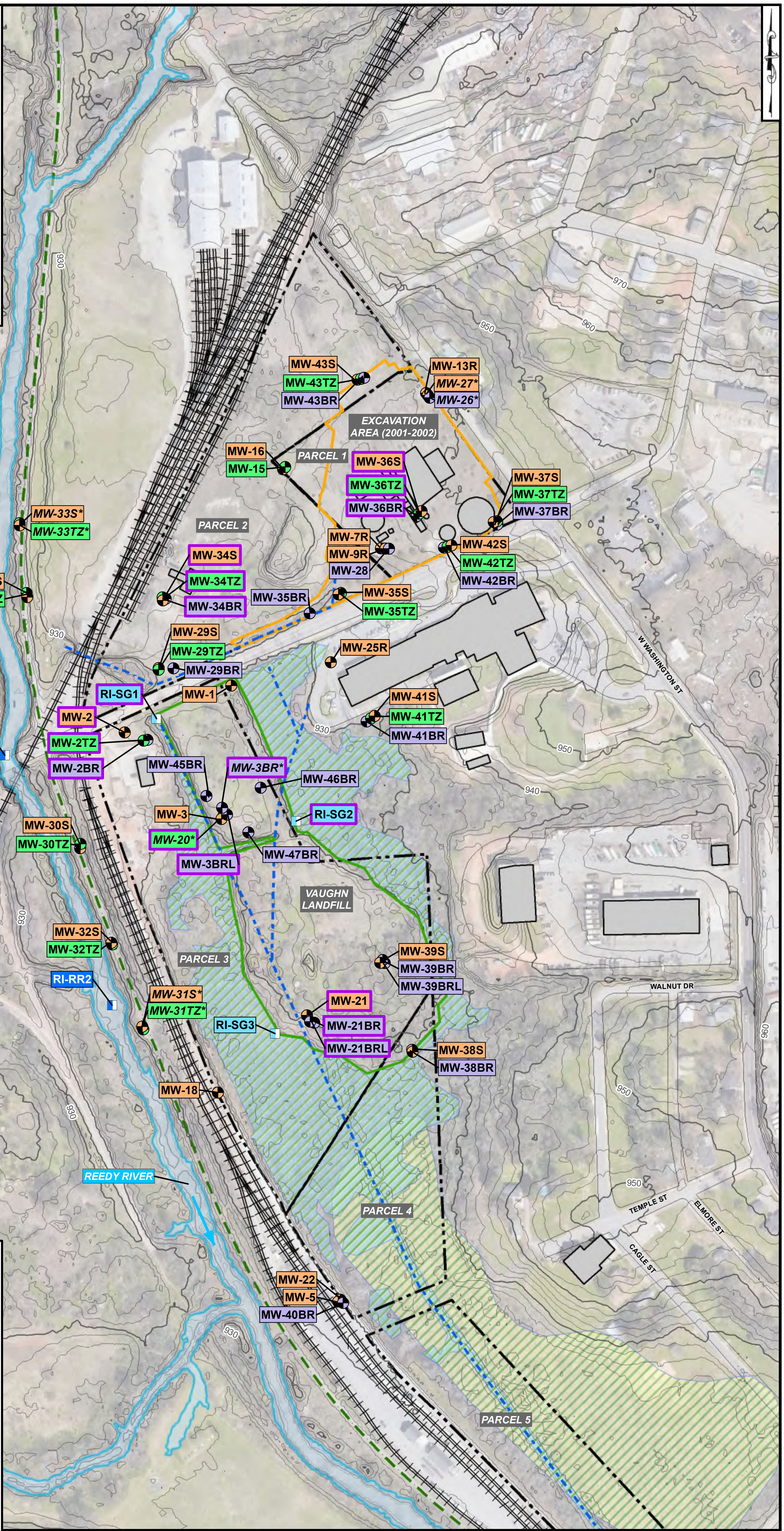
7. PROPERTY BOUNDARIES SOURCED FROM GREENVILLE COUNTY.

8. WETLANDS (USFWS) BY US FISH AND WILDLIFE NATIONAL WETLAND INVENTORY. WETLANDS (AES) DELINEATED BY APPLIED ENGINEERING AND SCIENCE, INC. IN 1999.

9. SWAMP RABBIT TRAIL CENTERLINE FROM CITY OF GREENVILLE.

10. AERIAL PHOTOGRAPHY OBTAINED FROM GOOGLE EARTH PRO ON MAY 3, 2019. AERIAL WAS COLLECTED ON MARCH 12, 2018.

11. DRAWING HAS BEEN SET WITH A PROJECTION OF SOUTH CAROLINA STATE PLANE COORDINATE SYSTEM FIPS 3900 (NAD83 INTERNATIONAL FEET).



LEGEND

- MW-2BR — WELL INSTRUMENTED WITH A PRESSURE TRANSDUCER
- RI-SG 1 — WETLANDS STAFF GAUGE INSTRUMENTED WITH A PRESSURE TRANSDUCER
- RI-RR 1 — REEDY RIVER STAFF GAUGE INSTRUMENTED WITH A PRESSURE TRANSDUCER
- WELL SCREENED IN SHALLOW ZONE
- WELL SCREENED IN TRANSITION ZONE
- WELL SCREENED IN BEDROCK ZONE
- STAFF GAUGE
- RIVER GAUGE
- TOPOGRAPHIC CONTOUR (10' INTERVAL)
- TOPOGRAPHIC CONTOUR (2' INTERVAL)
- FORMER DRAINAGE DITCH (1964)
- ROAD
- SWAMP RABBIT TRAIL
- RAILROAD
- BUILDING
- EXCAVATED AREA (2001-2002)
- VAUGHN LANDFILL BOUNDARY
- HYDROLOGY
- PARCEL BOUNDARY
- WETLANDS (AES)
- WETLANDS (USFWS)

DUKE ENERGY CAROLINAS

synTerra

GRAPHIC SCALE

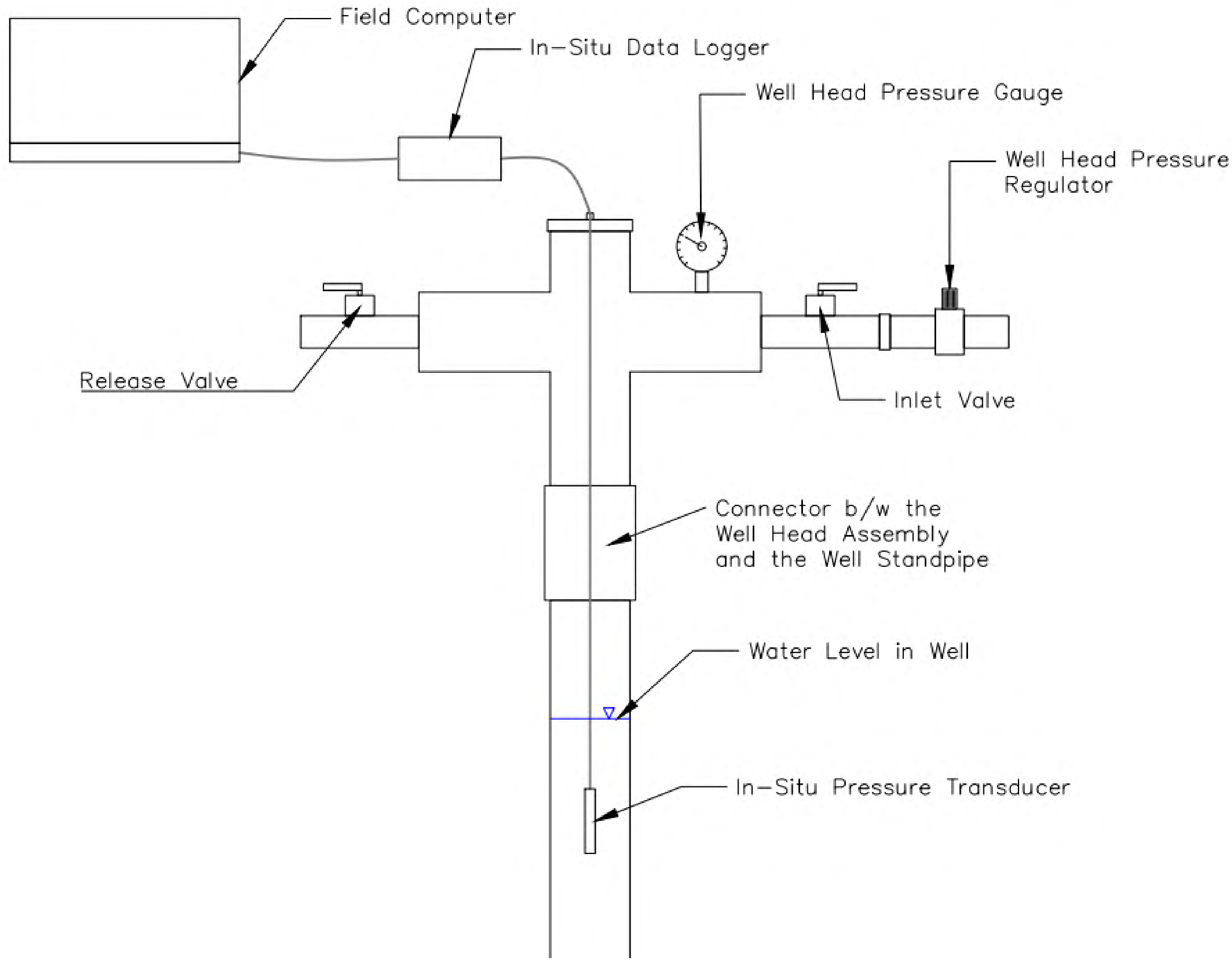
125 0 125 250

(IN FEET)

DRAWN BY: T. KING	DATE: 05/21/2019
REVISED BY: J. EBENHACK	DATE: 09/29/2020
CHECKED BY: E. HICKS	DATE: 09/29/2020
APPROVED BY: T. PLATING	DATE: 09/29/2020
PROJECT MANAGER: T. PLATING	

www.synterracorp.com

FIGURE 2-4
PROPOSED PRESSURE TRANSDUCER LOCATIONS FOR THE HYDROGRAPH EVALUATION
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA



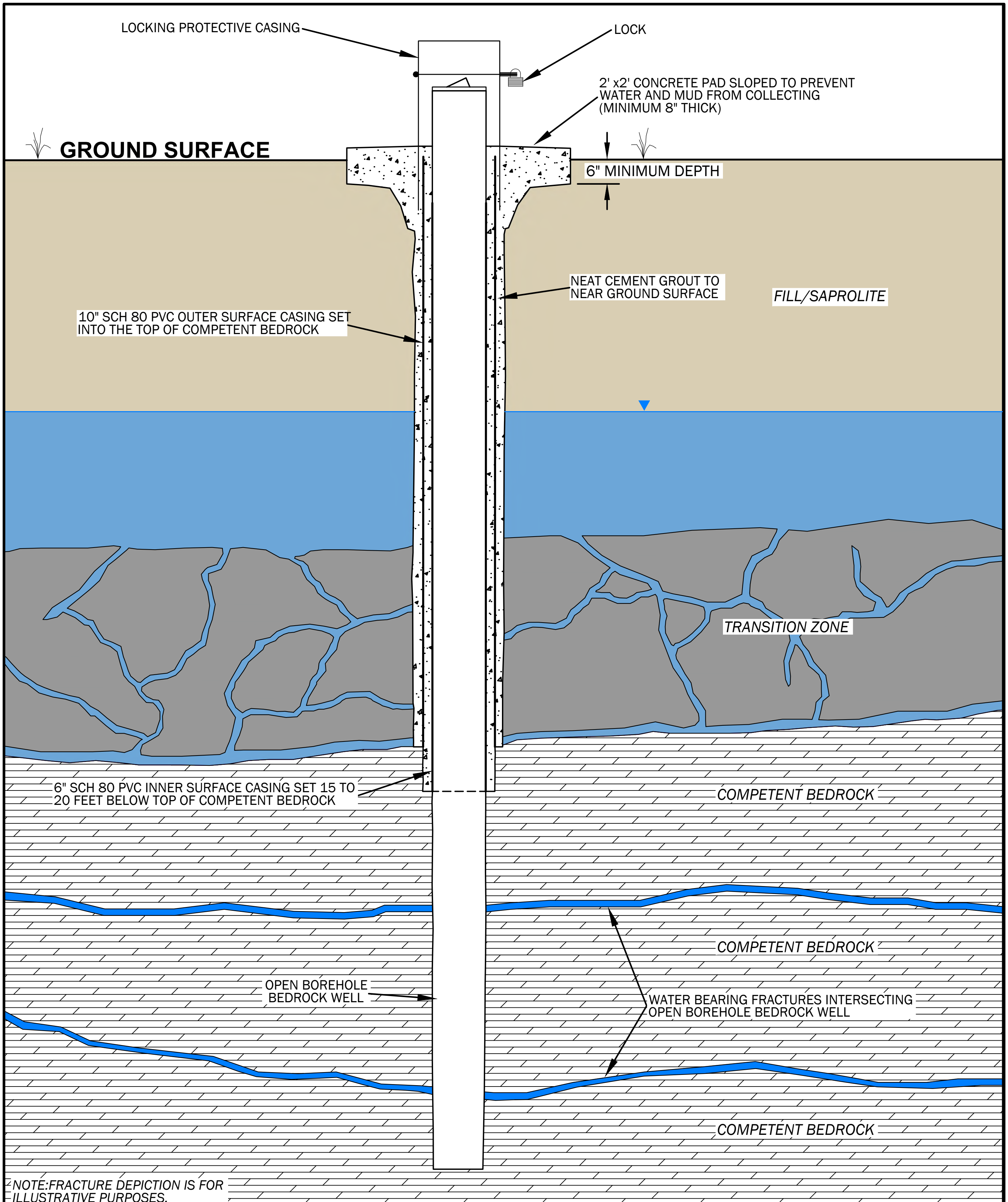
DUKE ENERGY. CAROLINAS

synTerra

DRAWN BY: J. EBENHACK	DATE: 09/17/2020
REVISED BY:	DATE: 09/17/2020
CHECKED BY: E. HICKS	DATE:09/17/2020
APPROVED BY: T. PLATING	DATE:09/17/2020
PROJECT MANAGER:	

www.synterracorp.com

FIGURE 2-5
PNEUMATIC WELL HEAD ASSEMBLY DIAGRAM
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA



synTerra

NOT TO SCALE

148 RIVER STREET, SUITE 220
GREENVILLE, SOUTH CAROLINA 29601
PHONE 864-421-9999
www.synterracorp.com

DRAWN BY: JOHNATHAN EBENHACK DATE: 09/23/2020
PROJECT MANAGER: TODD PLATING
LAYOUT: BEDROCK PUMPING WELL SCHEMATIC

FIGURE 2-6
BEDROCK PUMPING WELL SCHEMATIC
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA

NOTES:

1. MONITORING WELL LOCATIONS WITH EXISTING TRANSDUCERS ARE NOTED IN ITALICS AND WITH AN ASTERISK (*) AFTER THE WELL ID.

2. PROPOSED HYDROGRAPH MONITORING WELLS ARE NOTED IN ITALICS AND WITH TWO ASTERISKS (**) AFTER THE WELL ID.

3. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM 88 (NAVD 88).

4. SURFACE WATER LOCATIONS, FORMER DRAINAGE DITCHES, EXCAVATION AREA, AND VAUGHN LANDFILL BOUNDARY FROM ERM GROUNDWATER REMEDIAL INVESTIGATION WORK PLAN ADDENDUM, APRIL 13, 2018. THESE LAYERS ARE GEOREFERENCED AND APPROXIMATE.

5. MONITORING WELL LOCATIONS AND ELEVATIONS SURVEYED BY A SOUTH CAROLINA LICENSED PROFESSIONAL LAND SURVEYOR

6. TOPOGRAPHIC CONTOURS FOR GREENVILLE COUNTY FROM SC DNR (2013).

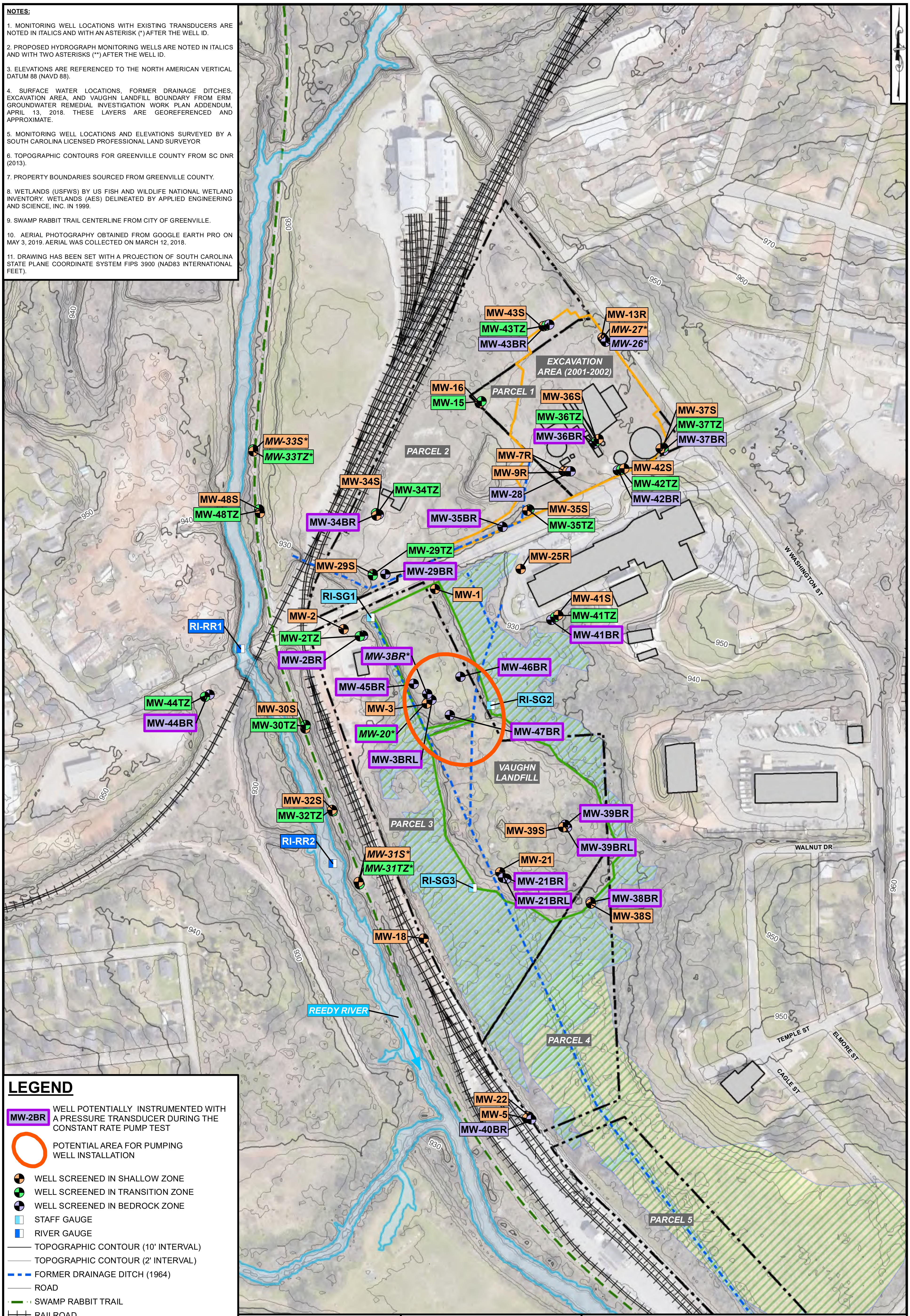
7. PROPERTY BOUNDARIES SOURCED FROM GREENVILLE COUNTY.

8. WETLANDS (USFWS) BY US FISH AND WILDLIFE NATIONAL WETLAND INVENTORY. WETLANDS (AES) DELINEATED BY APPLIED ENGINEERING AND SCIENCE, INC. IN 1999.

9. SWAMP RABBIT TRAIL CENTERLINE FROM CITY OF GREENVILLE.

10. AERIAL PHOTOGRAPHY OBTAINED FROM GOOGLE EARTH PRO ON MAY 3, 2019. AERIAL WAS COLLECTED ON MARCH 12, 2018.

11. DRAWING HAS BEEN SET WITH A PROJECTION OF SOUTH CAROLINA STATE PLANE COORDINATE SYSTEM FIPS 3900 (NAD83 INTERNATIONAL FEET).



LEGEND

- MW-2BR — WELL POTENTIALLY INSTRUMENTED WITH A PRESSURE TRANSDUCER DURING THE CONSTANT RATE PUMP TEST
- POTENTIAL AREA FOR PUMPING WELL INSTALLATION
- WELL SCREENED IN SHALLOW ZONE
- WELL SCREENED IN TRANSITION ZONE
- WELL SCREENED IN BEDROCK ZONE
- STAFF GAUGE
- RIVER GAUGE
- TOPOGRAPHIC CONTOUR (10' INTERVAL)
- TOPOGRAPHIC CONTOUR (2' INTERVAL)
- FORMER DRAINAGE DITCH (1964)
- ROAD
- SWAMP RABBIT TRAIL
- RAILROAD
- BUILDING
- EXCAVATED AREA (2001-2002)
- VAUGHN LANDFILL BOUNDARY
- HYDROLOGY
- PARCEL BOUNDARY
- WETLANDS (AES)
- WETLANDS (USFWS)

DUKE ENERGY. CAROLINAS

synTerra

GRAPHIC SCALE

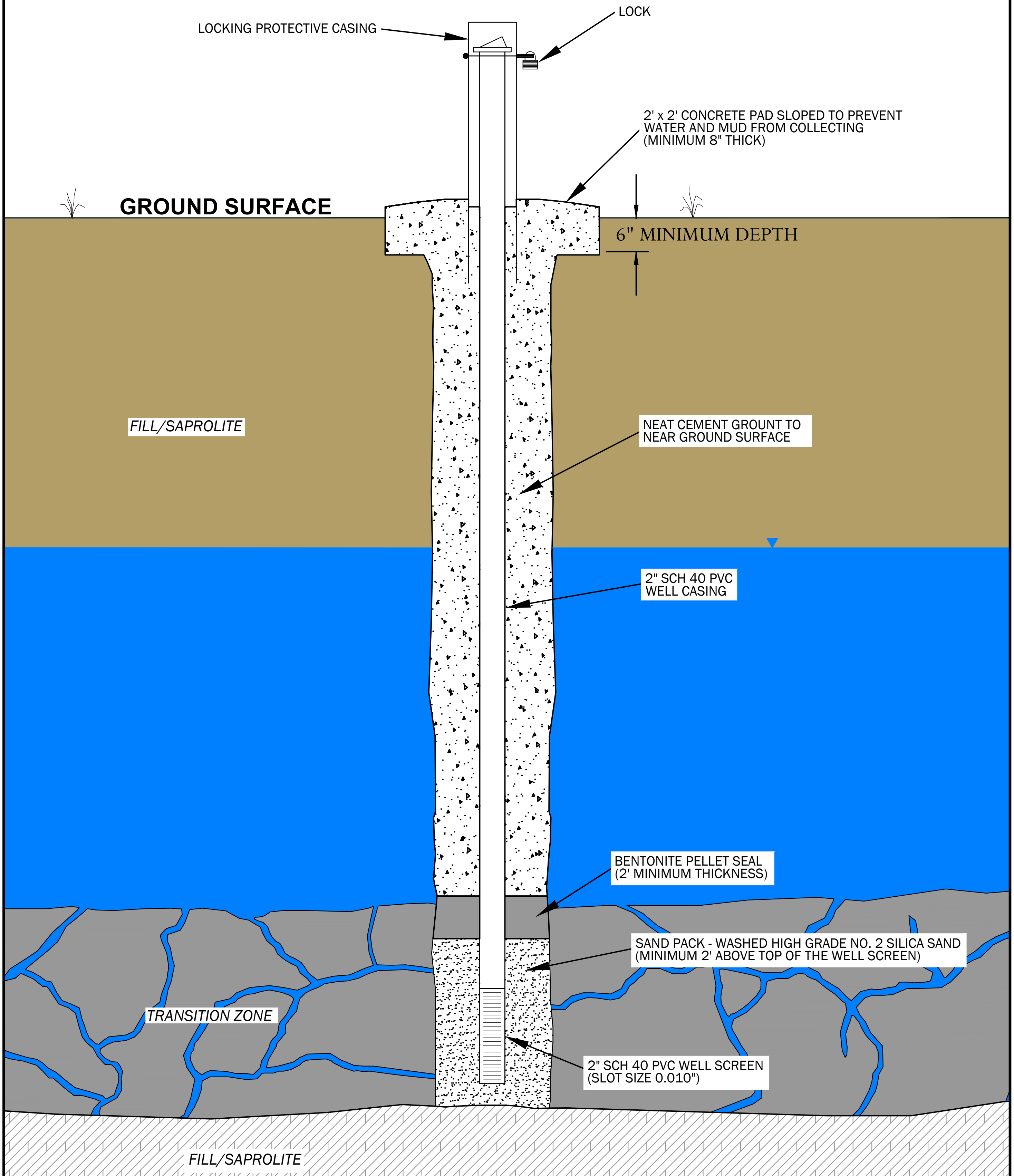
125 0 125 250

(IN FEET)

DRAWN BY: J. EBENHACK DATE: 10/26/2020
REVISED BY: J. EBENHACK DATE: 10/26/2020
CHECKED BY: E. HICKS DATE: 10/26/2020
APPROVED BY: T. PLATING DATE: 10/26/2020
PROJECT MANAGER: T. PLATING

www.synterracorp.com

FIGURE 2-7
POTENTIAL LOCATION FOR THE PROPOSED AQUIFER PERFORMANCE TEST PUMPING WELL
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA



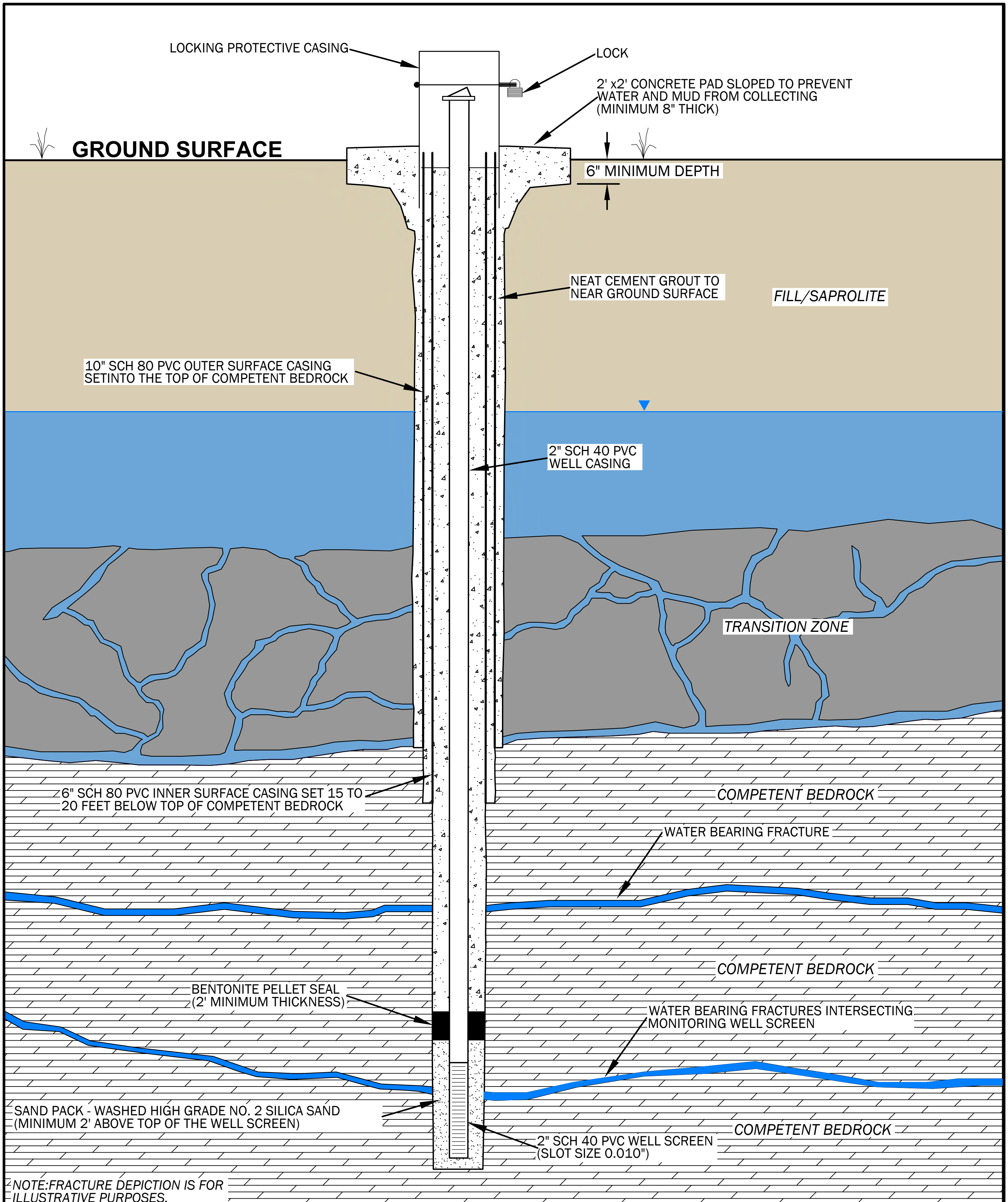
synTerra

NOT TO SCALE

148 RIVER STREET, SUITE 220
GREENVILLE, SOUTH CAROLINA 29601
PHONE 864-421-9999
www.synterracorp.com

DRAWN BY: JOHNATHAN EBENHACK DATE: 09-24-2020
PROJECT MANAGER: TODD PLATING
LAYOUT: SHALLOW MONITORING WELL SCHEMATIC

FIGURE 2-8
SHALLOW OBSERVATION WELL SCHEMATIC
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA



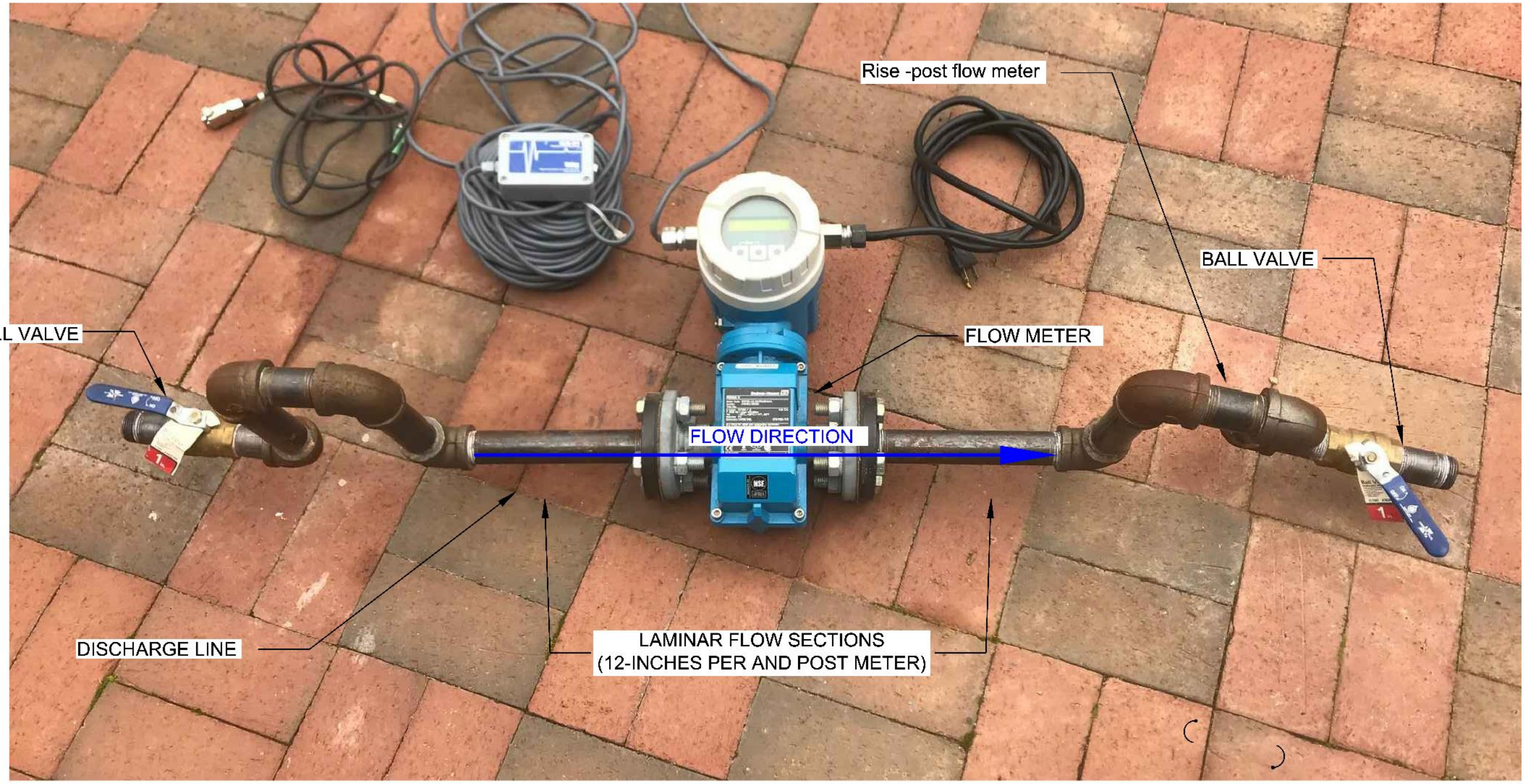
synTerra

NOT TO SCALE

148 RIVER STREET, SUITE 220
GREENVILLE, SOUTH CAROLINA 29601
PHONE 864-421-9999
www.synterracorp.com

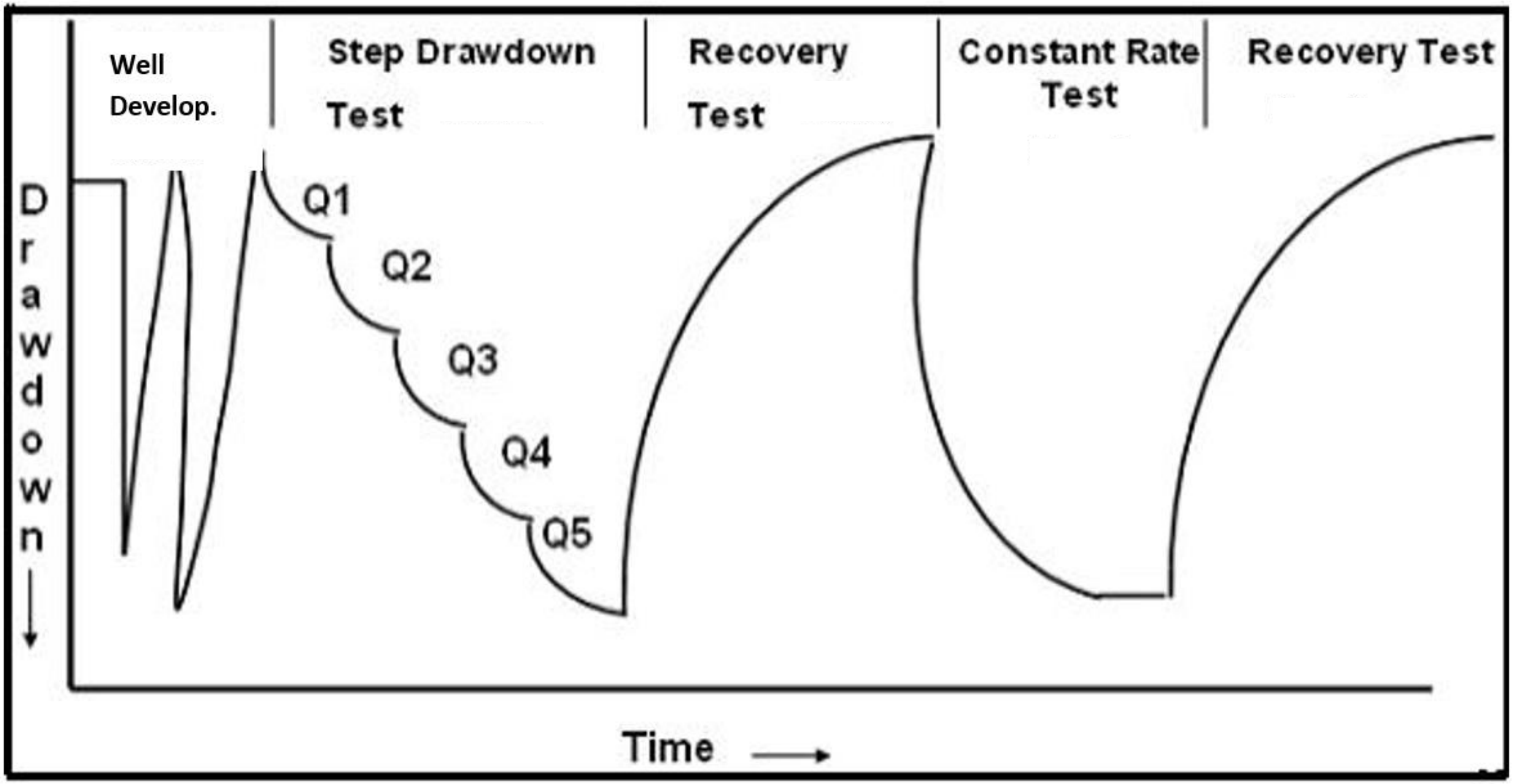
DRAWN BY: JOHNATHAN EBENHACK DATE: 09/23/2020
PROJECT MANAGER: TODD PLATING
LAYOUT: BEDROCK MONITORING WELL SCHEMATIC

FIGURE 2-9
BEDROCK OBSERVATION WELL SCHEMATIC
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA



THIS SHOWS THE GENERAL CONFIGURATION OF THE DISCHARGE LINE AND FLOW METER.
FLOW METER TYPE MAY VARY BUT SHOULD FOLLOW THIS GENERAL CONFIGURATION.

DUKE ENERGY CAROLINAS / synTerra	DRAWN BY: R. KIEKHAEFER DATE: 09/20/2020 REVISED BY: R. KIEKHAEFER DATE: 09/21/2020 CHECKED BY: E. HICKS DATE: 09/21/2020 APPROVED BY: T. PLATING DATE: 09/21/2020 PROJECT MANAGER: T. PLATING www.synterracorp.com	**FIGURE 2-10** **TYPICAL FLOW METER CONFIGURATION** **AQUIFER PERFORMANCE TEST WORK PLAN** **FORMER BRAMLETTE MGP SITE** **EAST BRAMLETTE ROAD** **GREENVILLE, SOUTH CAROLINA**



DUKE ENERGY CAROLINAS

synTerra

DRAWN BY: DATE: 09/23/2020
REVISED BY: E. HICKS DATE: 09/23/2020
CHECKED BY: J. EBENHACK DATE:09/23/2020
APPROVED BY: T. PLATING DATE:09/23/2020
PROJECT MANAGER:

www.synterracorp.com

FIGURE 2-11
TYPICAL DRAWDOWN CURVES
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA

TABLES

Science & Engineering Consultants

TABLE 2-1
SUMMARY OF HYDRAULIC CONDUCTIVITY VALUES FROM SLUG TESTING
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA

SHALLOW ZONE (UNCONFINED)								
Well ID	**Slug Test**	**Slug Test Number**	**Analytical Solution**	**Flow Zone**	**Hydraulic Conductivity (cm/sec)**		**Hydraulic Conductivity (ft/day)**	
					Measured	**Geometric Mean**	**Measured**	**Geometric Mean**
MW-29S	Rising Head	Test 1	Bouwer-Rice	Shallow	1.23E-02	1.23E-02	3.49E+01	3.49E+01
	Rising Head	Test 2	Bouwer-Rice	Shallow	1.23E-02		3.49E+01	
MW-30S	Rising Head	Test 1	Bouwer-Rice	Shallow	8.01E-03	5.74E-03	2.27E+01	1.63E+01
	Rising Head	Test 2	Bouwer-Rice	Shallow	4.12E-03		1.17E+01	
MW-31S	Rising Head	Test 1	Bouwer-Rice	Shallow	4.08E-03	2.43E-03	1.16E+01	6.88E+00
	Rising Head	Test 2	Bouwer-Rice	Shallow	1.45E-03		4.10E+00	
MW-32S	Falling Head	Test 1	Hvorslev	Shallow	3.04E-04	2.34E-04	8.61E-01	6.62E-01
	Rising Head	Test 2	Hvorslev	Shallow	1.80E-04		5.10E-01	
MW-33S	Falling Head	Test 1	Hvorslev	Shallow	1.32E-03	1.45E-03	3.75E+00	4.11E+00
	Rising Head	Test 2	Hvorslev	Shallow	1.59E-03		4.51E+00	
MW-34S	Falling Head	Test 1	Hvorslev	Shallow	9.06E-04	6.52E-04	2.57E+00	1.85E+00
	Rising Head	Test 2	Hvorslev	Shallow	4.70E-04		1.33E+00	
MW-35S	Falling Head	Test 1	Hvorslev	Shallow	6.55E-04	8.53E-04	1.86E+00	2.42E+00
	Rising Head	Test 2	Hvorslev	Shallow	1.11E-03		3.15E+00	
MW-36S	Falling Head	Test 1	Hvorslev	Shallow	3.71E-04	3.68E-04	1.05E+00	1.04E+00
	Rising Head	Test 2	Hvorslev	Shallow	3.64E-04		1.03E+00	
MW-37S	Falling Head	Test 1	Hvorslev	Shallow	1.12E-03	1.23E-03	3.18E+00	3.49E+00
	Rising Head	Test 2	Hvorslev	Shallow	1.35E-03		3.84E+00	
MW-38S	Falling Head	Test 1	Hvorslev	Shallow	3.67E-03	3.85E-03	1.04E+01	1.09E+01
	Rising Head	Test 2	Hvorslev	Shallow	3.79E-03		1.08E+01	
	Falling Head	Test 3	Hvorslev	Shallow	3.77E-03		1.07E+01	
	Rising Head	Test 4	Hvorslev	Shallow	3.88E-03		1.10E+01	
	Falling Head	Test 5	Hvorslev	Shallow	3.78E-03		1.07E+01	
	Rising Head	Test 6	Hvorslev	Shallow	4.24E-03		1.20E+01	
MW-39S	Falling Head	Test 1	Springer-Gelhar	Shallow	3.54E-02	7.19E-03	1.00E+02	2.04E+01
	Rising Head	Test 2	Hvorslev	Shallow	1.46E-03		4.14E+00	
MW-41S	Falling Head	Test 1	Hvorslev	Shallow	1.13E-03	9.77E-04	3.20E+00	2.77E+00
	Rising Head	Test 2	Hvorslev	Shallow	8.46E-04		2.40E+00	
MW-42S	Falling Head	Test 1	Hvorslev	Shallow	9.36E-04	9.15E-04	2.65E+00	2.59E+00
	Rising Head	Test 2	Hvorslev	Shallow	8.95E-04		2.54E+00	
MW-43S	Falling Head	Test 1	Hvorslev	Shallow	2.90E-03	2.73E-03	8.22E+00	7.75E+00
	Rising Head	Test 2	Bouwer-Rice	Shallow	2.44E-03		6.92E+00	
	Falling Head	Test 3	Hvorslev	Shallow	2.81E-03		7.98E+00	
	Rising Head	Test 4	Bouwer-Rice	Shallow	3.40E-03		9.65E+00	
	Falling Head	Test 5	Hvorslev	Shallow	1.99E-03		5.65E+00	
	Rising Head	Test 6	Bouwer-Rice	Shallow	3.09E-03		8.75E+00	
				GEOMETRIC MEAN		1.91E-03		5.40E+00
				HIGHEST CONDUCTIVITY		3.54E-02		1.00E+02
				LOWEST CONDUCTIVITY		1.80E-04		5.10E-01

TABLE 2-1
SUMMARY OF HYDRAULIC CONDUCTIVITY VALUES FROM SLUG TESTING
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA

