CONDUCTING CLOSE INTERVAL POTENTIAL SURVEYS

Presented by:

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Appalachian Underground Corrosion Short Course

CONDUCTING CLOSE INTERVAL POTENTIAL SURVEYS

- DEFINITION OF CLOSE INTERVAL SURVEYS (CIS)
- REASONS FOR CONDUCTING CIS
- TYPES OF CIS
- PRE-SURVEY CONSIDERATIONS
- DATA COLLECTION CONSIDERATIONS
- POST SURVEY PROCESSING AND ANALYSIS
- CONCLUSIONS

DEFINITION OF CLOSE INTERVAL SURVEY

- NACE DEFINITION – SP0207-2007
  - A potential survey performed on a buried or submerged metallic pipeline, in order to obtain valid DC structure-to-electrolyte potential measurements at a regular interval sufficiently small to permit a detailed assessment.

- PHMSA MANDATES
  - **§192.455 Subpart I External corrosion control: Buried or submerged pipelines installed after July 31, 1971.**
  - **§192.465 External corrosion control: Monitoring.**
  - **§ 195.573 Subpart H Hazardous Liquid Pipeline: Exterior Corrosion Control**

REASONS FOR CONDUCTING CLOSE INTERVAL SURVEYS

Compliance with PHMSA Requirements

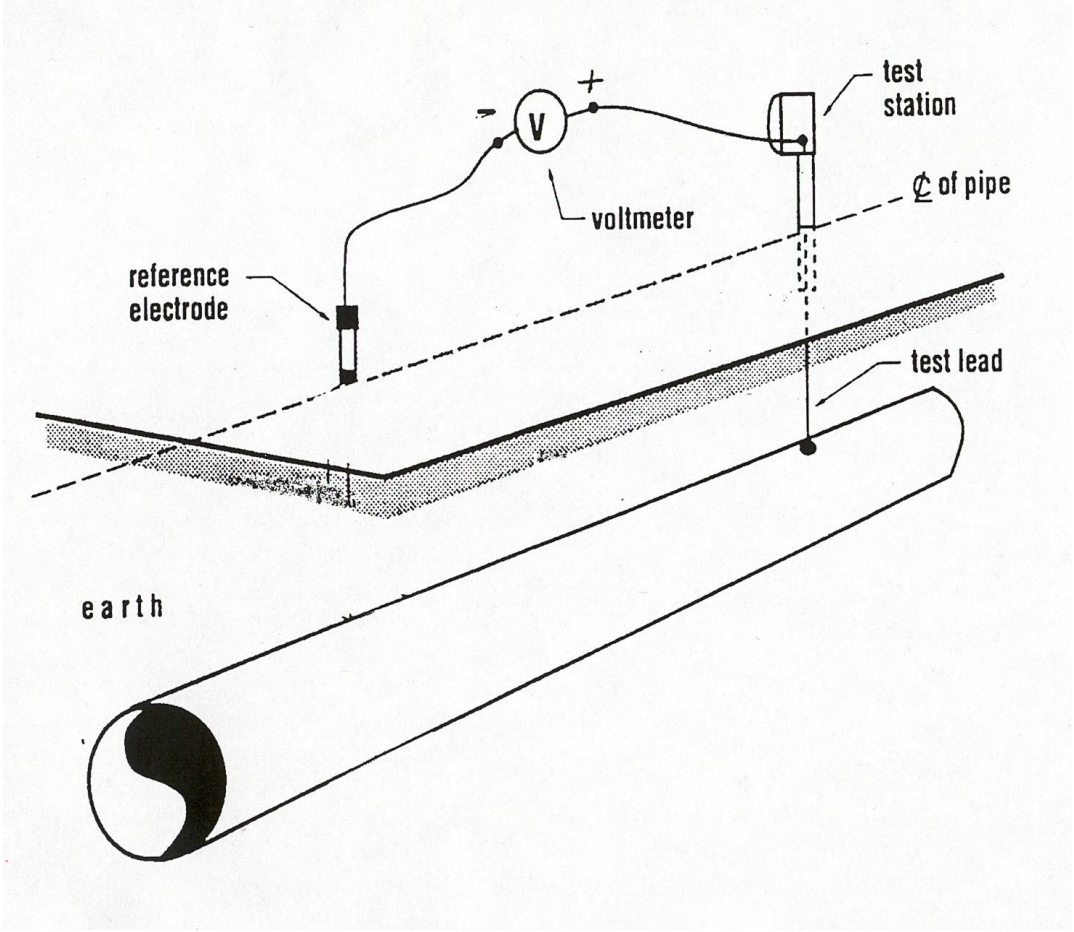
Testing for adequate levels of CP over the entire length of the structure

Evaluation and Identification of coating anomalies/damage

Determine Presence of Interfering currents from DC sources

Evaluation of electrical isolation from casings/other foreign structures

Schematic Of A Close Interval Survey



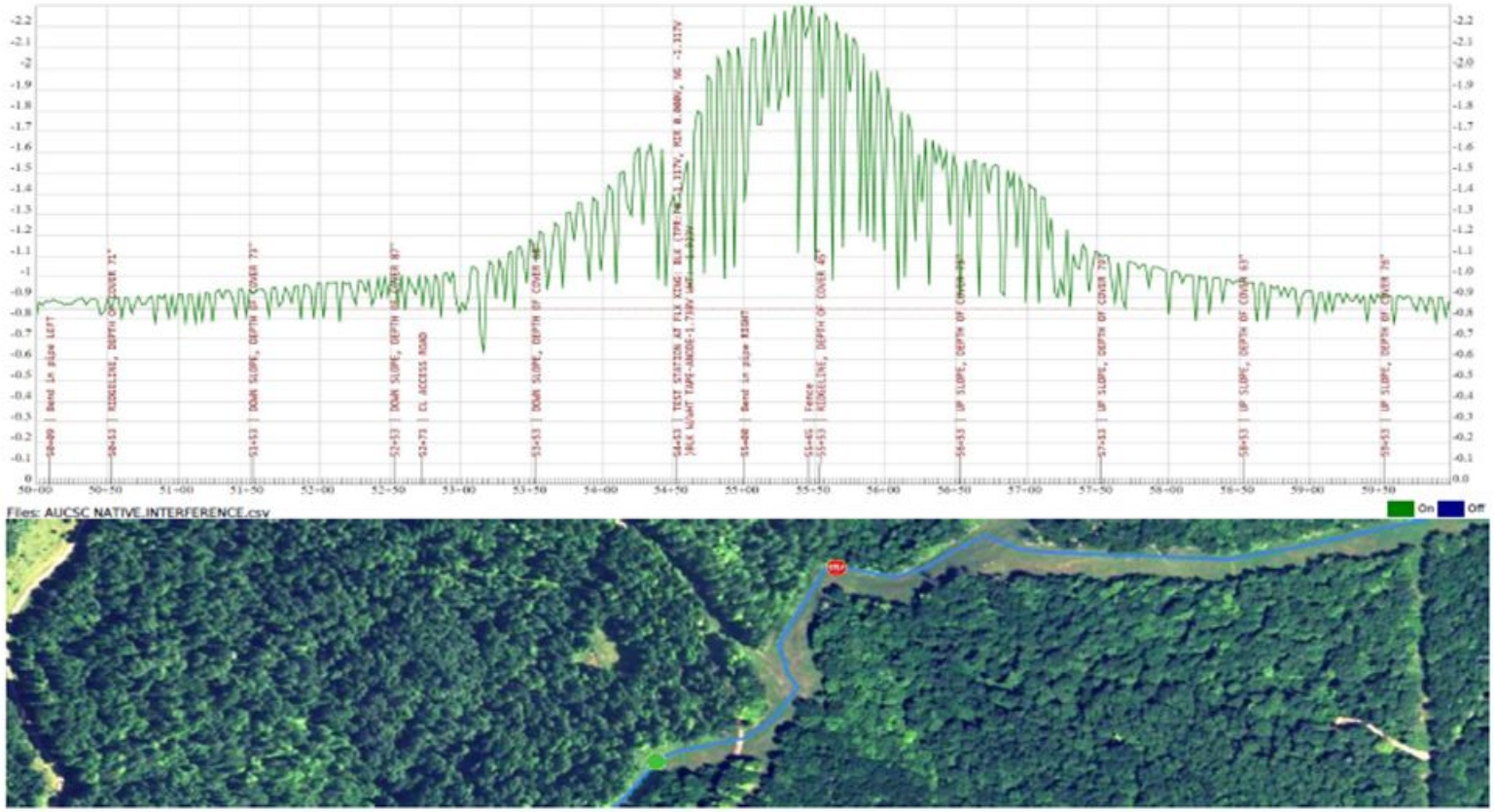
TYPES OF CLOSE INTERVAL SURVEYS

- NATIVE SURVEY
- CURRENT APPLIED OR “ON ONLY” CORROSION SURVEY
- ON/INTERRUPTED SURVEY
- DEPOLARIZED SURVEY

NATIVE SURVEY

- A Native pipe-to-soil survey is used to establish a base-line profile of the pipeline system, before designed CP is ever applied
- Can help to determine if foreign or interference currents are present before CP is applied.
- Often used in conjunction with On/Interrupted surveys to establish 100mv polarization shift criteria.
- Can create future cost savings and minimize risks associated with de-energizing facilities to obtain depolarized potentials.

NATIVE SURVEY W/FOREIGN CURRENT



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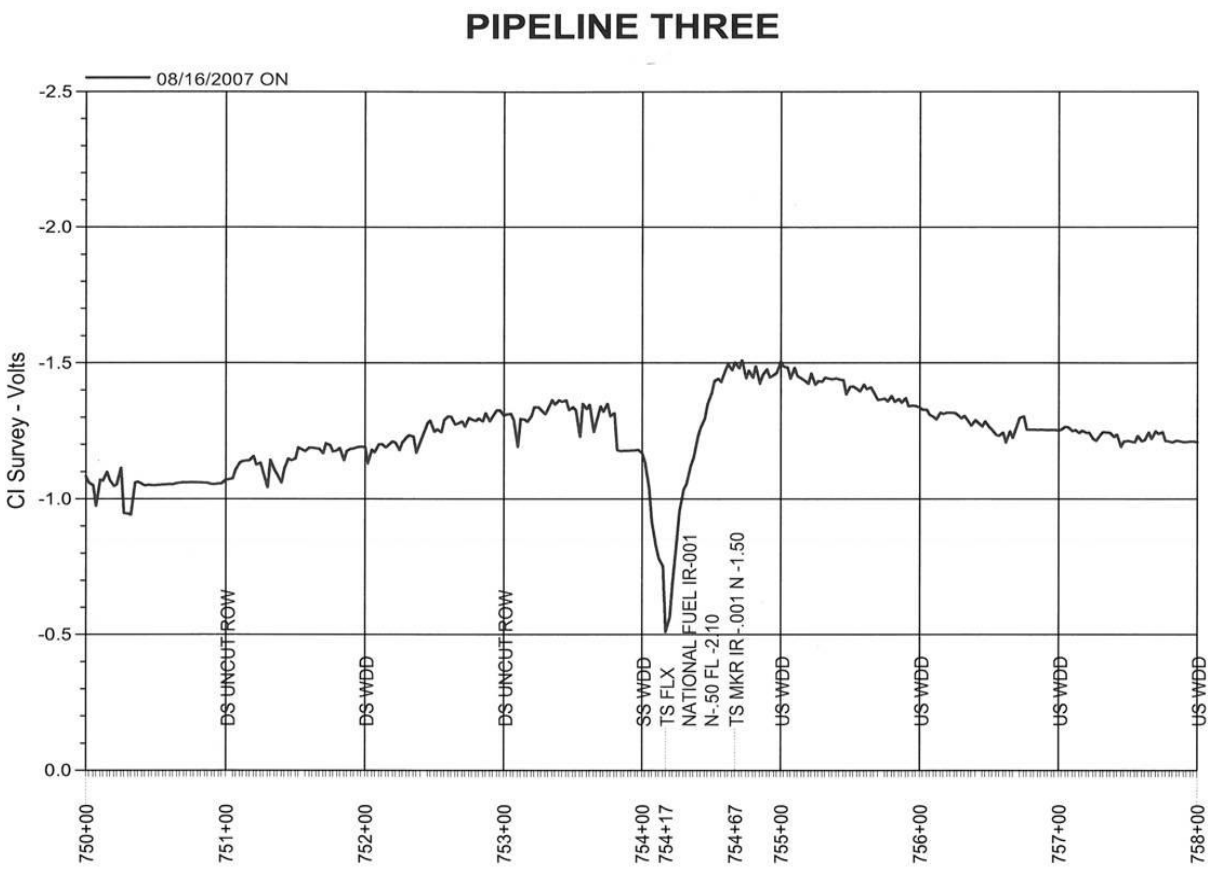
CURRENT APPLIED OR “ON” SURVEY

- The On/only survey is normally conducted on structures that have magnesium anodes directly attached to the structure, where it’s not practical to obtain IR Free potentials.
- An on survey does not take into account “IR drop (Voltage Error)”.
- Sometimes used in conjunction with IR drop Free Coupons to confirm levels of cathodic protection.
- These surveys are performed to help verify cathodic protection levels and coating efficiency.