TRANSITION ZONE (UNCONFINED)								
Well ID	Slug Test	Slug Test Number	Analytical Solution	Flow Zone	Hydraulic Conductivity (cm/sec)		Hydraulic Conductivity (ft/day)	
					Measured	Geometric Mean	Measured	Geometric Mean
MW-02TZ	Falling Head	Test 1	Hvorslev	Transition Zone	9.45E-04	9.53E-04	2.68E+00	2.70E+00
	Rising Head	Test 2	Hvorslev	Transition Zone	9.61E-04		2.73E+00	
MW-29TZ	Rising Head	Test 1	Hvorslev	Transition Zone	8.22E-05	9.60E-05	2.33E-01	2.72E-01
	Rising Head	Test 2	Hvorslev	Transition Zone	1.12E-04		3.18E-01	
MW-30TZ	Falling Head	Test 1	Hvorslev	Transition Zone	9.16E-05	9.13E-05	2.60E-01	2.59E-01
	Rising Head	Test 2	Hvorslev	Transition Zone	9.11E-05		2.58E-01	
MW-31TZ	Rising Head	Test 1	Hvorslev	Transition Zone	2.00E-04	1.94E-04	5.67E-01	5.50E-01
	Rising Head	Test 2	Hvorslev	Transition Zone	1.88E-04		5.32E-01	
MW-32TZ	Falling Head	Test 1	Springer-Gelhar	Transition Zone	2.72E-02	3.56E-02	7.71E+01	1.01E+02
	Rising Head	Test 2	Springer-Gelhar	Transition Zone	4.66E-02		1.32E+02	
MW-33TZ	Falling Head	Test 1	Hvorslev	Transition Zone	2.47E-05	5.39E-05	7.01E-02	1.53E-01
	Rising Head	Test 2	Hvorslev	Transition Zone	1.18E-04		3.33E-01	
MW-34TZ	Falling Head	Test 1	Hvorslev	Transition Zone	9.00E-04	7.93E-04	2.55E+00	2.25E+00
	Rising Head	Test 2	Hvorslev	Transition Zone	6.99E-04		1.98E+00	
MW-35TZ	Falling Head	Test 1	Hvorslev	Transition Zone	3.64E-04	1.29E-04	1.03E+00	3.66E-01
	Rising Head	Test 2	Hvorslev	Transition Zone	4.58E-05		1.30E-01	
MW-36TZ	Falling Head	Test 1	Hvorslev	Transition Zone	3.77E-03	3.73E-03	1.07E+01	1.06E+01
	Rising Head	Test 2	Hvorslev	Transition Zone	3.69E-03		1.05E+01	
MW-37TZ	Falling Head	Test 1	Hvorslev	Transition Zone	3.33E-05	3.43E-05	9.45E-02	9.71E-02
	Rising Head	Test 2	Hvorslev	Transition Zone	3.52E-05		9.98E-02	
MW-41TZ	Falling Head	Test 1	Hvorslev	Transition Zone	2.05E-05	1.95E-05	5.81E-02	5.53E-02
	Rising Head	Test 2	Hvorslev	Transition Zone	1.86E-05		5.27E-02	
MW-42TZ	Falling Head	Test 1	Hvorslev	Transition Zone	1.01E-03	1.01E-03	2.86E+00	2.86E+00
	Rising Head	Test 2	Hvorslev	Transition Zone	1.01E-03		2.86E+00	
MW-43TZ	Falling Head	Test 1	Hvorslev	Transition Zone	8.47E-04	8.08E-04	2.40E+00	2.29E+00
	Rising Head	Test 2	Hvorslev	Transition Zone	7.96E-04		2.26E+00	
	Falling Head	Test 3	Hvorslev	Transition Zone	8.33E-04		2.36E+00	
	Rising Head	Test 4	Hvorslev	Transition Zone	7.80E-04		2.21E+00	
	Falling Head	Test 5	Hvorslev	Transition Zone	8.32E-04		2.36E+00	
	Rising Head	Test 6	Hvorslev	Transition Zone	7.61E-04		2.16E+00	
MW-44TZ	Falling Head	Test 1	Hvorslev	Transition Zone	1.00E-02	1.05E-02	2.84E+01	2.98E+01
	Rising Head	Test 2	Hvorslev	Transition Zone	1.15E-02		3.26E+01	
	Falling Head	Test 3	Hvorslev	Transition Zone	9.42E-03		2.67E+01	
	Rising Head	Test 4	Hvorslev	Transition Zone	1.15E-02		3.27E+01	
	Falling Head	Test 5	Hvorslev	Transition Zone	9.44E-03		2.68E+01	
	Rising Head	Test 6	Hvorslev	Transition Zone	1.15E-02		3.26E+01	
				GEOMETRIC MEAN		6.55E-04		1.86E+00
				HIGHEST CONDUCTIVITY		4.66E-02		1.32E+02
				LOWEST CONDUCTIVITY		1.86E-05		5.27E-02

TABLE 2-1
SUMMARY OF HYDRAULIC CONDUCTIVITY VALUES FROM SLUG TESTING
AQUIFER PERFORMANCE TEST WORK PLAN
FORMER BRAMLETTE MGP SITE
EAST BRAMLETTE ROAD
GREENVILLE, SOUTH CAROLINA

BEDROCK ZONE (CONFINED)								
Well ID	Slug Test	Slug Test Number	Analytical Solution	Flow Zone	Hydraulic Conductivity (cm/sec)		Hydraulic Conductivity (ft/day)	
					Measured	Geometric Mean	Measured	Geometric Mean
MW-02BR	Falling Head	Test 1	Hvorslev	Bedrock	2.65E-04	1.11E-04	7.50E-01	3.14E-01
	Rising Head	Test 2	Hvorslev	Bedrock	4.64E-05		1.32E-01	
MW-03BR	Rising Head	Test 1	Hvorslev	Bedrock	1.90E-05	1.87E-05	5.38E-02	5.29E-02
	Rising Head	Test 2	Hvorslev	Bedrock	1.84E-05		5.21E-02	
MW-03BRL	Falling Head	Test 1	Hvorslev	Bedrock	9.57E-04	3.81E-04	2.71E+00	1.08E+00
	Rising Head	Test 2	Hvorslev	Bedrock	1.52E-04		4.30E-01	
MW-21BR	Falling Head	Test 1	Hvorslev	Bedrock	1.49E-03	1.47E-03	4.21E+00	4.17E+00
	Rising Head	Test 2	Hvorslev	Bedrock	1.46E-03		4.13E+00	
MW-21BRL	Falling Head	Test 1	Hvorslev	Bedrock	5.26E-04	5.19E-04	1.49E+00	1.47E+00
	Rising Head	Test 2	Hvorslev	Bedrock	5.12E-04		1.45E+00	
MW-29BR	Falling Head	Test 1	Hvorslev	Bedrock	8.87E-05	9.05E-05	2.51E-01	2.56E-01
	Rising Head	Test 2	Hvorslev	Bedrock	9.23E-05		2.62E-01	
MW-34BR	Falling Head	Test 1	Hvorslev	Bedrock	6.26E-05	6.28E-05	1.78E-01	1.78E-01
	Rising Head	Test 2	Hvorslev	Bedrock	6.29E-05		1.78E-01	
MW-35BR	Falling Head	Test 1	Hvorslev	Bedrock	3.65E-07	3.65E-07	1.03E-03	1.03E-03
MW-36BR	Falling Head	Test 1	Hvorslev	Bedrock	1.65E-03	1.48E-03	4.68E+00	4.19E+00
	Rising Head	Test 2	Hvorslev	Bedrock	1.33E-03		3.76E+00	
MW-37BR	Falling Head	Test 1	Hvorslev	Bedrock	4.97E-04	4.75E-04	1.41E+00	1.35E+00
	Rising Head	Test 2	Hvorslev	Bedrock	4.55E-04		1.29E+00	
MW-38BR	Falling Head	Test 1	Hvorslev	Bedrock	1.61E-03	1.52E-03	4.57E+00	4.30E+00
	Rising Head	Test 2	Hvorslev	Bedrock	1.43E-03		4.05E+00	
MW-39BR	Falling Head	Test 1	Hvorslev	Bedrock	2.82E-04	2.80E-04	7.98E-01	7.94E-01
	Rising Head	Test 2	Hvorslev	Bedrock	2.79E-04		7.91E-01	
MW-39BRL	Falling Head	Test 1	Hvorslev	Bedrock	3.73E-04	4.48E-04	1.06E+00	1.27E+00
	Rising Head	Test 2	Hvorslev	Bedrock	5.38E-04		1.52E+00	
MW-41BR	Falling Head	Test 1	Hvorslev	Bedrock	2.10E-04	2.17E-04	5.94E-01	6.15E-01
	Rising Head	Test 2	Hvorslev	Bedrock	2.25E-04		6.37E-01	
MW-42BR	Falling Head	Test 1	Hvorslev	Bedrock	1.50E-03	1.24E-03	4.24E+00	3.51E+00
	Rising Head	Test 2	Hvorslev	Bedrock	1.02E-03		2.90E+00	
MW-43BR	Rising Head	Test 1	Hvorslev	Bedrock	1.13E-05	1.13E-05	3.20E-02	3.20E-02
MW-44BR	Falling Head	Test 1	Hvorslev	Bedrock	1.11E-04	6.94E-05	3.15E-01	1.97E-01
	Rising Head	Test 2	Hvorslev	Bedrock	4.34E-05		1.23E-01	
MW-45BR	Falling Head	Test 1	Hvorslev	Bedrock	4.98E-07	3.92E-07	1.41E-03	1.11E-03
	Rising Head	Test 2	Hvorslev	Bedrock	3.09E-07		8.77E-04	
MW-46BR	Falling Head	Test 1	Hvorslev	Bedrock	1.07E-05	6.10E-06	3.03E-02	1.73E-02
	Rising Head	Test 2	Hvorslev	Bedrock	3.49E-06		9.89E-03	
MW-47BR	Falling Head	Test 1	Hvorslev	Bedrock	3.46E-05	2.09E-05	9.80E-02	5.94E-02
	Rising Head	Test 2	Hvorslev	Bedrock	1.27E-05		3.59E-02	
				GEOMETRIC MEAN		1.12E-04		3.18E-01
				HIGHEST CONDUCTIVITY		1.65E-03		4.68E+00
				LOWEST CONDUCTIVITY		3.09E-07		8.77E-04

Prepared by: RLK Checked by: JFE

APPENDIX A

GEOPHYSICAL LOGGING REPORT: MW-02BR, MW-21BR, MW-29BR, MW-34BR, MW-35BR, MW-36BR, MW-37BR, MW-39BR, MW-42BR

Science & Engineering Consultants

GEL Solutions

821 Livingston Court, Suite E
Marietta, GA 30067

P 770.980.1002

Geophysical Logging Report

MW – 02 BR, MW – 21 BR, MW – 29 BR, MW – 34 BR, MW – 35 BR, MW – 36 BR, MW – 37 BR, MW – 39 BR, MW – 42 BR

Former Bramlette MGP Plant, Greenville, South Carolina

Performed for:

SynTerra

March 3, 2020

Geophysical Logging Report: MW – 02 BR, MW – 21 BR, MW – 29 BR, MW – 34 BR, MW – 35 BR, MW – 36 BR, MW – 37 BR, MW – 39 BR, MW – 42 BR, Former Bramlette MGP Plant, Greenville, South Carolina

TABLE OF CONTENTS

Section ... Page

Signature Page ... ii

Executive Summary ... iii

1.0 Introduction ... 1

2.0 Equipment and Methodology ... 1

2.1 Acoustic Televiewer ... 1

2.2 Optical Televiewer ... 2

2.3 3-Arm Caliper ... 2

2.4 Fluid Temperature ... 2

2.5 Fluid Conductivity ... 2

2.6 Single Point Resistance (SPR) ... 3

2.7 Spontaneous Potential (SP) ... 3

2.8 Heat Pulse Flowmeter (HPF) ... 3

3.0 Field Procedures ... 3

4.0 Data Processing and Results ... 5

Appendices

Appendix 1 Fracture Summary Table

Appendix 2 Schmidt Stereonets and Rose Diagrams

Appendix 3 Heat Pulse Flowmeter Logs and Fracture Characteristics

Appendix 4 Geophysical Logs

SIGNATURE PAGE

This report, entitled "Geophysical Logging Report: MW – 02 BR, MW – 21 BR, MW – 29 BR, MW – 34 BR, MW – 35 BR, MW – 36 BR, MW – 37 BR, MW – 39 BR MW – 42 BR, Former Bramlette MGP Plant, Greenville, South Carolina" has been prepared for SynTerra located in Greenville, South Carolina. It has been prepared under the supervision of Mr. Jorgen Bergstrom at the request of and the exclusive use of SynTerra. This report has been prepared in accordance with accepted quality control practices and has been reviewed by the undersigned.

GEL Solutions, LLC
A Member of the GEL Group, Inc.

Jorgen Bergstrom, P.Gp.
Senior Geophysicist

Nicholas Rebman
Geophysical Specialist

February 28, 2020

Date

EXECUTIVE SUMMARY

GEL Solutions performed geophysical borehole logging services in 9 borings located at a Former Bramlette MGP Plant in Greenville, South Carolina. The field investigations were performed on various dates between November 22, 2019 and February 4, 2020. This investigation was conducted to aid SynTerra in evaluating potential pathways for groundwater migration through fractured bedrock at the site. The geophysical logs consisted of acoustic televiewer, optical televiewer, caliper, fluid conductivity, fluid temperature, single point resistance (SPR), spontaneous potential (SP), and heat pulse flowmeter (HPF). HPF logging was conducted under both ambient and pumping conditions throughout the logging intervals.

The logging data was analyzed to determine the location and orientation of fractures; and other features. In addition to these data sets, synthetic caliper logs were calculated from the acoustic televiewer travel time data to aid in the interpretation. The logs were analyzed for fractures and other features. Dip and azimuth (dip direction) were calculated for each detected fracture based on the televiewer dataset. HPF data was analyzed to detect water producing fractures.

1.0 INTRODUCTION

GEL Solutions performed geophysical borehole logging services in 9 borings located at a Former Duke Energy MGP Plant in Greenville, South Carolina. The geophysical logs consisted of acoustic and optical televiewer, 3-arm caliper, fluid conductivity, fluid temperature, single point resistance (SPR), spontaneous potential (SP), and heat pulse flowmeter (HPF). The field investigation was performed . The logging data was analyzed to determine the location and orientation of fractures; and other features. In addition to these data sets, synthetic caliper logs were calculated from the acoustic televiewer travel time data to aid in the interpretation.

2.0 EQUIPMENT AND METHODOLOGY

The information below is an overview of the geophysical methodologies used for this investigation. The intent of this overview is to give the reader a better understanding of each method, and background information as to what is actually measured, the resolution of the method, and the limitations imposed by site-specific subsurface conditions.

2.1 Acoustic Televiewer

Acoustic televiewer (ATV) logging produces a high resolution, magnetically oriented digital image of the borehole wall to map the location and orientation of intersecting fractures, foliations, and lithologic contacts. The Acoustic televiewer tool emits a rotating, narrow, acoustic beam that is reflected off the borehole wall. The travel time and amplitude of the reflected wave are recorded by the tool and used to create borehole images. Both datasets are useful for identifying the location and orientation of fractures. The amplitude of the reflected signal will decrease at the location of fractures and the travel time will increase. The travel time data can also be used for developing a high resolution caliper log for a more comprehensive analysis of fractures. Acoustic televiewers can only be used in fluid filled boreholes. However, the fluid does not have to be optically clear for the method to work.

When operating the ATV, a “time window” is set based on the borehole diameter. The time window is the time interval in which the ATV instrument searches for an echo from the borehole wall. For smaller increases in borehole diameter around fractures and sections of weaker rock, the ATV typically records an accurate borehole diameter (correlates well with three-arm caliper data). However, if borehole openings are much larger than the borehole diameter, the echo from the borehole wall may fall outside the time window, or be too weak to be detected. In these situations, borehole diameters recorded with ATV may be inaccurate. Since ATV only records the reflection from the borehole wall, the data cannot be used to determine how far a fracture extends from the borehole. The acoustic televiewer has a vertical resolution of 2 millimeters.

2.2 Optical Televiewer

Optical televiewer (OTV) logging is used to record and digitize a 360-degree color image of the borehole wall. Planar features such as fractures, foliation, and lithologic contacts can be identified directly on the images. The tool is magnetically oriented in order to determine the strike and dip of features. Televiewers have a vertical resolution of 2mm. As a result, it is able to see features other tools may not resolve. Optical images can be collected above or below the water surface, provided the water is sufficiently clear for viewing the borehole wall.

2.3 3-Arm Caliper

Caliper logging is used to generate a profile of the borehole diameter with depth. The tool measures the borehole diameter using three spring-loaded arms. Narrow enlargements in the borehole diameter can, in most cases, be attributed to fractures. Caliper logging can be conducted above and below the water surface.

2.4 Fluid Temperature

Fluid temperature logging is used to identify where water enters or exits the borehole. In the absence of fluid flow, a gradual increase on water temperature of approximately 1^{o}F per 100 feet of depth is expected. Rapid changes in the fluid temperature indicate water-producing or water-receiving zones. Little or no temperature gradient indicates intervals of vertical flow.

2.5 Fluid Conductivity

Fluid conductivity logging is used to measure the electrical conductivity of the fluid in the borehole. Variations in fluid conductivity can be contributed to concentration variations of dissolved solids. These differences can occur when sources of water have contrasting chemistry and have come from different transmissive zones. Fluid temperature and conductivity are measured concurrently using the same logging tool.

2.6 Single Point Resistance (SPR)

Single point resistance logging involves passing an alternate current between a surface electrode and a probe electrode and measuring the voltage difference created by the current. SPR is then calculated using Ohm's law. SPR is the sum of cable resistance, and the resistance based on the composition of the medium, the cross sectional area and length of the path through the medium. Therefore, the single point resistance log does not provide quantitative data. In general, SPR increases with increasing grain size and decreases with increasing borehole diameter, fracture density, and the concentration of dissolved solids in the water. Single-point resistance logs are useful in the determination of lithology, water quality, and location of fracture zones

2.7 Spontaneous Potential (SP)

SP logging is conducted to measure naturally occurring voltage differences along a borehole. The method has been found useful for delineating sandstone/shale layering and other boundaries between permeable and impermeable beds. The measurements are made with reference to an electrode at ground level. Therefore, SP logging does not provide quantitative data.

2.8 Heat Pulse Flowmeter (HPF)

HPF logging measures the direction and rate of vertical fluid flow in a borehole by heating up a small volume of water and monitoring temperature variations as the heated water moves with the fluid flow in the borehole. Under ambient conditions, differences in hydraulic head between two transmissive fractures produce vertical flow in the borehole. However, if the hydraulic head is the same, no flow will occur under ambient conditions. Therefore, HPF logging is also conducted under low-rate pumping conditions. HPF readings are point readings at the location of fractures. The location and number of these readings can be determined after analyzing the other geophysical logs for fractures. HPF can be used for measuring vertical flows between 0.005 gallons per minute (gpm) and approximately 1.5 gpm. In HPF data, upward flow is shown as positive flow, and downward flow is shown as negative flow.

3.0 FIELD PROCEDURES

All GEL Solutions activities on-site were supervised by a senior geophysicist. For this investigation, GEL Solutions used a Mount Sopris Matrix logging system. Pumping tests during HPF testing were conducted using a Grundfos Redi-Flow-2 water pump with variable speed control box and an in-situ Mini-Troll pressure transducer with logging capabilities. The pump is placed above the interval to be analyzed and preferably in the casing (unless the water level is too low). HPF logging under pumping conditions commenced after the borehole water level had stabilized. HPF logging was conducted at every 5 feet throughout the logging intervals under ambient and pumping conditions. More closely spaced readings were then conducted at sections with abrupt changes in flow. A summary of the configuration of the boreholes, pumping rates, and water levels is provided below. All depth measurements are referenced from the ground surface. All borings are surface cased and open hole below the casing.

Logging Configuration Summary

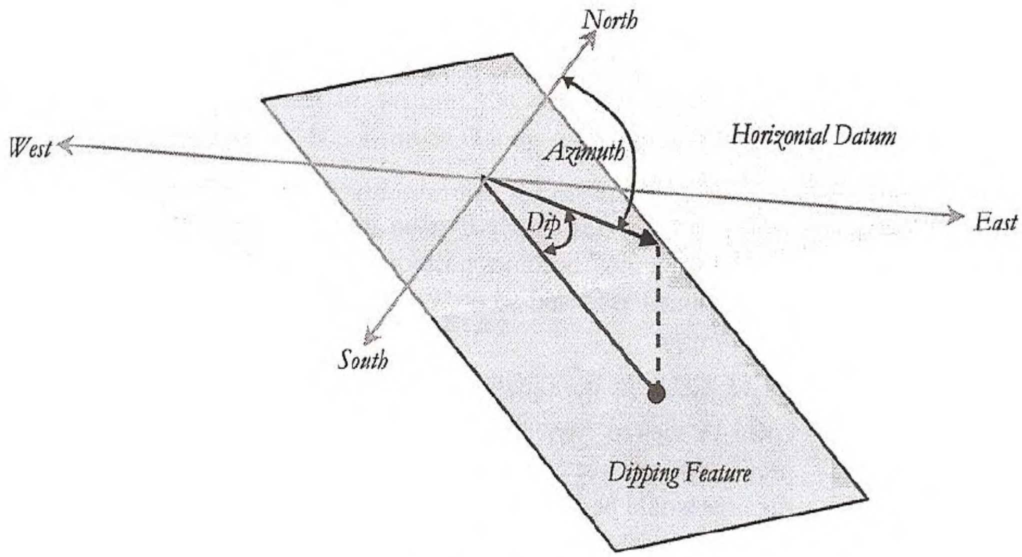
Well ID:	MW - 29 BR	MW - 35 BR	MW - 36 BR	MW - 37 BR	MW - 42 BR
Casing Material:	PVC	PVC	PVC	PVC	PVC
Casing Diameter (in):	5.9	5.9	5.9	5.9	5.9
Open Hole (ft):	38 - 88	39 - 89	54 - 102	73 - 122	63 - 113
Open Hole Diameter (in):	5.0	5.0	5.0	5.0	5.0
Pumping Rate (gpm):	0.2	< 0.1	1.0	1.0	1.0
Pump Depth (ft)	30	30	30	30	30
Water level before Pumping (ft):	3.5	0.9	4.8	4.8	4.15
Water level at equilibrium (ft):	22.6	25.4	6.9	21.4	21.45

Well ID:	MW-02 BR	MW-21 BR	MW-34 BR	MW-39 BR
Casing Material:	PVC	PVC	PVC	PVC
Casing diameter (in):	5.9	5.9	5.9	5.9
Open hole (ft):	39-72	24-120	69-118	35-84
Open hole diameter (in):	5.0	5.0	5.0	5.0
Pumping rate (gpm):	1.0	1.0	0.1	0.5
Pump depth (ft):	30	20	45	30
Water level before pumping (ft):	7.6	5.6	17.2	10.3
Water level at equilibrium (ft):	26.8	7.8	39.85	28.3

4.0 DATA PROCESSING AND RESULTS

The logs were analyzed for fractures and other features using WellCAD software, manufactured by Advanced Logic Technology. The travel time data from the acoustic televiewer log was used to develop a maximum caliper log. Fractures were interpreted through a complete data analysis of all logs. Dip and azimuth (dip direction) were calculated for each detected fracture. The fracture data was corrected from apparent to true dip and azimuth using deviation logs included with the televiewer dataset, and from magnetic north to true north by rotating the fracture azimuths 6.7° counterclockwise. Magnetic north is 6.7° west of true north at the site (according to National Oceanic and Atmospheric Administration). The reported azimuth is measured clockwise from true north (Figure 1). A fracture summary table including fracture attributes is provided in Appendix 1. Dominating water producing fractures based on flow logging or other evidence are highlighted and shown in bold and italics text. Minor water producing fractures based on flow logging are shown in bold.

Schmidt stereonets (lower hemisphere) with fracture characteristics and fracture rose diagrams are presented on Appendix 2. HPF logs and fracture characteristics are shown on Appendix 3. All logs are presented on Appendix 4. All depths are referenced from ground surface.



Relations between Dip and Azimuth angle

Figure 1 Explanation of azimuth and dip for fractures

Appendix 1

Fracture Summary Table
Former Bramlette MGP Plant

MW - 29 BR

Depth ft	Azimuth deg	Dip deg
39.9	18	54
40.4	268	62
42.3	**345**	**51**
47.8	295	34
53.4	65	26
54.0	30	36
54.1	23	34
57.2	32	28
57.6	41	28
58.0	20	34
58.5	31	37
58.9	49	38
60.9	21	45
61.8	19	15
63.6	94	15
65.2	36	35
65.4	37	40
66.3	26	30
66.8	41	19
67.5	296	29
68.9	14	33
69.5	49	35
71.2	46	31
72.7	358	10
73.0	**322**	**20**
75.9	271	38
78.5	36	40
82.8	**34**	**20**
84.7	**36**	**46**

MW - 35 BR

Depth ft	Azimuth deg	Dip deg
39.6	45	49
41.1	**344**	**57**
43.3	**334**	**40**
43.7	12	28
44.4	211	24
50.2	358	38
54.1	3	13
65.2	15	40
66.7	22	24
66.9	96	41
68.9	341	27
69.1	43	15
76.6	72	33
81.2	34	42
81.3	54	43
81.5	31	51
81.9	13	32
82.3	16	33
83.3	61	20
83.7	112	17
85.0	99	40
85.7	356	48
87.3	26	41
88.5	33	49

MW - 36 BR

Depth ft	Azimuth deg	Dip deg
54.7	***147***	***29***
55.2	175	11
58.2	66	37
58.8	251	22
63.4	177	79
64.1	109	38
65.7	183	42
66.5	152	73
66.8	351	45
67.4	168	51
67.4	358	61
69.7	294	23
70.0	316	37
78.1	36	31
87.1	96	23
87.7	9	28
92.7	83	29
92.9	58	27
94.1	**307**	**52**
94.2	32	34
94.3	4	58
95.7	348	44
95.8	12	34
95.9	357	23
96.3	2	41
96.9	3	30
97.3	310	48
97.9	**274**	**28**

Dominating water producing fractures are highlighted and shown in bold italicized text. Minor water producing fractures are shown in bold text. Closed fractures are shown in plain text.

Fracture Summary Table
Former Bramlette MGP Plant

MW - 37 BR

Depth ft	Azimuth deg	Dip deg
73.1	104	17
73.8	1	82
76.4	176	81
80.9	344	40
81.4	346	36
82.5	62	45
84.9	42	45
87.1	**86**	**19**
87.3	**76**	**43**
90.9	345	25
91.2	353	21
98.1	242	1
98.3	293	82
105.8	34	59
114.6	***33***	***59***
116.2	**34**	**79**

MW - 42 BR

Depth ft	Azimuth deg	Dip deg
64.4	213	49
65.5	343	69
66.4	22	38
67.4	18	43
68.9	276	70
69.0	335	44
70.1	16	21
70.6	336	20
72.4	48	43
73.7	***60***	***46***
75.6	351	61
78.0	53	12
79.3	331	39
79.5	46	26
82.5	46	44
83.7	26	51
83.9	268	50
85.7	**316**	**71**
89.3	**49**	**43**
89.5	***56***	***40***
92.0	39	57
92.2	43	49
94.3	30	38
97.5	38	32
98.0	28	42
98.3	82	51
98.6	84	44
99.0	39	38
99.9	55	40
101.9	66	33
102.2	72	11
102.5	68	34
103.6	43	45
112.2	52	45

Dominating water producing fractures are highlighted and shown in bold italicized text. Minor water producing fractures are shown in bold text. Closed fractures are shown in plain text.

Fracture Summary Table
Former Bramlette MGP Plant

MW-02 BR

Depth ft	Azimuth deg	Dip deg
39.3	**244**	**8**
40.4	**264**	**42**
46.0	**38**	**59**
46.5	***43***	***42***
46.9	**40**	**60**
52.0	49	64
54.6	38	44
54.8	234	31
55.6	162	48
57.5	8	30
57.7	343	18
57.9	12	22
58.6	356	38
60.1	269	53
60.2	267	40
62.5	53	47
64.6	**2**	**35**
65.8	**31**	**46**

MW-21 BR

Depth ft	Azimuth deg	Dip deg
24.3	***66***	***18***
27.7	149	26
29.1	**19**	**28**
34.6	52	15
35.3	**208**	**55**
35.7	**216**	**56**
36.2	147	20
36.3	207	13
36.5	52	1
37.0	48	30
37.5	87	40
37.9	274	27
38.3	219	46
38.4	219	48
40.1	**210**	**46**
43.7	42	2
45.3	182	16
45.8	186	21
46.3	162	27
46.6	181	17
47.1	42	1
48.9	221	51
49.4	45	1
49.7	179	4
49.7	196	22
49.9	83	20
50.0	59	22
50.6	46	1
50.6	358	6
51.1	344	30
52.0	269	19
52.1	43	1
52.3	144	12
52.5	205	32
53.2	111	33
53.3	160	34
53.6	346	9
53.7	358	11

MW-21 BR

Depth ft	Azimuth deg	Dip deg
54.0	32	31
54.3	275	37
54.5	319	35
54.8	108	31
55.4	323	39
56.0	343	28
56.6	54	16
57.1	309	24
57.8	**19**	**35**
58.0	358	31
58.8	60	79
59.0	38	31
59.6	345	16
59.9	315	18
60.6	349	28
61.5	**49**	**35**
62.1	191	17
62.5	***9***	***46***
63.0	***20***	***51***
63.2	**39**	**50**
64.4	26	54
64.9	17	33
65.2	0	29
66.1	**96**	**26**
66.6	35	16
72.5	12	19
72.8	59	17
73.2	42	24
78.5	5	7
78.7	353	10
84.0	**22**	**38**
88.5	147	7
89.9	42	2
90.6	149	42
91.1	40	2
96.7	**353**	**71**
98.9	357	59
102.0	358	43

Dominating water producing fractures are highlighted and shown in bold italicized text. Minor water producing fractures are shown in bold text. Closed fractures are shown in plain text.

Fracture Summary Table
Former Bramlette MGP Plant

MW-21 BR

Depth ft	Azimuth deg	Dip deg
104.1	15	53
105.4	185	60
106.0	349	33
106.0	173	15
106.1	16	40
110.9	336	23
111.1	37	2
111.2	38	2
111.6	15	33
111.9	179	17
112.0	37	2
112.2	163	9
114.2	**67**	**22**
114.4	**43**	**30**
114.6	**28**	**40**

MW-34 BR

Depth ft	Azimuth deg	Dip deg
71.7	**318**	**39**
73.1	**349**	**36**
74.4	345	35
75.7	345	27
77.6	357	17
77.8	6	14
78.2	5	30
80.9	326	43
85.4	46	39
86.5	32	47
87.4	31	44
87.7	38	47
88.3	21	44
89.8	14	52
90.4	330	39
91.1	12	46
92.0	50	37
94.2	72	38
95.4	38	31
95.8	20	32
96.8	18	24
98.4	52	50
99.2	32	49
100.1	35	40
101.2	50	31
103.8	131	76
104.0	328	16
104.2	300	66
104.8	***317***	***43***
105.1	***319***	***52***
105.6	40	26
106.6	268	39
107.0	62	33
107.7	69	54
108.6	68	64
108.7	195	54
109.4	253	22
110.9	80	45

MW-34 BR

Depth ft	Azimuth deg	Dip deg
111.3	43	44
111.6	71	51
112.0	7	29
112.2	55	56
112.7	58	60
113.2	21	42
115.1	**51**	**36**
115.3	**44**	**38**

Dominating water producing fractures are highlighted and shown in bold italicized text. Minor water producing fractures are shown in bold text. Closed fractures are shown in plain text.

Fracture Summary Table
Former Bramlette MGP Plant

MW-39 BR

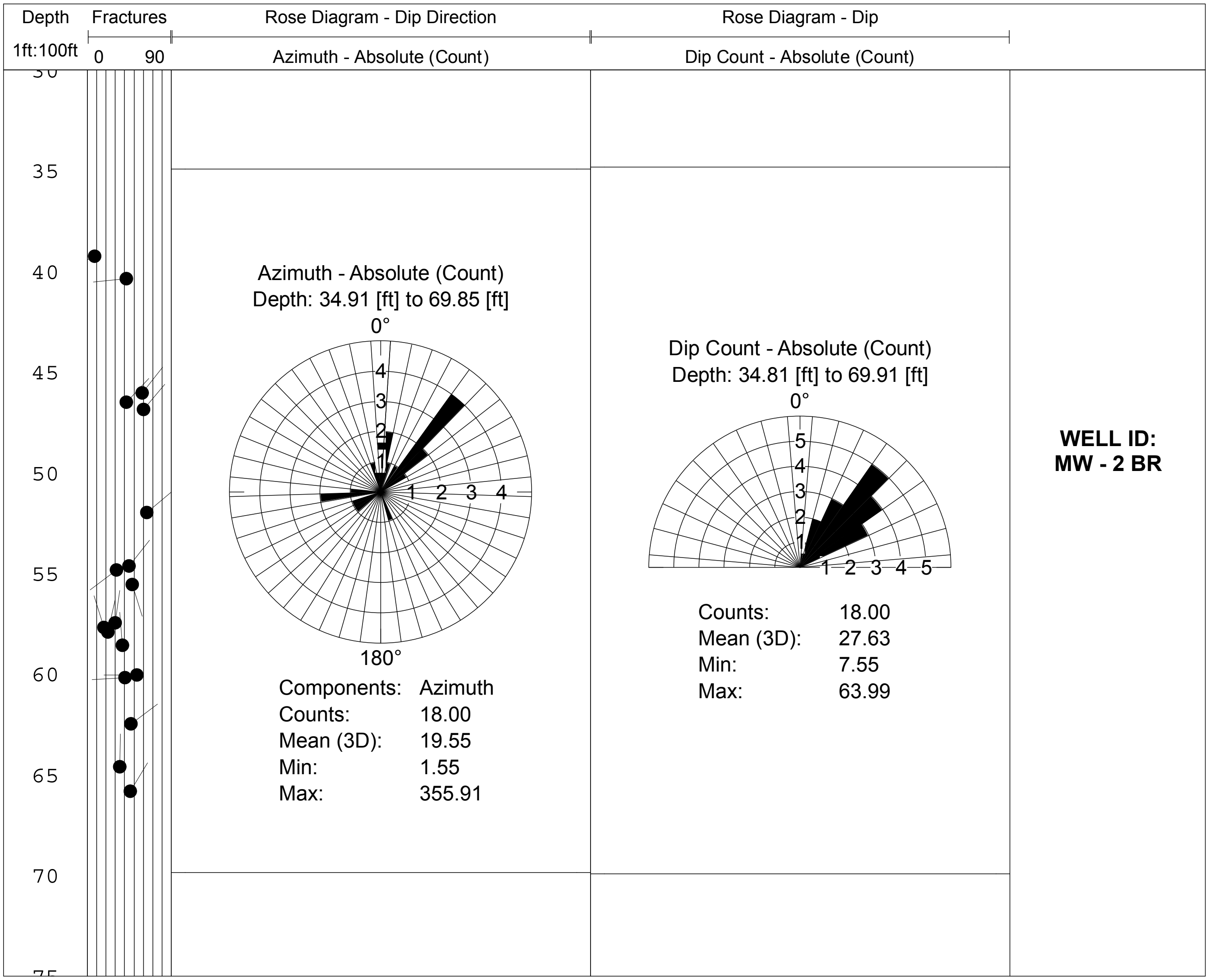
Depth ft	Azimuth deg	Dip deg
35.8	**72**	**12**
36.2	31	30
36.3	39	20
37.1	54	31
37.3	55	31
37.8	13	65
38.2	84	32
38.5	98	6
38.7	68	37
39.7	87	27
40.1	63	38
40.4	110	24
42.1	69	29
42.6	82	32
42.7	64	18
42.9	82	32
43.3	61	25
44.0	**0**	**20**
44.0	**120**	**11**
44.5	356	11
44.7	359	10
45.4	**119**	**16**
45.9	131	23
46.2	**153**	**11**
46.7	351	34
47.2	44	35
47.8	46	37
49.2	334	35
49.7	**223**	**6**
50.1	342	30
50.5	335	26
50.8	342	25
50.9	33	16
51.9	**35**	**26**
52.3	**309**	**19**
52.5	**78**	**32**
52.8	52	27
53.3	28	21

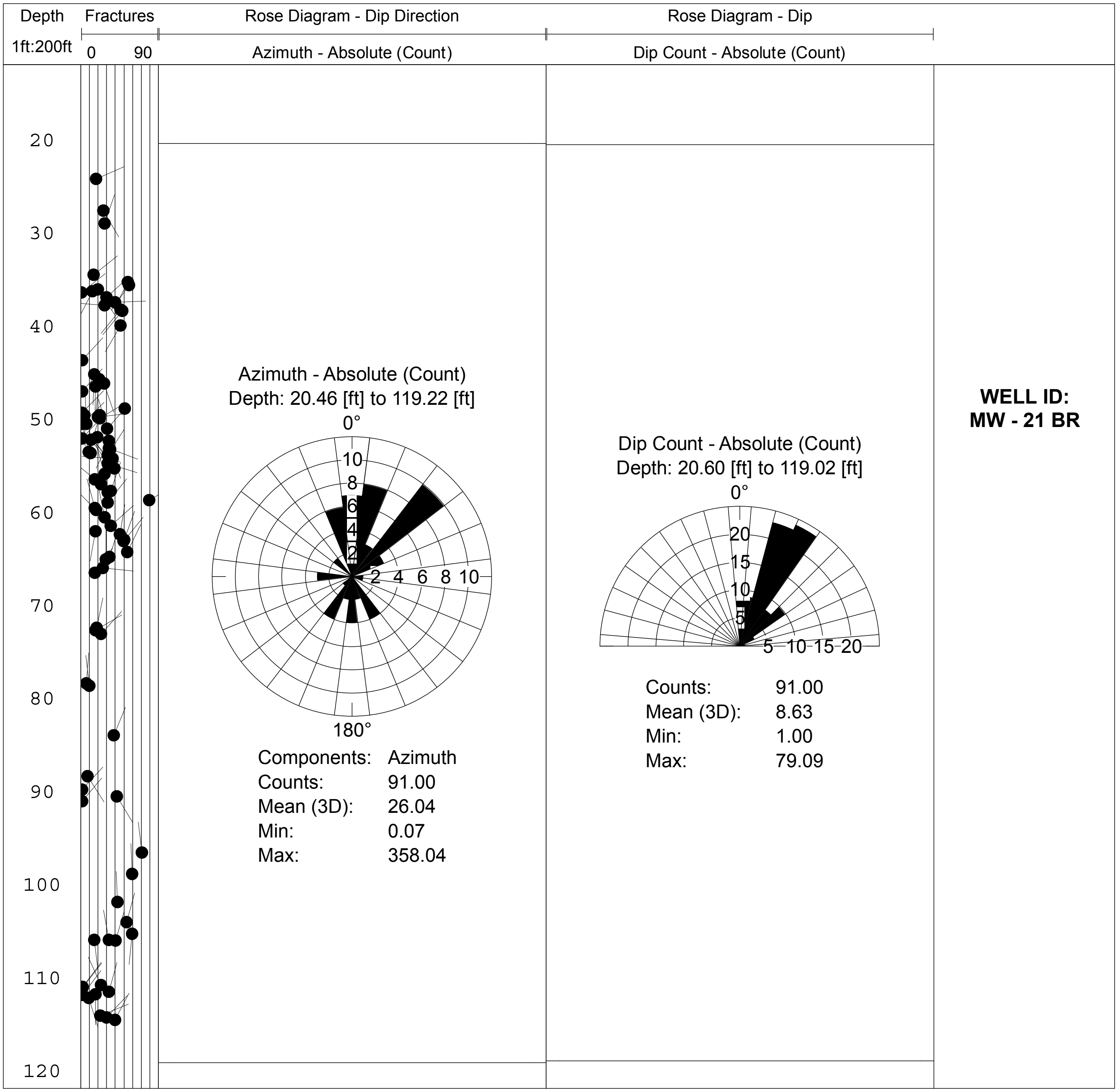
MW-39 BR

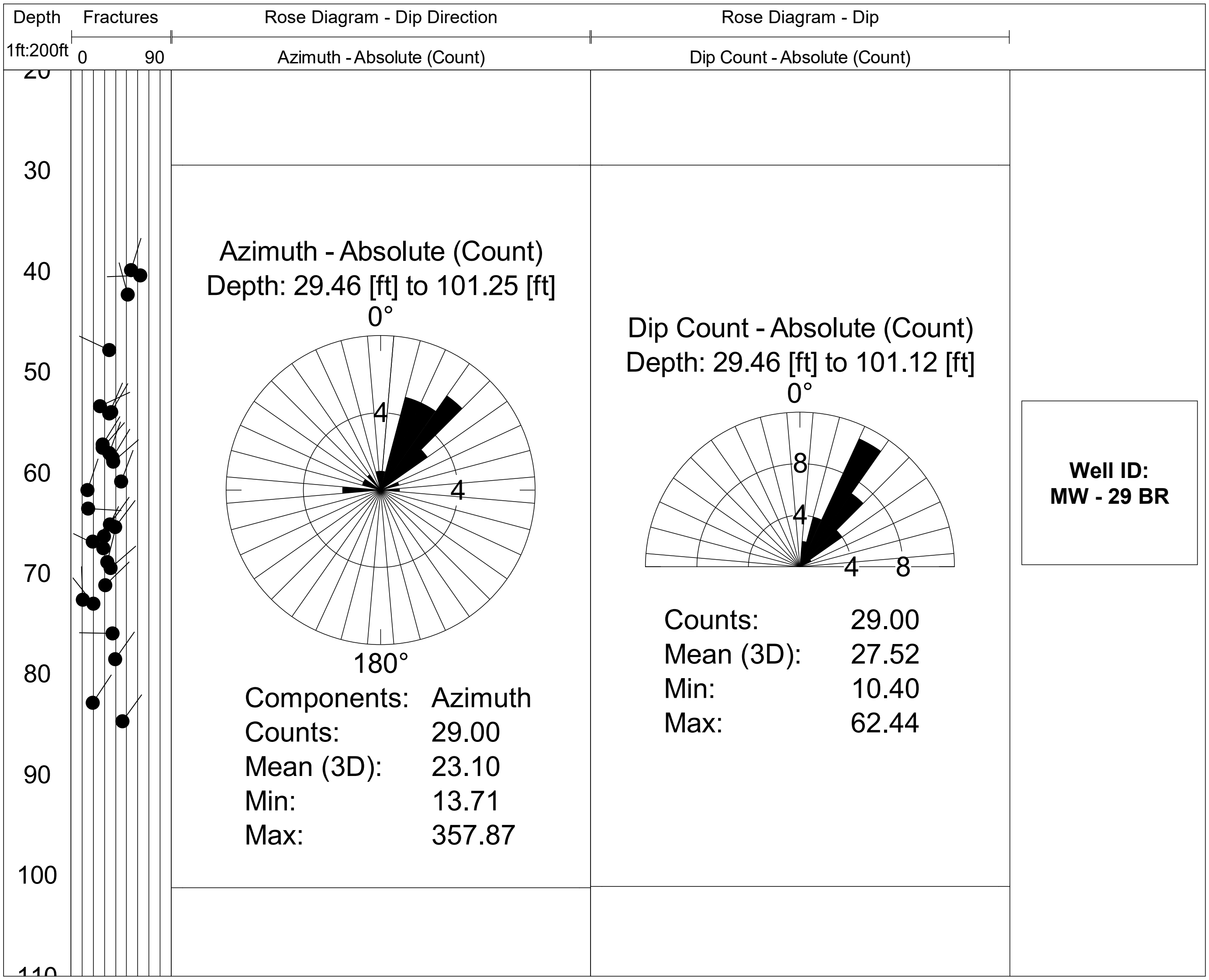
Depth ft	Azimuth deg	Dip deg
53.5	26	38
54.7	169	25
55.5	13	26
55.8	4	25
56.7	59	11
58.1	206	20
59.9	295	26
60.9	86	51
61.6	273	45
61.8	91	25
64.8	321	39
70.6	76	34
71.2	77	25
73.8	61	37
74.0	66	38
74.7	**84**	**32**
77.6	**164**	**73**

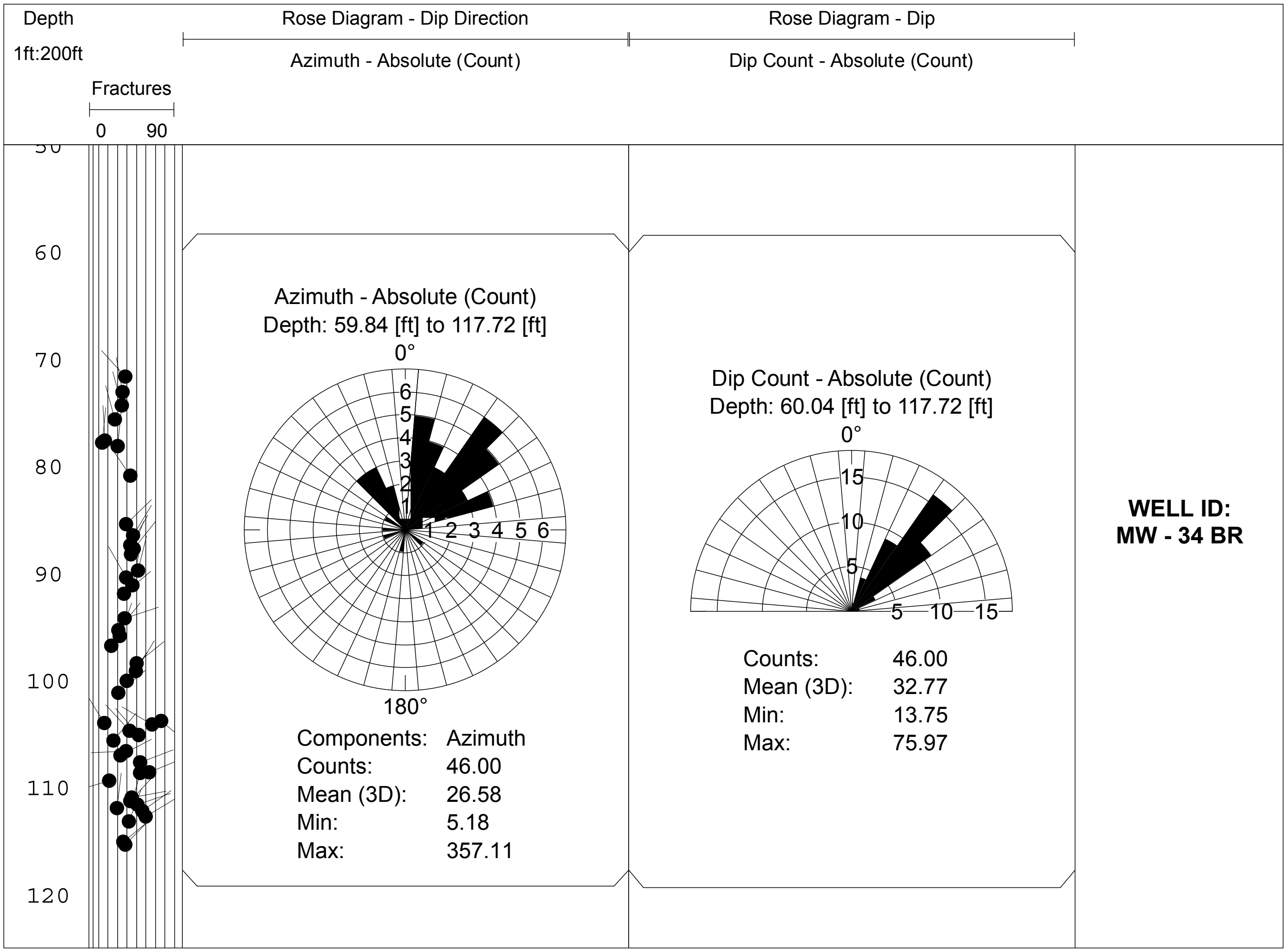
Dominating water producing fractures are highlighted and shown in bold italicized text. Minor water producing fractures are shown in bold text. Closed fractures are shown in plain text.