Current Applied "On" Survey



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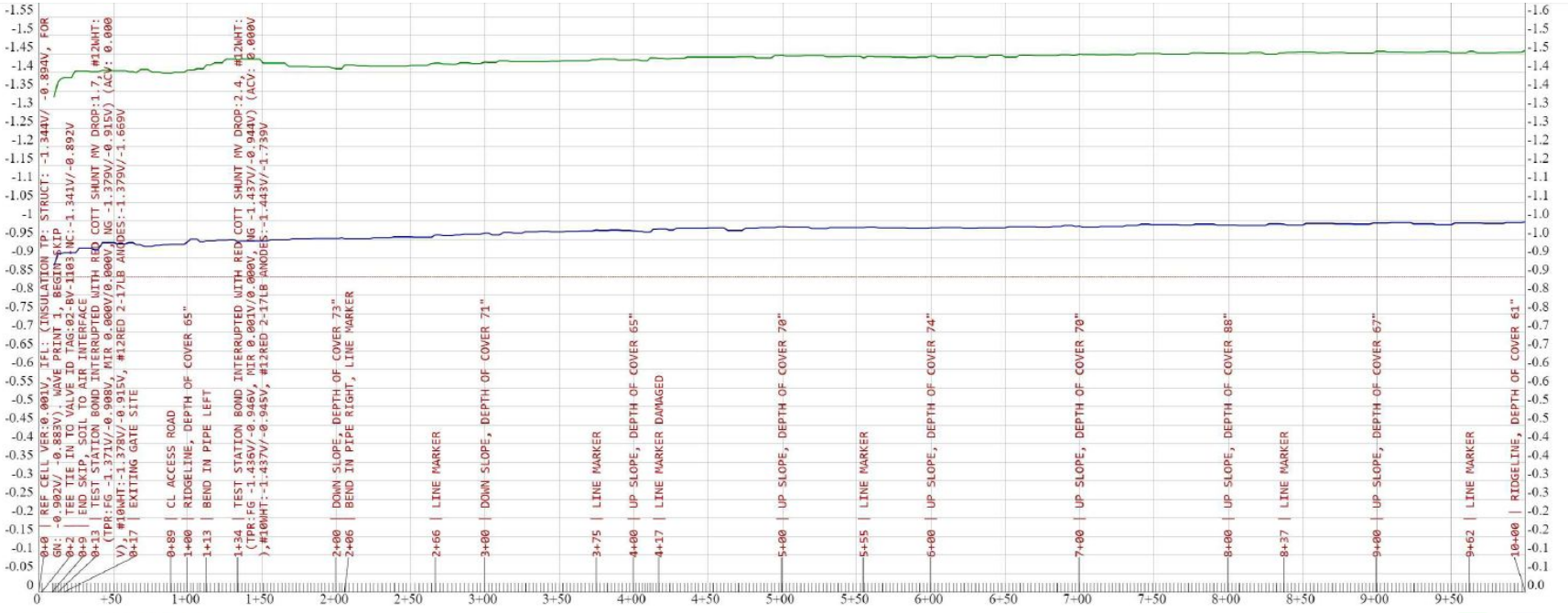
ON/INTERRUPTED SURVEY

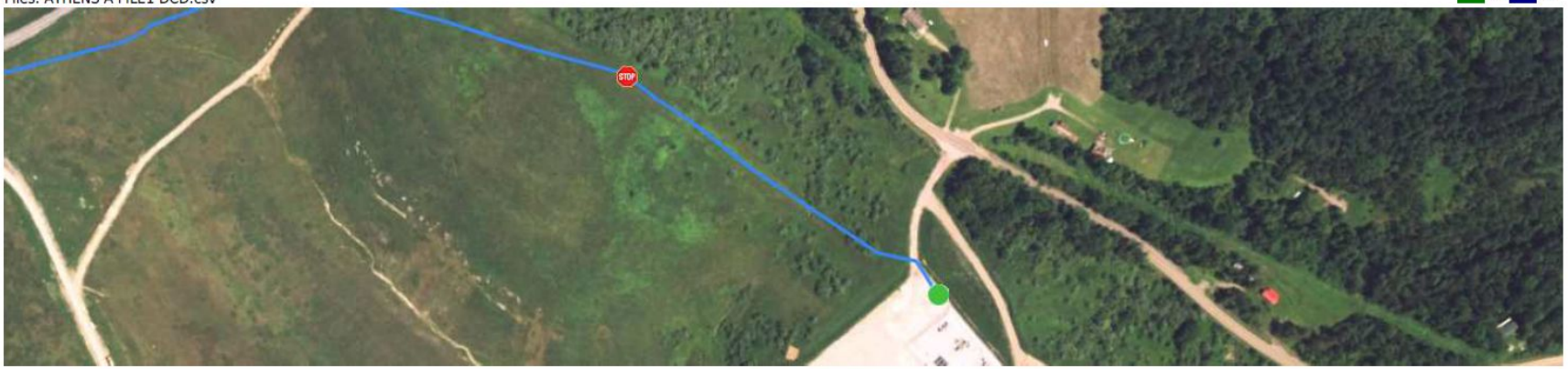
- This is the most common type of CIS used on impressed current systems and galvanic systems where current sources can be interrupted.
- Generally the interval for each potential measurement collected is approximately 2.5 to 5 feet.
- Requires "**all**" influencing current sources to be interrupted using synchronized current interrupters.
- Instant-off potentials provides an IR free reading of polarized pipe potentials.

Instant Off Potentials Factors

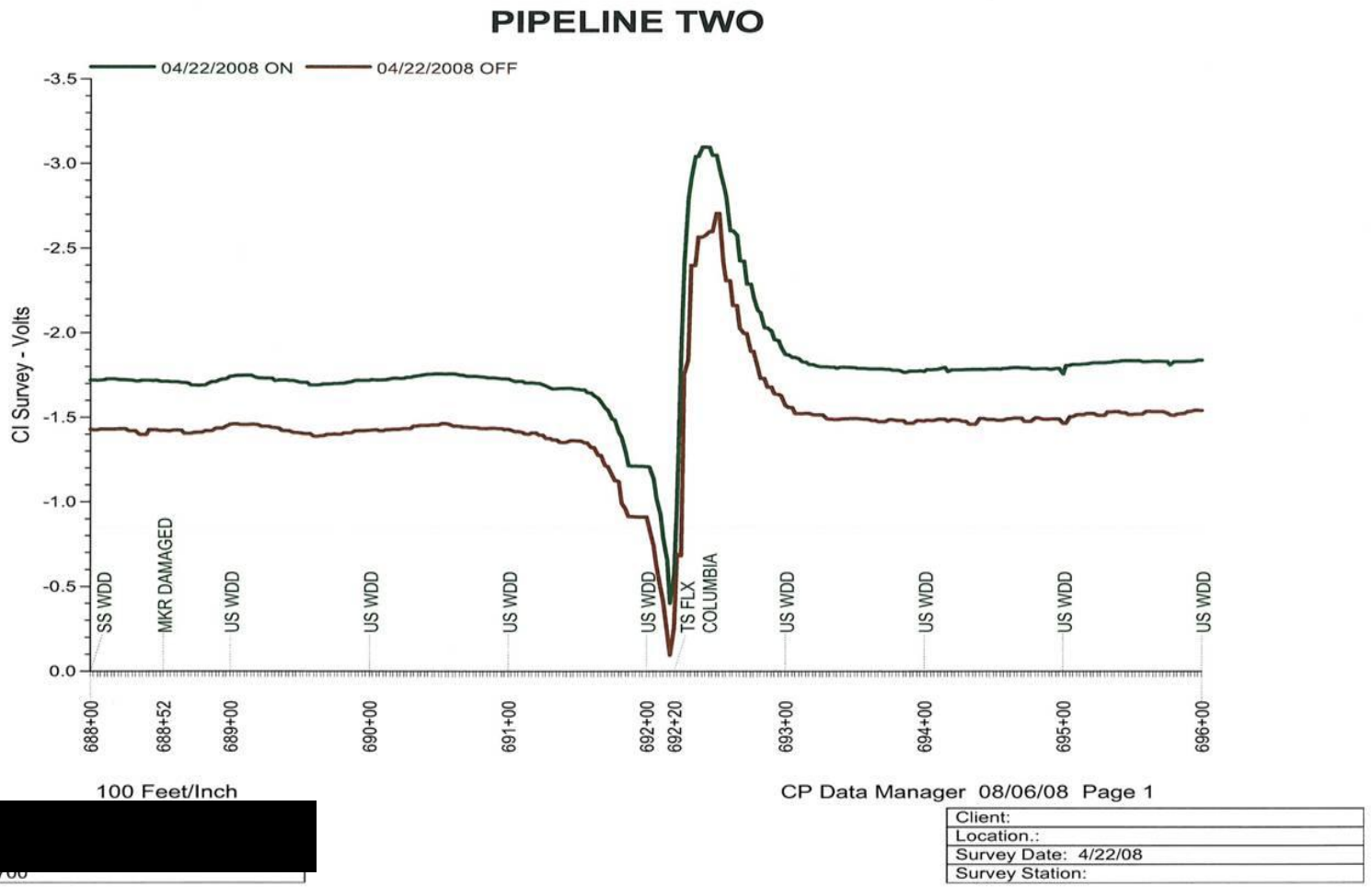
- Ensure “On” vs. “Off” cycle time (3/1) allows accuracy in the instant off potential measurement.
- Evaluate the “delay time” where the data logger captures the current on and instant off potential measurement. (wave prints)
- Evaluate all AC mitigation devices that may effect the capture of the instant off potential measurement. (Capacitance effect)
- Usage of an oscilloscope to help evaluate unknown DC sources that may effect the instant off potential measurement.