Appendix 2


Depth
1ft:100ft
Fractures
0
90
Rose Diagram - Dip Direction
Azimuth - Absolute (Count)
Rose Diagram - Dip
Dip Count - Absolute (Count)
35
40
45
50
55
60
65
70
Azimuth - Absolute (Count)
Depth: 34.91 [ft] to 69.85 [ft]
0°
180°
Components: Azimuth
Counts: 18.00
Mean (3D): 19.55
Min: 1.55
Max: 355.91
Dip Count - Absolute (Count)
Depth: 34.81 [ft] to 69.91 [ft]
0°
Counts: 18.00
Mean (3D): 27.63
Min: 7.55
Max: 63.99
WELL ID:
MW - 2 BR

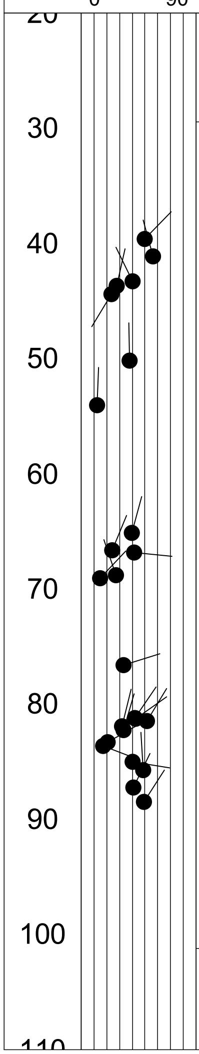

Depth
Fractures
Rose Diagram - Dip Direction
Rose Diagram - Dip
1ft:200ft
0
90
Azimuth - Absolute (Count)
Dip Count - Absolute (Count)
20
30
40
50
60
70
80
90
100
110
120
Azimuth - Absolute (Count)
Depth: 20.46 [ft] to 119.22 [ft]
0°
180°
2 4 6 8 10
Components: Azimuth
Counts: 91.00
Mean (3D): 26.04
Min: 0.07
Max: 358.04
Dip Count - Absolute (Count)
Depth: 20.60 [ft] to 119.02 [ft]
0°
20
15
10
5
5 10 15 20
Counts: 91.00
Mean (3D): 8.63
Min: 1.00
Max: 79.09
WELL ID:
MW - 21 BR


Depth
Fractures
Rose Diagram - Dip Direction
Rose Diagram - Dip
1ft:200ft
0
90
Azimuth - Absolute (Count)
Dip Count - Absolute (Count)
20
30
40
50
60
70
80
90
100
110
Azimuth - Absolute (Count)
Depth: 29.46 [ft] to 101.25 [ft]
0°
4
4
180°
Components: Azimuth
Counts: 29.00
Mean (3D): 23.10
Min: 13.71
Max: 357.87
Dip Count - Absolute (Count)
Depth: 29.46 [ft] to 101.12 [ft]
0°
8
4
4
8
Counts: 29.00
Mean (3D): 27.52
Min: 10.40
Max: 62.44
Well ID:
MW - 29 BR

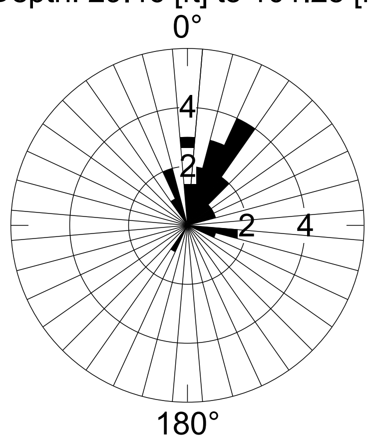


Depth
1ft:200ft
Fractures
0 90
Rose Diagram - Dip Direction
Azimuth - Absolute (Count)
Rose Diagram - Dip
Dip Count - Absolute (Count)
60
70
80
90
100
110
120
Azimuth - Absolute (Count)
Depth: 59.84 [ft] to 117.72 [ft]
0°
180°
Components: Azimuth
Counts: 46.00
Mean (3D): 26.58
Min: 5.18
Max: 357.11
Dip Count - Absolute (Count)
Depth: 60.04 [ft] to 117.72 [ft]
0°
Counts: 46.00
Mean (3D): 32.77
Min: 13.75
Max: 75.97
WELL ID:
MW - 34 BR

Depth	Fractures	Rose Diagram - Dip Direction	Rose Diagram - Dip
1ft:200ft	0 90	Azimuth - Absolute (Count)	Dip Count - Absolute (Count)

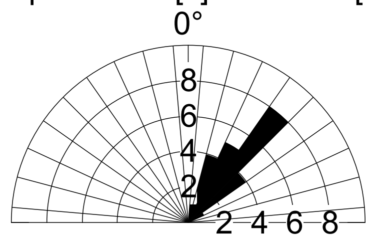


Azimuth - Absolute (Count)
Depth: 29.46 [ft] to 101.25 [ft]



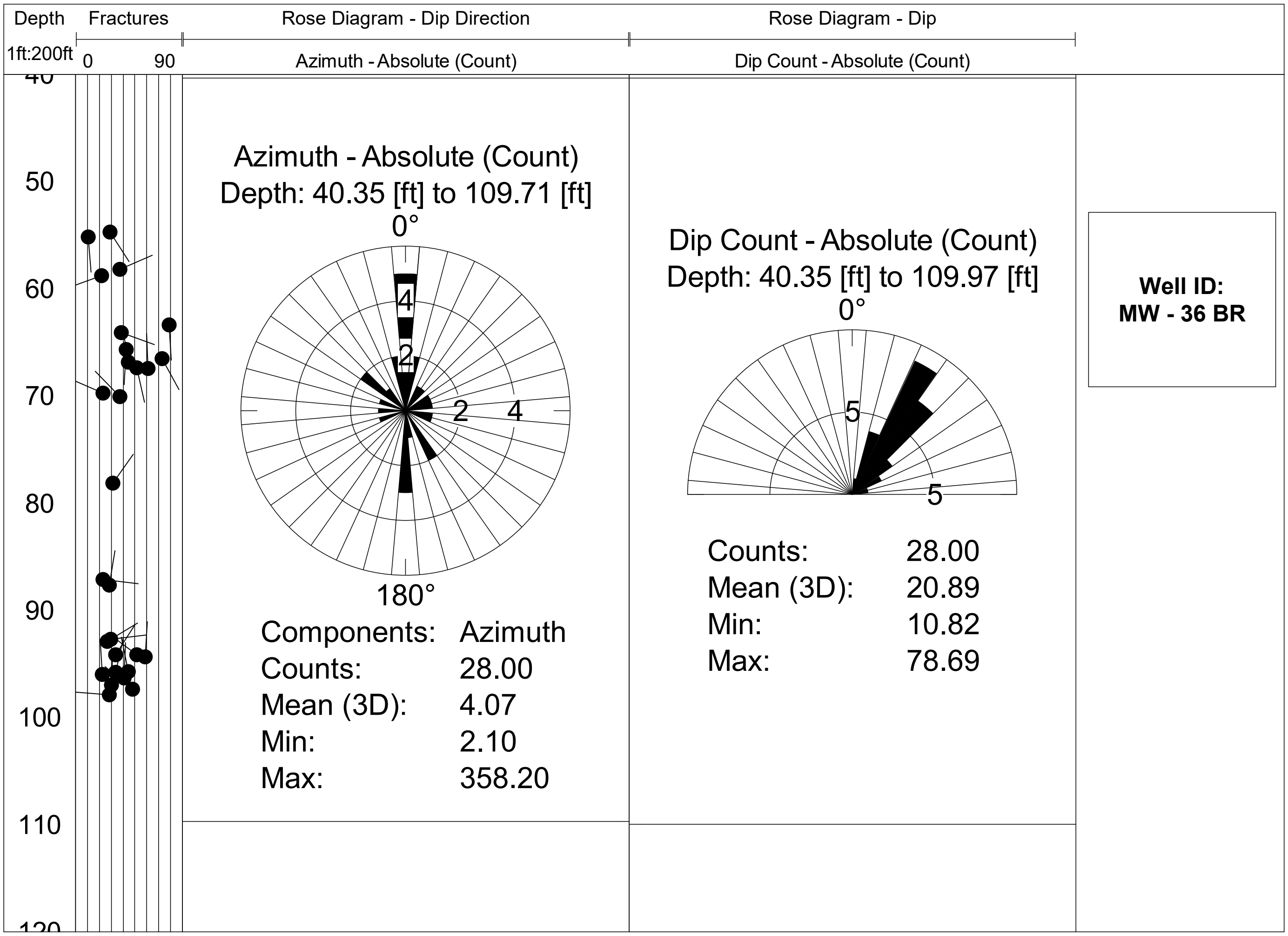
Components:	Azimuth
Counts:	24.00
Mean (3D):	27.55
Min:	2.69
Max:	358.29

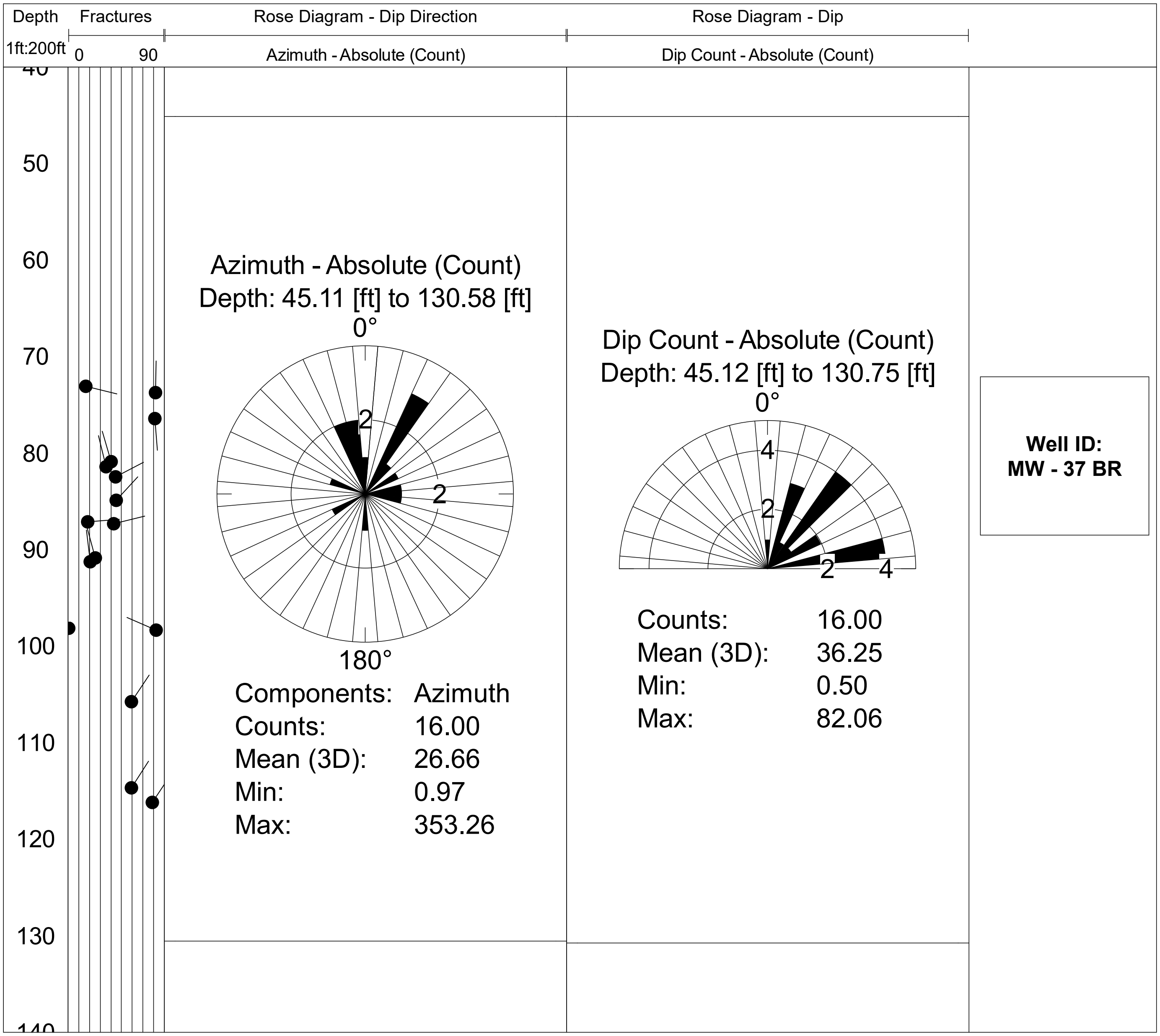
Dip Count - Absolute (Count)
Depth: 29.46 [ft] to 101.12 [ft]

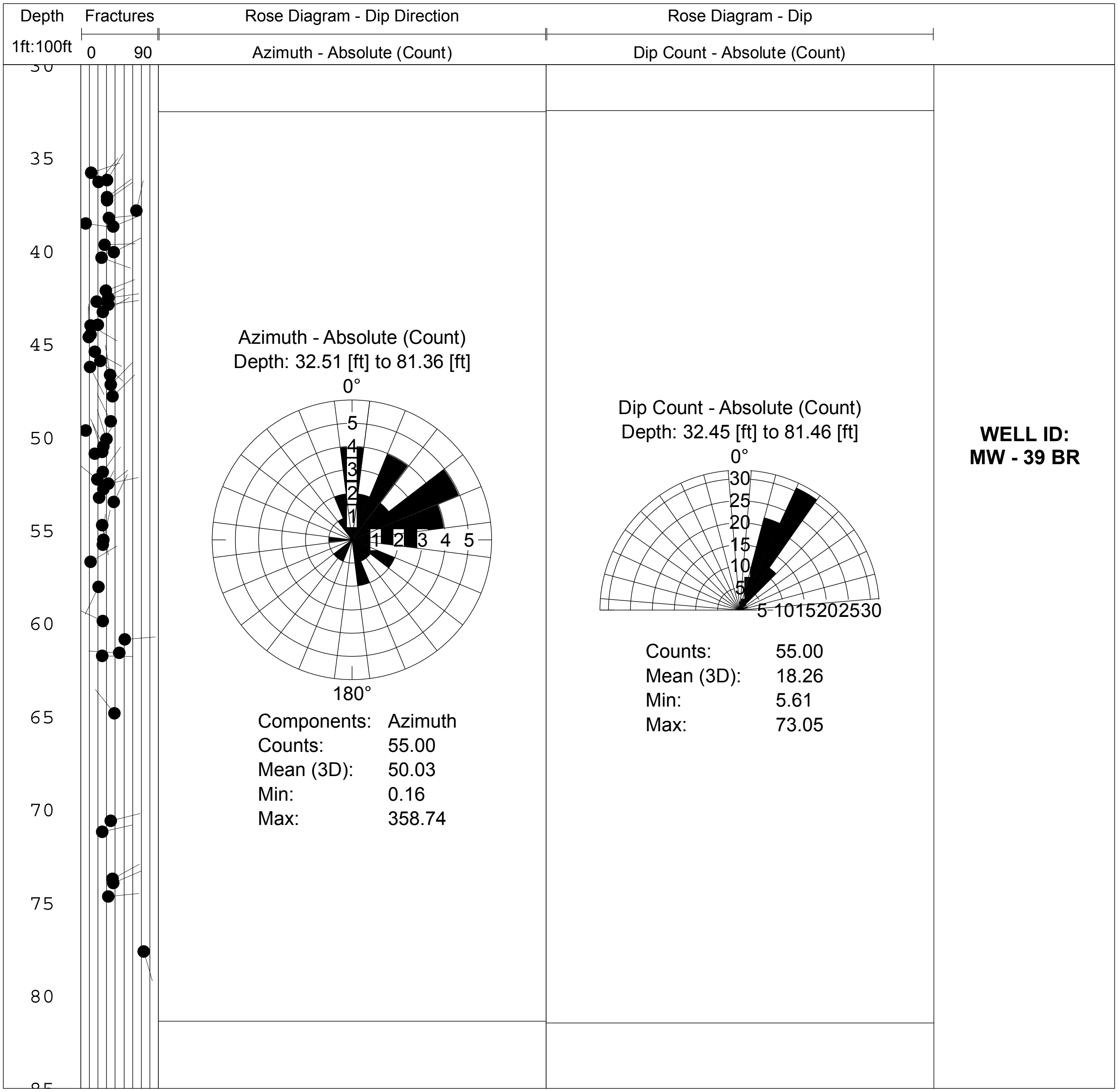


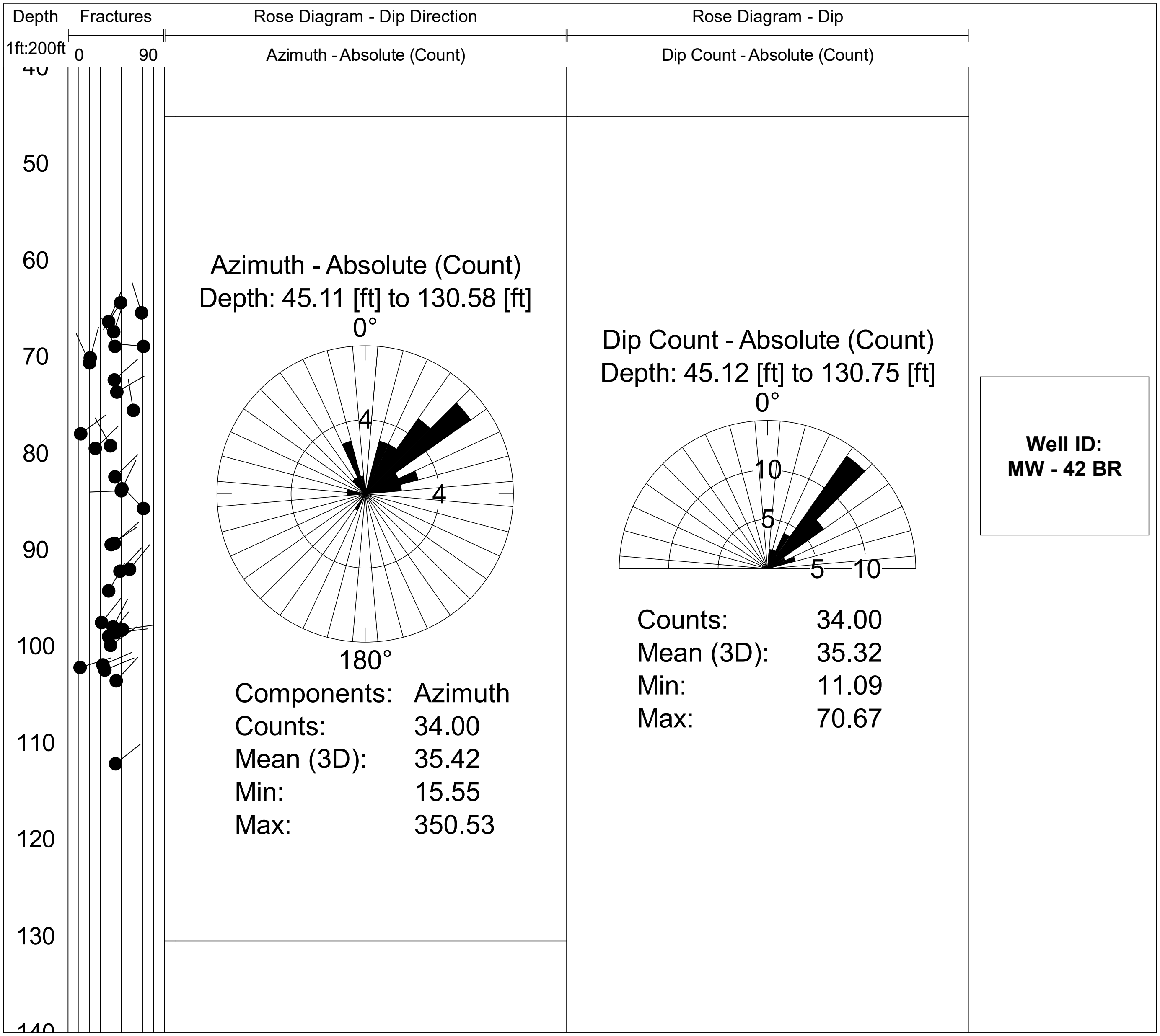
Counts:	24.00
Mean (3D):	29.43
Min:	12.53
Max:	56.52

Well ID:
MW - 35 BR

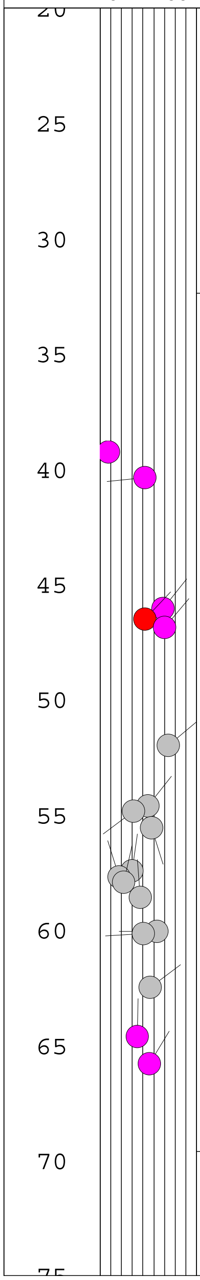

Depth
Fractures
Rose Diagram - Dip Direction
Rose Diagram - Dip
1ft:200ft
0
90
Azimuth - Absolute (Count)
Dip Count - Absolute (Count)
40
50
60
70
80
90
100
110
120
Azimuth - Absolute (Count)
Depth: 40.35 [ft] to 109.71 [ft]
0°
180°
Components: Azimuth
Counts: 28.00
Mean (3D): 4.07
Min: 2.10
Max: 358.20
Dip Count - Absolute (Count)
Depth: 40.35 [ft] to 109.97 [ft]
0°
Counts: 28.00
Mean (3D): 20.89
Min: 10.82
Max: 78.69
Well ID:
MW - 36 BR


Depth
Fractures
Rose Diagram - Dip Direction
Rose Diagram - Dip
1ft:200ft
0
90
Azimuth - Absolute (Count)
Dip Count - Absolute (Count)
50
60
70
80
90
100
110
120
130
Azimuth - Absolute (Count)
Depth: 45.11 [ft] to 130.58 [ft]
0°
2
2
180°
Components: Azimuth
Counts: 16.00
Mean (3D): 26.66
Min: 0.97
Max: 353.26
Dip Count - Absolute (Count)
Depth: 45.12 [ft] to 130.75 [ft]
0°
4
2
2
4
Counts: 16.00
Mean (3D): 36.25
Min: 0.50
Max: 82.06
Well ID:
MW - 37 BR


Depth
1ft:100ft
Fractures
0
90
Rose Diagram - Dip Direction
Azimuth - Absolute (Count)
Rose Diagram - Dip
Dip Count - Absolute (Count)
35
40
45
50
55
60
65
70
75
80
Azimuth - Absolute (Count)
Depth: 32.51 [ft] to 81.36 [ft]
0°
180°
1 2 3 4 5
Components: Azimuth
Counts: 55.00
Mean (3D): 50.03
Min: 0.16
Max: 358.74
Dip Count - Absolute (Count)
Depth: 32.45 [ft] to 81.46 [ft]
0°
5 10 15 20 25 30
Counts: 55.00
Mean (3D): 18.26
Min: 5.61
Max: 73.05
WELL ID:
MW - 39 BR


Depth
Fractures
Rose Diagram - Dip Direction
Rose Diagram - Dip
1ft:200ft
0
90
Azimuth - Absolute (Count)
Dip Count - Absolute (Count)
40
50
60
70
80
90
100
110
120
130
140
Azimuth - Absolute (Count)
Depth: 45.11 [ft] to 130.58 [ft]
0°
4
4
180°
Components: Azimuth
Counts: 34.00
Mean (3D): 35.42
Min: 15.55
Max: 350.53
Dip Count - Absolute (Count)
Depth: 45.12 [ft] to 130.75 [ft]
0°
10
5
5
10
Counts: 34.00
Mean (3D): 35.32
Min: 11.09
Max: 70.67
Well ID:
MW - 42 BR

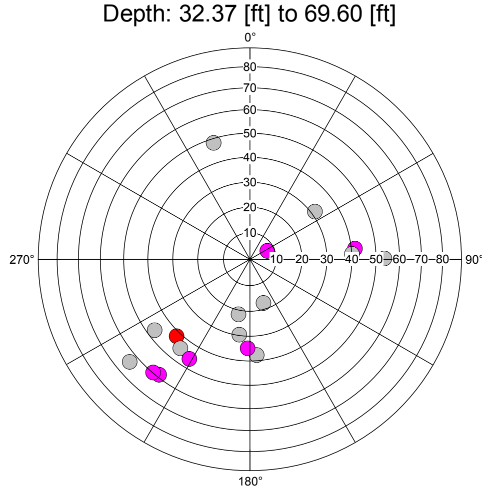
Depth	Fractures	Poles - Dip - Lower Hemisphere	Great Circles - Strike - Lower Hemisphere
1ft:100ft	0 90	Schmidt Plot - LH - Type	Schmidt Plot (Strike) - LH - Type



Well ID:
MW - 02 BR

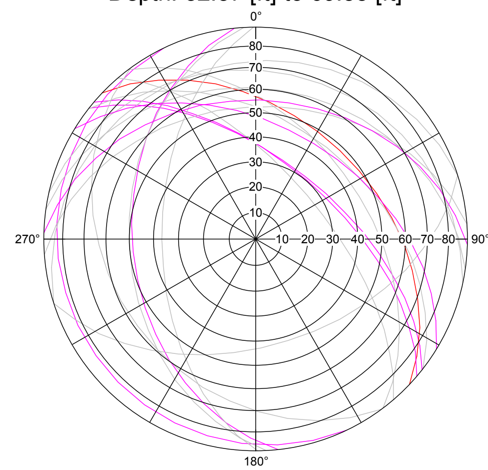
Major open fracture
Minor open fracture
Closed fracture

Schmidt Plot - LH - Type
Depth: 32.37 [ft] to 69.60 [ft]



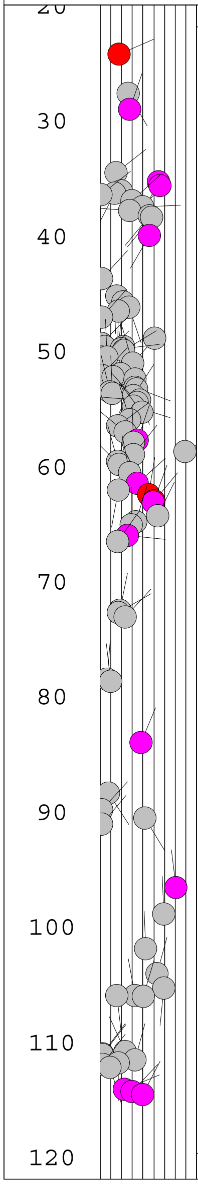
	Counts	Dip[deg]	Azi[deg]
Mean	18	27.63	19.55
	6	35.97	23.71
	1	41.86	43.49
	11	20.04	5.58

Schmidt Plot (Strike) - LH - Type
Depth: 32.37 [ft] to 69.55 [ft]



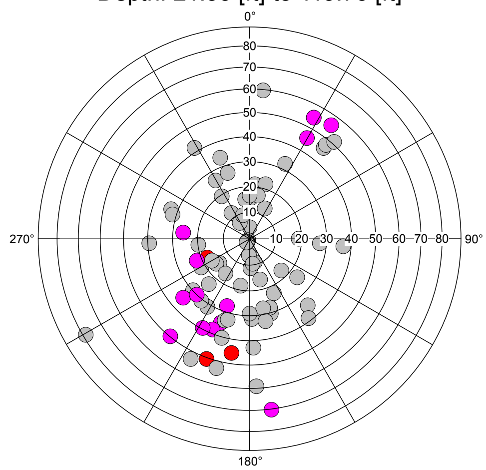
	Counts	Dip[deg]	Strike[deg]
Mean	18	27.63	289.55
	6	35.97	293.71
	1	41.86	313.49
	11	20.04	275.58

Depth	Fractures	Poles - Dip - Lower Hemisphere	Great Circles - Strike - Lower Hemisphere
1ft:200ft	0 90	Schmidt Plot - LH - Type	Schmidt Plot (Strike) - LH - Type

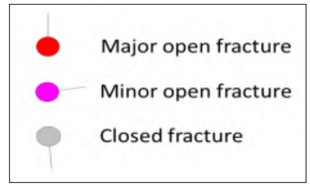


Well ID:
MW - 21 BR

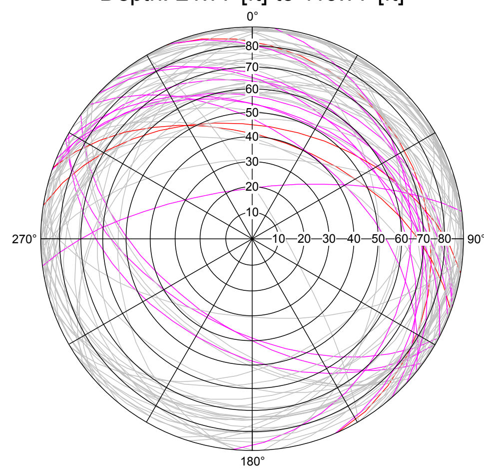
Schmidt Plot - LH - Type
Depth: 21.90 [ft] to 119.70 [ft]



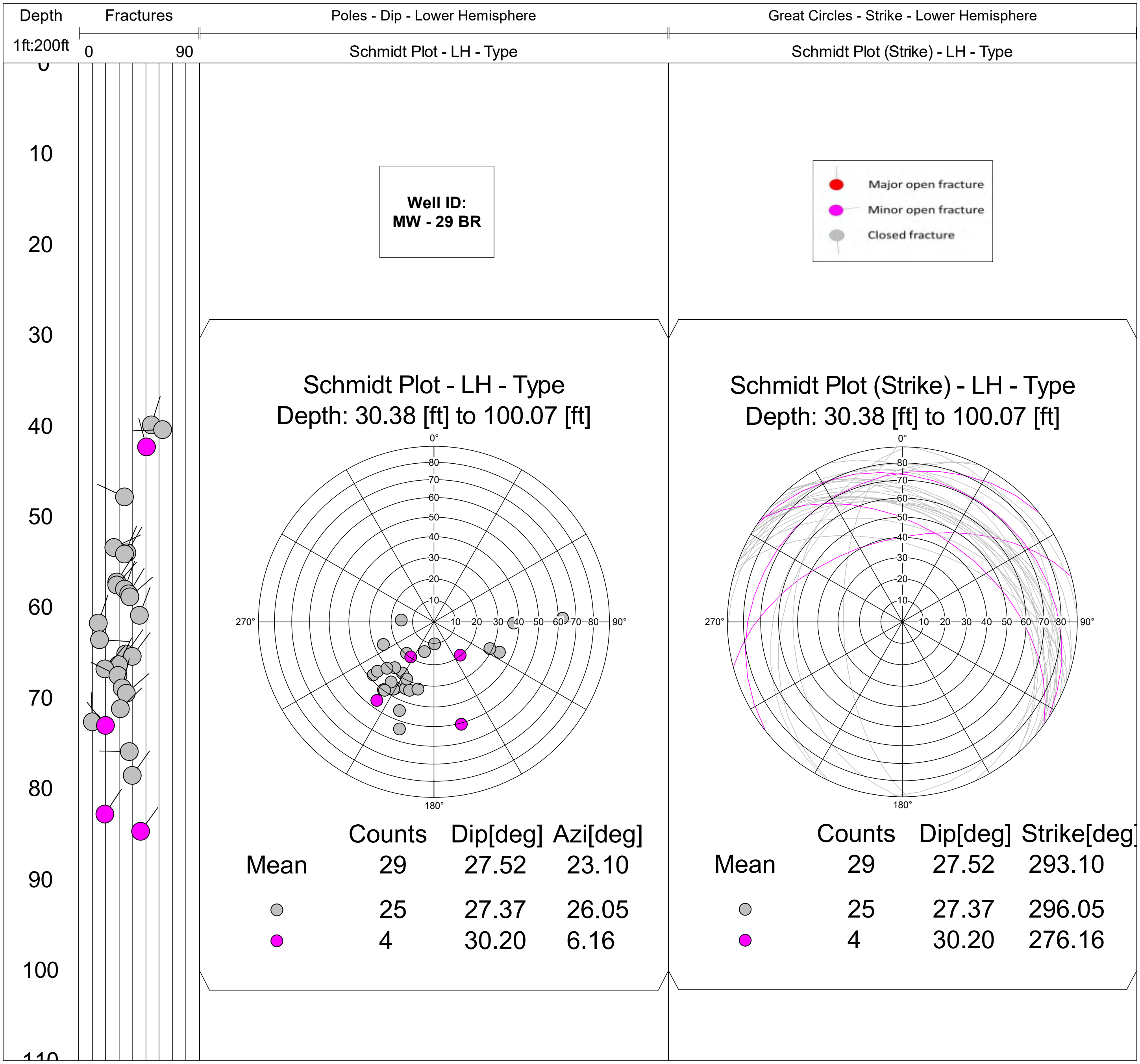
	Counts	Dip[deg]	Azi[deg]
Mean	91	8.63	26.04
● (red)	3	37.14	22.41
● (grey)	75	5.26	20.38
● (magenta)	13	31.53	33.65



Schmidt Plot (Strike) - LH - Type
Depth: 21.77 [ft] to 119.77 [ft]

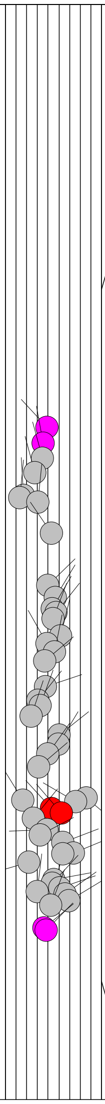


	Counts	Dip[deg]	Strike[deg]
Mean	91	8.63	296.04
● (red)	3	37.14	292.41
● (grey)	75	5.26	290.38
● (magenta)	13	31.53	303.65

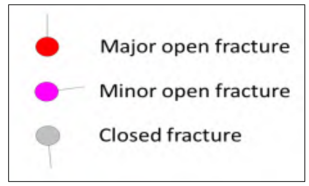

Depth
1ft:200ft
Fractures
0
90
Poles - Dip - Lower Hemisphere
Schmidt Plot - LH - Type
Great Circles - Strike - Lower Hemisphere
Schmidt Plot (Strike) - LH - Type
10
20
30
40
50
60
70
80
90
100
Well ID:
MW - 29 BR
Major open fracture
Minor open fracture
Closed fracture
Schmidt Plot - LH - Type
Depth: 30.38 [ft] to 100.07 [ft]
Counts Dip[deg] Azi[deg]
Mean 29 27.52 23.10
25 27.37 26.05
4 30.20 6.16
Schmidt Plot (Strike) - LH - Type
Depth: 30.38 [ft] to 100.07 [ft]
Counts Dip[deg] Strike[deg]
Mean 29 27.52 293.10
25 27.37 296.05
4 30.20 276.16

Depth	Fractures	Poles - Dip - Lower Hemisphere	Great Circles - Strike - Lower Hemisphere
1ft:200ft	0 90	Schmidt Plot - LH - Type	Schmidt Plot (Strike) - LH - Type

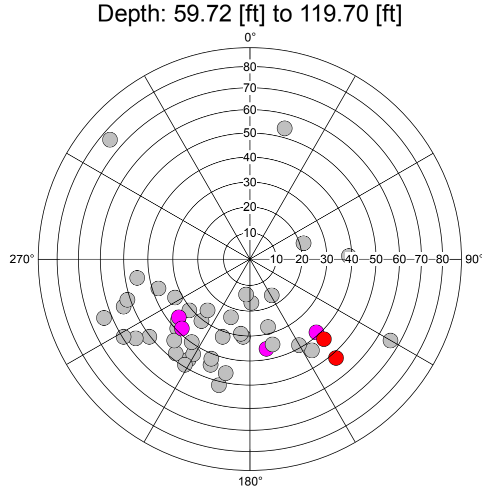
40
50
60
70
80
90
100
110
120



Well ID:
MW - 34 BR

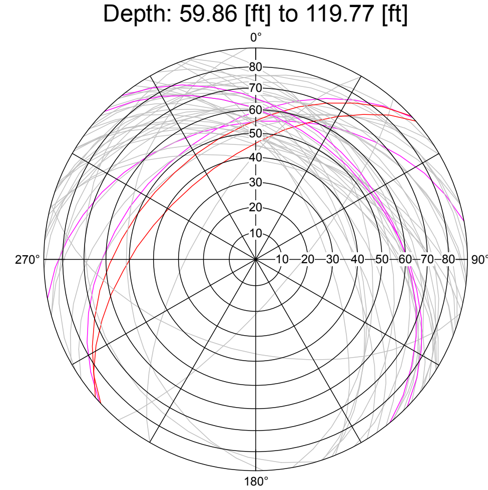


Schmidt Plot - LH - Type
Depth: 59.72 [ft] to 119.70 [ft]

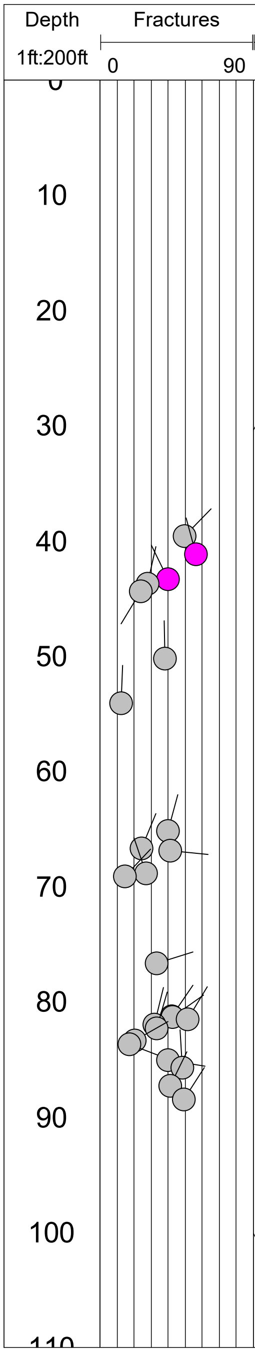


	Counts	Dip[deg]	Azi[deg]
Mean	46	32.77	26.58
Minor open fracture (magenta)	4	30.75	12.09
Closed fracture (grey)	40	33.74	32.04
Major open fracture (red)	2	47.64	318.19

Schmidt Plot (Strike) - LH - Type
Depth: 59.86 [ft] to 119.77 [ft]



	Counts	Dip[deg]	Strike[deg]
Mean	46	32.77	296.58
Minor open fracture (magenta)	4	30.75	282.09
Closed fracture (grey)	40	33.74	302.04
Major open fracture (red)	2	47.64	228.19



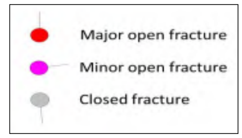
Poles - Dip - Lower Hemisphere

Schmidt Plot - LH - Type

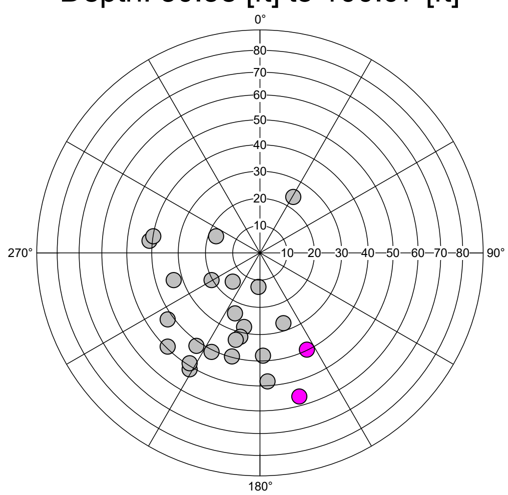
Great Circles - Strike - Lower Hemisphere

Schmidt Plot (Strike) - LH - Type

Well ID:
MW - 35 BR

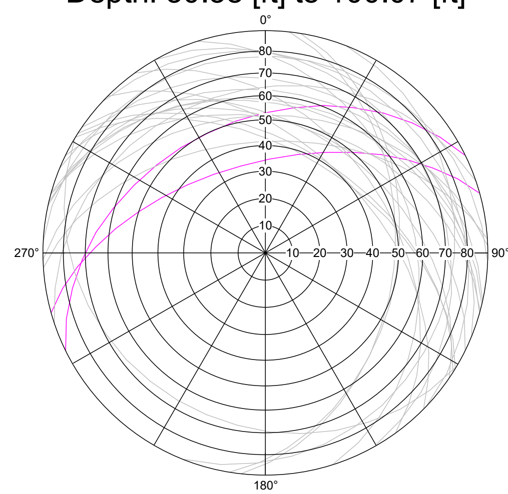


Schmidt Plot - LH - Type
Depth: 30.38 [ft] to 100.07 [ft]



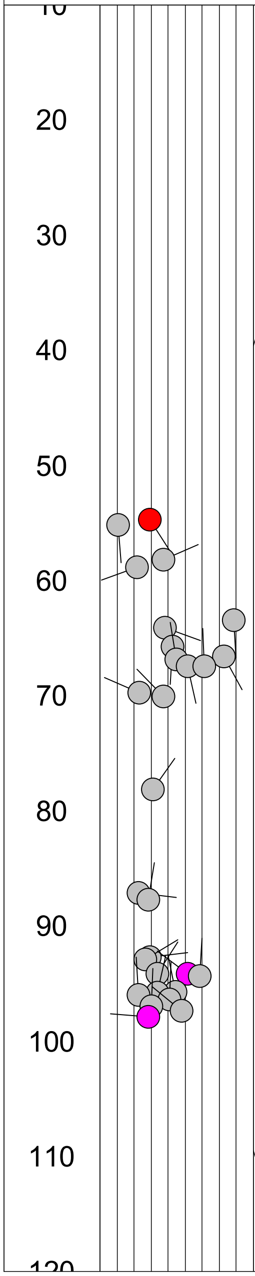
	Counts	Dip[deg]	Azi[deg]
Mean	24	29.43	27.55
● (grey)	22	28.96	33.70
● (magenta)	2	48.15	339.96

Schmidt Plot (Strike) - LH - Type
Depth: 30.38 [ft] to 100.07 [ft]



	Counts	Dip[deg]	Strike[deg]
Mean	24	29.43	297.55
● (grey)	22	28.96	303.70
● (magenta)	2	48.15	249.96