On-Interrupted Galvanic Survey





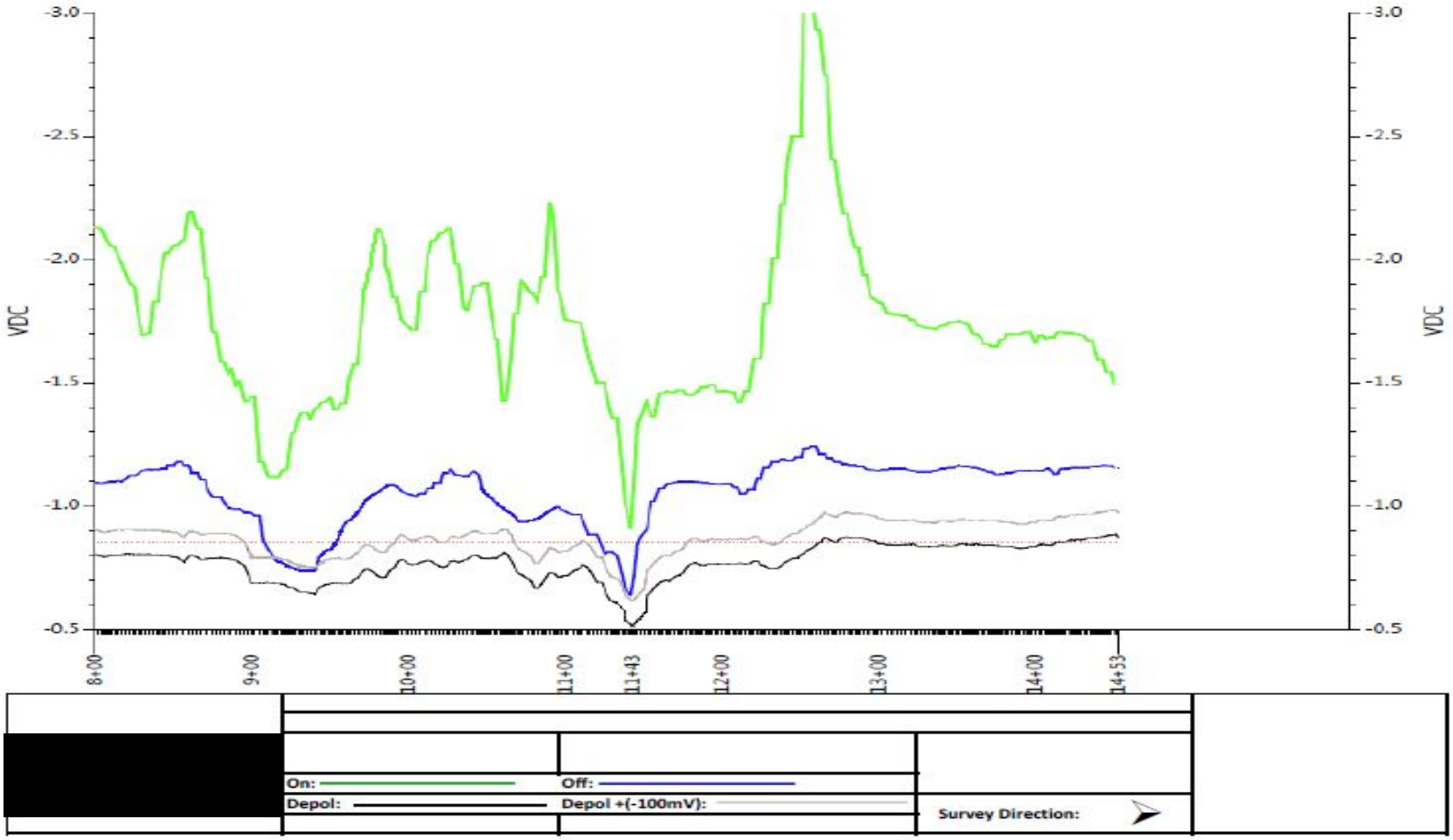
On/Interrupted Survey



DEPOLARIZED SURVEY

- A depolarized survey is used in conjunction with an On/Interrupted survey to verify 100mV polarization.
- The pipeline must have all influencing sources of current turned off and be allowed to depolarize sufficiently before conducting the survey.
- It is necessary to survey as accurately as possible to the original On/Interrupted survey to be able to overlay potentials.
- The Depolarized data is then graphed against the On/interrupted data to determine if the 100mV polarization criteria has been achieved.
  - Graph includes calculated line Depolarized Potential + 100mv

Depolarized Survey



Vertical Scale: 0.0vDC - (-3.0)
Horizontal Scale: 1 Inch = 100Ft

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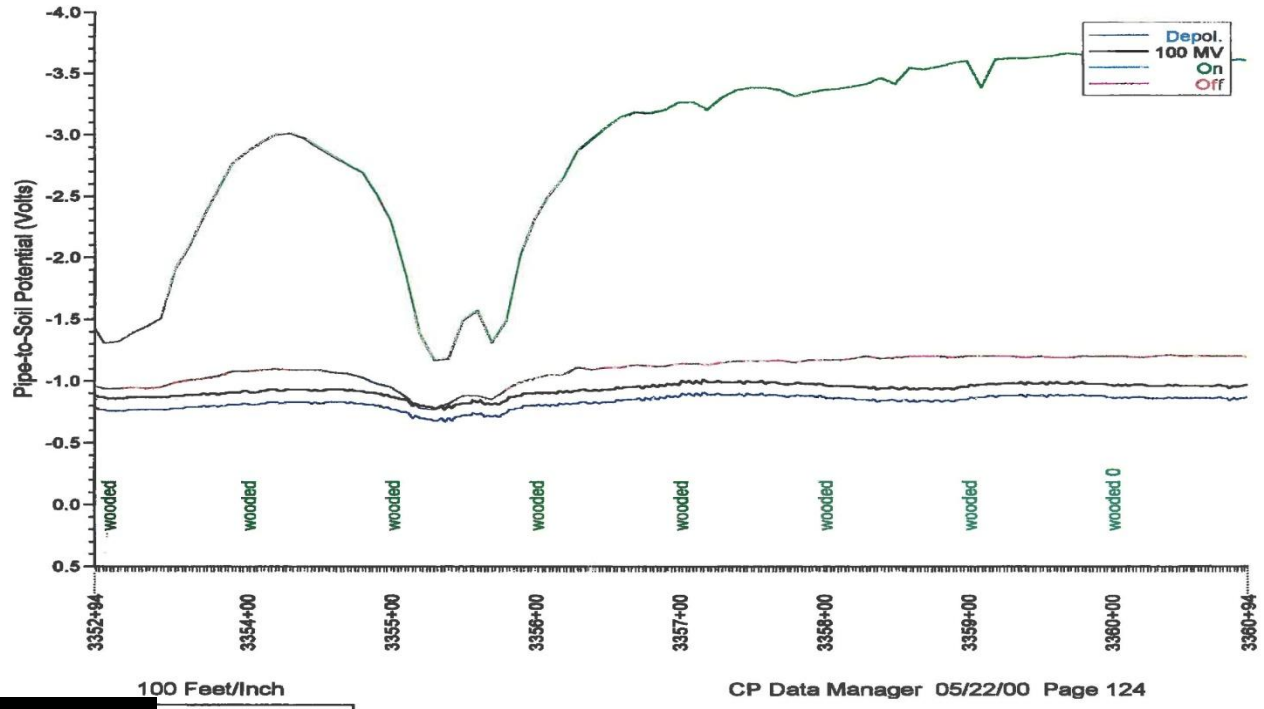
Depolarized Survey Graph



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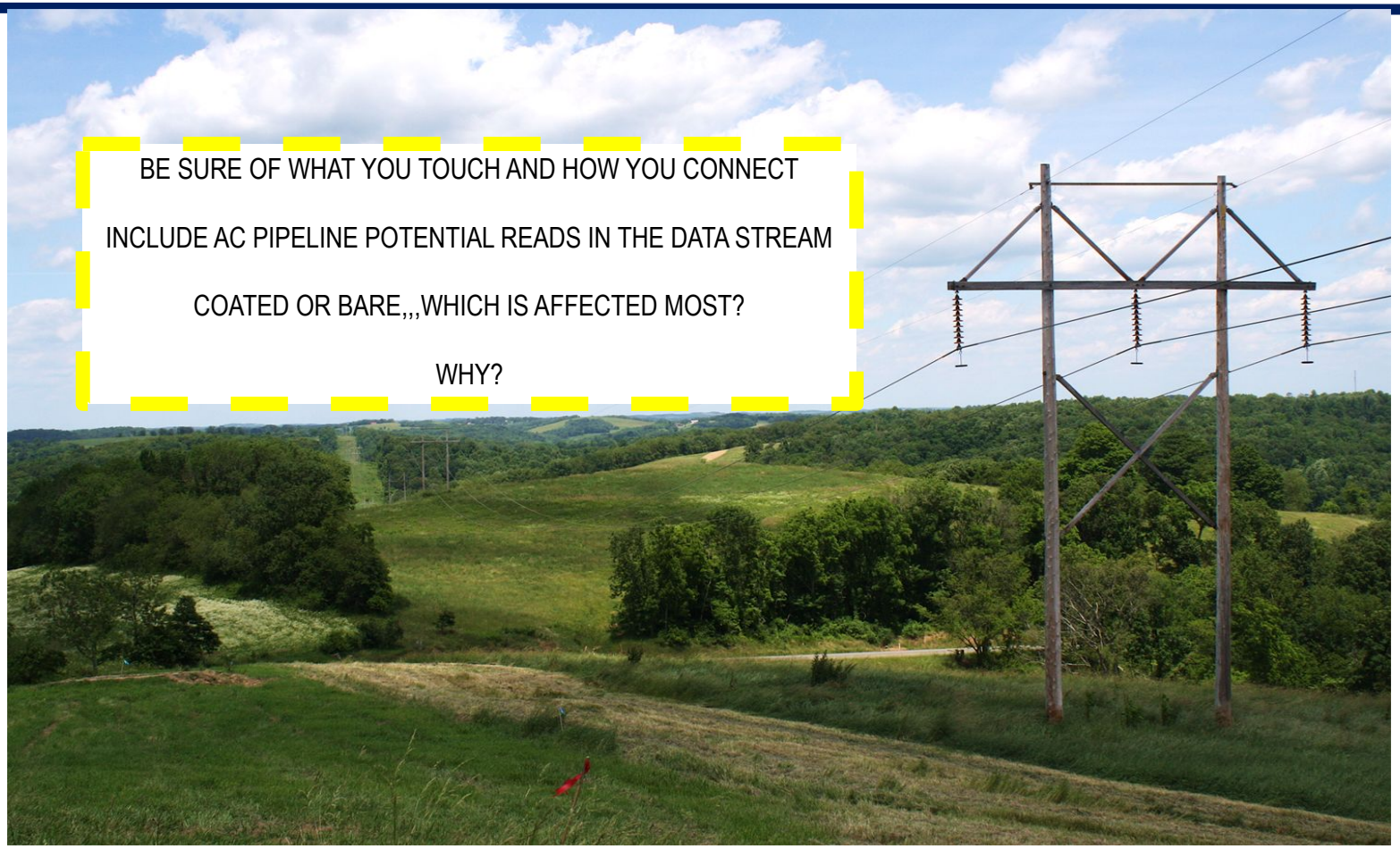
Pre-Survey Consideration