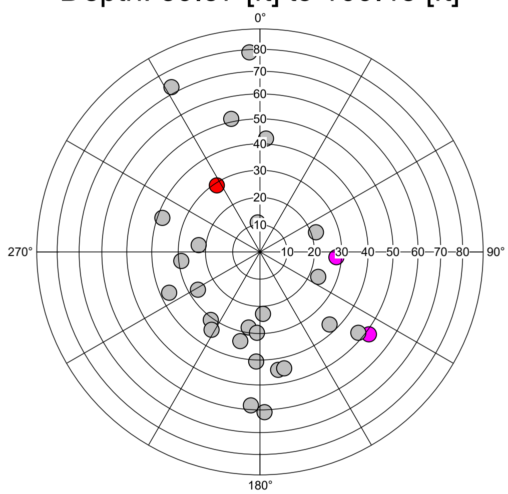
Depth	Fractures	Poles - Dip - Lower Hemisphere	Great Circles - Strike - Lower Hemisphere
1ft:200ft	0 90	Schmidt Plot - LH - Type	Schmidt Plot (Strike) - LH - Type



Well ID:
MW - 36 BR

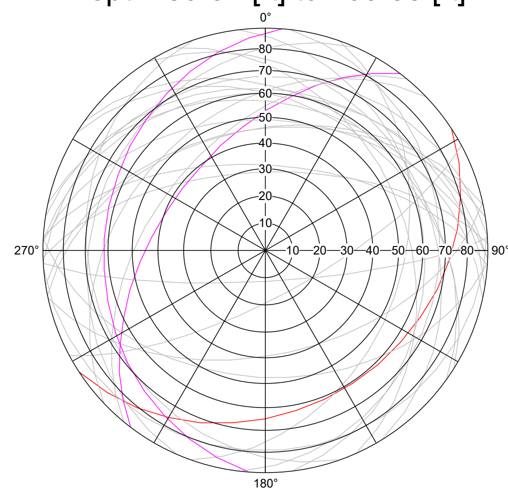
Major open fracture
Minor open fracture
Closed fracture

Schmidt Plot - LH - Type
Depth: 39.57 [ft] to 109.45 [ft]



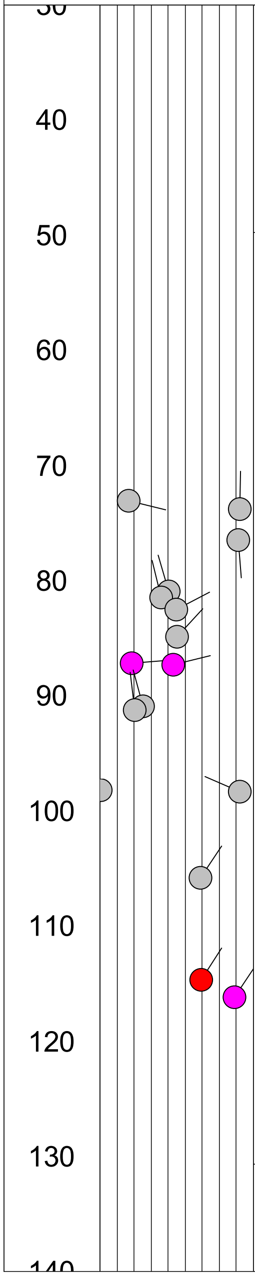
	Counts	Dip[deg]	Azi[deg]
Mean	28	20.89	4.07
● (red)	1	29.29	146.81
● (grey)	25	23.66	10.10
● (magenta)	2	38.82	294.96

Schmidt Plot (Strike) - LH - Type
Depth: 39.57 [ft] to 109.58 [ft]

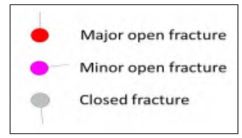


	Counts	Dip[deg]	Strike[deg]
Mean	28	20.89	274.07
● (red)	1	29.29	56.81
● (grey)	25	23.66	280.10
● (magenta)	2	38.82	204.96

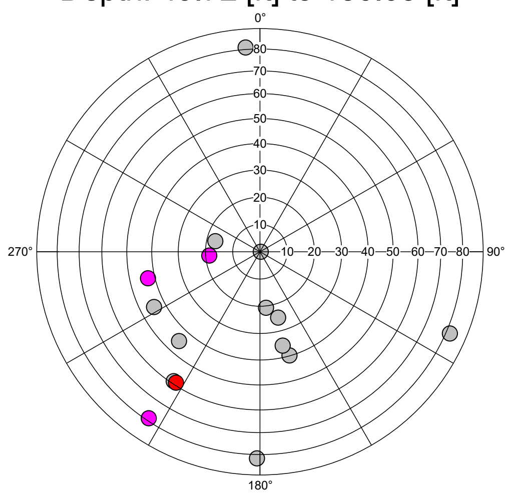
Depth	Fractures	Poles - Dip - Lower Hemisphere	Great Circles - Strike - Lower Hemisphere
1ft:200ft	0 90	Schmidt Plot - LH - Type	Schmidt Plot (Strike) - LH - Type



Well ID:
MW - 37 BR

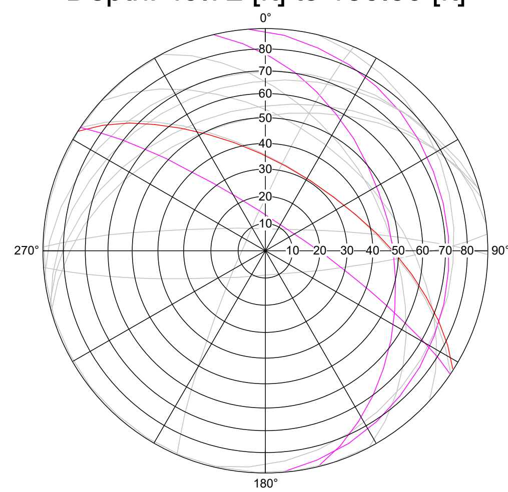


Schmidt Plot - LH - Type
Depth: 49.72 [ft] to 130.63 [ft]



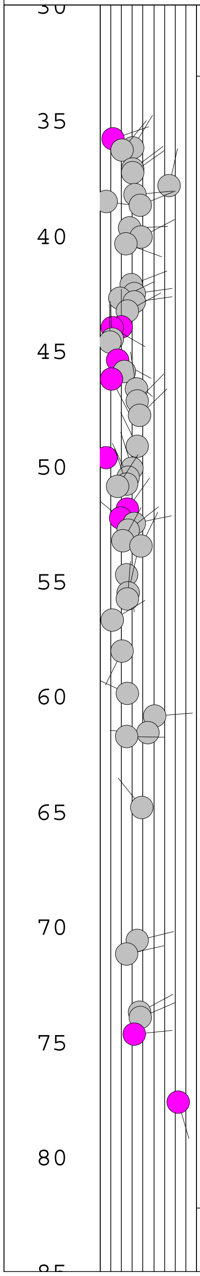
	Counts	Dip[deg]	Azi[deg]
Mean	16	36.25	26.66
● (grey)	12	33.70	12.00
● (magenta)	3	42.09	59.77
● (red)	1	59.30	32.54

Schmidt Plot (Strike) - LH - Type
Depth: 49.72 [ft] to 130.50 [ft]

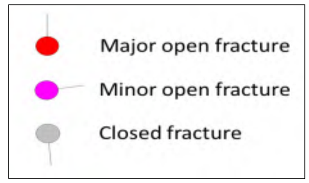


	Counts	Dip[deg]	Strike[deg]
Mean	16	36.25	296.66
● (grey)	12	33.70	282.00
● (magenta)	3	42.09	329.77
● (red)	1	59.30	302.54

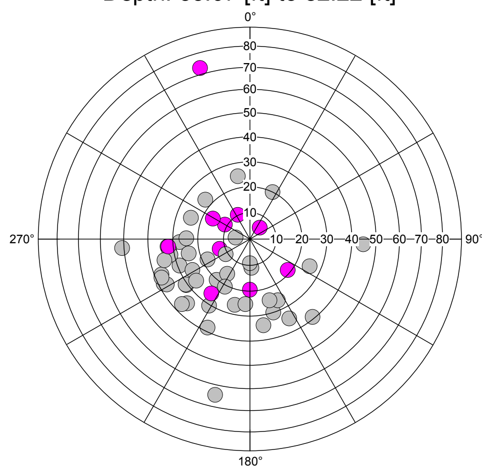
Depth	Fractures	Poles - Dip - Lower Hemisphere	Great Circles - Strike - Lower Hemisphere
1ft:100ft	0 90	Schmidt Plot - LH - Type	Schmidt Plot (Strike) - LH - Type



Well ID:
MW - 39 BR

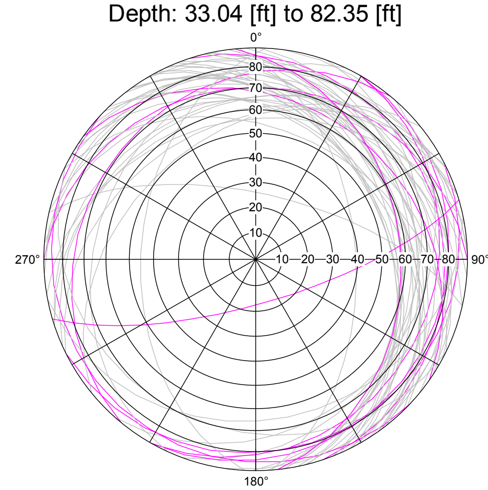


Schmidt Plot - LH - Type
Depth: 33.07 [ft] to 82.22 [ft]



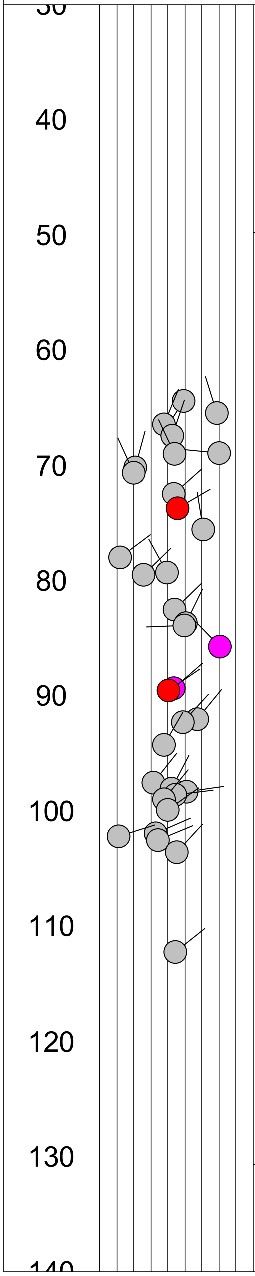
	Counts	Dip[deg]	Azi[deg]
Mean	55	18.26	50.03
● (magenta)	10	8.37	80.09
● (gray)	45	20.62	48.02

Schmidt Plot (Strike) - LH - Type
Depth: 33.04 [ft] to 82.35 [ft]

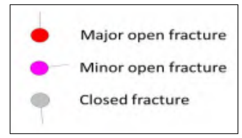


	Counts	Dip[deg]	Strike[deg]
Mean	55	18.26	320.03
● (magenta)	10	8.37	350.09
● (gray)	45	20.62	318.02

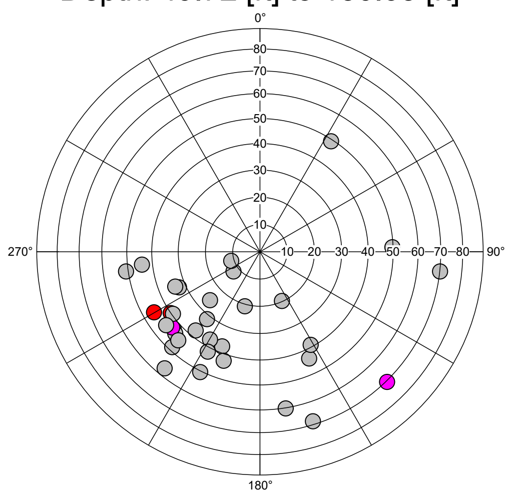
Depth	Fractures	Poles - Dip - Lower Hemisphere	Great Circles - Strike - Lower Hemisphere
1ft:200ft	0 90	Schmidt Plot - LH - Type	Schmidt Plot (Strike) - LH - Type



Well ID:
MW - 42 BR

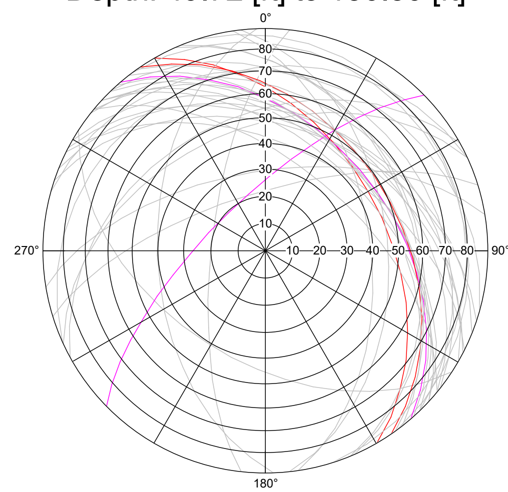


Schmidt Plot - LH - Type
Depth: 49.72 [ft] to 130.63 [ft]



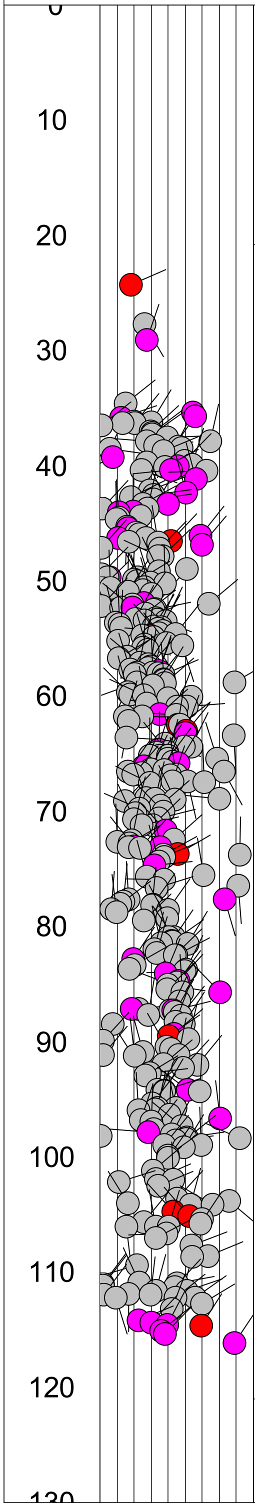
	Counts	Dip[deg]	Azi[deg]
Mean	34	35.32	35.42
● (grey)	30	34.51	33.68
● (red)	2	42.95	57.96
● (magenta)	2	46.94	352.87

Schmidt Plot (Strike) - LH - Type
Depth: 49.72 [ft] to 130.50 [ft]

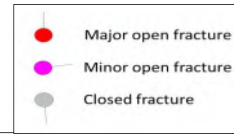


	Counts	Dip[deg]	Strike[deg]
Mean	34	35.32	305.42
● (grey)	30	34.51	303.68
● (red)	2	42.95	327.96
● (magenta)	2	46.94	262.87

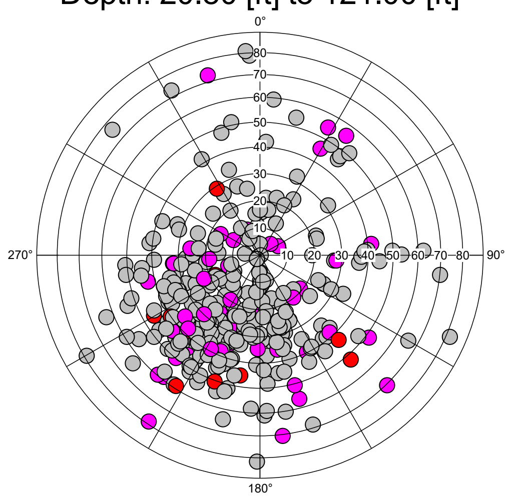
Depth	Fractures	Poles - Dip - Lower Hemisphere	Great Circles - Strike - Lower Hemisphere
1ft:200ft	0 90	Schmidt Plot - LH - Type	Schmidt Plot (Strike) - LH - Type



All Fractures

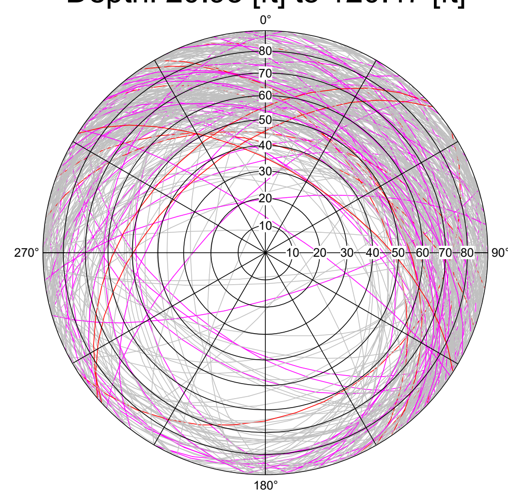


Schmidt Plot - LH - Type
Depth: 20.80 [ft] to 121.00 [ft]



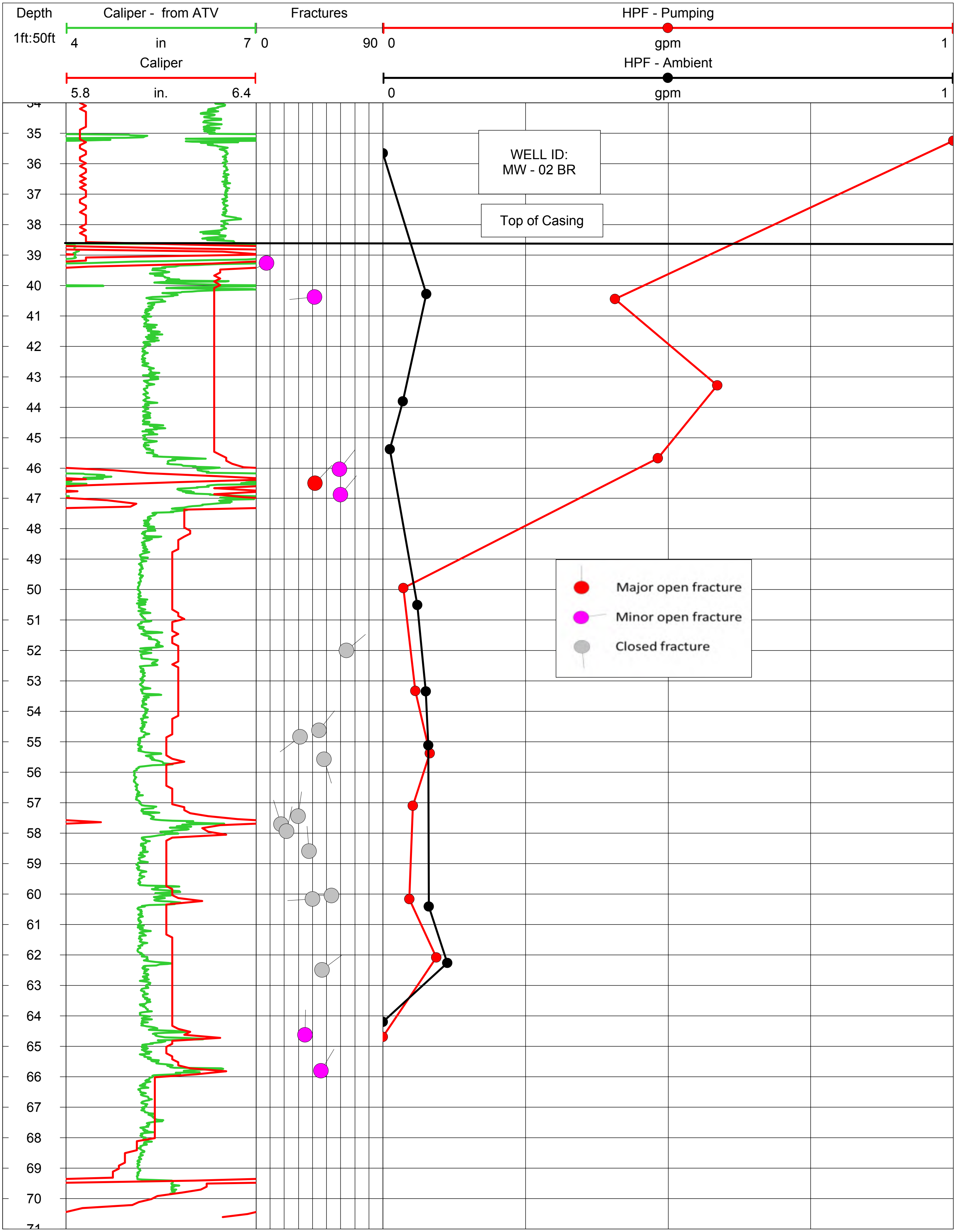
	Counts	Dip[deg]	Azi[deg]
Mean	341	22.32	28.54
● (red)	10	35.14	28.19
● (grey)	285	21.59	29.65
● (magenta)	46	24.51	21.59

Schmidt Plot (Strike) - LH - Type
Depth: 20.93 [ft] to 120.47 [ft]

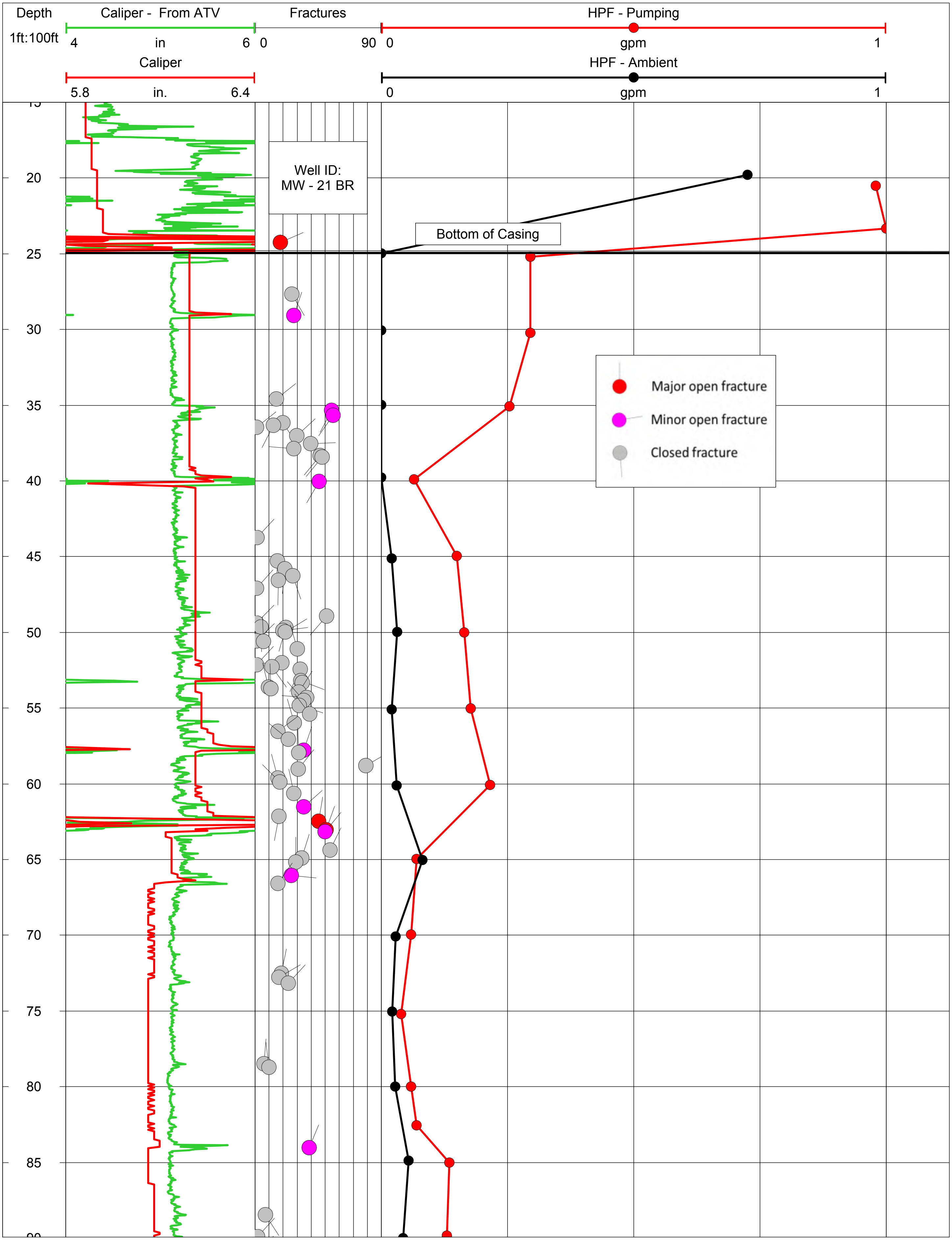


	Counts	Dip[deg]	Strike[deg]
Mean	341	22.32	298.54
● (red)	10	35.14	298.19
● (grey)	285	21.59	299.65
● (magenta)	46	24.51	291.59

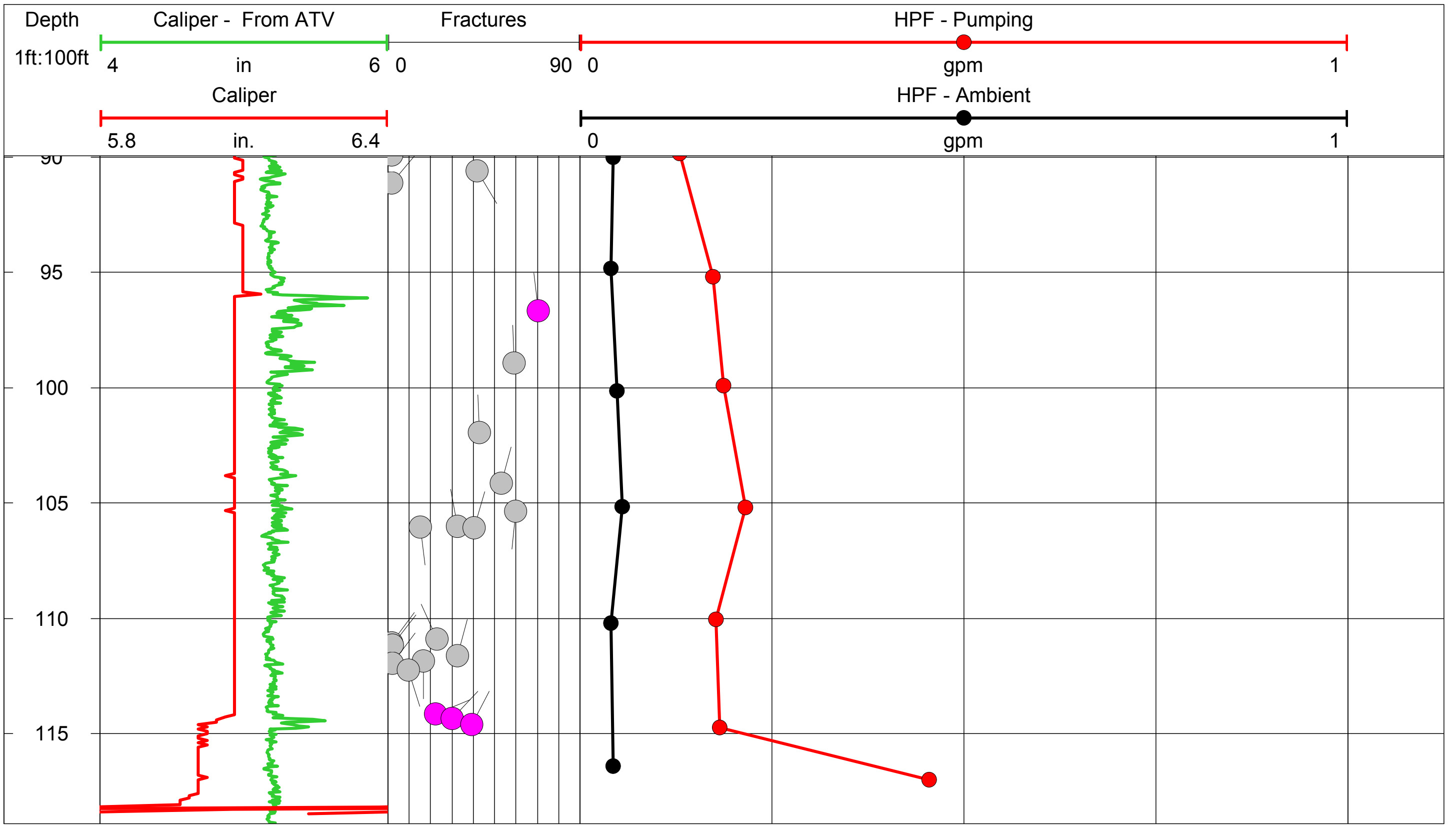
Appendix 3



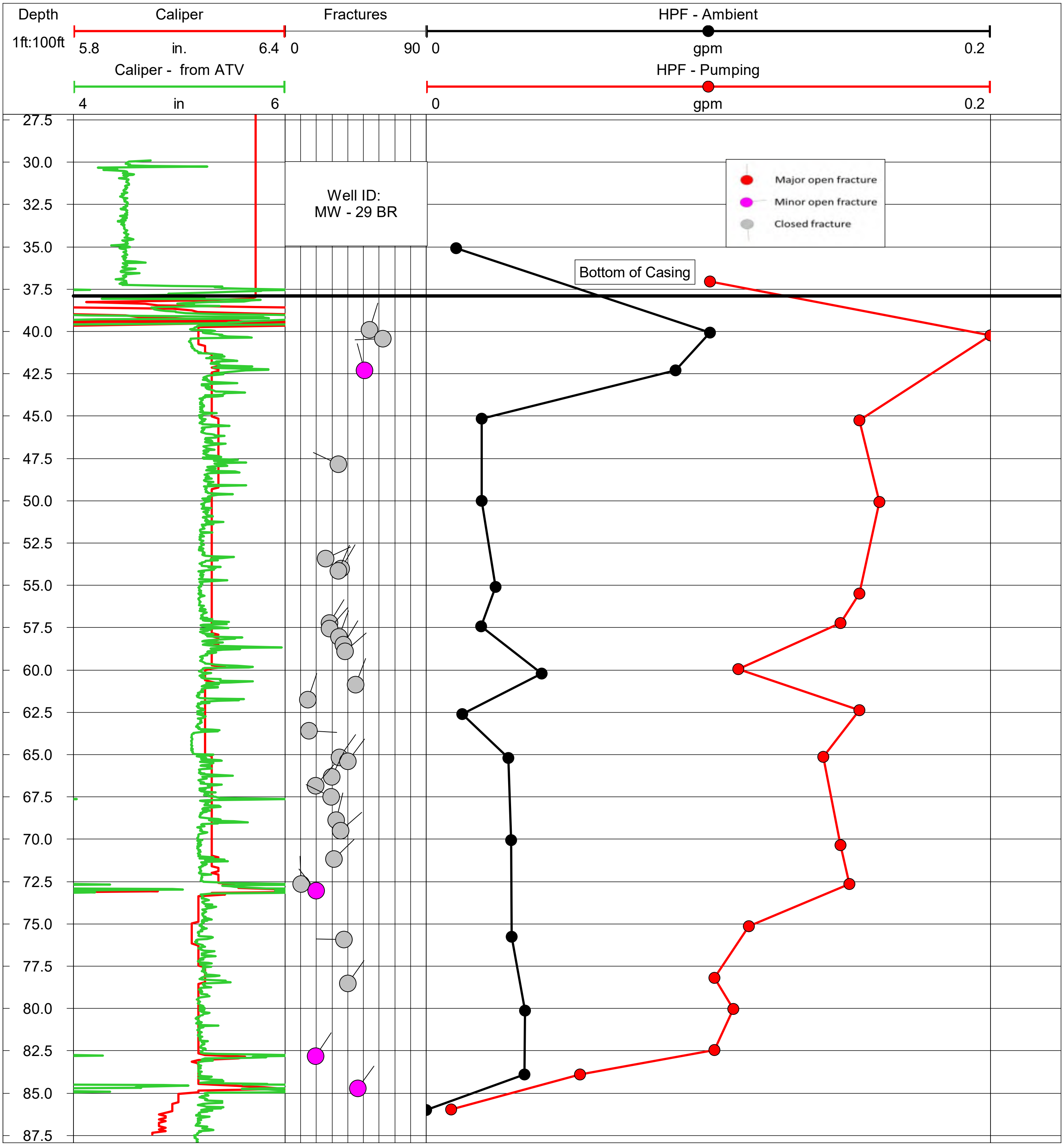
Depth
1ft:50ft
Caliper - from ATV
4 in 7
Caliper
5.8 in. 6.4
Fractures
0 90
HPF - Pumping
0 gpm 1
HPF - Ambient
0 gpm 1
WELL ID:
MW - 02 BR
Top of Casing
Major open fracture
Minor open fracture
Closed fracture
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70

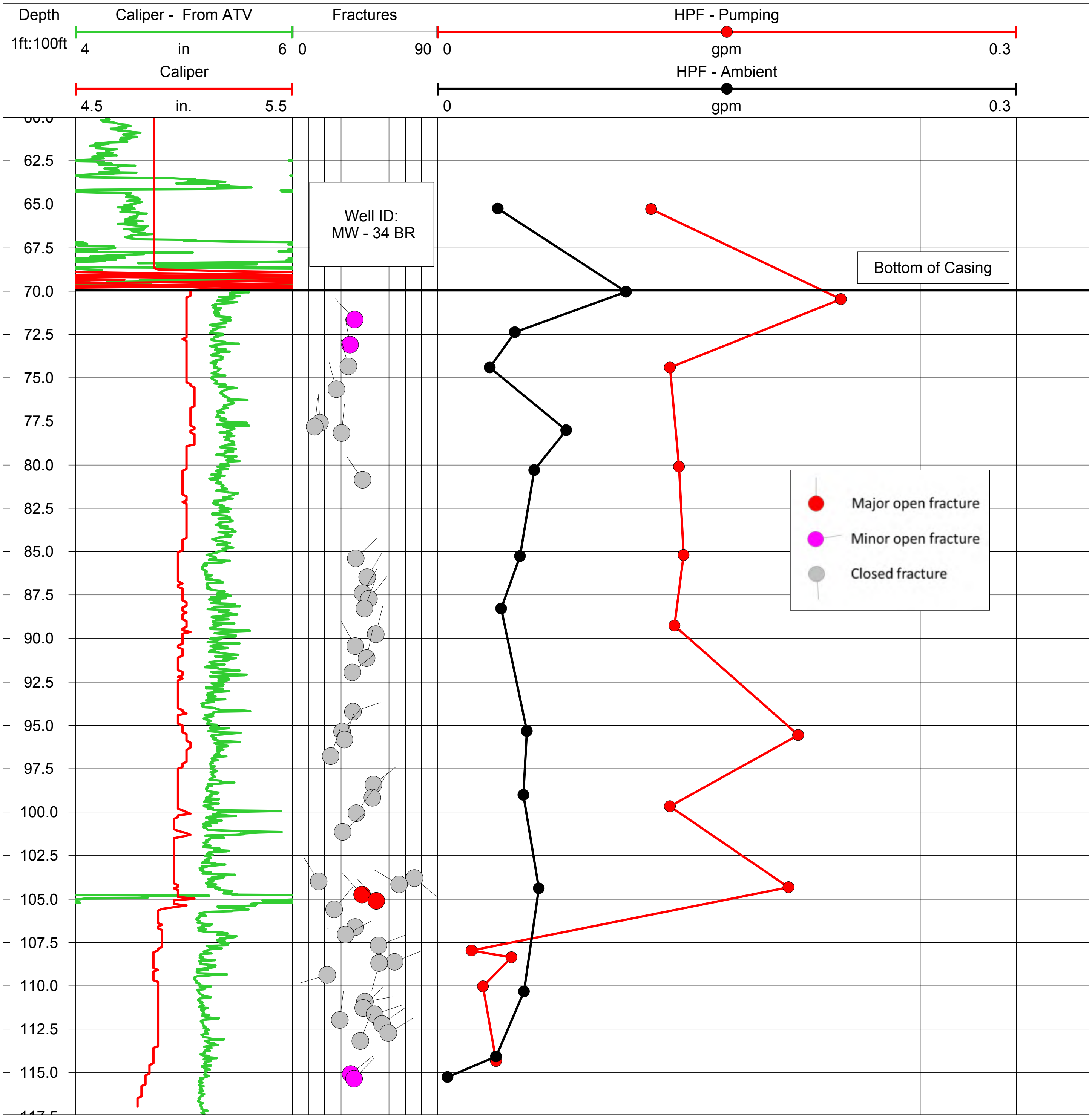


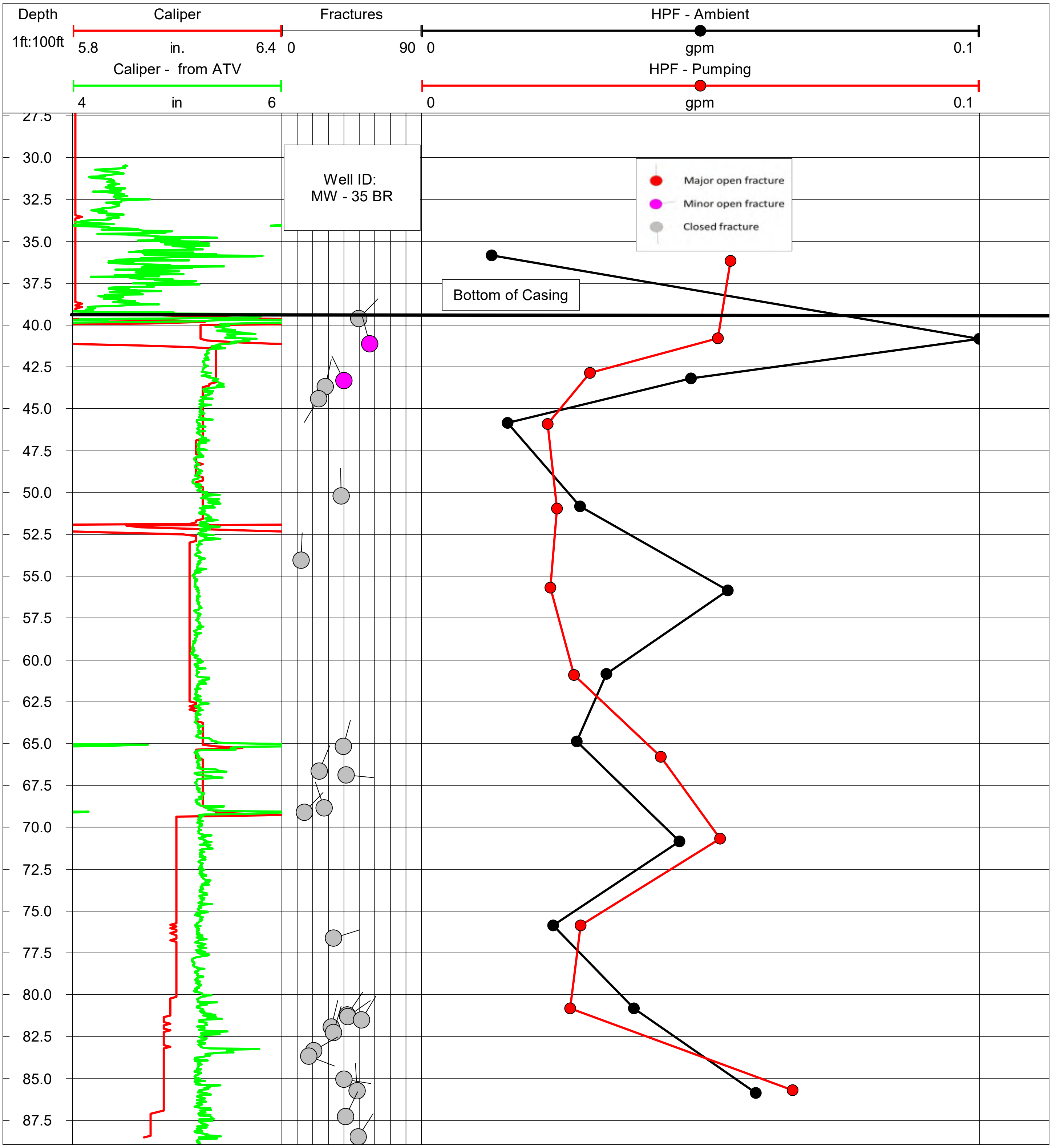
Depth
1ft:100ft
Caliper - From ATV
4
in
6
Caliper
5.8
in.
6.4
Fractures
0
90
HPF - Pumping
0
gpm
1
HPF - Ambient
0
gpm
1
Well ID:
MW - 21 BR
Bottom of Casing
Major open fracture
Minor open fracture
Closed fracture
20
25
30
35
40
45
50
55
60
65
70
75
80
85



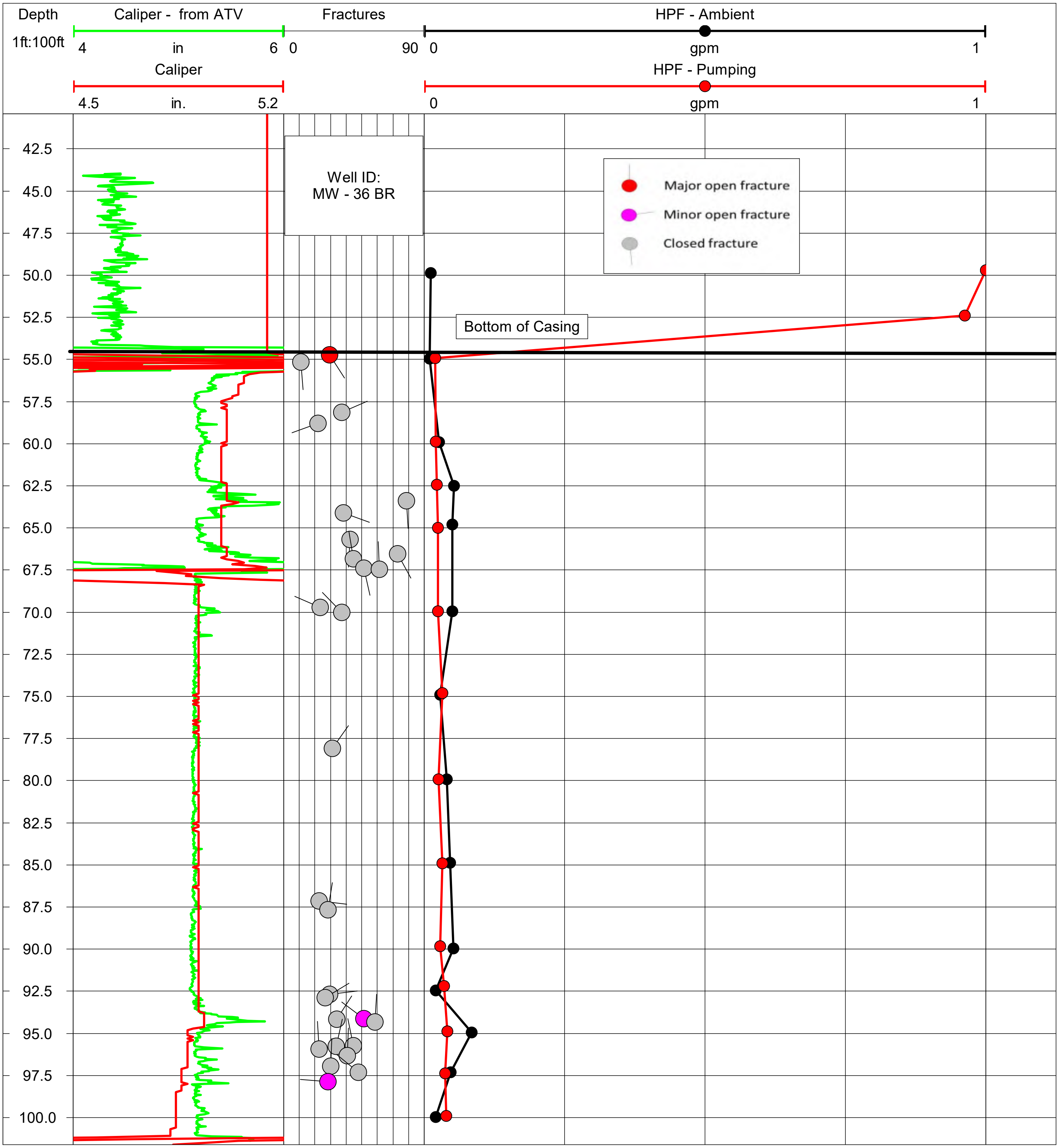
Depth
1ft:100ft
Caliper - From ATV
4
in
6
Caliper
5.8
in.
6.4
Fractures
0
90
HPF - Pumping
0
gpm
1
HPF - Ambient
0
gpm
1
90
95
100
105
110
115


Depth
1ft:100ft
Caliper
5.8 in. 6.4
Caliper - from ATV
4 in 6
Fractures
0 90
HPF - Ambient
0 gpm 0.2
HPF - Pumping
0 gpm 0.2
Well ID:
MW - 29 BR
Major open fracture
Minor open fracture
Closed fracture
Bottom of Casing
27.5
30.0
32.5
35.0
37.5
40.0
42.5
45.0
47.5
50.0
52.5
55.0
57.5
60.0
62.5
65.0
67.5
70.0
72.5
75.0
77.5
80.0
82.5
85.0
87.5

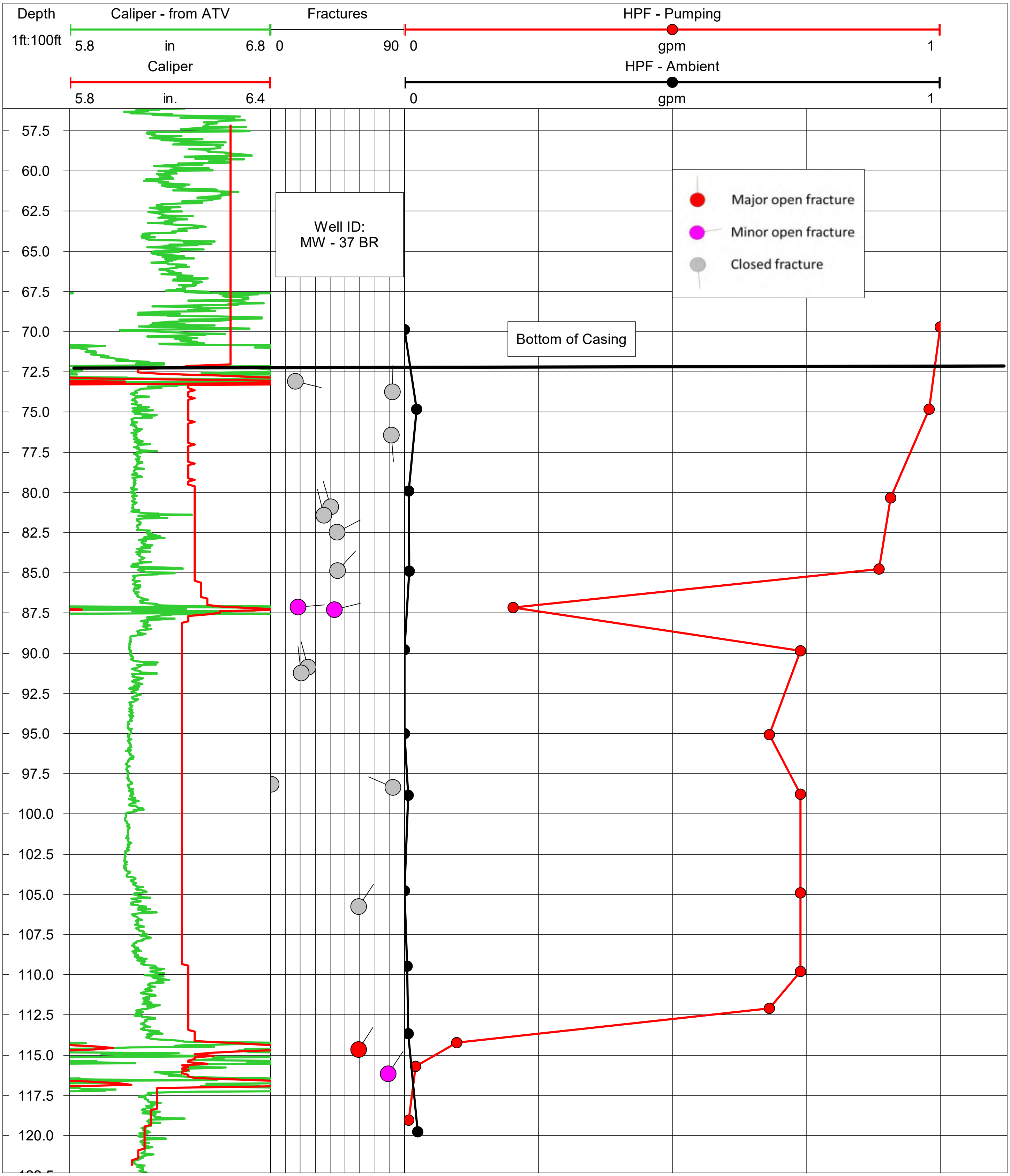

Depth
1ft:100ft
Caliper - From ATV
4
in
6
Caliper
4.5
in.
5.5
Fractures
0
90
HPF - Pumping
0
gpm
0.3
HPF - Ambient
0
gpm
0.3
62.5
65.0
67.5
70.0
72.5
75.0
77.5
80.0
82.5
85.0
87.5
90.0
92.5
95.0
97.5
100.0
102.5
105.0
107.5
110.0
112.5
115.0
Well ID:
MW - 34 BR
Bottom of Casing
Major open fracture
Minor open fracture
Closed fracture



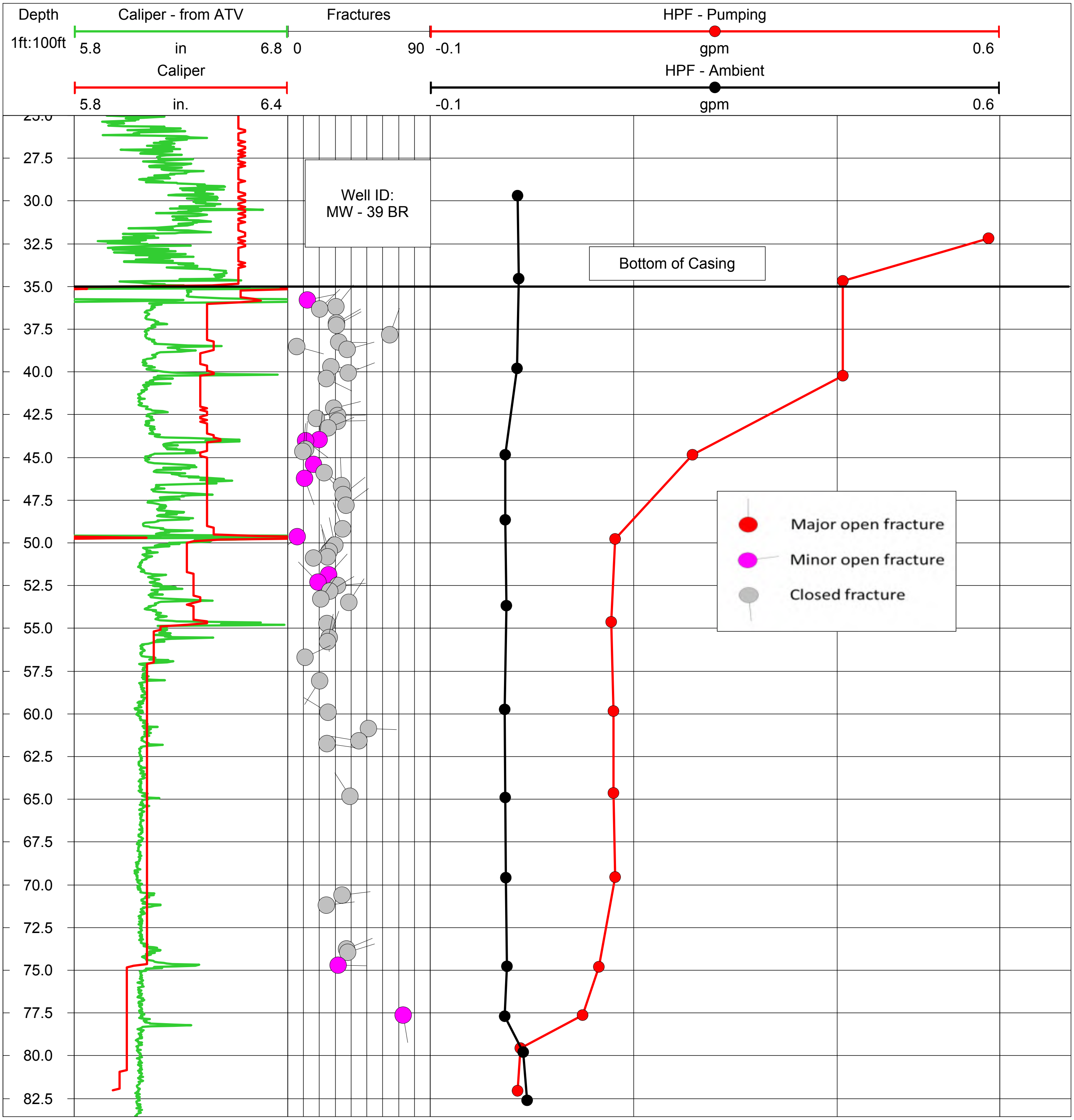
Depth
1ft:100ft
Caliper
5.8 in. 6.4
Caliper - from ATV
4 in 6
Fractures
0 90
HPF - Ambient
0 gpm 0.1
HPF - Pumping
0 gpm 0.1
Well ID:
MW - 35 BR
Major open fracture
Minor open fracture
Closed fracture
Bottom of Casing
27.5
30.0
32.5
35.0
37.5
40.0
42.5
45.0
47.5
50.0
52.5
55.0
57.5
60.0
62.5
65.0
67.5
70.0
72.5
75.0
77.5
80.0
82.5
85.0
87.5



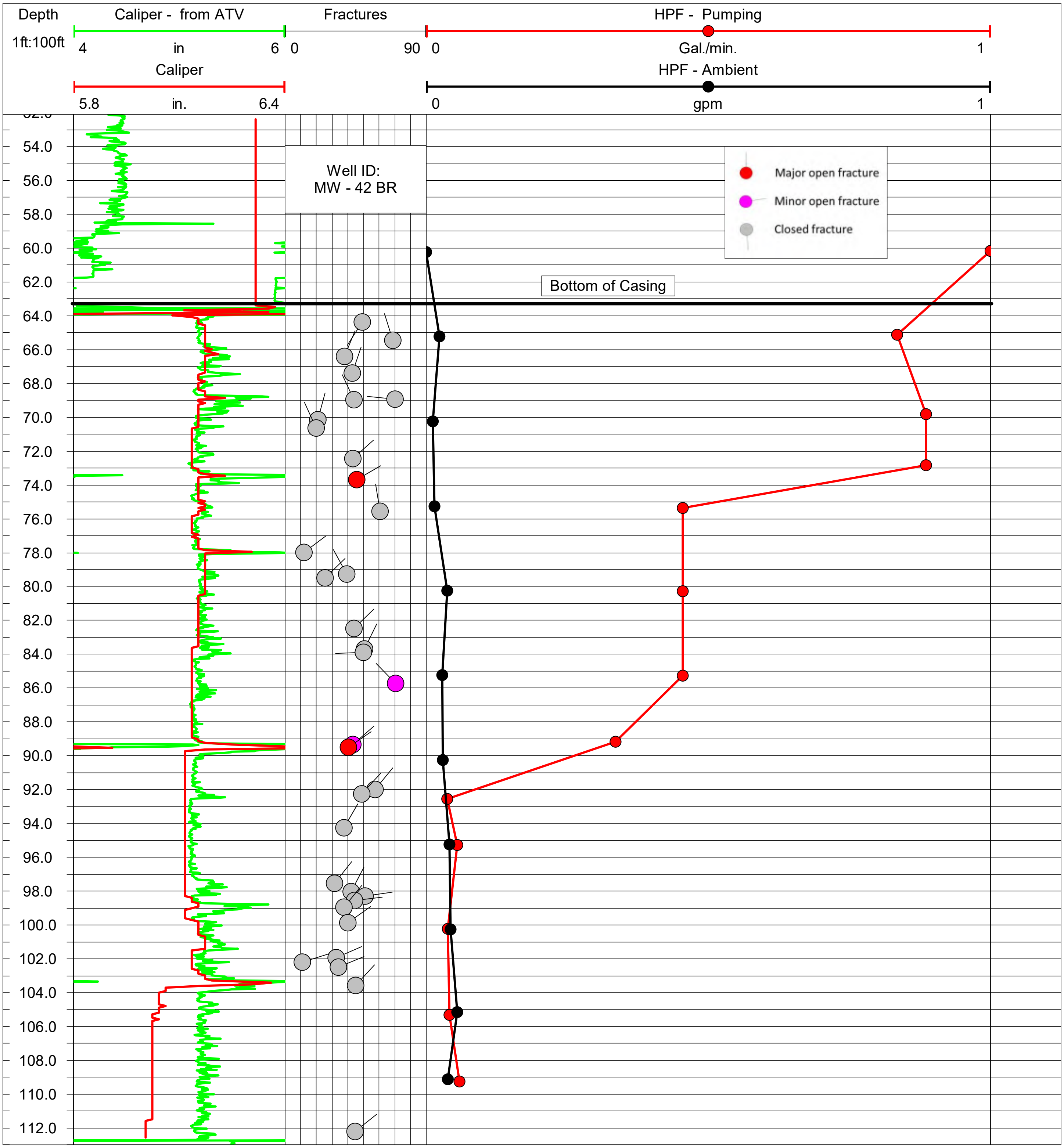
Depth
1ft:100ft
Caliper - from ATV
4
in
6
Caliper
4.5
in.
5.2
Fractures
0
90
HPF - Ambient
0
gpm
1
HPF - Pumping
0
gpm
1
Well ID:
MW - 36 BR
Major open fracture
Minor open fracture
Closed fracture
Bottom of Casing
42.5
45.0
47.5
50.0
52.5
55.0
57.5
60.0
62.5
65.0
67.5
70.0
72.5
75.0
77.5
80.0
82.5
85.0
87.5
90.0
92.5
95.0
97.5
100.0



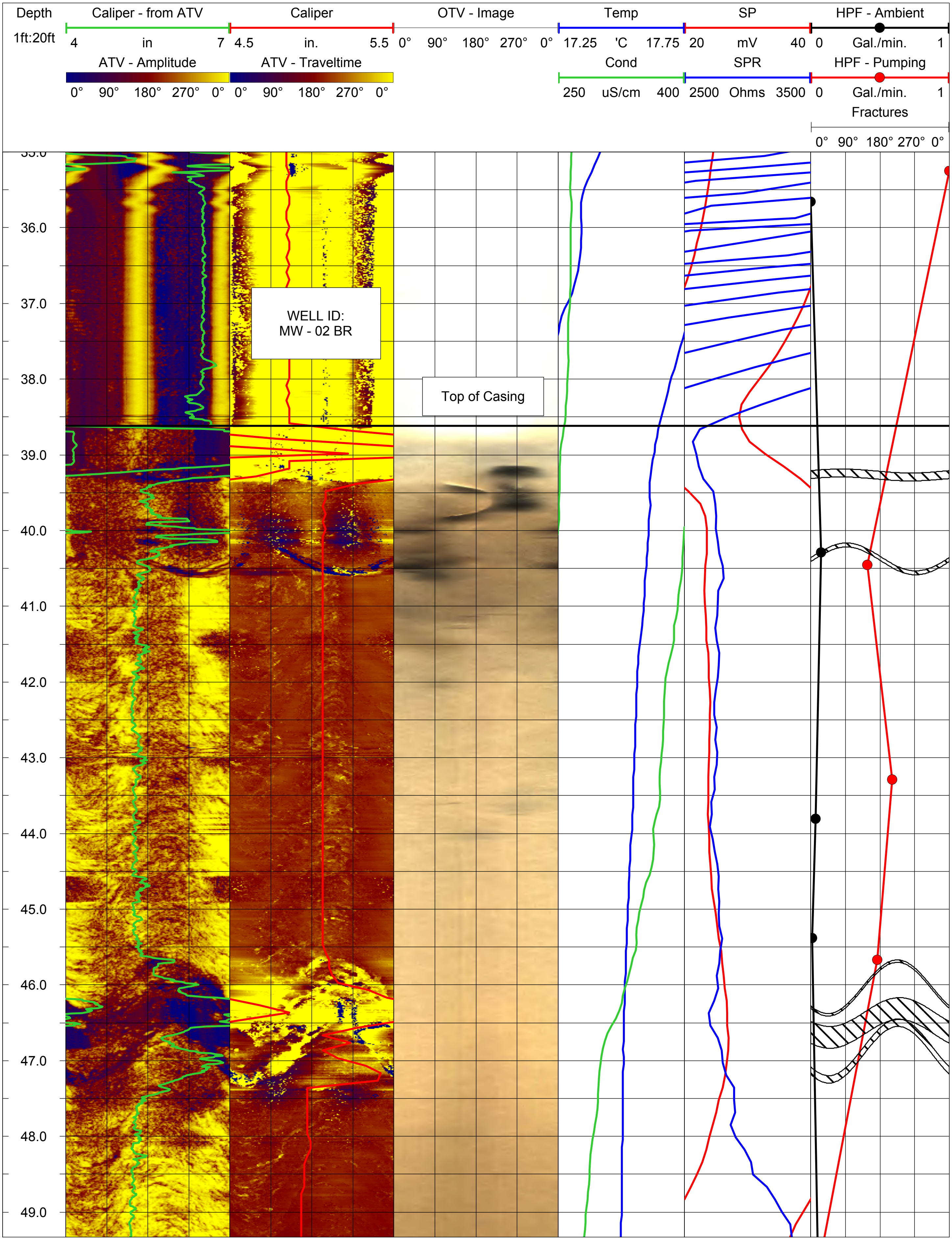
Depth
1ft:100ft
Caliper - from ATV
5.8
in
6.8
Caliper
5.8
in.
6.4
Fractures
0
90
HPF - Pumping
0
gpm
1
HPF - Ambient
0
gpm
1
57.5
60.0
62.5
65.0
67.5
70.0
72.5
75.0
77.5
80.0
82.5
85.0
87.5
90.0
92.5
95.0
97.5
100.0
102.5
105.0
107.5
110.0
112.5
115.0
117.5
120.0
Well ID:
MW - 37 BR
Major open fracture
Minor open fracture
Closed fracture
Bottom of Casing

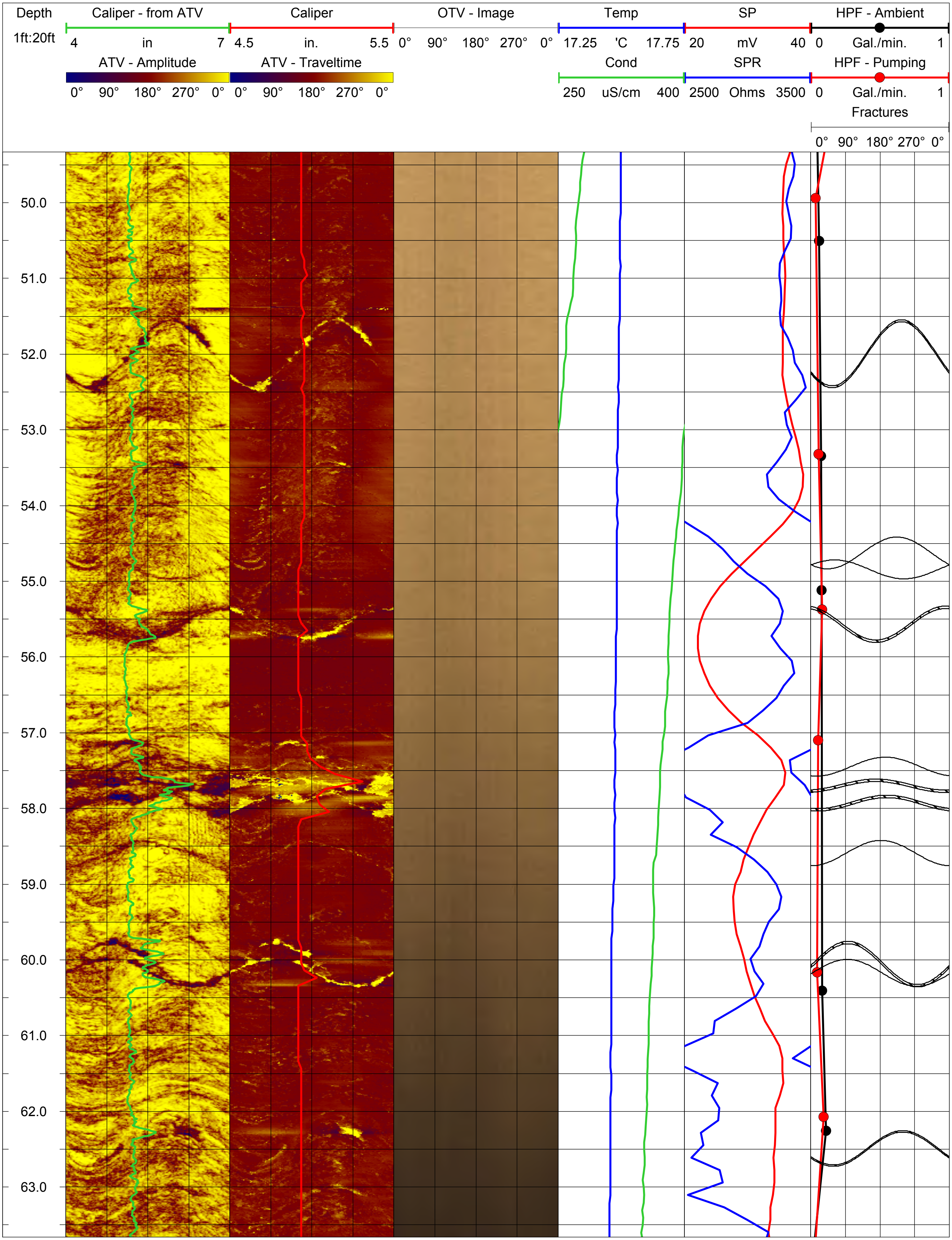


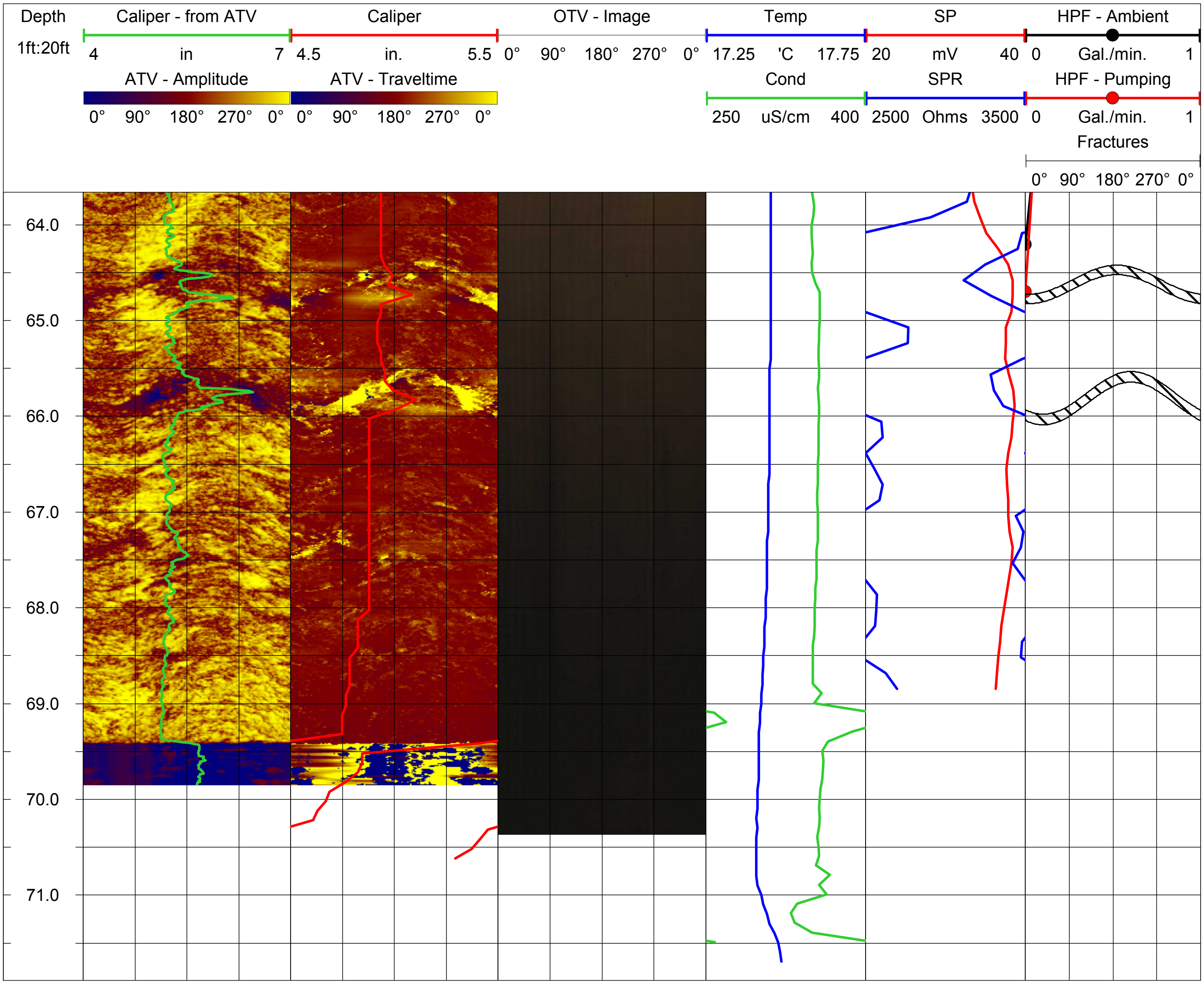
Depth
1ft:100ft
Caliper - from ATV
5.8 in 6.8
Caliper
5.8 in. 6.4
Fractures
0 90
HPF - Pumping
-0.1 gpm 0.6
HPF - Ambient
-0.1 gpm 0.6
27.5
30.0
32.5
35.0
37.5
40.0
42.5
45.0
47.5
50.0
52.5
55.0
57.5
60.0
62.5
65.0
67.5
70.0
72.5
75.0
77.5
80.0
82.5
Well ID:
MW - 39 BR
Bottom of Casing
Major open fracture
Minor open fracture
Closed fracture


Depth
1ft:100ft
Caliper - from ATV
4 in 6
Caliper
5.8 in. 6.4
Fractures
0 90
HPF - Pumping
0 Gal./min. 1
HPF - Ambient
0 gpm 1
Well ID:
MW - 42 BR
Major open fracture
Minor open fracture
Closed fracture
Bottom of Casing
54.0
56.0
58.0
60.0
62.0
64.0
66.0
68.0
70.0
72.0
74.0
76.0
78.0
80.0
82.0
84.0
86.0
88.0
90.0
92.0
94.0
96.0
98.0
100.0
102.0
104.0
106.0
108.0
110.0
112.0

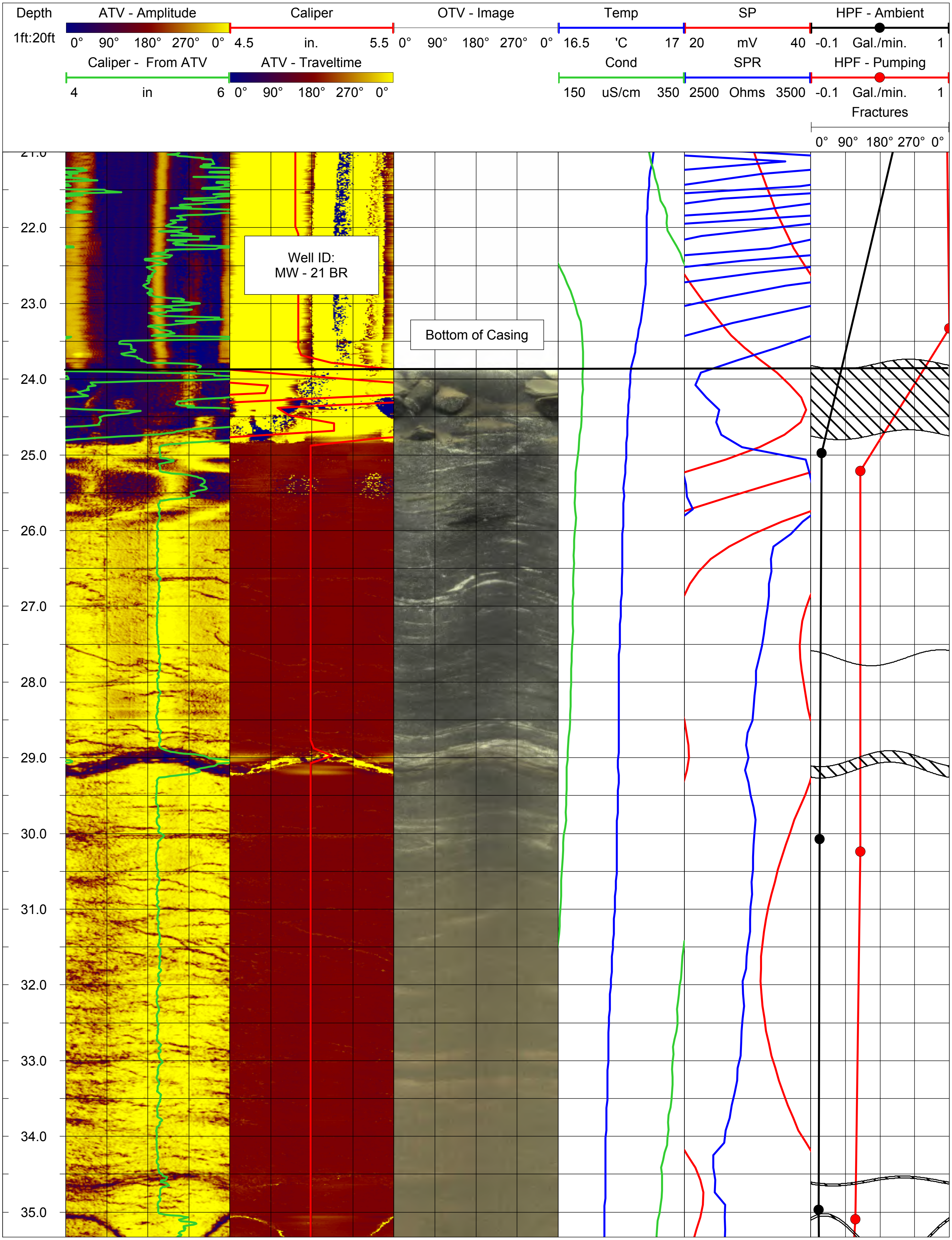
Appendix 4


Depth
1ft:20ft
Caliper - from ATV
4 in 7
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
17.25 'C 17.75
Cond
250 uS/cm 400
SP
20 mV 40
SPR
2500 Ohms 3500
HPF - Ambient
0 Gal./min. 1
HPF - Pumping
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
36.0
37.0
38.0
39.0
40.0
41.0
42.0
43.0
44.0
45.0
46.0
47.0
48.0
49.0
WELL ID:
MW - 02 BR
Top of Casing

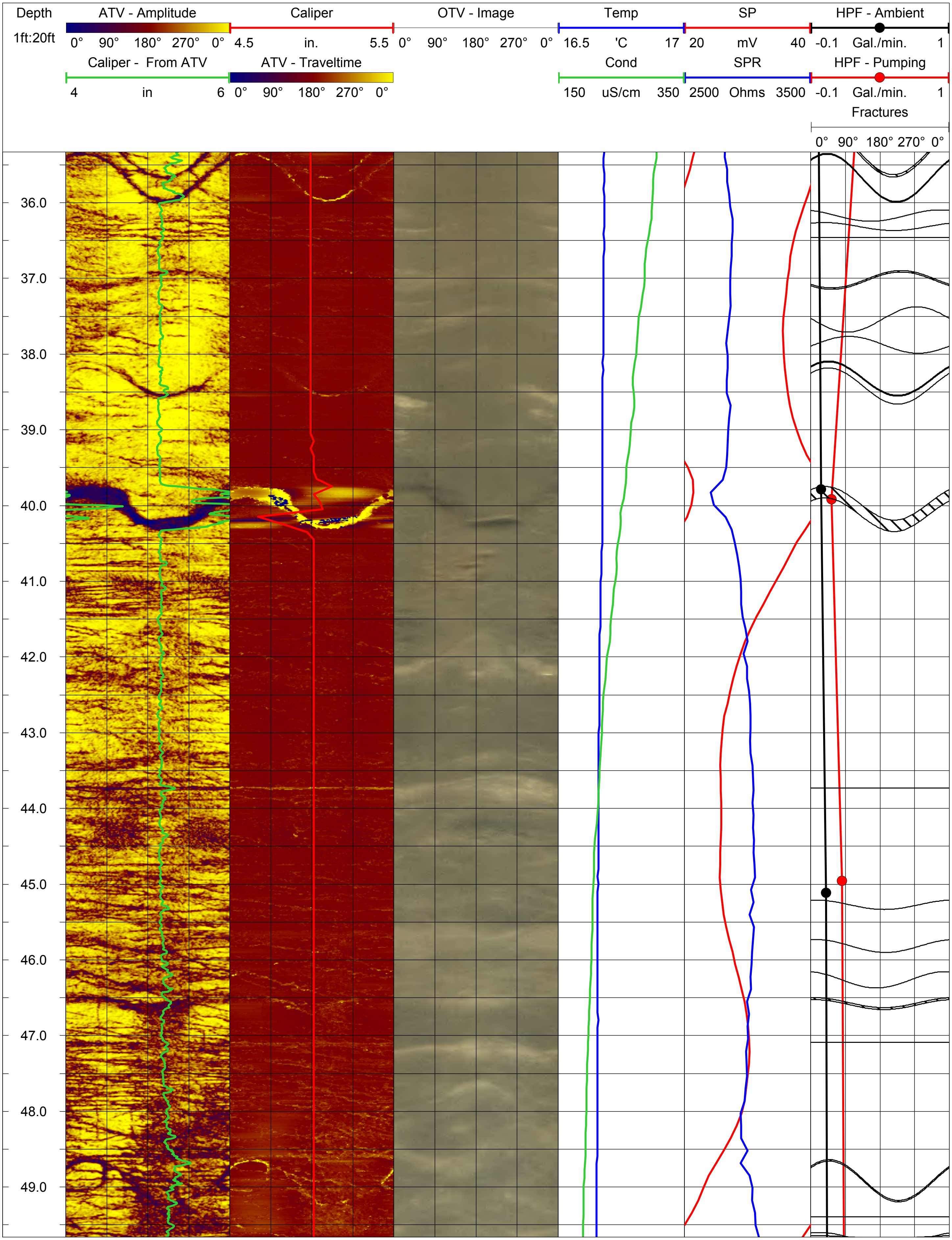

Depth
1ft:20ft
Caliper - from ATV
4 in 7
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
17.25 'C 17.75
Cond
250 uS/cm 400
SP
20 mV 40
SPR
2500 Ohms 3500
HPF - Ambient
0 Gal./min. 1
HPF - Pumping
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
50.0
51.0
52.0
53.0
54.0
55.0
56.0
57.0
58.0
59.0
60.0
61.0
62.0
63.0

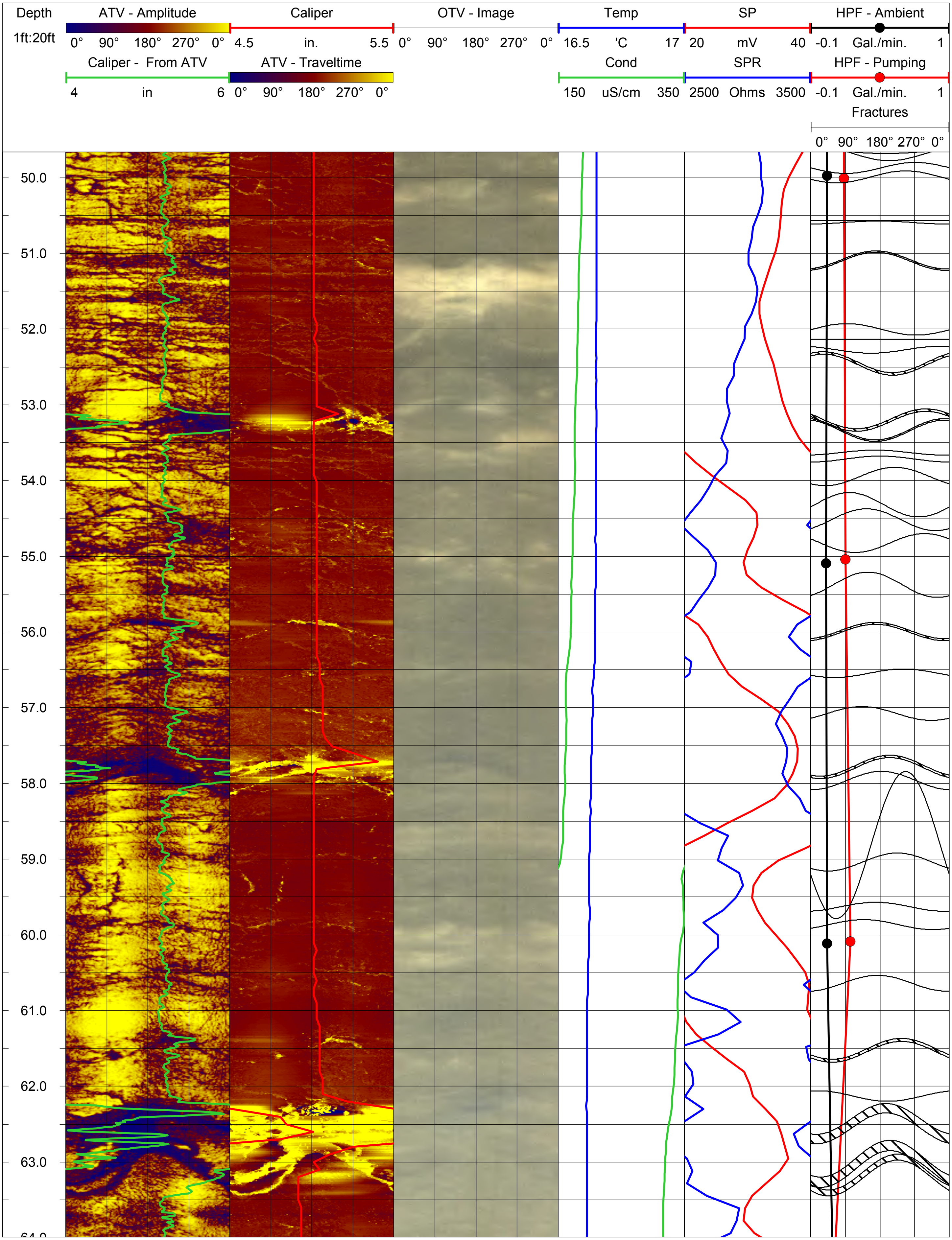


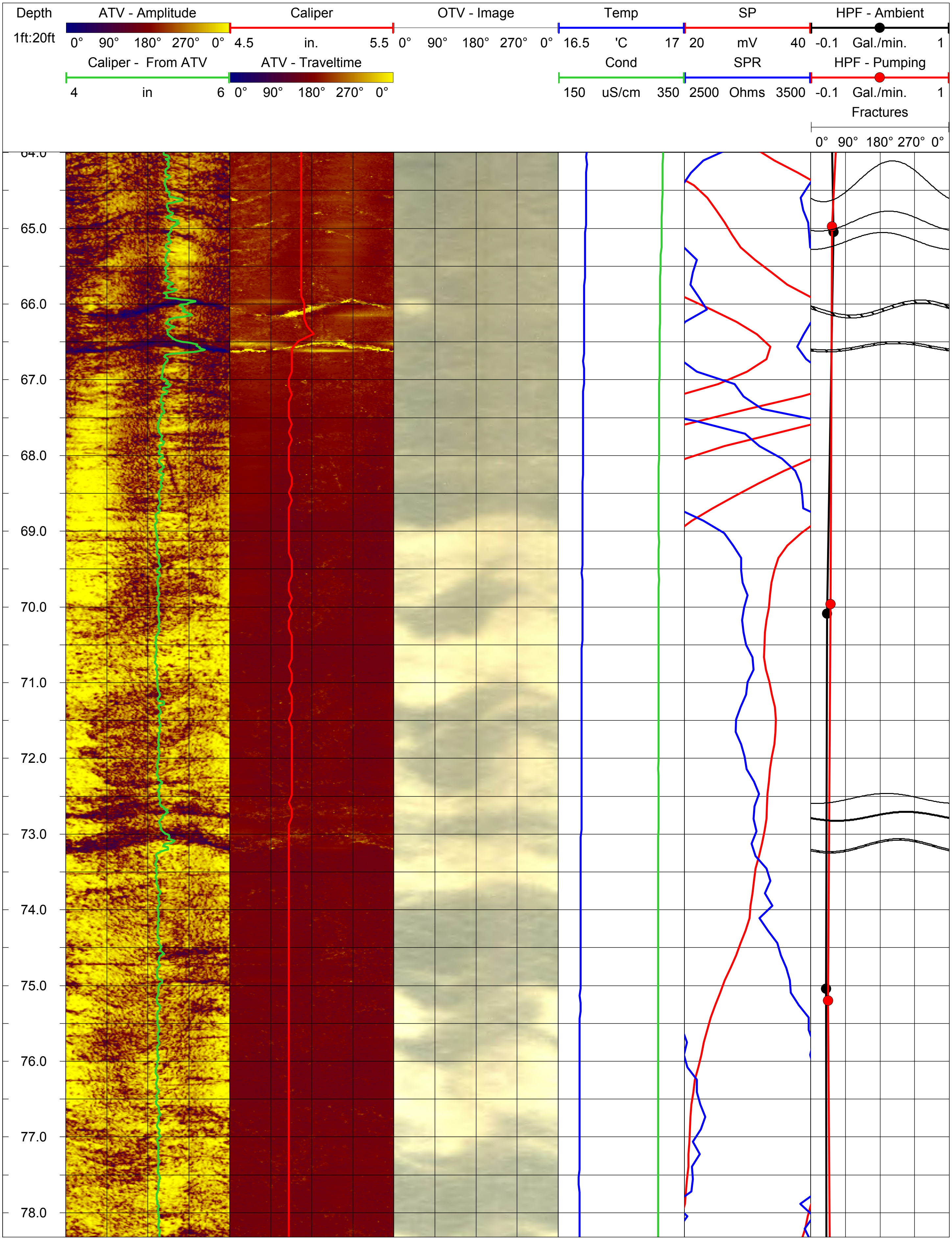
Depth
1ft:20ft
Caliper - from ATV
4 in 7
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
17.25 'C 17.75
Cond
250 uS/cm 400
SP
20 mV 40
SPR
2500 Ohms 3500
HPF - Ambient
0 Gal./min. 1
HPF - Pumping
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
64.0
65.0
66.0
67.0
68.0
69.0
70.0
71.0



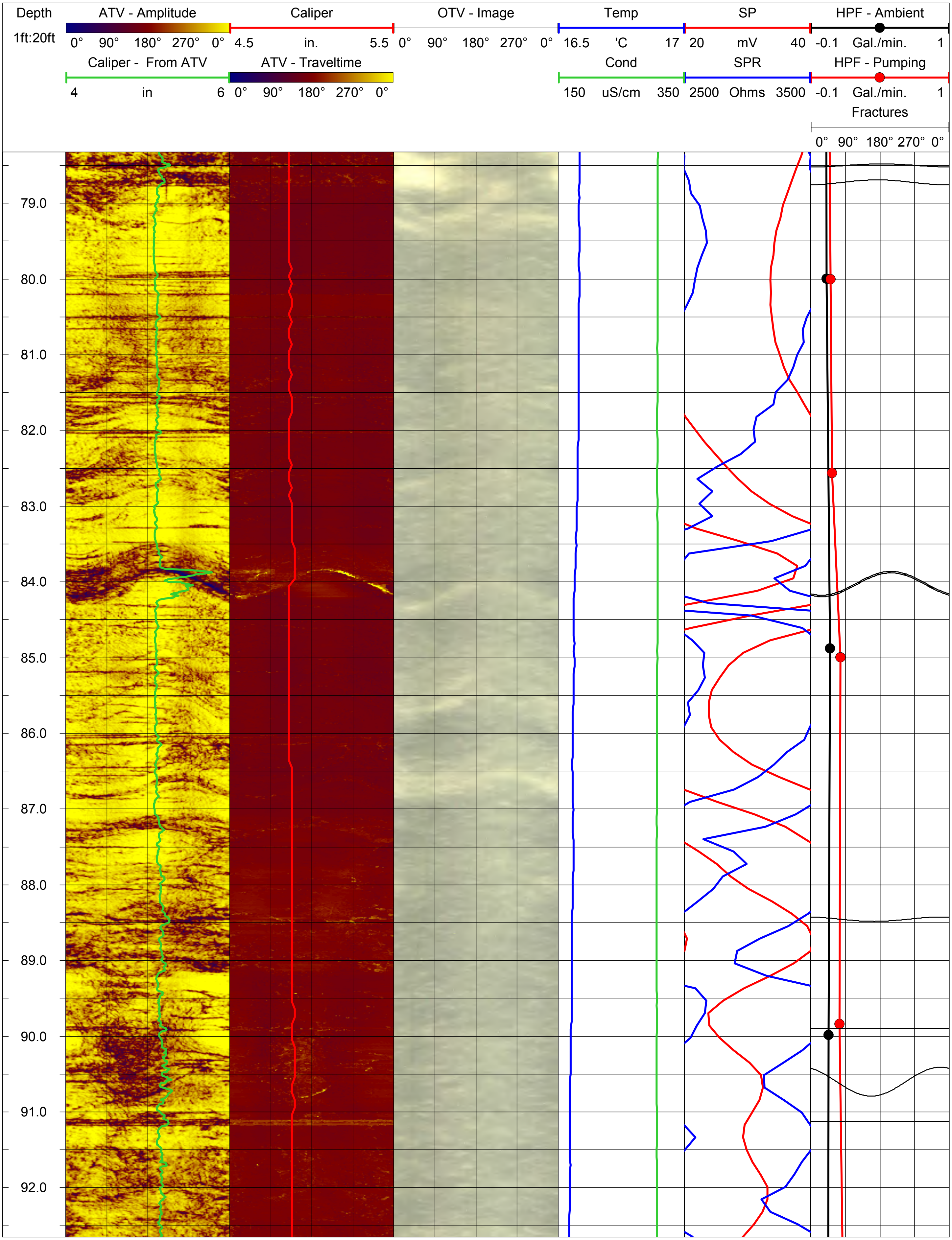
Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - From ATV
4 in 6
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
16.5 'C 17
Cond
150 uS/cm 350
SP
20 mV 40
SPR
2500 Ohms 3500
HPF - Ambient
-0.1 Gal./min. 1
HPF - Pumping
-0.1 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
32.0
33.0
34.0
35.0
Well ID:
MW - 21 BR
Bottom of Casing