- ***Know the CIS Specifications and Requirements***
- Set a Pre-Job meeting with the Corrosion vendor or request one with the Operator
    - PPE and Safety Requirements (NACE SPO 0177)
    - Required OQ covered tasks for CIS crew
    - Scope of work (Where and What type of CIS will be preformed)
    - Review list of DC current sources to be interrupted
    - What Interruption cycle will be used
    - Special Features during data collection (Unusual line crossings, offset or flush test stations, AC mitigation devices)
    - Review any land owner or ROW access issues
    - Required Daily Reports and Daily Communication
    - Problems that may encountered during data collection process (uncut ROW, frozen ground, weather delays, Telluric, Static or dynamic DC sources)

Paralleling AC Corridors? Safety is Paramount



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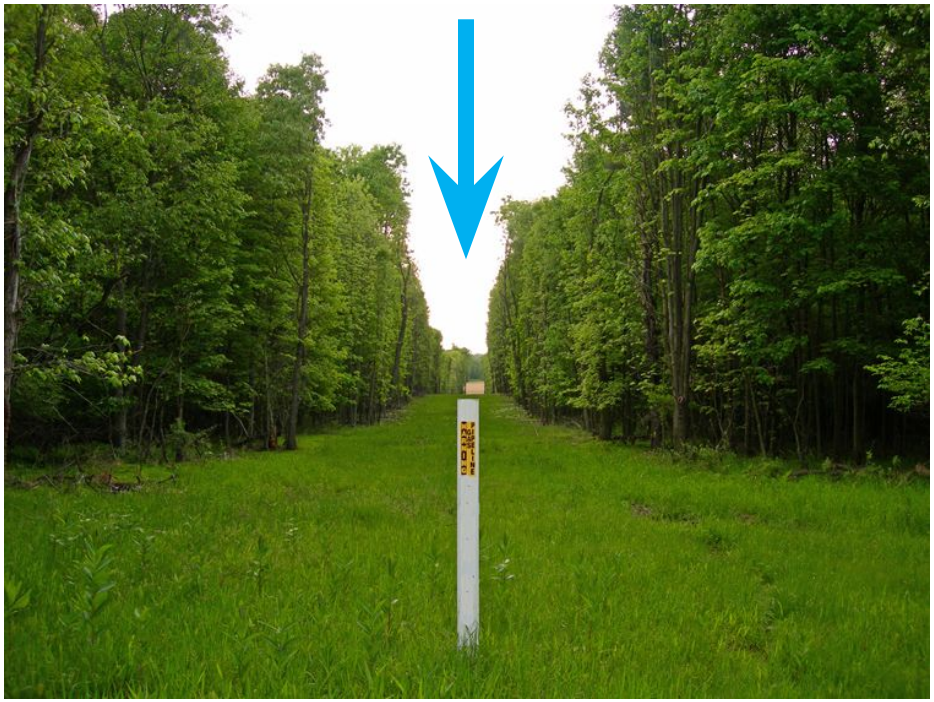
ROW Mowed or Not?



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Pre Survey Consideration

- Specifications Cont'd
  - Historical Data
    - Type of CP applied
    - Annual Test Point Inspections
    - Evaluation of historical rectifier outputs
    - Electrical bonds with Foreign structures or across isolation devices
    - Previous CIS data
  - Mapping and Alignment Sheets:
    - Test Points / Rectifier locations
    - Test Station wiring configurations
    - Tie-in points and location of electrical Isolation devices
    - Pipeline mapping or goggle earth files