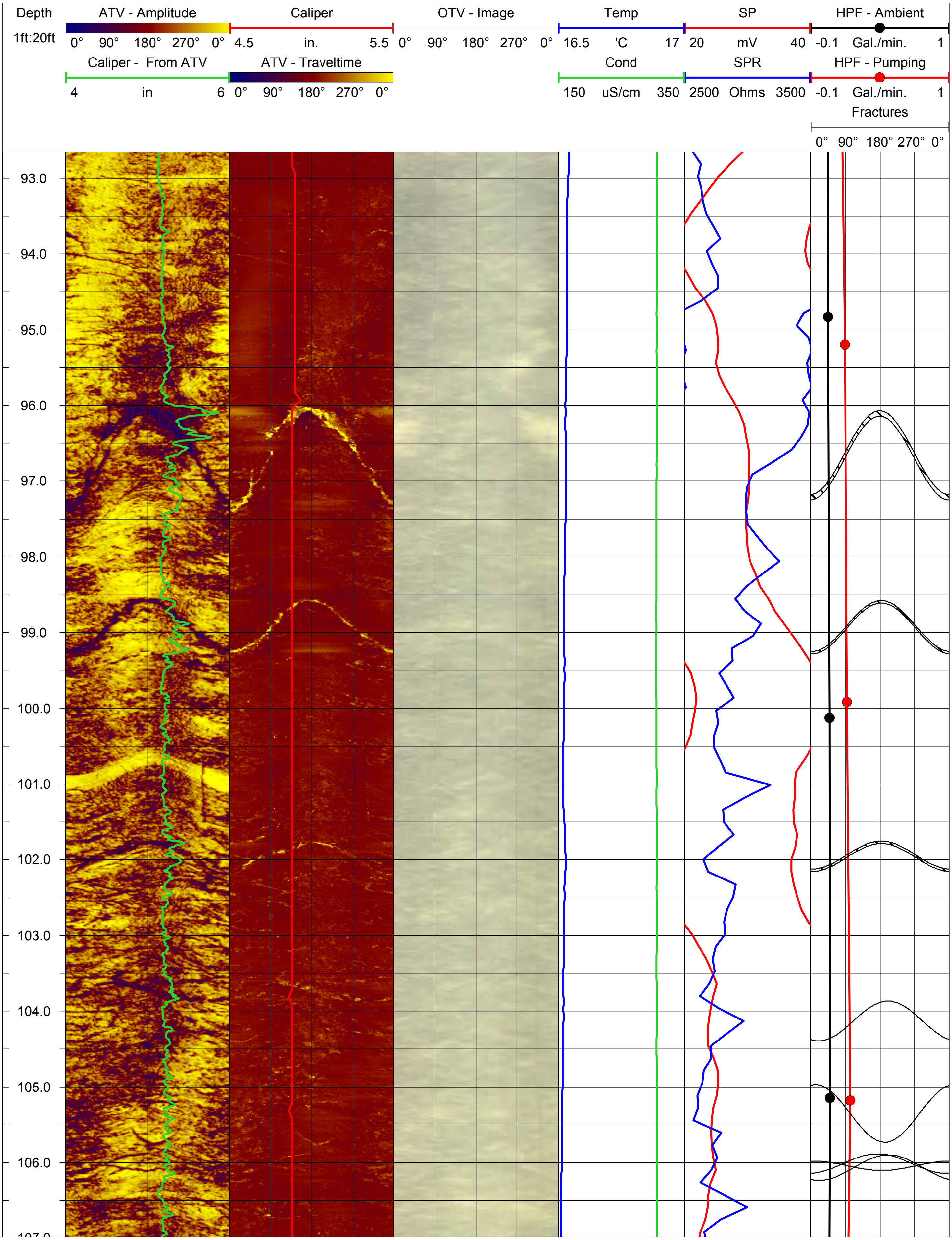

Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - From ATV
4 in 6
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
16.5 'C 17
Cond
150 uS/cm 350
SP
20 mV 40
SPR
2500 Ohms 3500
HPF - Ambient
-0.1 Gal./min. 1
HPF - Pumping
-0.1 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
36.0
37.0
38.0
39.0
40.0
41.0
42.0
43.0
44.0
45.0
46.0
47.0
48.0
49.0

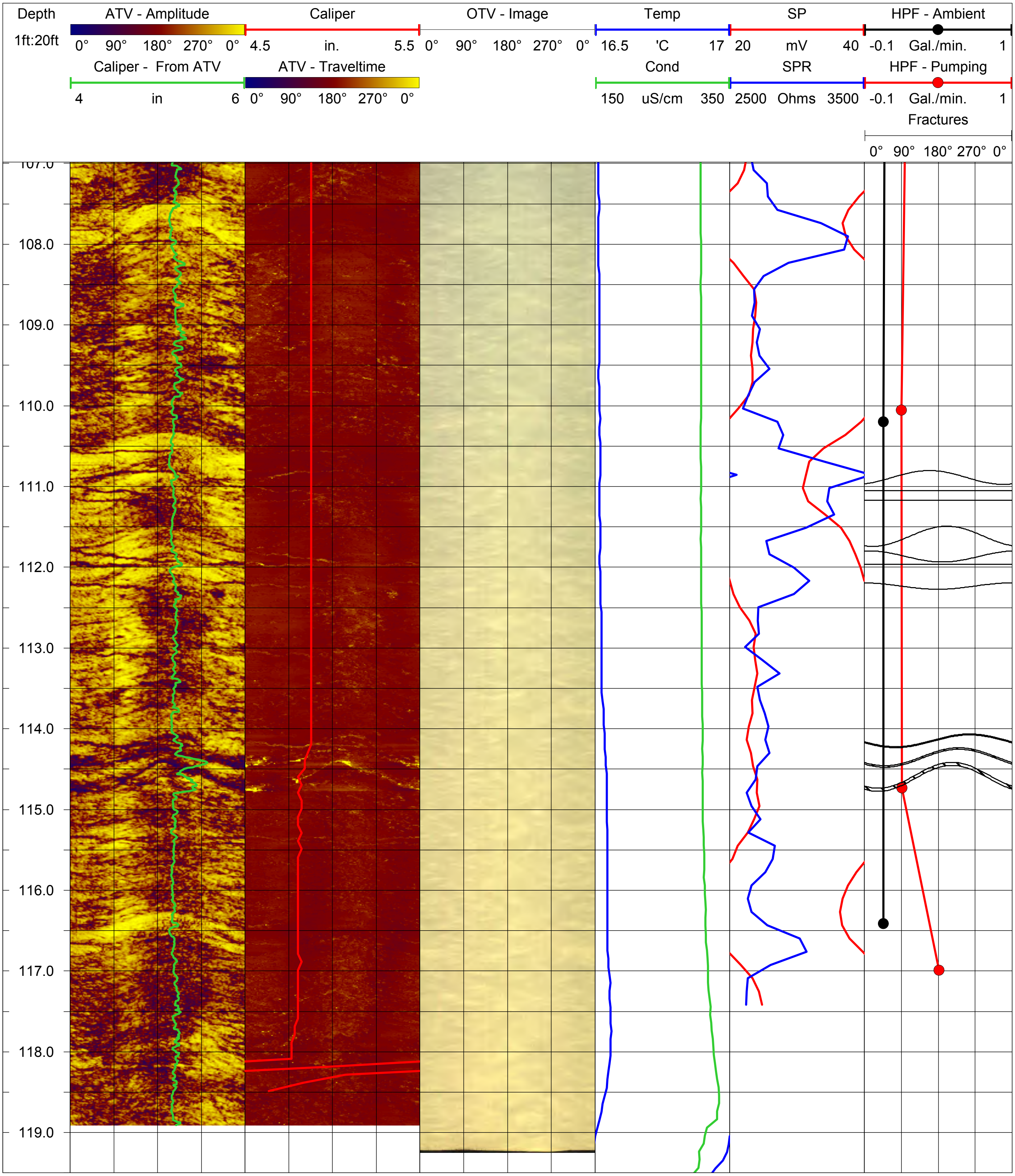

Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - From ATV
4 in 6
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
16.5 'C 17
Cond
150 uS/cm 350
SP
20 mV 40
SPR
2500 Ohms 3500
HPF - Ambient
-0.1 Gal./min. 1
HPF - Pumping
-0.1 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
50.0
51.0
52.0
53.0
54.0
55.0
56.0
57.0
58.0
59.0
60.0
61.0
62.0
63.0

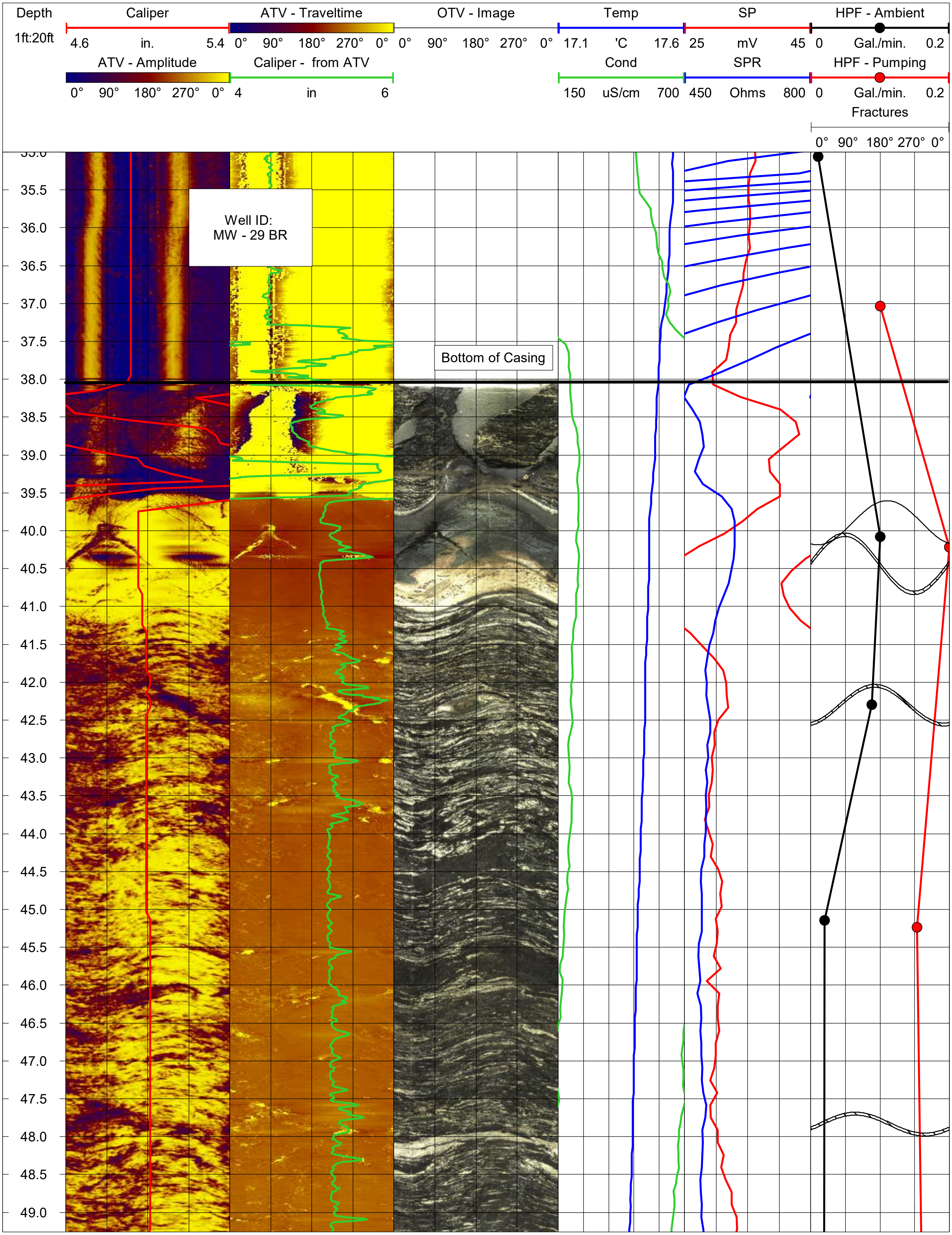


Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - From ATV
4 in 6
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
16.5 'C 17
Cond
150 uS/cm 350
SP
20 mV 40
SPR
2500 Ohms 3500
HPF - Ambient
-0.1 Gal./min. 1
HPF - Pumping
-0.1 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
65.0
66.0
67.0
68.0
69.0
70.0
71.0
72.0
73.0
74.0
75.0
76.0
77.0
78.0

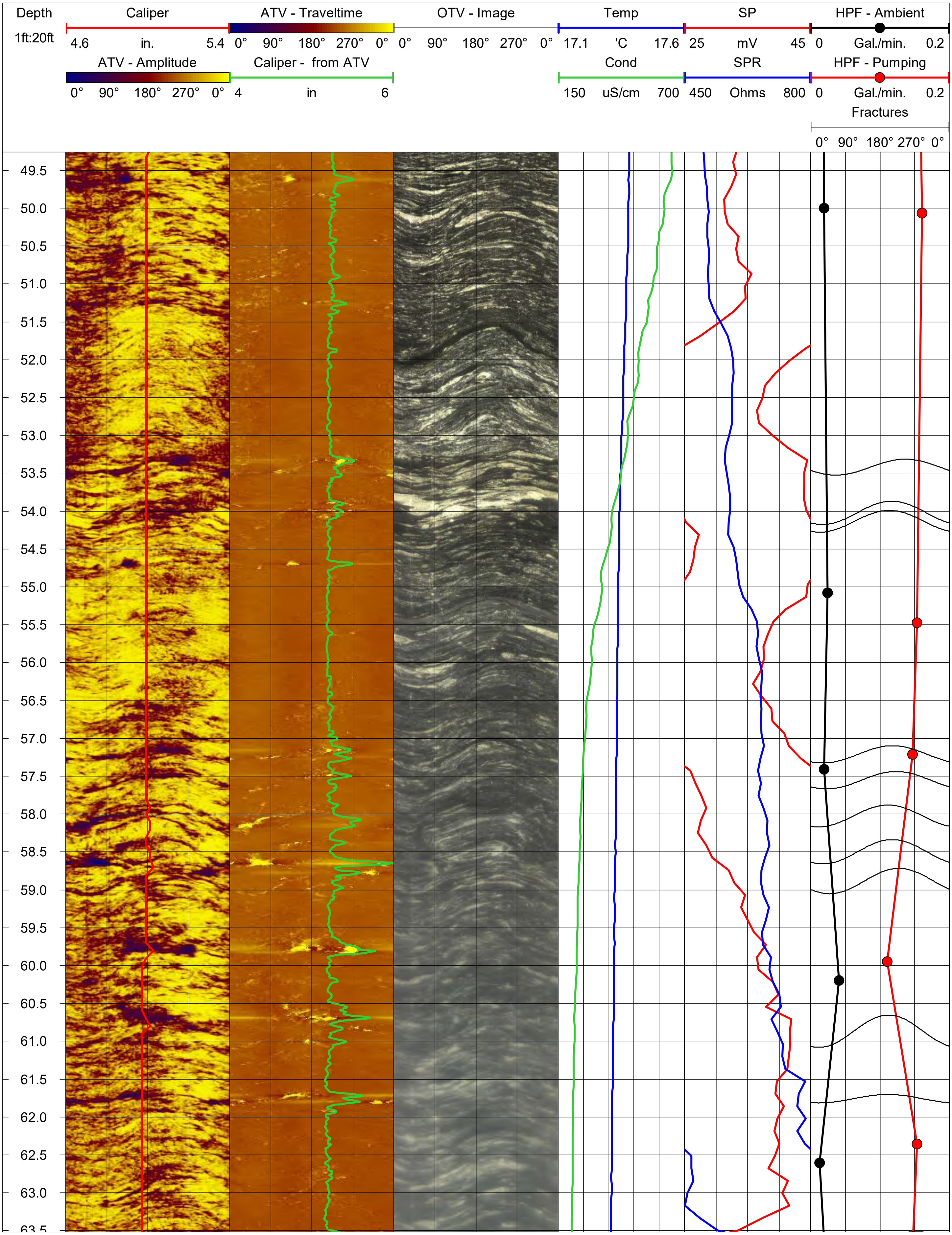

Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - From ATV
4 in 6
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
16.5 'C 17
Cond
150 uS/cm 350
SP
20 mV 40
SPR
2500 Ohms 3500
HPF - Ambient
-0.1 Gal./min. 1
HPF - Pumping
-0.1 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
79.0
80.0
81.0
82.0
83.0
84.0
85.0
86.0
87.0
88.0
89.0
90.0
91.0
92.0

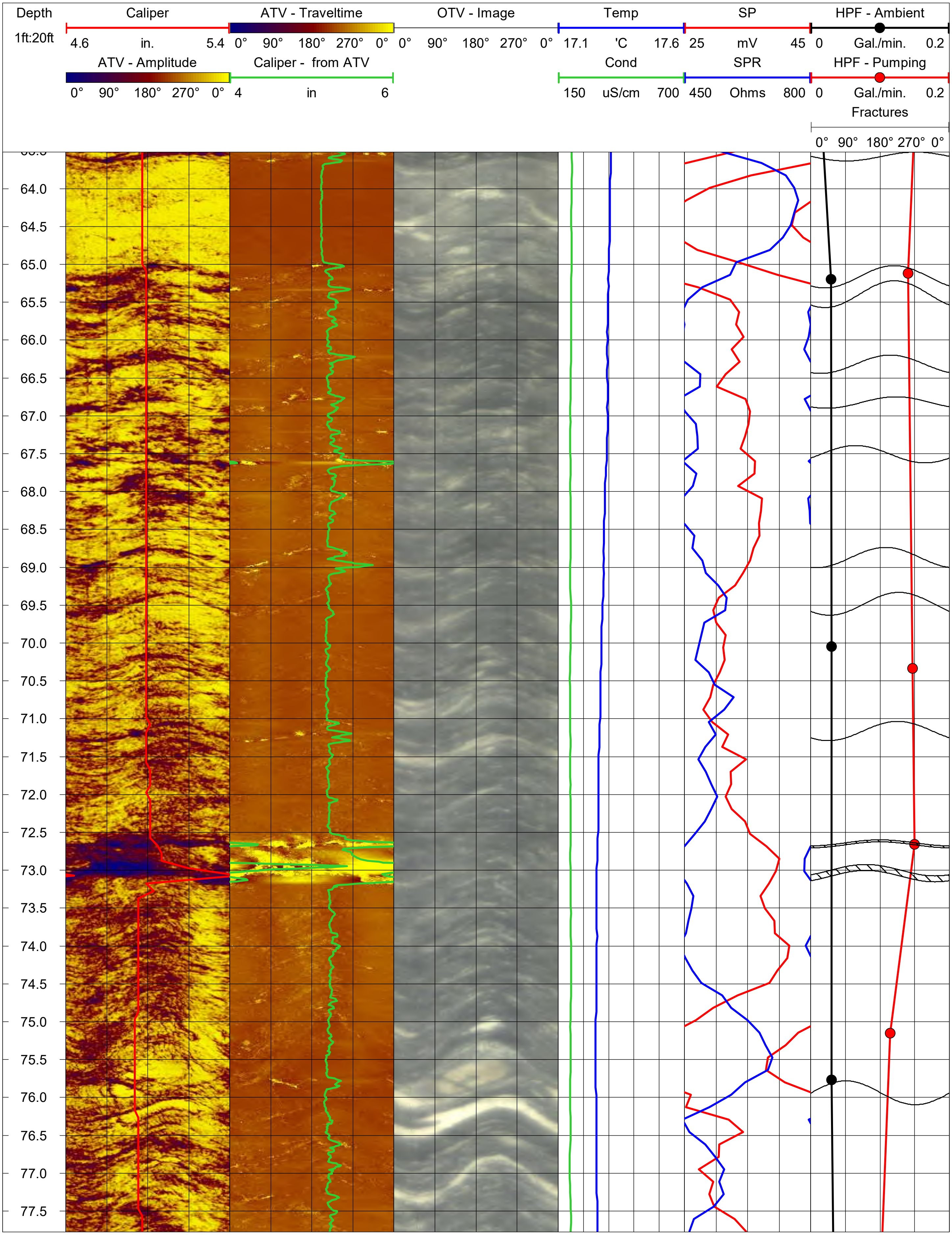

Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - From ATV
4 in 6
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
16.5 'C 17
Cond
150 uS/cm 350
SP
20 mV 40
SPR
2500 Ohms 3500
HPF - Ambient
-0.1 Gal./min. 1
HPF - Pumping
-0.1 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
93.0
94.0
95.0
96.0
97.0
98.0
99.0
100.0
101.0
102.0
103.0
104.0
105.0
106.0


Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - From ATV
4 in 6
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
16.5 'C 17
Cond
150 uS/cm 350
SP
20 mV 40
SPR
2500 Ohms 3500
HPF - Ambient
-0.1 Gal./min. 1
HPF - Pumping
-0.1 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
108.0
109.0
110.0
111.0
112.0
113.0
114.0
115.0
116.0
117.0
118.0
119.0

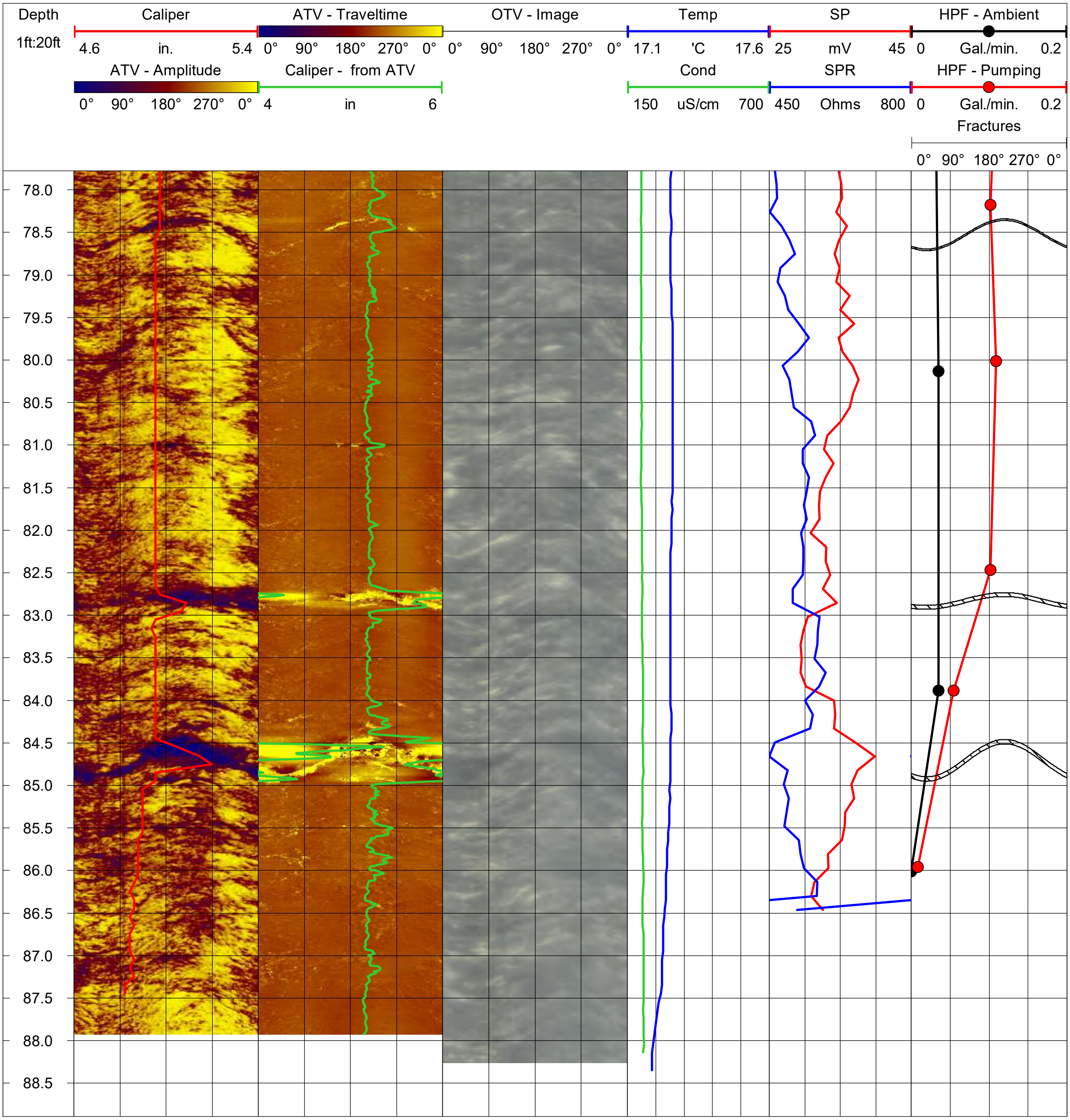


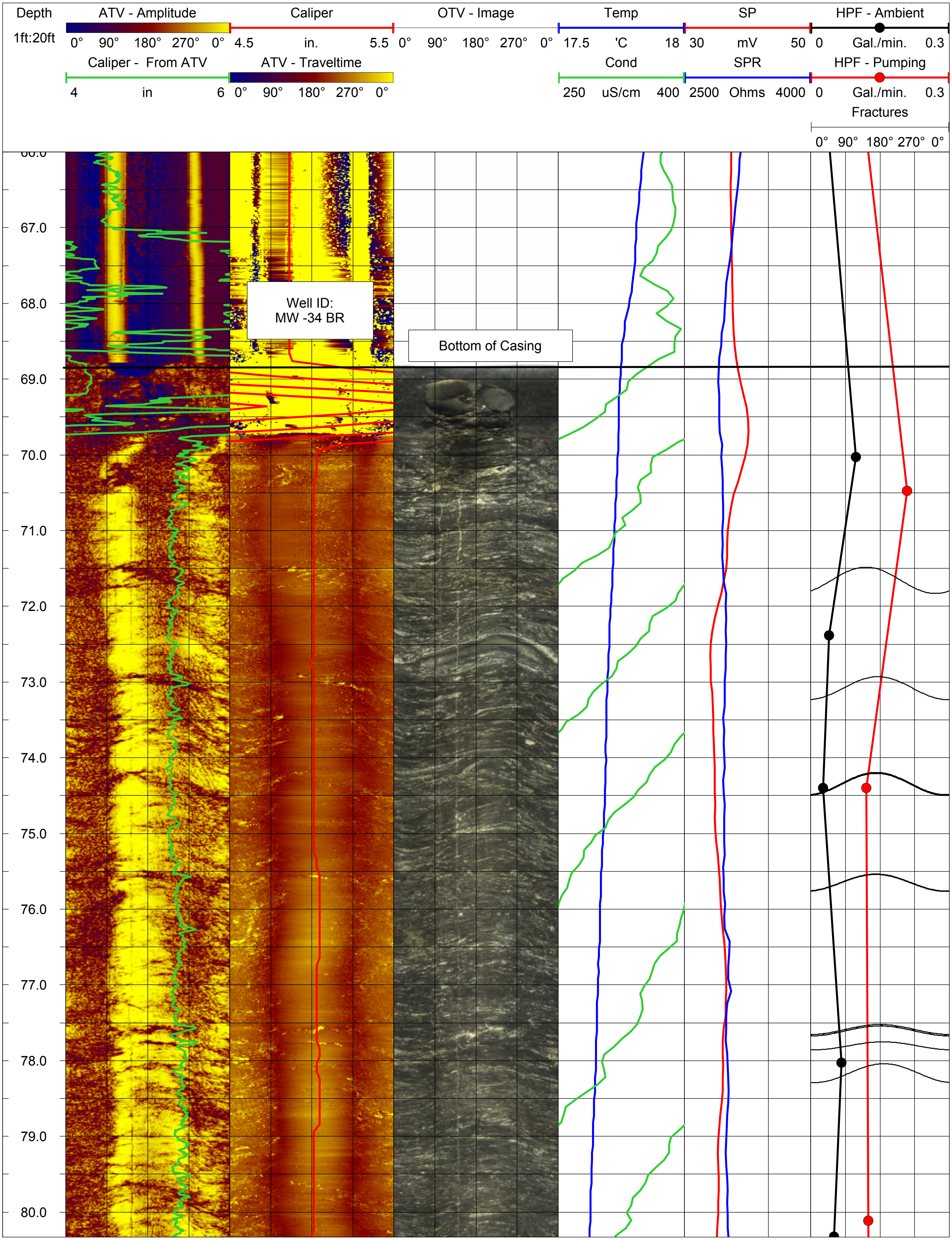
Depth
1ft:20ft
Caliper
4.6 in. 5.4
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper - from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
17.1 'C 17.6
Cond
150 uS/cm 700
SP
25 mV 45
SPR
450 Ohms 800
HPF - Ambient
0 Gal./min. 0.2
HPF - Pumping
0 Gal./min. 0.2
Fractures
0° 90° 180° 270° 0°
Well ID:
MW - 29 BR
Bottom of Casing
35.5
36.0
36.5
37.0
37.5
38.0
38.5
39.0
39.5
40.0
40.5
41.0
41.5
42.0
42.5
43.0
43.5
44.0
44.5
45.0
45.5
46.0
46.5
47.0
47.5
48.0
48.5
49.0

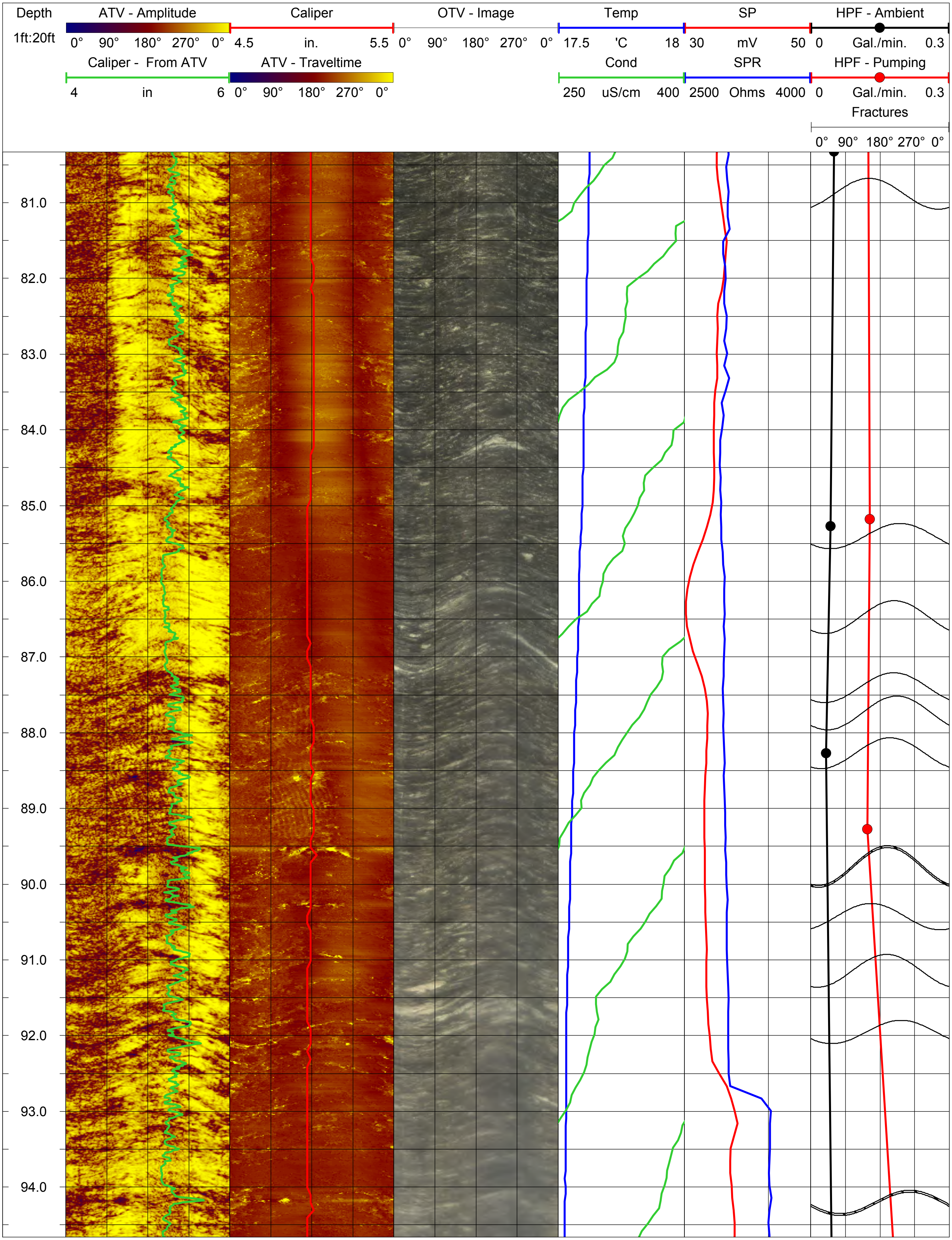

Depth
1ft:20ft
Caliper
4.6 in. 5.4
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper - from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
17.1 'C 17.6
Cond
150 uS/cm 700
SP
25 mV 45
SPR
450 Ohms 800
HPF - Ambient
0 Gal./min. 0.2
HPF - Pumping
0 Gal./min. 0.2
Fractures
0° 90° 180° 270° 0°
49.5
50.0
50.5
51.0
51.5
52.0
52.5
53.0
53.5
54.0
54.5
55.0
55.5
56.0
56.5
57.0
57.5
58.0
58.5
59.0
59.5
60.0
60.5
61.0
61.5
62.0
62.5
63.0
63.5

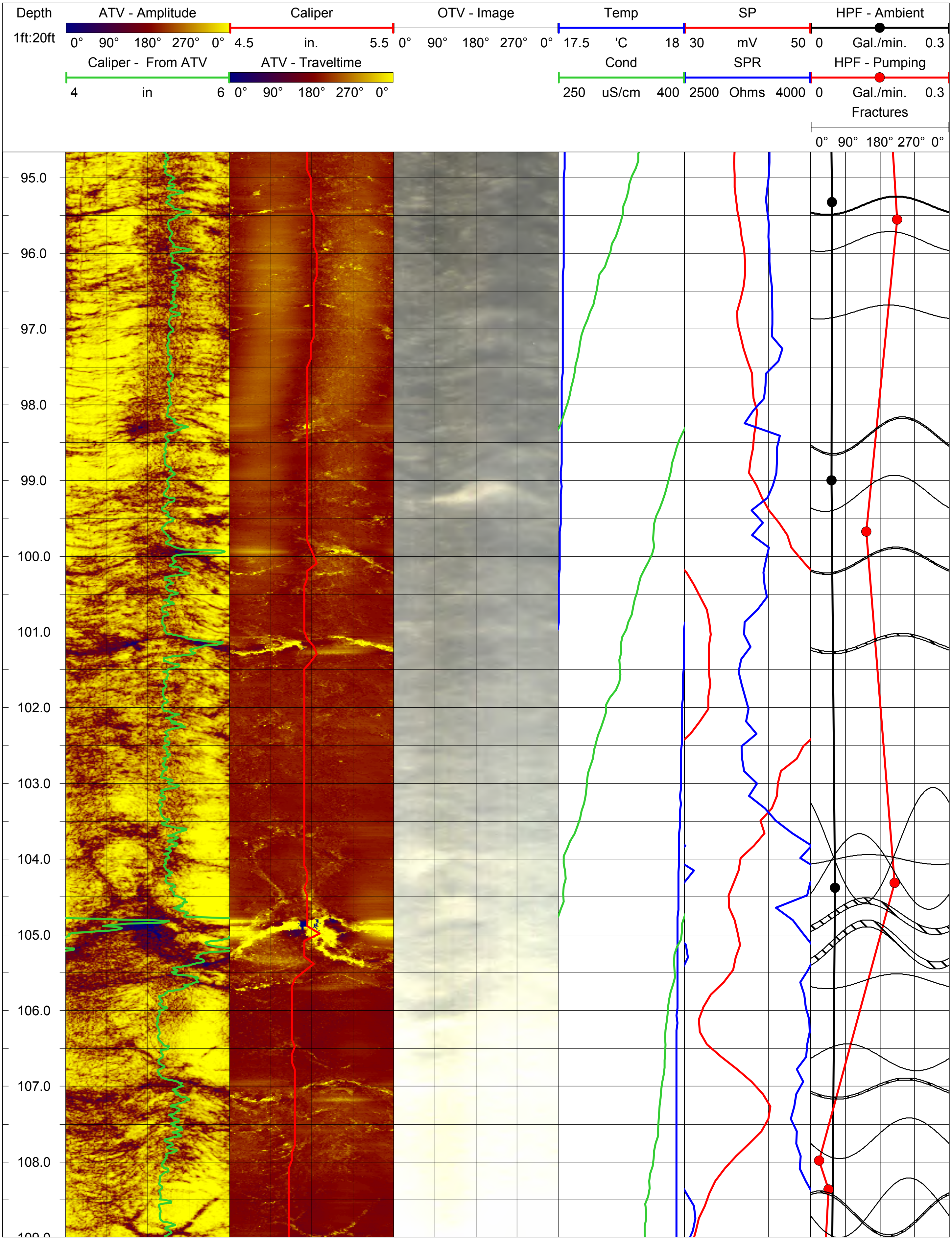


Depth
1ft:20ft
Caliper
4.6 in. 5.4
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper - from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
17.1 'C 17.6
Cond
150 uS/cm 700
SP
25 mV 45
SPR
450 Ohms 800
HPF - Ambient
0 Gal./min. 0.2
HPF - Pumping
0 Gal./min. 0.2
Fractures
0° 90° 180° 270° 0°
64.0
64.5
65.0
65.5
66.0
66.5
67.0
67.5
68.0
68.5
69.0
69.5
70.0
70.5
71.0
71.5
72.0
72.5
73.0
73.5
74.0
74.5
75.0
75.5
76.0
76.5
77.0
77.5

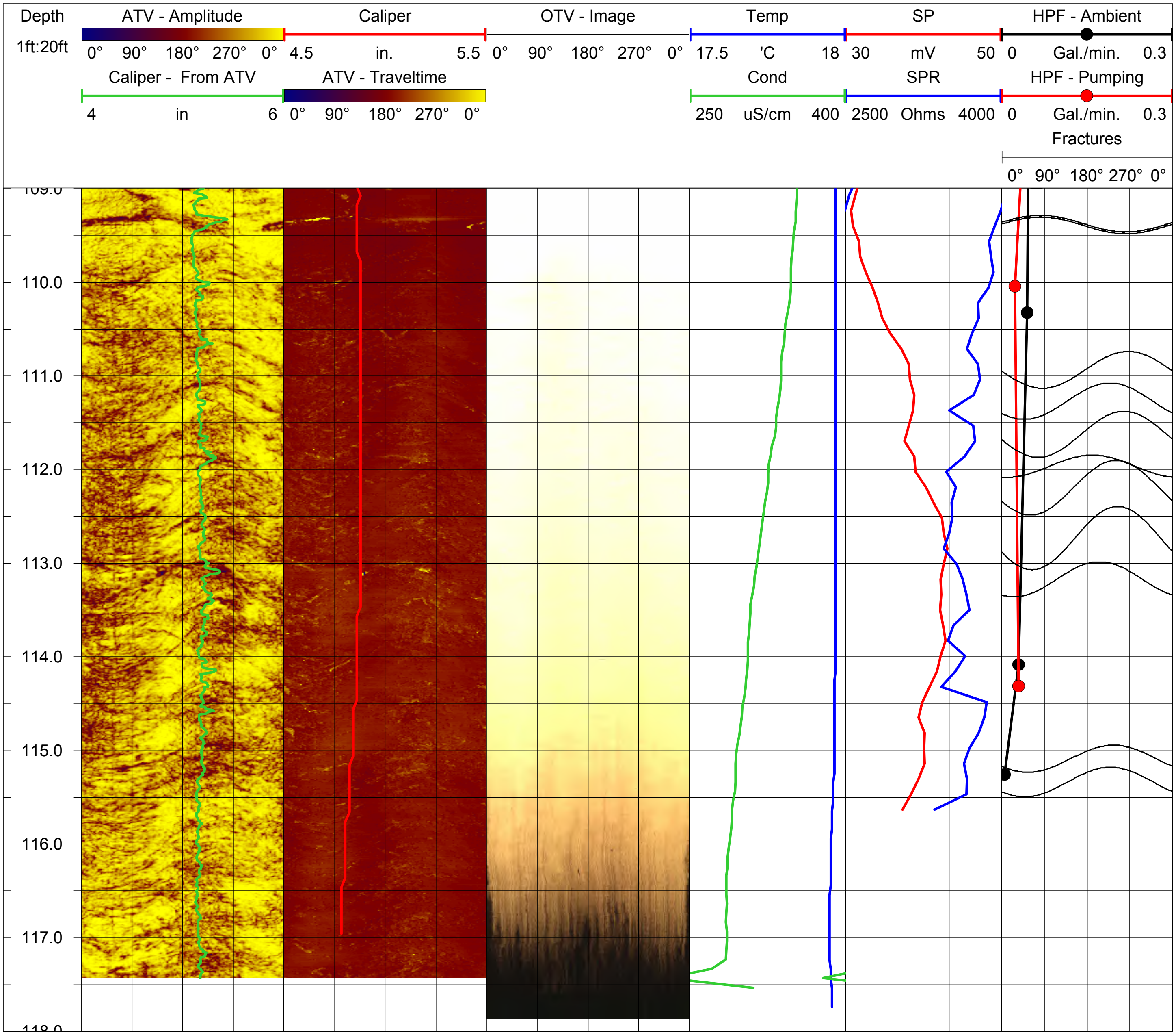

Depth
1ft:20ft
Caliper
4.6 in. 5.4
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper - from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
17.1 'C 17.6
Cond
150 uS/cm 700
SP
25 mV 45
SPR
450 Ohms 800
HPF - Ambient
0 Gal./min. 0.2
HPF - Pumping
0 Gal./min. 0.2
Fractures
0° 90° 180° 270° 0°
78.0
78.5
79.0
79.5
80.0
80.5
81.0
81.5
82.0
82.5
83.0
83.5
84.0
84.5
85.0
85.5
86.0
86.5
87.0
87.5
88.0
88.5

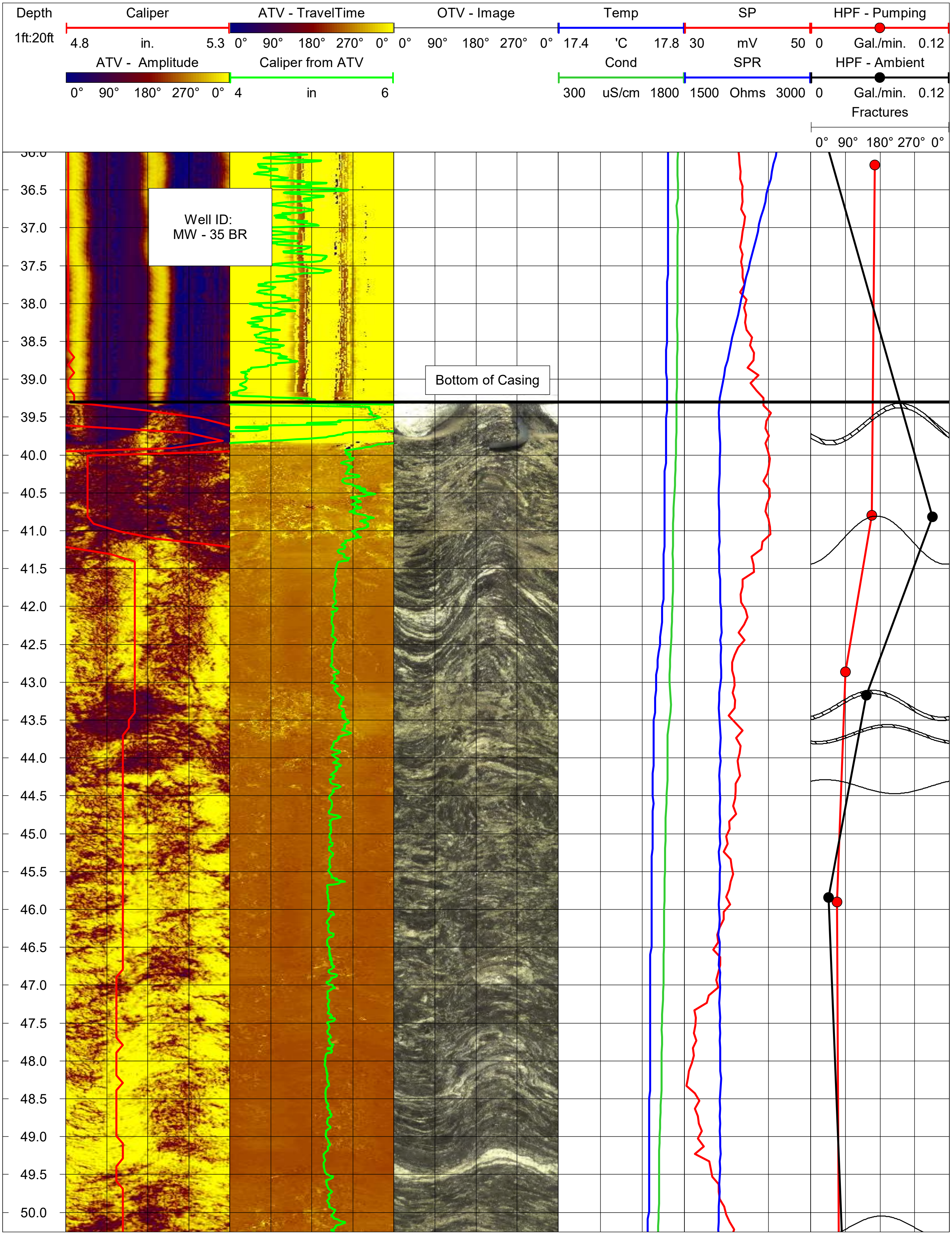

Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - From ATV
4 in 6
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
17.5 'C 18
Cond
250 uS/cm 400
SP
30 mV 50
SPR
2500 Ohms 4000
HPF - Ambient
0 Gal./min. 0.3
HPF - Pumping
0 Gal./min. 0.3
Fractures
0° 90° 180° 270° 0°
Well ID:
MW -34 BR
Bottom of Casing
67.0
68.0
69.0
70.0
71.0
72.0
73.0
74.0
75.0
76.0
77.0
78.0
79.0
80.0

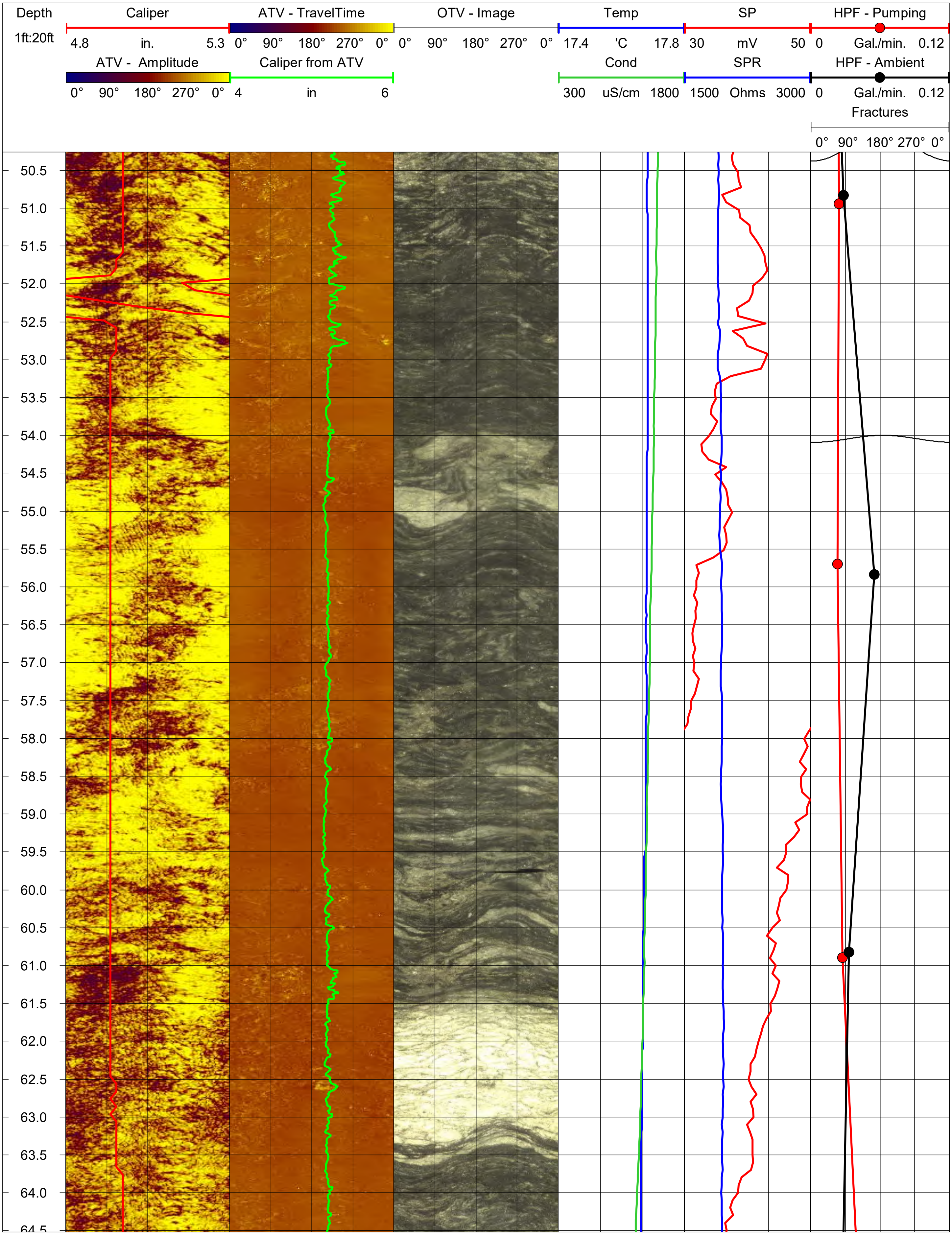

Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - From ATV
4 in 6
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
17.5 'C 18
Cond
250 uS/cm 400
SP
30 mV 50
SPR
2500 Ohms 4000
HPF - Ambient
0 Gal./min. 0.3
HPF - Pumping
0 Gal./min. 0.3
Fractures
0° 90° 180° 270° 0°
81.0
82.0
83.0
84.0
85.0
86.0
87.0
88.0
89.0
90.0
91.0
92.0
93.0
94.0

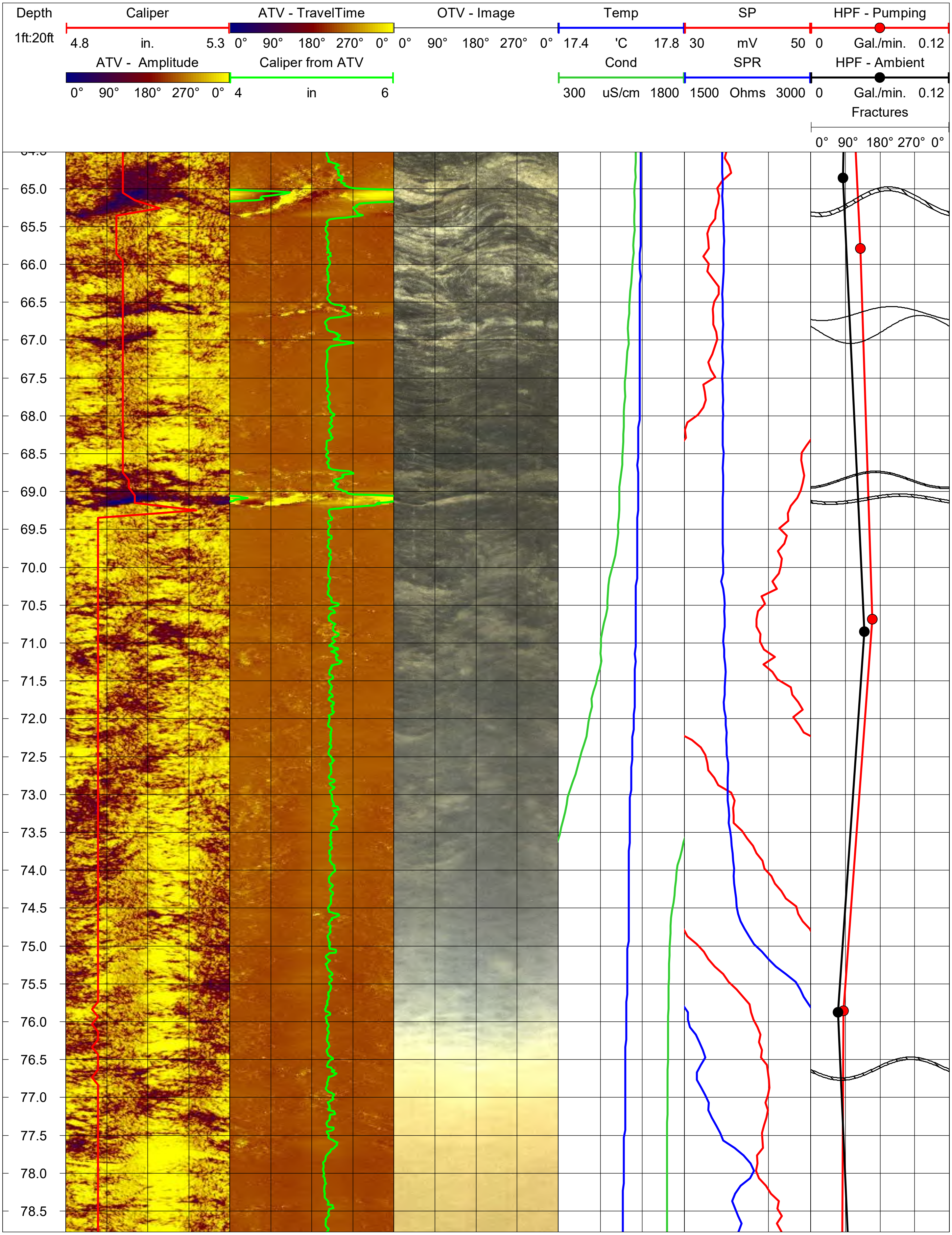


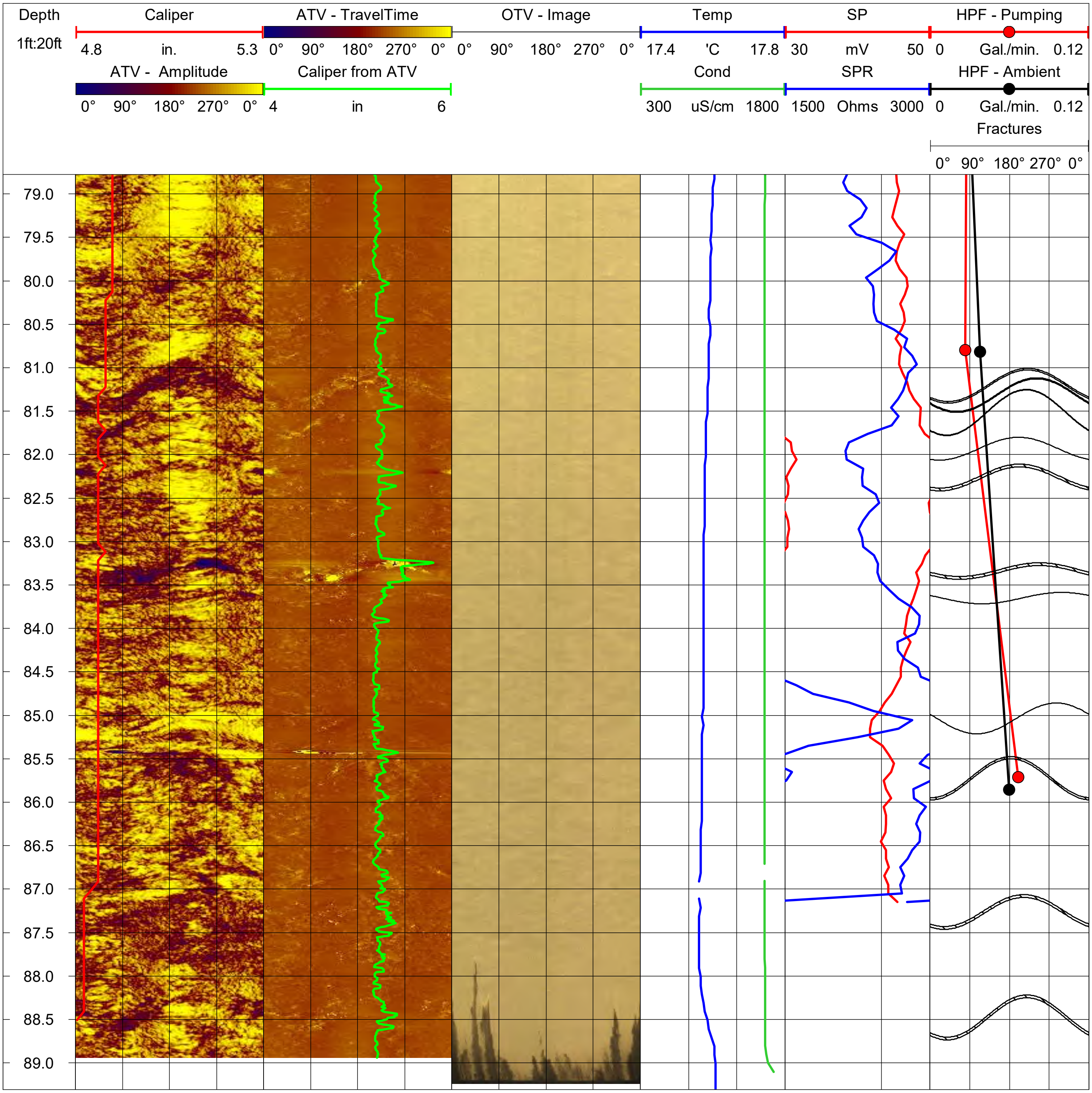
Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - From ATV
4 in 6
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
17.5 'C 18
Cond
250 uS/cm 400
SP
30 mV 50
SPR
2500 Ohms 4000
HPF - Ambient
0 Gal./min. 0.3
HPF - Pumping
0 Gal./min. 0.3
Fractures
0° 90° 180° 270° 0°
95.0
96.0
97.0
98.0
99.0
100.0
101.0
102.0
103.0
104.0
105.0
106.0
107.0
108.0

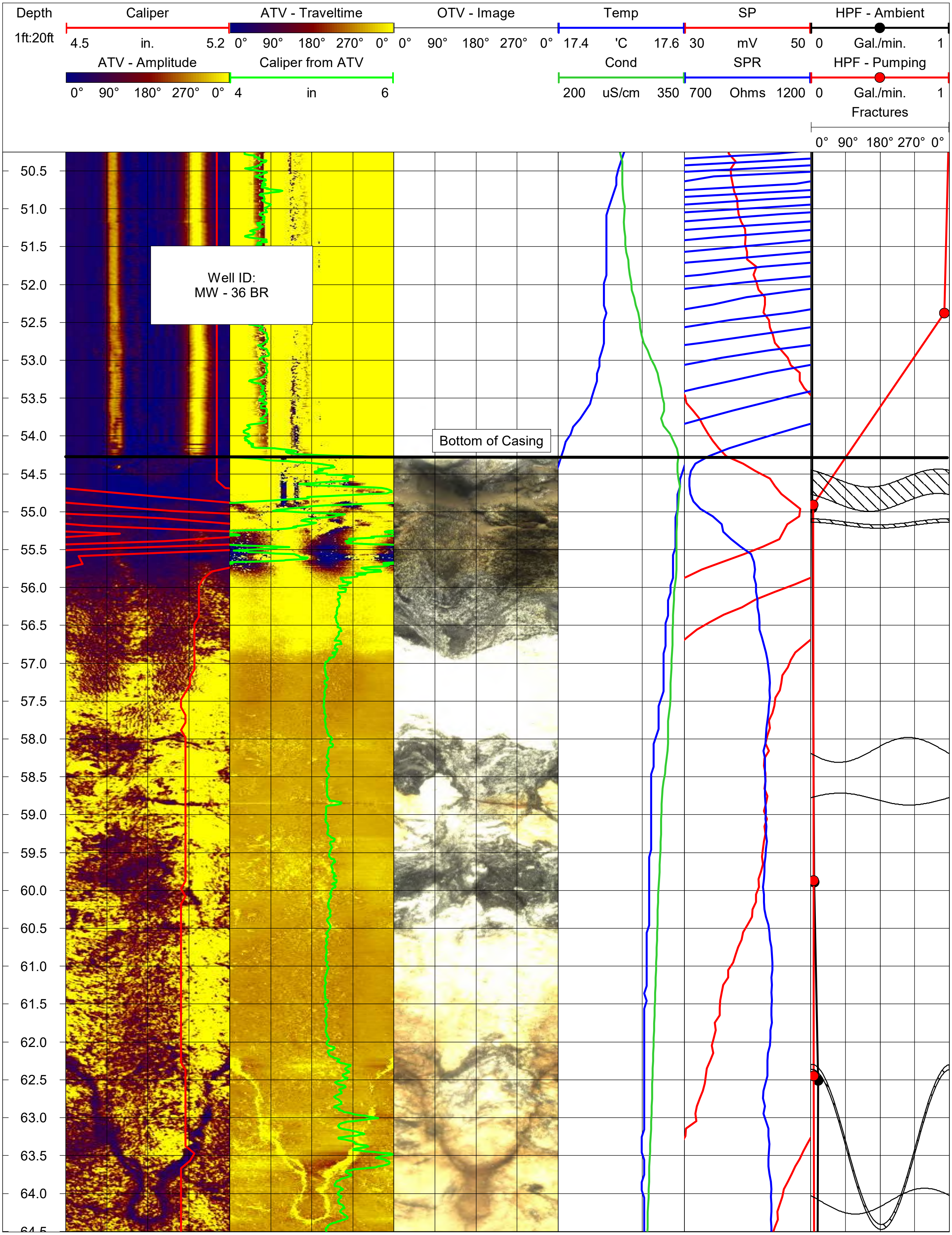

Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - From ATV
4 in 6
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
17.5 'C 18
Cond
250 uS/cm 400
SP
30 mV 50
SPR
2500 Ohms 4000
HPF - Ambient
0 Gal./min. 0.3
HPF - Pumping
0 Gal./min. 0.3
Fractures
0° 90° 180° 270° 0°
110.0
111.0
112.0
113.0
114.0
115.0
116.0
117.0

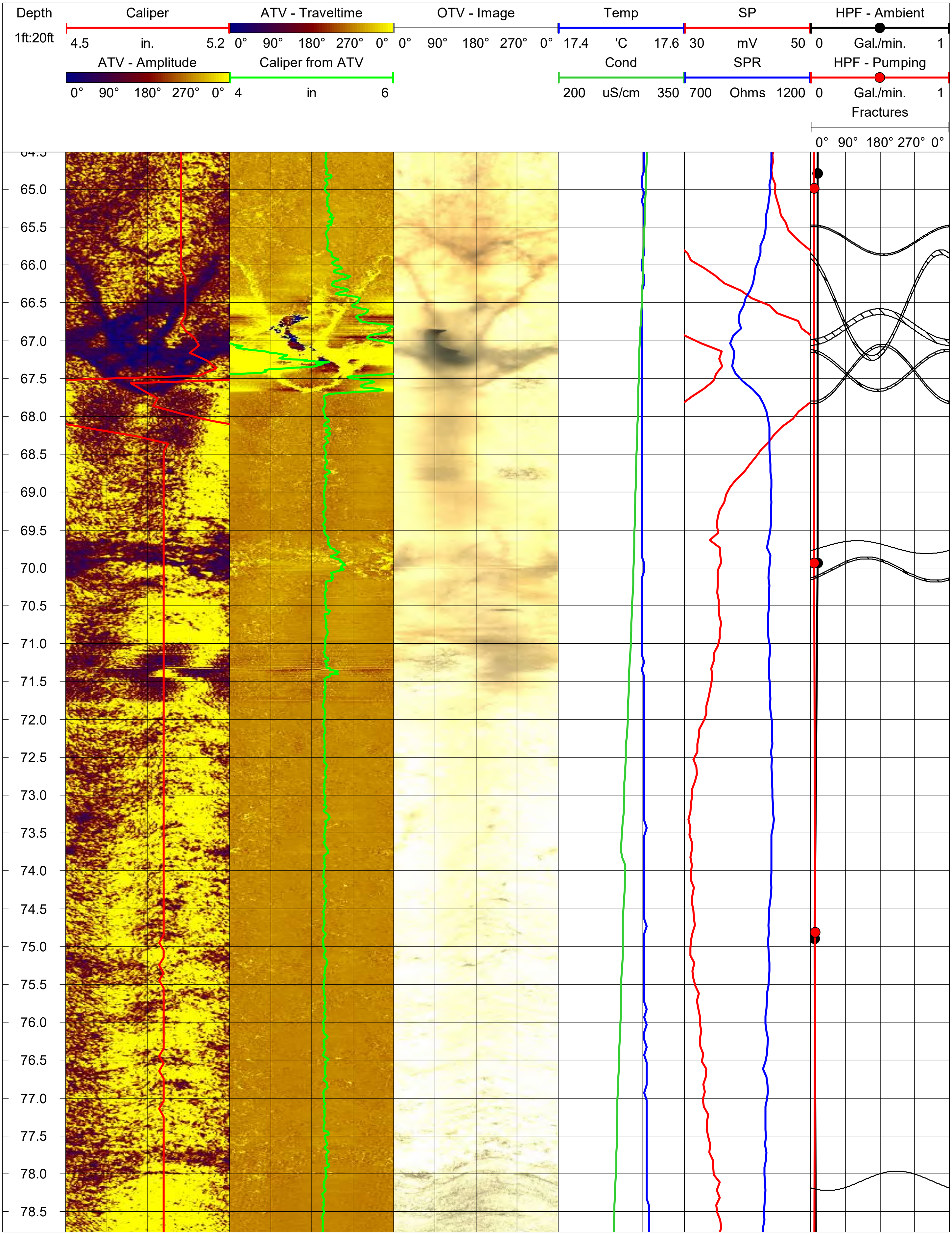

Depth
1ft:20ft
Caliper
4.8 in. 5.3
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - TravelTime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
17.4 'C 17.8
Cond
300 uS/cm 1800
SP
30 mV 50
SPR
1500 Ohms 3000
HPF - Pumping
0 Gal./min. 0.12
HPF - Ambient
0 Gal./min. 0.12
Fractures
0° 90° 180° 270° 0°
36.5
37.0
37.5
38.0
38.5
39.0
39.5
40.0
40.5
41.0
41.5
42.0
42.5
43.0
43.5
44.0
44.5
45.0
45.5
46.0
46.5
47.0
47.5
48.0
48.5
49.0
49.5
50.0
Well ID:
MW - 35 BR
Bottom of Casing

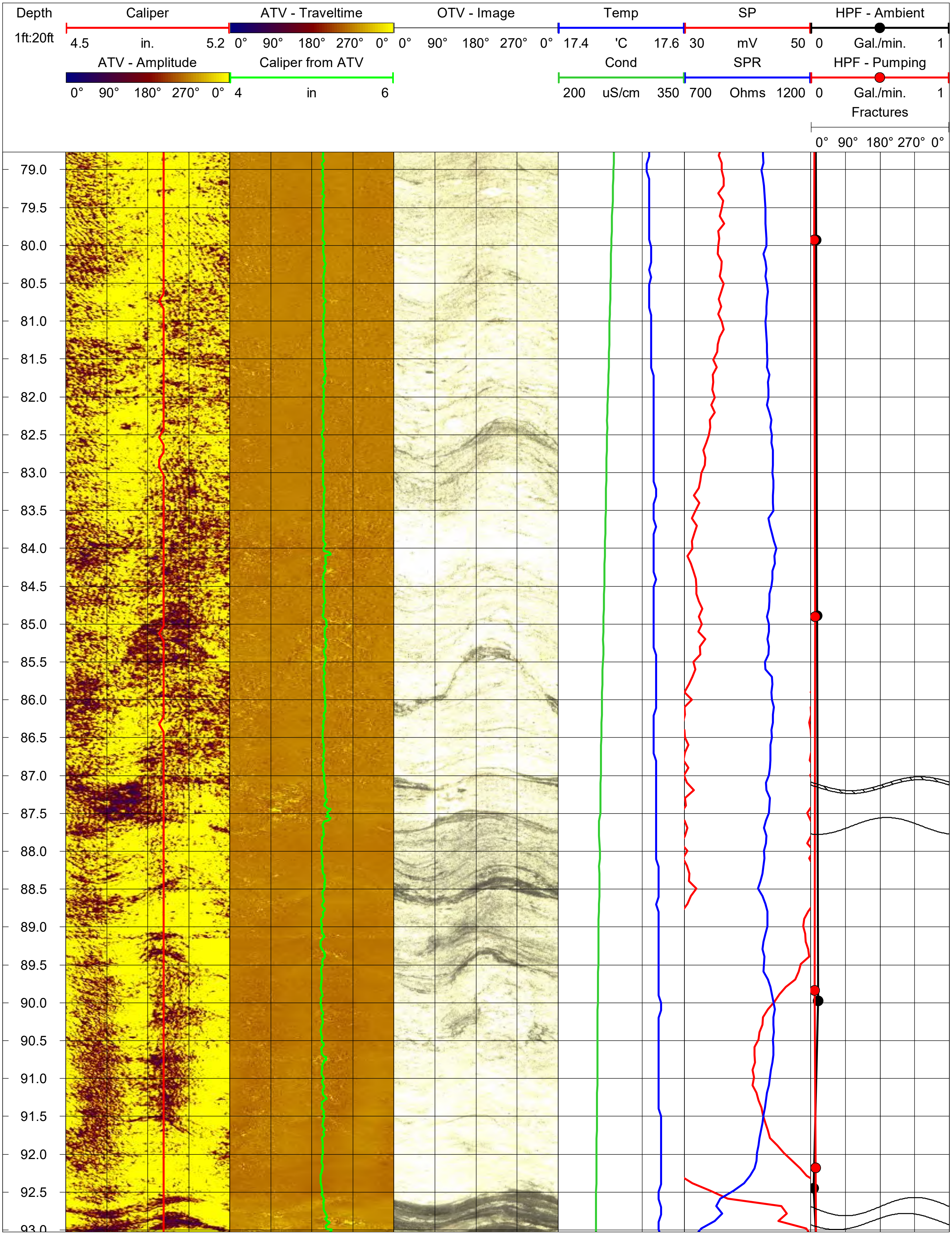

Depth
1ft:20ft
Caliper
4.8 in. 5.3
ATV - TravelTime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
17.4 'C 17.8
SP
30 mV 50
HPF - Pumping
0 Gal./min. 0.12
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
Cond
300 uS/cm 1800
SPR
1500 Ohms 3000
HPF - Ambient
0 Gal./min. 0.12
Fractures
0° 90° 180° 270° 0°
50.5
51.0
51.5
52.0
52.5
53.0
53.5
54.0
54.5
55.0
55.5
56.0
56.5
57.0
57.5
58.0
58.5
59.0
59.5
60.0
60.5
61.0
61.5
62.0
62.5
63.0
63.5
64.0


Depth
1ft:20ft
Caliper
4.8 in. 5.3
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - TravelTime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
17.4 'C 17.8
Cond
300 uS/cm 1800
SP
30 mV 50
SPR
1500 Ohms 3000
HPF - Pumping
0 Gal./min. 0.12
HPF - Ambient
0 Gal./min. 0.12
Fractures
0° 90° 180° 270° 0°
65.0
65.5
66.0
66.5
67.0
67.5
68.0
68.5
69.0
69.5
70.0
70.5
71.0
71.5
72.0
72.5
73.0
73.5
74.0
74.5
75.0
75.5
76.0
76.5
77.0
77.5
78.0
78.5

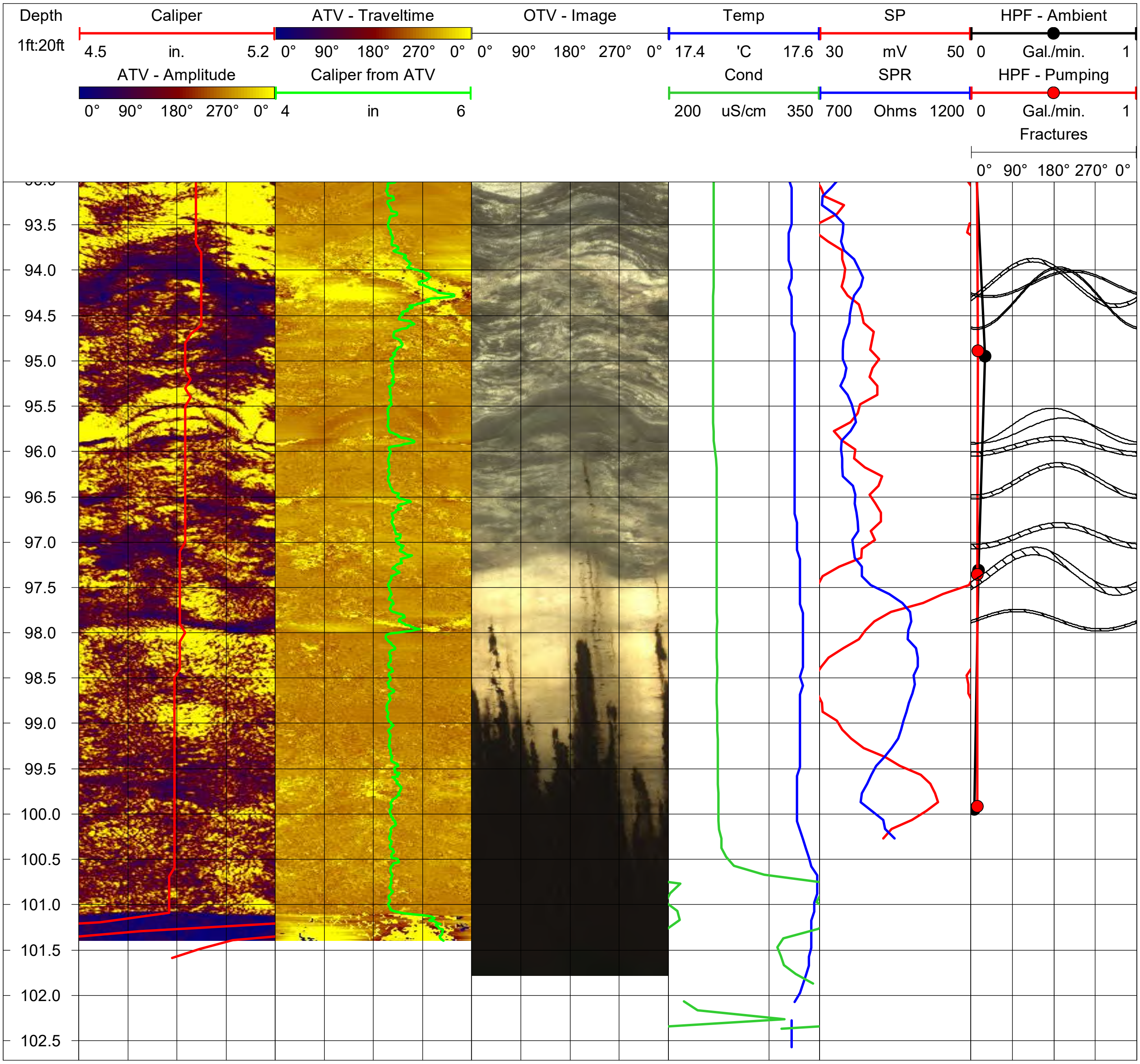

Depth
1ft:20ft
Caliper
4.8 in. 5.3
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - TravelTime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
17.4 'C 17.8
Cond
300 uS/cm 1800
SP
30 mV 50
SPR
1500 Ohms 3000
HPF - Pumping
0 Gal./min. 0.12
HPF - Ambient
0 Gal./min. 0.12
Fractures
0° 90° 180° 270° 0°
79.0
79.5
80.0
80.5
81.0
81.5
82.0
82.5
83.0
83.5
84.0
84.5
85.0
85.5
86.0
86.5
87.0
87.5
88.0
88.5
89.0

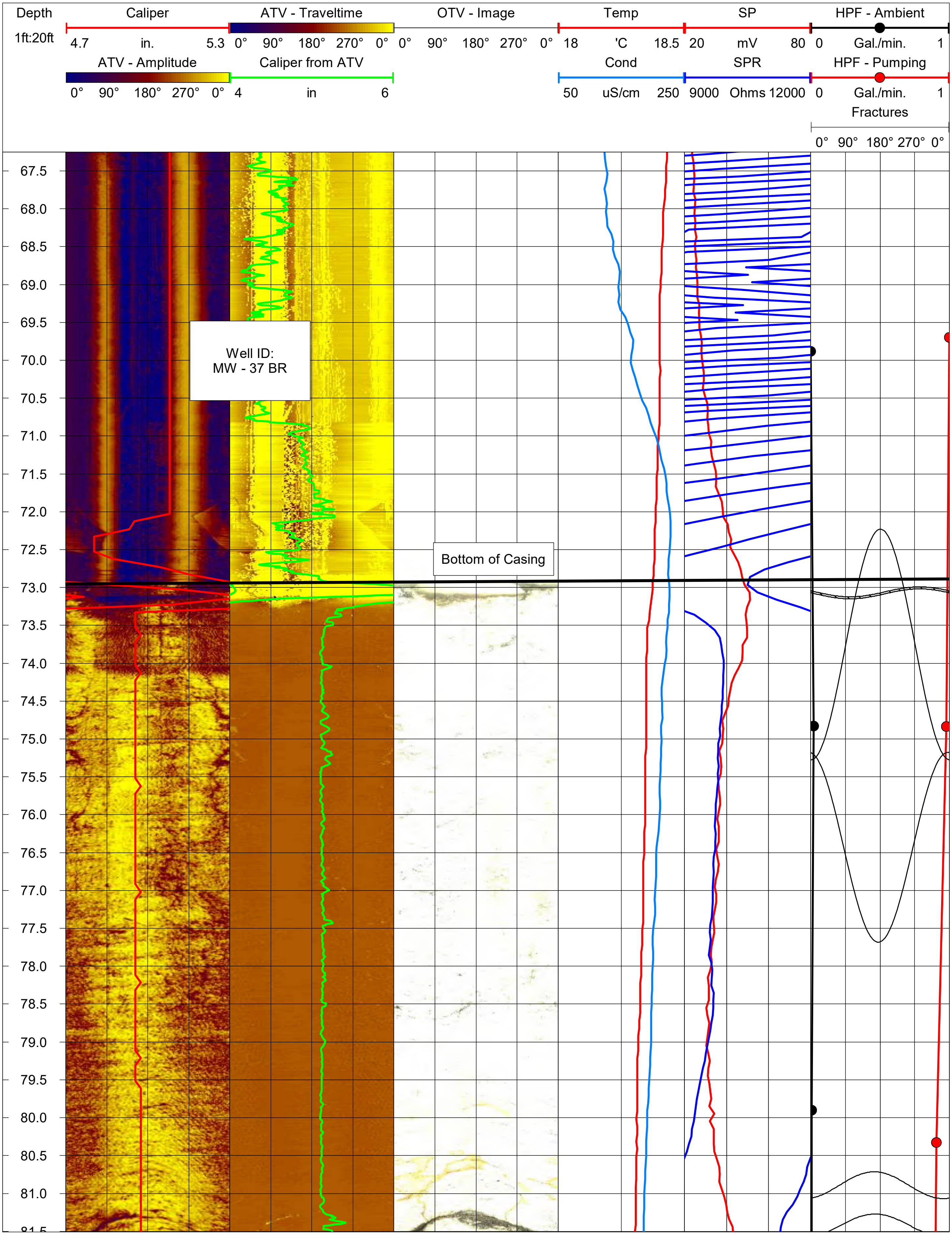

Depth
1ft:20ft
Caliper
4.5 in. 5.2
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
17.4 'C 17.6
Cond
200 uS/cm 350
SP
30 mV 50
SPR
700 Ohms 1200
HPF - Ambient
0 Gal./min. 1
HPF - Pumping
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
Well ID:
MW - 36 BR
Bottom of Casing
50.5
51.0
51.5
52.0
52.5
53.0
53.5
54.0
54.5
55.0
55.5
56.0
56.5
57.0
57.5
58.0
58.5
59.0
59.5
60.0
60.5
61.0
61.5
62.0
62.5
63.0
63.5
64.0
64.5

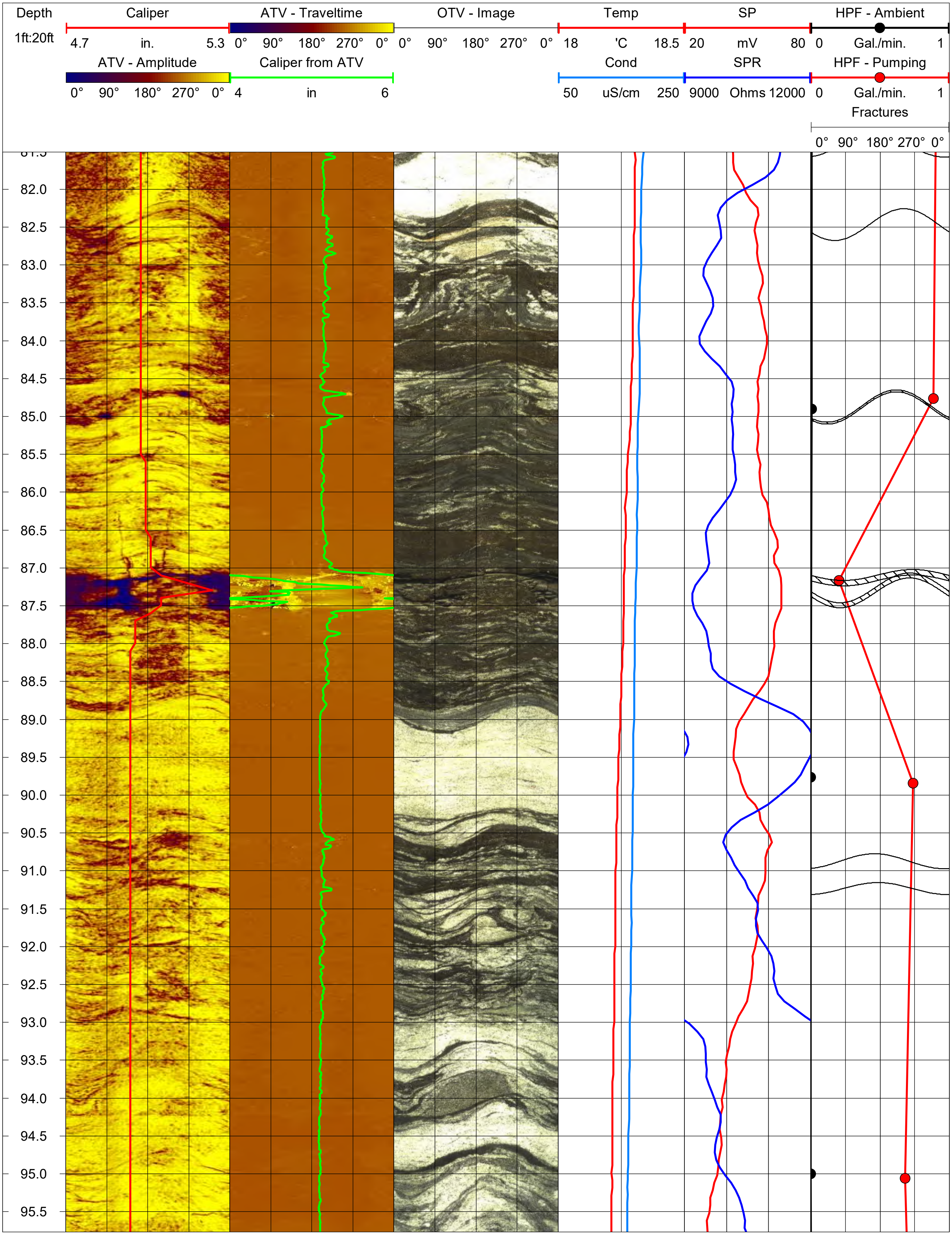

Depth
1ft:20ft
Caliper
4.5 in. 5.2
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
17.4 'C 17.6
Cond
200 uS/cm 350
SP
30 mV 50
SPR
700 Ohms 1200
HPF - Ambient
0 Gal./min. 1
HPF - Pumping
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
65.0
65.5
66.0
66.5
67.0
67.5
68.0
68.5
69.0
69.5
70.0
70.5
71.0
71.5
72.0
72.5
73.0
73.5
74.0
74.5
75.0
75.5
76.0
76.5
77.0
77.5
78.0
78.5

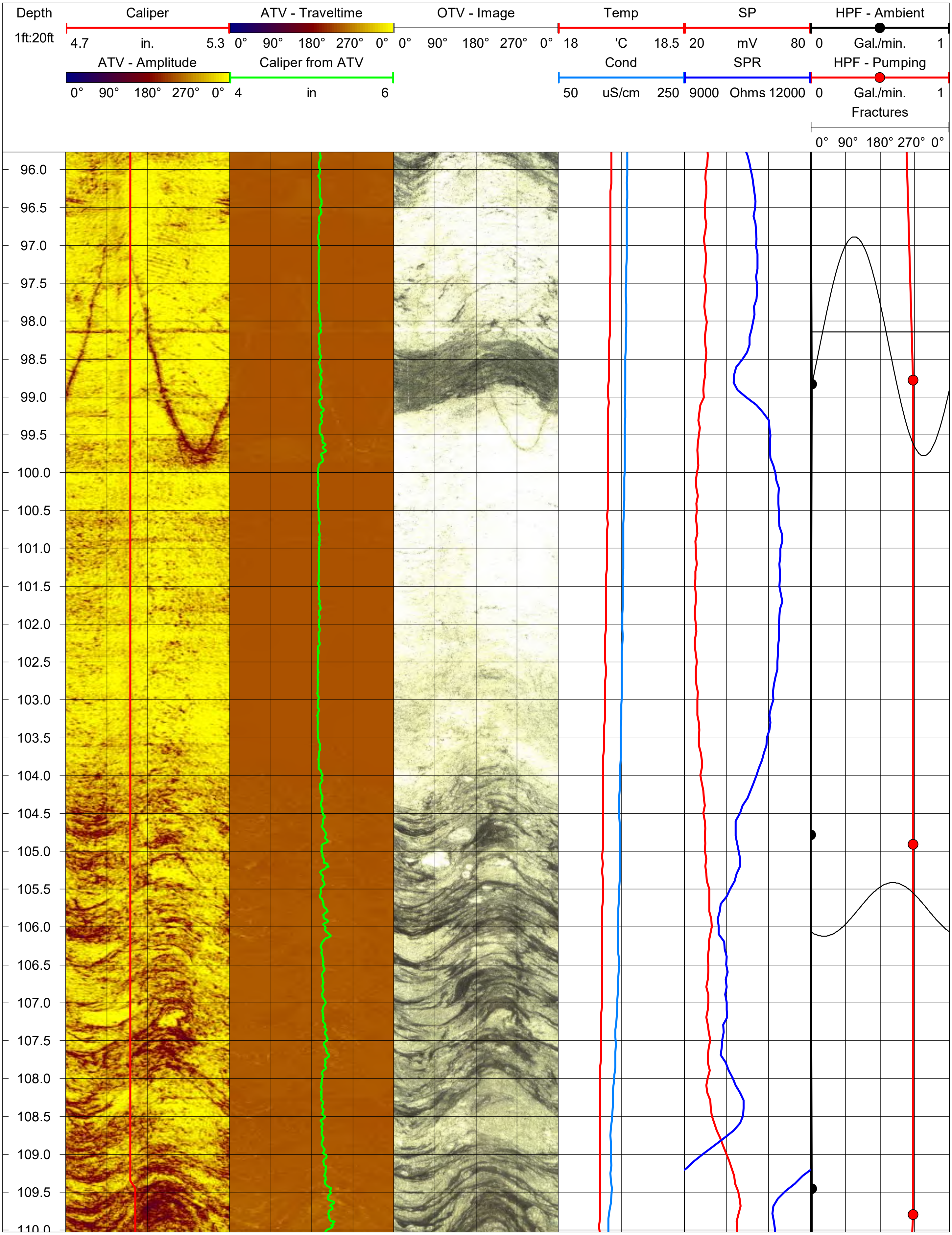


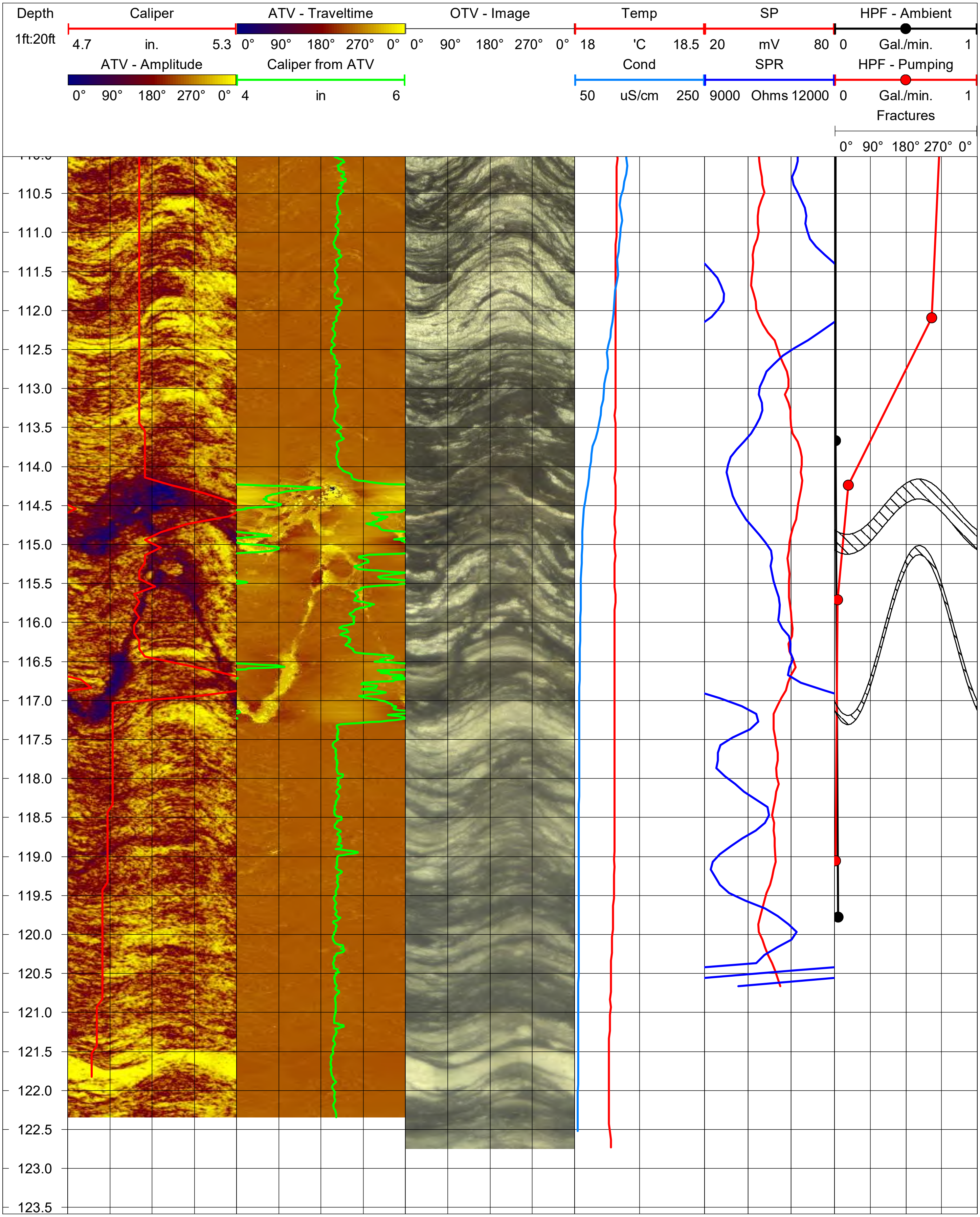
Depth
1ft:20ft
Caliper
4.5 in. 5.2
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
17.4 'C 17.6
Cond
200 uS/cm 350
SP
30 mV 50
SPR
700 Ohms 1200
HPF - Ambient
0 Gal./min. 1
HPF - Pumping
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
79.0
79.5
80.0
80.5
81.0
81.5
82.0
82.5
83.0
83.5
84.0
84.5
85.0
85.5
86.0
86.5
87.0
87.5
88.0
88.5
89.0
89.5
90.0
90.5
91.0
91.5
92.0
92.5
93.0