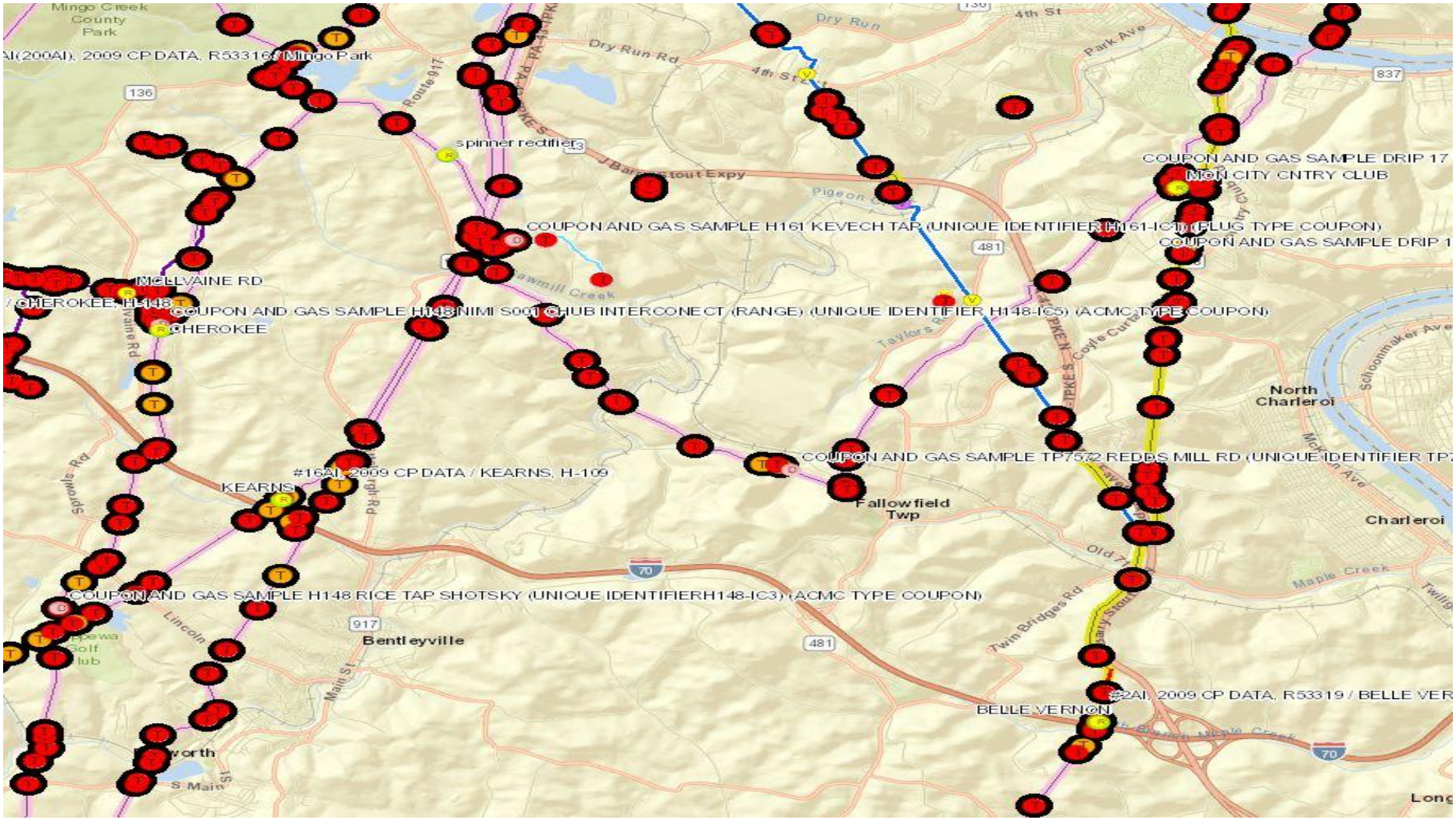
Pre-Survey Test Point Information

Facility	AssetNumber	InspectionDate	StructurePS	StructureIRF	CasingPS	ForeignPS	ForeignIRF	Technician	Latitude	Longitude
Pipeline-1	P1-TP10	9/18/2014	-2.672	-1.476	-0.529			DLR	39.94716	-80.13893127
Pipeline-1	P1-TP10	7/22/2015	-2.466	-1.089	-0.539			BRS	39.94716	-80.13893127
Pipeline-1	P1-TP10	7/18/2016	-2.423		-0.559			RJS	39.94716	-80.13893127
Pipeline-1	P1-TP11	9/18/2014	-2.235	-1.47		-1.314	-1.273	DLR	39.95998	-80.13088989
Pipeline-1	P1-TP11	7/23/2015	-2.228	-1.095		-1.472		BRS	39.95998	-80.13088989
Pipeline-1	P1-TP11	7/21/2016	-2.13			-1.41		RJS	39.95998	-80.13088989
Pipeline-1	P1-TP12	9/18/2014	-2.402	-1.581		-1.363		DLR	39.96117	-80.13009644
Pipeline-1	P1-TP12	7/22/2015	-2.162	-1.119		-1.337		BRS	39.96117	-80.13009644
Pipeline-1	P1-TP12	7/21/2016	-2.073			-1.921		RJS	39.96117	-80.13009644
Pipeline-1	P1-TP13	9/18/2014	-2.364	-1.535		-1.38	-1.378	DLR	39.96346	-80.12945557
Pipeline-1	P1-TP13	7/23/2015	-2.129	-1.038		-1.389		BRS	39.96346	-80.12945557
Pipeline-1	P1-TP13	7/21/2016	-2.024			-1.349		RJS	39.96346	-80.12945557
Pipeline-1	P1-TP14	9/18/2014	-2.115	-1.407		-2.175		DLR	39.96681	-80.12885284
Pipeline-1	P1-TP14	7/23/2015	-2.032	-1.026		-1.3		BRS	39.96681	-80.12885284
Pipeline-1	P1-TP14	7/18/2016	-1.933			-1.323		RJS	39.96681	-80.12885284

Pre-Survey Influencing Rectifier Information

Facility	AssetNumber	FacilityID	Latitude	Longitude	Inspection Date	Tap Settings	Rectifier Output Volts Found	RectifierOutput Current Found	Tech
Pipeline - 1	Pipeline1-RT01	A1	39.96685791	-80.1112442	5/1/2017	B-4	27.69	10.2	RJS
Pipeline - 1	Pipeline1-RT02	WARD	40.0201683	-79.9968338	5/1/2017	D-3	36.18	14.53	RJS
Pipeline - 1	Pipeline1-RT03	THOMPSON	40.03536606	-80.05788422	5/1/2017	C-1	39.66	7.69	RJS
Pipeline - 1	Pipeline1-RT04	HUD M-82	39.90620422	-80.14971161	5/1/2017	C-4	38.33	10.08	RJS
Pipeline - 1	Pipeline1-RT05	M78 - RT 221 RUFF CK	39.94706345	-80.13899994	5/1/2017	B-3	17.68	3.06	RJS
Pipeline - 1	Pipeline1-RT06	PRATT STATION #47	39.912323	-80.12850952	5/1/2017	C-2	27.08	9.47	RJS
Pipeline - 1	Pipeline1-RT07	EDGAR #1 PRATT	39.95070267	-80.12539673	5/1/2017	A-2	4.86	0.61	RJS
Pipeline - 1	Pipeline1-RT08	HAWKINS #1 - H-106	39.94681931	-80.11604309	5/1/2017	A-3	14.55	4.04	RJS
Pipeline - 1	Pipeline1-RT09	CASTILE RUN #1	39.9718895	-80.10402679	5/1/2017	A-3	14.36	3.53	RJS
Pipeline - 1	Pipeline1-RT10	PYLES	39.96728516	-80.10668182	5/1/2017	A-6	17.98	3.65	RJS
Pipeline - 1	Pipeline1-RT11	VRBANIC	39.9522934	-80.07000732	5/1/2017	A-6	23.68	13.63	RJS
Pipeline - 2	Pipeline2-RT01	JEFFERSON H-111	39.92829895	-80.06137085	5/1/2017	A-3	4.86	0.57	RJS
Pipeline - 2	Pipeline2-RT02	REESE - H109	40.03881454	-80.15016937	5/1/2017	B-2	15.2	5.58	RJS
Pipeline - 2	Pipeline2-RT03	JEFFERSON COMP STA	39.90927505	-80.07463074	5/1/2017	B-4	26.08	11.49	RJS
Station - 1	Station1-RT01	IO COMP STATION	39.95553207	-80.13075256	5/1/2017	A-4	5.09	5.18	RJS
Station - 2	Station2-RT02	JUPITER CS 2	39.96892929	-80.11095428	5/1/2017	B-4	15.06	12.29	RJS
Foreign Operator - 1		MOWL RD	40.11929	-80.18359	4/10/2017	A-2	13.14	10.4	