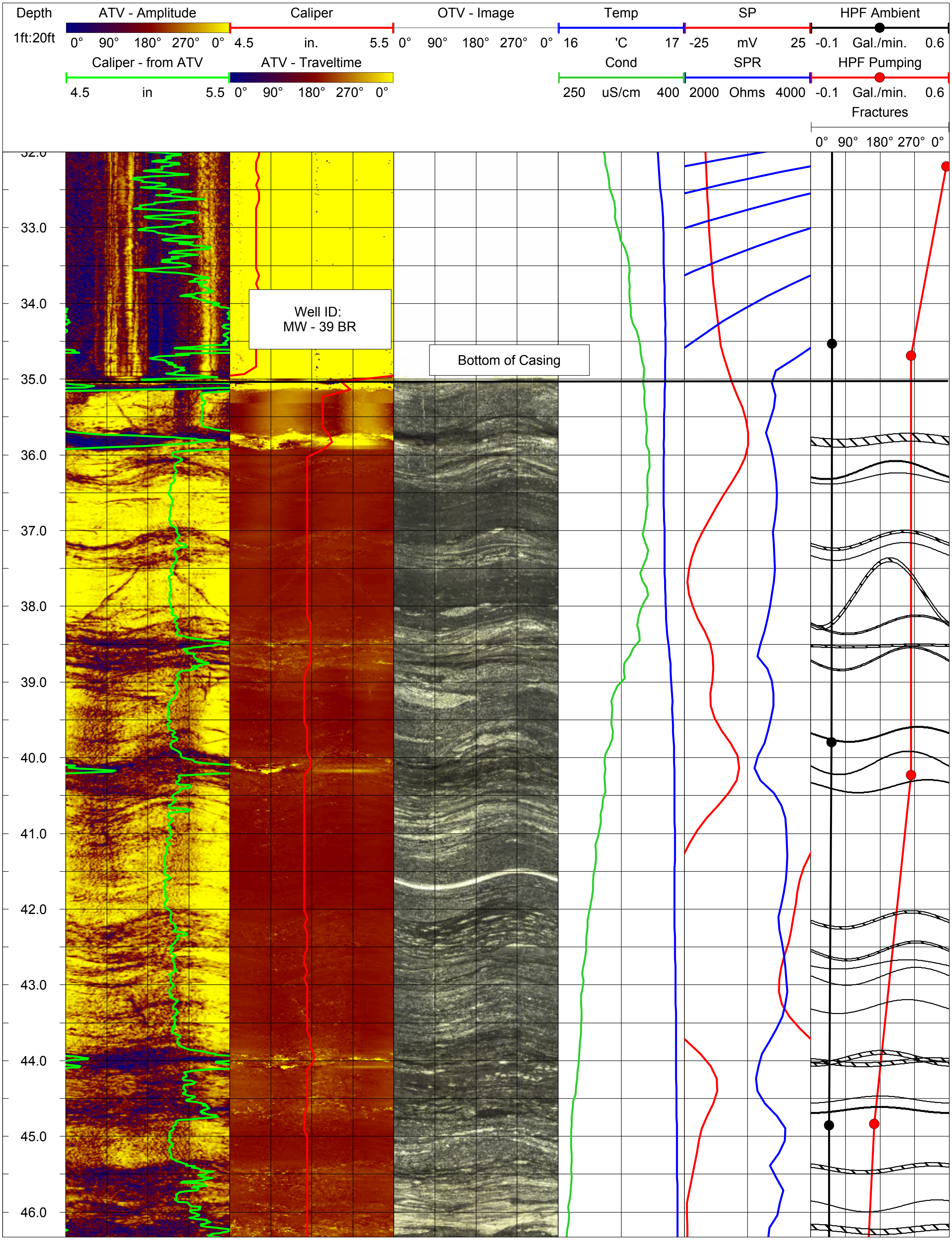

Depth
1ft:20ft
Caliper
4.5 in. 5.2
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
17.4 'C 17.6
Cond
200 uS/cm 350
SP
30 mV 50
SPR
700 Ohms 1200
HPF - Ambient
0 Gal./min. 1
HPF - Pumping
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
93.5
94.0
94.5
95.0
95.5
96.0
96.5
97.0
97.5
98.0
98.5
99.0
99.5
100.0
100.5
101.0
101.5
102.0
102.5

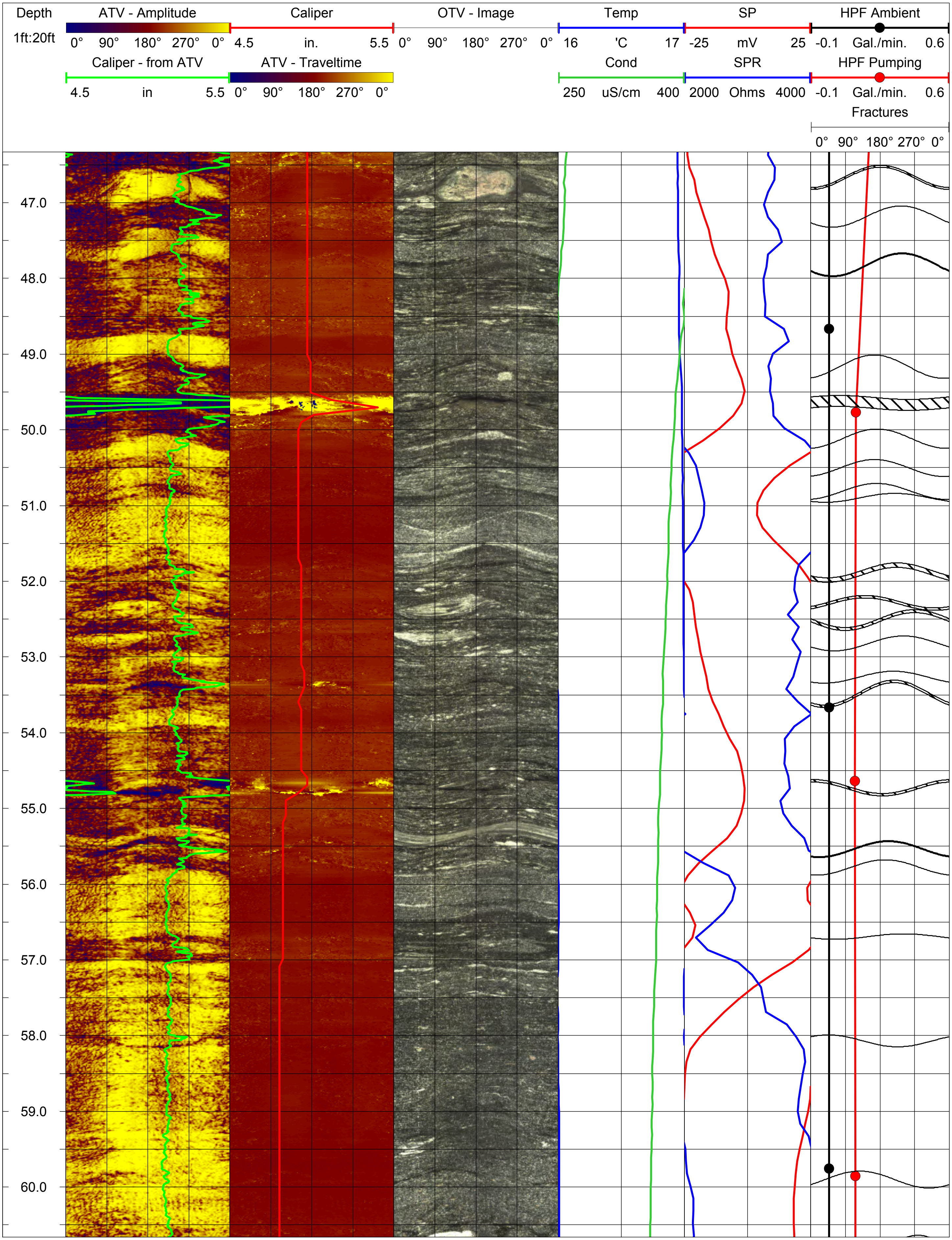

Depth
1ft:20ft
Caliper
4.7 in. 5.3
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
18 'C 18.5
Cond
50 uS/cm 250
SP
20 mV 80
SPR
9000 Ohms 12000
HPF - Ambient
0 Gal./min. 1
HPF - Pumping
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
Well ID:
MW - 37 BR
Bottom of Casing
67.5
68.0
68.5
69.0
69.5
70.0
70.5
71.0
71.5
72.0
72.5
73.0
73.5
74.0
74.5
75.0
75.5
76.0
76.5
77.0
77.5
78.0
78.5
79.0
79.5
80.0
80.5
81.0
81.5

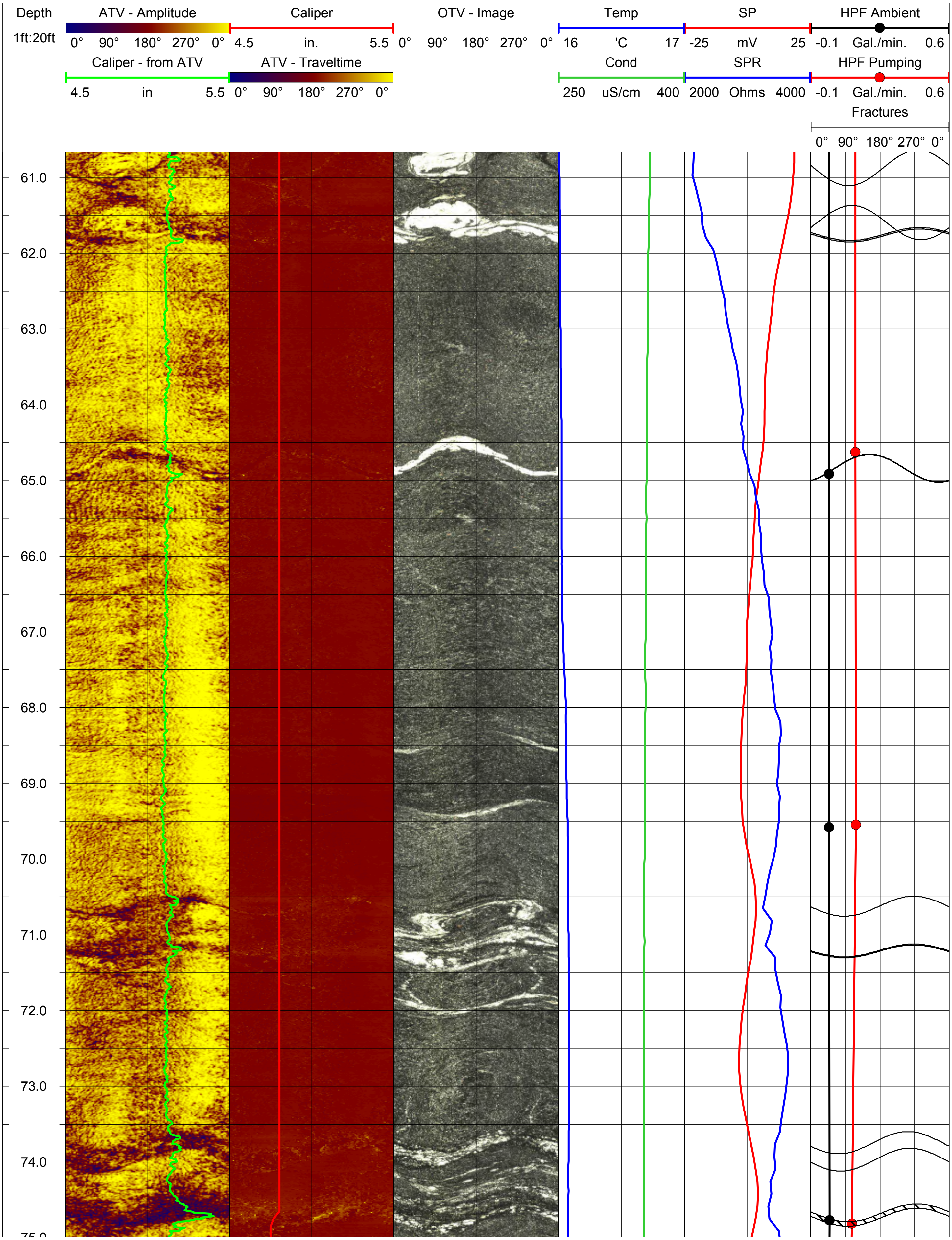

Depth
1ft:20ft
Caliper
4.7 in. 5.3
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
18 'C 18.5
Cond
50 uS/cm 250
SP
20 mV 80
SPR
9000 Ohms 12000
HPF - Ambient
0 Gal./min. 1
HPF - Pumping
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
82.0
82.5
83.0
83.5
84.0
84.5
85.0
85.5
86.0
86.5
87.0
87.5
88.0
88.5
89.0
89.5
90.0
90.5
91.0
91.5
92.0
92.5
93.0
93.5
94.0
94.5
95.0
95.5


Depth
1ft:20ft
Caliper
4.7 in. 5.3
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
18 'C 18.5
Cond
50 uS/cm 250
SP
20 mV 80
SPR
9000 Ohms 12000
HPF - Ambient
0 Gal./min. 1
HPF - Pumping
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
96.0
96.5
97.0
97.5
98.0
98.5
99.0
99.5
100.0
100.5
101.0
101.5
102.0
102.5
103.0
103.5
104.0
104.5
105.0
105.5
106.0
106.5
107.0
107.5
108.0
108.5
109.0
109.5
110.0

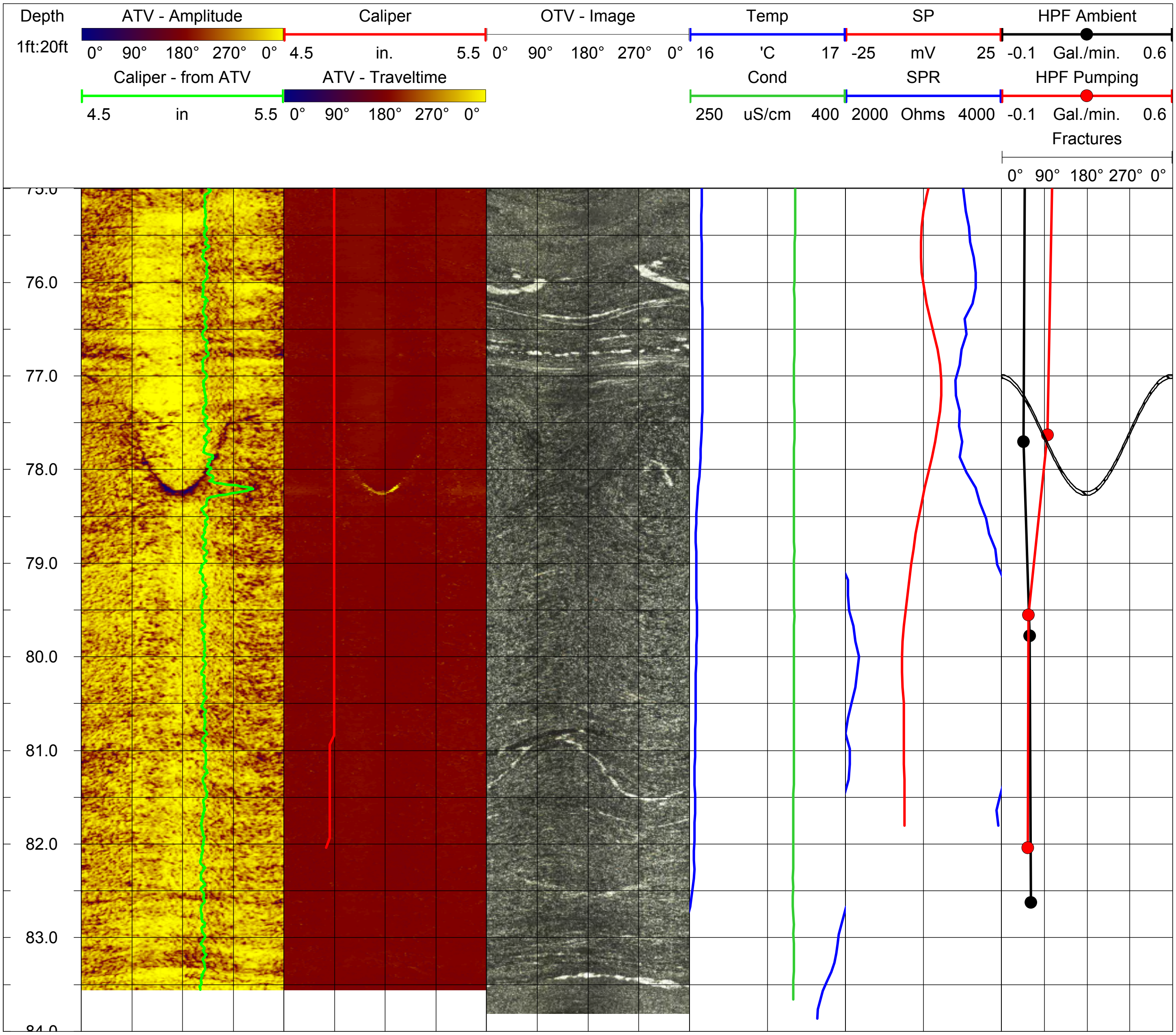

Depth
1ft:20ft
Caliper
4.7 in. 5.3
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
18 'C 18.5
Cond
50 uS/cm 250
SP
20 mV 80
SPR
9000 Ohms 12000
HPF - Ambient
0 Gal./min. 1
HPF - Pumping
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
110.5
111.0
111.5
112.0
112.5
113.0
113.5
114.0
114.5
115.0
115.5
116.0
116.5
117.0
117.5
118.0
118.5
119.0
119.5
120.0
120.5
121.0
121.5
122.0
122.5
123.0
123.5

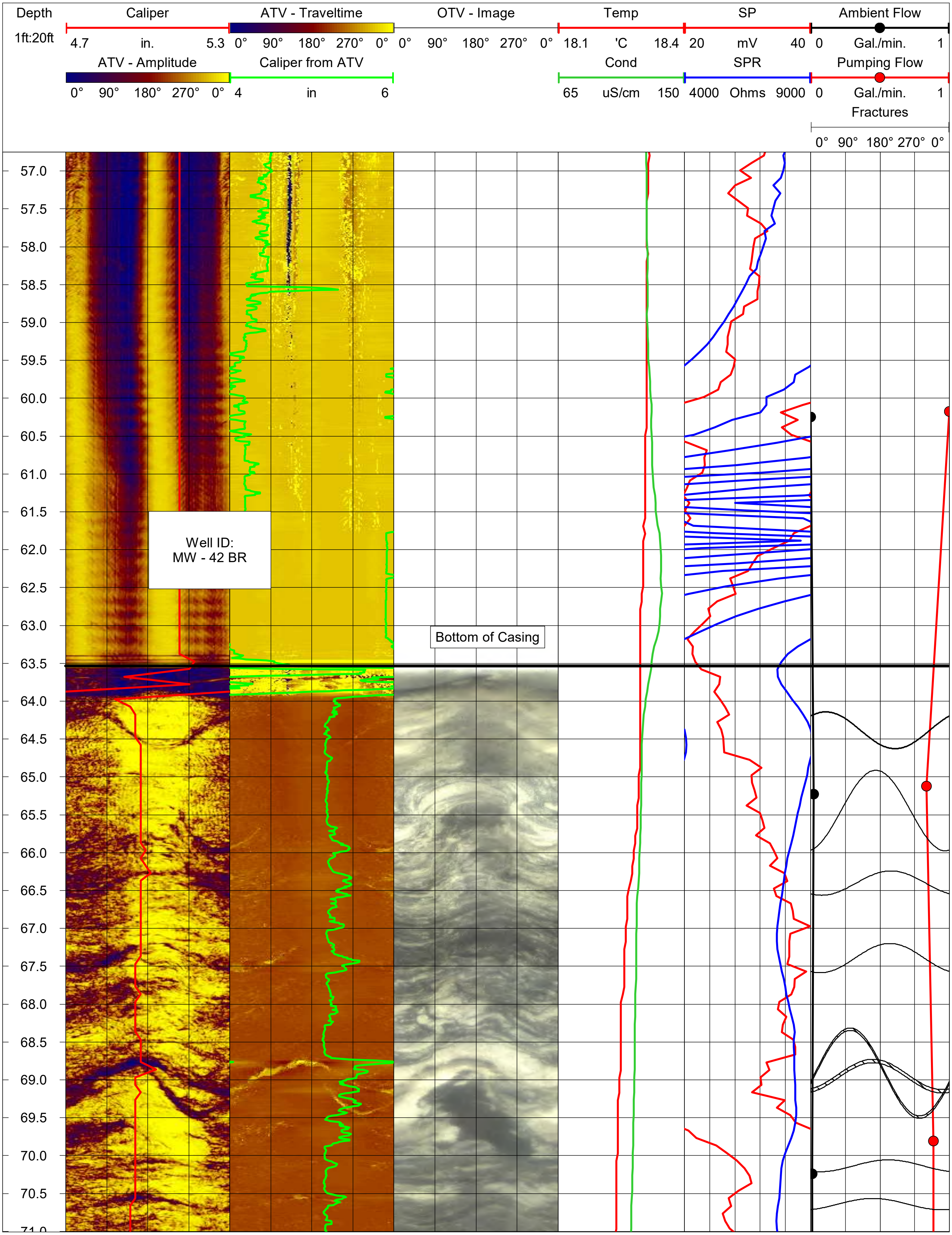

Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - from ATV
4.5 in 5.5
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
16 'C 17
Cond
250 uS/cm 400
SP
-25 mV 25
SPR
2000 Ohms 4000
HPF Ambient
-0.1 Gal./min. 0.6
HPF Pumping
-0.1 Gal./min. 0.6
Fractures
0° 90° 180° 270° 0°
33.0
34.0
35.0
36.0
37.0
38.0
39.0
40.0
41.0
42.0
43.0
44.0
45.0
46.0
Well ID:
MW - 39 BR
Bottom of Casing


Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - from ATV
4.5 in 5.5
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
16 'C 17
Cond
250 uS/cm 400
SP
-25 mV 25
SPR
2000 Ohms 4000
HPF Ambient
-0.1 Gal./min. 0.6
HPF Pumping
-0.1 Gal./min. 0.6
Fractures
0° 90° 180° 270° 0°
47.0
48.0
49.0
50.0
51.0
52.0
53.0
54.0
55.0
56.0
57.0
58.0
59.0
60.0

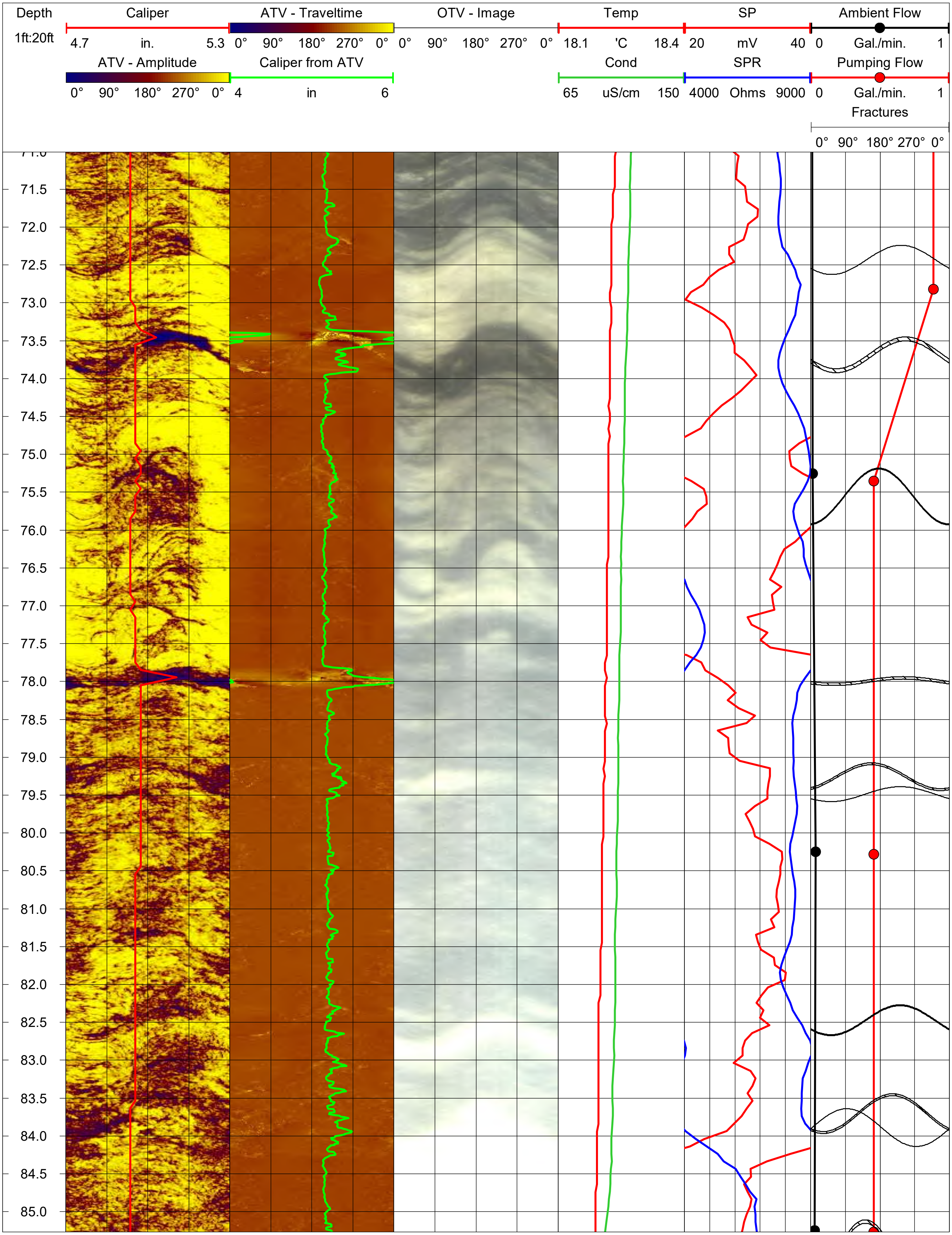


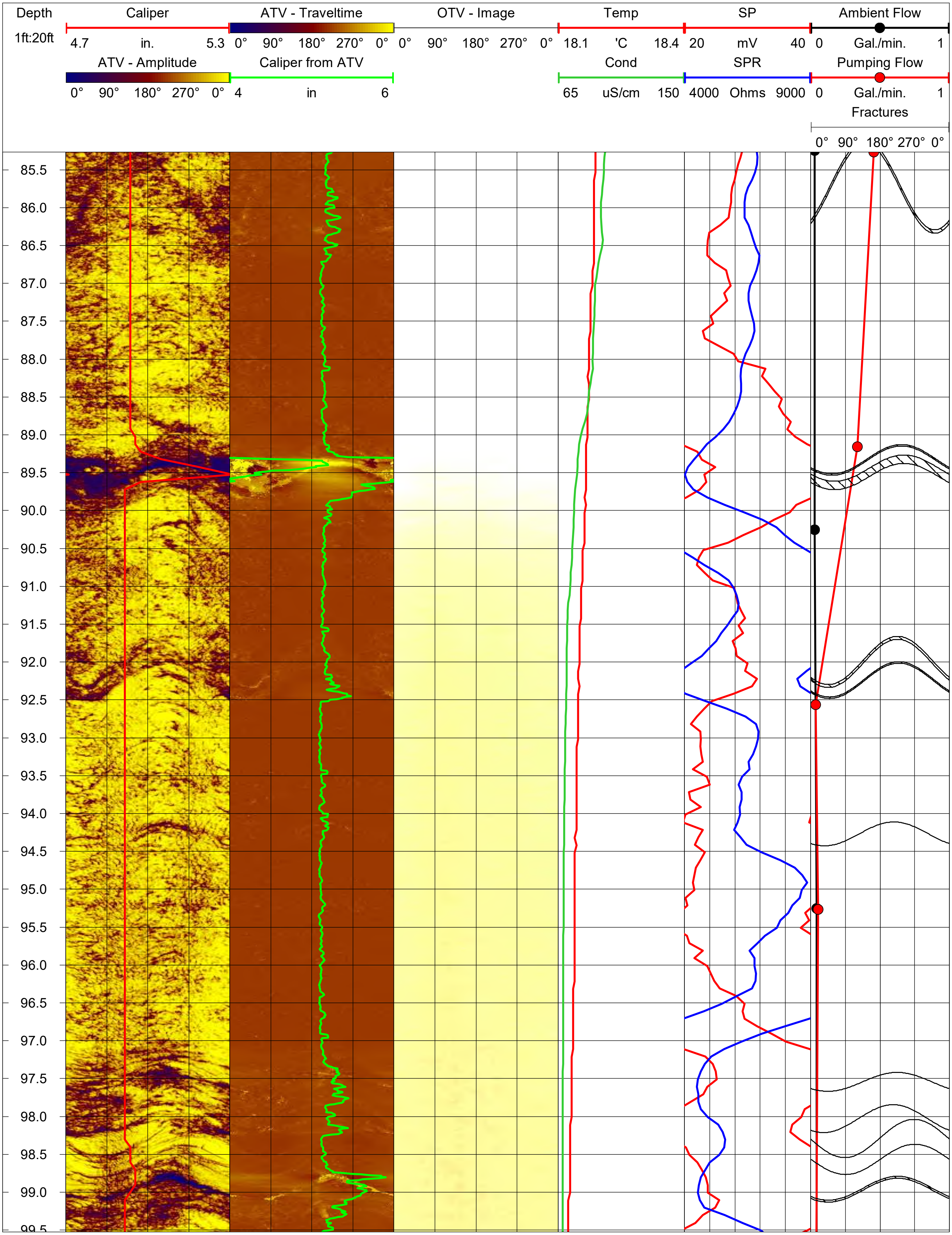
Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - from ATV
4.5 in 5.5
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
16 'C 17
Cond
250 uS/cm 400
SP
-25 mV 25
SPR
2000 Ohms 4000
HPF Ambient
-0.1 Gal./min. 0.6
HPF Pumping
-0.1 Gal./min. 0.6
Fractures
0° 90° 180° 270° 0°
61.0
62.0
63.0
64.0
65.0
66.0
67.0
68.0
69.0
70.0
71.0
72.0
73.0
74.0

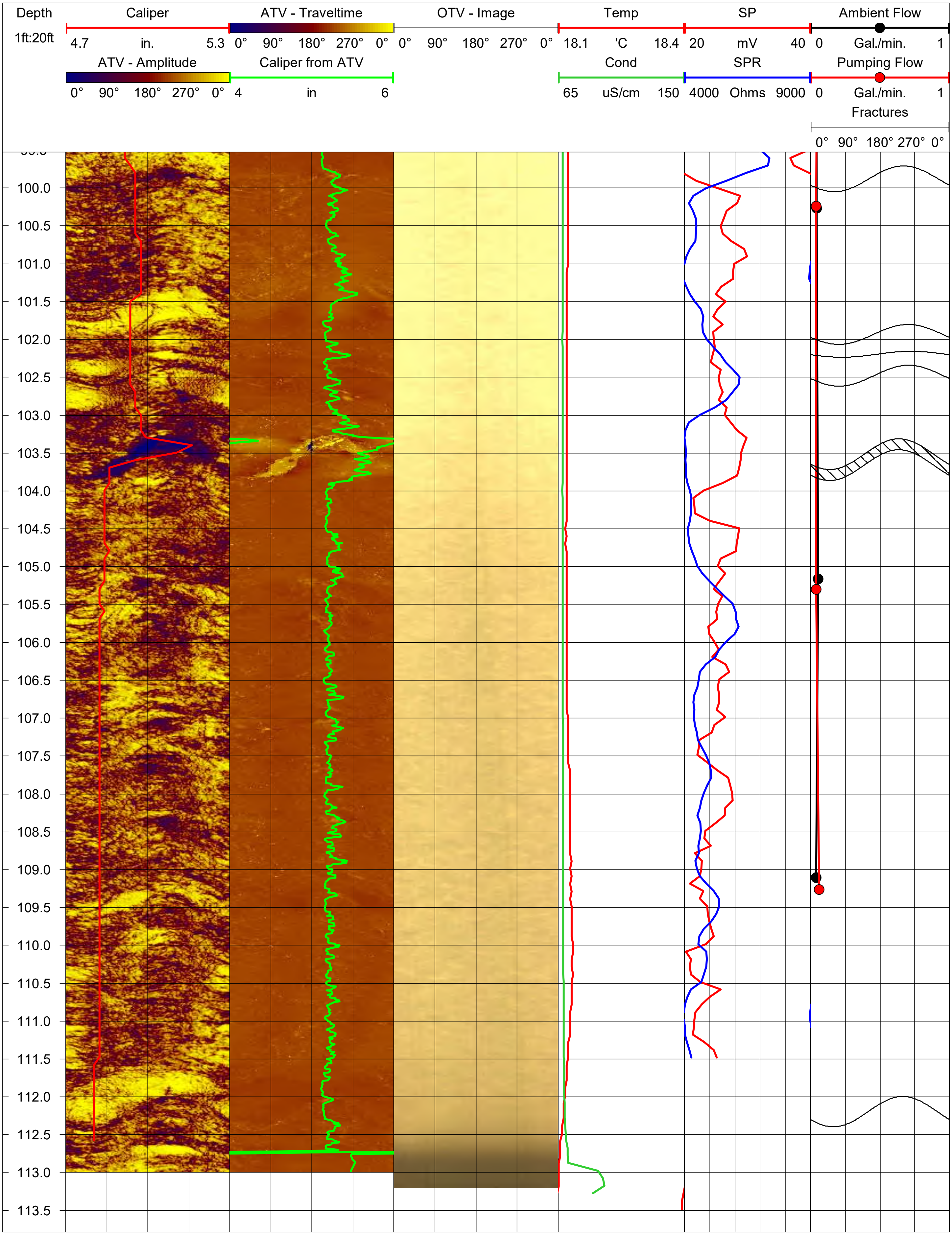

Depth
1ft:20ft
ATV - Amplitude
0° 90° 180° 270° 0°
Caliper - from ATV
4.5 in 5.5
Caliper
4.5 in. 5.5
ATV - Traveltime
0° 90° 180° 270° 0°
OTV - Image
0° 90° 180° 270° 0°
Temp
16 'C 17
Cond
250 uS/cm 400
SP
-25 mV 25
SPR
2000 Ohms 4000
HPF Ambient
-0.1 Gal./min. 0.6
HPF Pumping
-0.1 Gal./min. 0.6
Fractures
0° 90° 180° 270° 0°
76.0
77.0
78.0
79.0
80.0
81.0
82.0
83.0



Depth
1ft:20ft
Caliper
4.7 in. 5.3
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
18.1 'C 18.4
Cond
65 uS/cm 150
SP
20 mV 40
SPR
4000 Ohms 9000
Ambient Flow
0 Gal./min. 1
Pumping Flow
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
57.0
57.5
58.0
58.5
59.0
59.5
60.0
60.5
61.0
61.5
62.0
62.5
63.0
63.5
64.0
64.5
65.0
65.5
66.0
66.5
67.0
67.5
68.0
68.5
69.0
69.5
70.0
70.5
71.0
Well ID:
MW - 42 BR
Bottom of Casing


Depth
1ft:20ft
Caliper
4.7 in. 5.3
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
18.1 'C 18.4
Cond
65 uS/cm 150
SP
20 mV 40
SPR
4000 Ohms 9000
Ambient Flow
0 Gal./min. 1
Pumping Flow
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
71.5
72.0
72.5
73.0
73.5
74.0
74.5
75.0
75.5
76.0
76.5
77.0
77.5
78.0
78.5
79.0
79.5
80.0
80.5
81.0
81.5
82.0
82.5
83.0
83.5
84.0
84.5
85.0


Depth
1ft:20ft
Caliper
4.7 in. 5.3
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
18.1 'C 18.4
Cond
65 uS/cm 150
SP
20 mV 40
SPR
4000 Ohms 9000
Ambient Flow
0 Gal./min. 1
Pumping Flow
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
85.5
86.0
86.5
87.0
87.5
88.0
88.5
89.0
89.5
90.0
90.5
91.0
91.5
92.0
92.5
93.0
93.5
94.0
94.5
95.0
95.5
96.0
96.5
97.0
97.5
98.0
98.5
99.0
99.5


Depth
1ft:20ft
Caliper
4.7 in. 5.3
ATV - Amplitude
0° 90° 180° 270° 0°
ATV - Traveltime
0° 90° 180° 270° 0°
Caliper from ATV
4 in 6
OTV - Image
0° 90° 180° 270° 0°
Temp
18.1 'C 18.4
Cond
65 uS/cm 150
SP
20 mV 40
SPR
4000 Ohms 9000
Ambient Flow
0 Gal./min. 1
Pumping Flow
0 Gal./min. 1
Fractures
0° 90° 180° 270° 0°
100.0
100.5
101.0
101.5
102.0
102.5
103.0
103.5
104.0
104.5
105.0
105.5
106.0
106.5
107.0
107.5
108.0
108.5
109.0
109.5
110.0
110.5
111.0
111.5
112.0
112.5
113.0
113.5

APPENDIX B

FIELD PROCEDURES FOR CONDUCTING PNEUMATIC INTERFERENCE SLUG TESTS

Science & Engineering Consultants

Procedures for Conducting Pneumatic Interference Slug Tests

September 23, 2020

The procedures for conducting pneumatic interference slug tests (PISTs) for Bramlette aquifer performance testing is presented in detail below:

1. Instrument the selected monitoring wells with high resolution In-Situ real time water level pressure transducers and set the transducers to record a measurement every 0.5 to 2 seconds
    a. Immediately before and after instrumenting a monitoring well the depth to water level in the well will be measured and recorded in a field notebook
    b. The time the pressure transducer is installed to the correct depth will be recorded in a field notebook
    c. The frequency of measurement will be based on site specific considerations
    d. Pressure transducers should be set to depths large enough to ensure that they remain below the water level in the well during tests; it is assumed 5 feet below the water level in the well is sufficient to maintain full submergence
2. Attach the PIST well head assembly to the top of the test well and install the test well pressure transducer and set it to record a measurement every 0.5 seconds; the well head assembly will include all necessary valves, pressure regulators, gauges, and the pressure transducer for the test well
    a. Immediately before attaching the PIST well head assembly to the test well the depth to water level in the well will be measured and recorded in a field notebook
    b. Place the pressure transducer deep enough in the test well to insure that it remains under the water level in the well under pressurized well conditions; this will vary depending on pressures needed to influence groundwater level responses in surrounding observation wells
3. Connect the test well pressure transducer to a field computer for real time data collection and check to ensure a signal is being received from the transducer and that data is being plotted in real time in the In-Situ software program

4. Close the inlet and release valves and well head regulator on the PIST well head assembly and connect it to a nitrogen tank or other source of pressurized gas/air
5. Set the regulator on the nitrogen tank or pressurized gas source to the max pressure that will be used for the test
6. Open the inlet valve on the PIST well head assembly located between the well head and the pressure source and slowly open the regulator on the well head assembly to pressurize the well head until desired max pressure is reached.
7. Once max pressure in the well is reached based on the well head assembly pressure gauge, close the inlet valve to isolate the pressurized head space in the well
    a. Perform leak checks on the well head assembly fittings either by listening for air release or by spraying bio-degradable soapy water on the fittings and connections and watching for bubbles (leak checks on the PIST well head assembly should also be conducted prior to starting any field work)
    b. If leaks are detected, depressurize the head space in the well and the well head assembly and tighten or replace any necessary fittings; repeat steps six through nine
8. After max pressure is reached and the pressurized well head is isolated allow the pressure in the well to reach equilibrium before performing the slug test
    a. Observe the well head assembly pressure gauge and test well pressure transducer to determine when equilibrium is reached
9. Quickly open the release valve on the well head assembly to initiate the slug test; the pressure release should be as close to instantaneous as possible
10. Observe the groundwater level response in the test well to insure it behaves as expected
11. Allow for sufficient time for the test well and monitoring wells to return to static water levels
    a. Due to lag times in signal response and varying hydraulic properties around the test well and monitoring wells, initially allow 10 to 15 minutes after the test well returns to static conditions for the monitoring wells to return to static water levels

12. After static water level conditions are expected to be reached download the groundwater level data from the monitoring well data loggers and review the data from the initial slug test
13. Based on field review of test well and monitoring well data collected during the initial slug test, parameters of the slug test such as slug pressure, data measurement interval, and equilibration time both before and after the slug test is initialized may need to be modified to best account for site specific conditions
14. After determining the appropriate slug test parameters, additional slug tests will be performed at each test well to insure test repeatability and to improve the overall dataset for each slug test
    a. The number of additional slug tests will be adjusted as needed based on field conditions and time constraints but it is anticipated that approximately 5 slug tests, including the initial slug test, will be performed at each well
15. After completing slug tests at a test well, check to make sure the system is depressurized and disconnect the PIST well head from the nitrogen tank/pressure source and then the test well
16. Decontaminate the test well pressure transducer and transducer cable using Liquinox (or similar) and water
17. Move to the next test well location and repeat steps 1 through 16 as necessary
    a. The location of monitoring wells may vary between test well locations but some locations will overlap between test well locations and will not be moved