Pre-Survey Corrosion Asset Mapping



PRE-SURVEY CONSIDERATION

- Specifications Cont'd
  - Instrumentation and Equipment
    - Volt Meter / Data Loggers
      - High Input Resistance – 10 Mega-ohm or greater
      - High Input Impedance – 100 Mega-ohm and able to filter 25vac of induced AC
      - Meter's calibrated annually documentation
    - Reference Electrode
      - Type – Saturated Copper/Copper Sulfate
      - Reference Cell Balance/Calibration Intervals (Typically within 5mV)
    - Pipeline Location
      - Measurement Techniques – GPS / Slope Chain
      - Depth of Cover

Close Interval Survey Equipment

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SURVEY CONSIDERATON

- Survey Specifications
  - Interruption
    - Cycle Time – On: Off (3/1) ratio
    - Interruption Starting Position – “On” or “Off”
    - How will the rectifier be interrupted? (DC or AC side)
    - GPS Synchronized
    - Usage of portable interrupters or remote monitoring interruption?
    - AC Mitigation Devices (SSD/PCR) interruption capacitance effect
    - Method to interruption bonds or electrical isolation devices

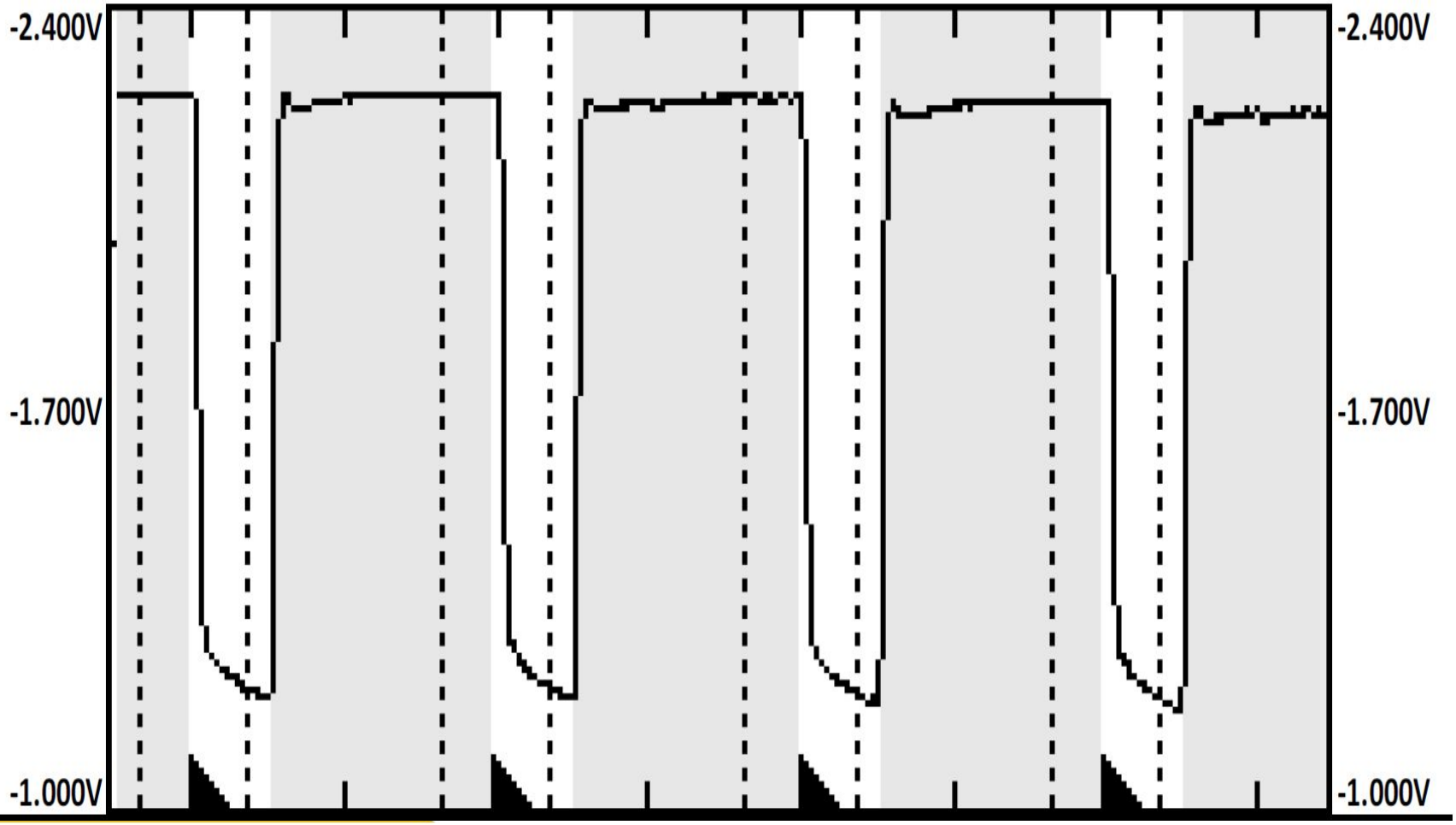
SURVEY CONSIDERATON

- Survey Specifications
  - Pipe-to-Electrolyte Potentials
    - Potential Measurements Interval and Range
    - Survey Lead Connections – (-)Ref. Electrode (+)Structure
    - Field Data Collection
      - Electrolyte Contacts – Concrete/Asphalt/Casings/Bores
      - Far Ground / Structure IR Drop / Near Ground Potentials
      - Foreign / Casing / Points of Isolation / AC Potentials
      - Reconnect Frequency (Typically over 1000ft)
      - Communication on areas below -.850vdc instant off criteria **OR** instant off potential above -1.20vdc

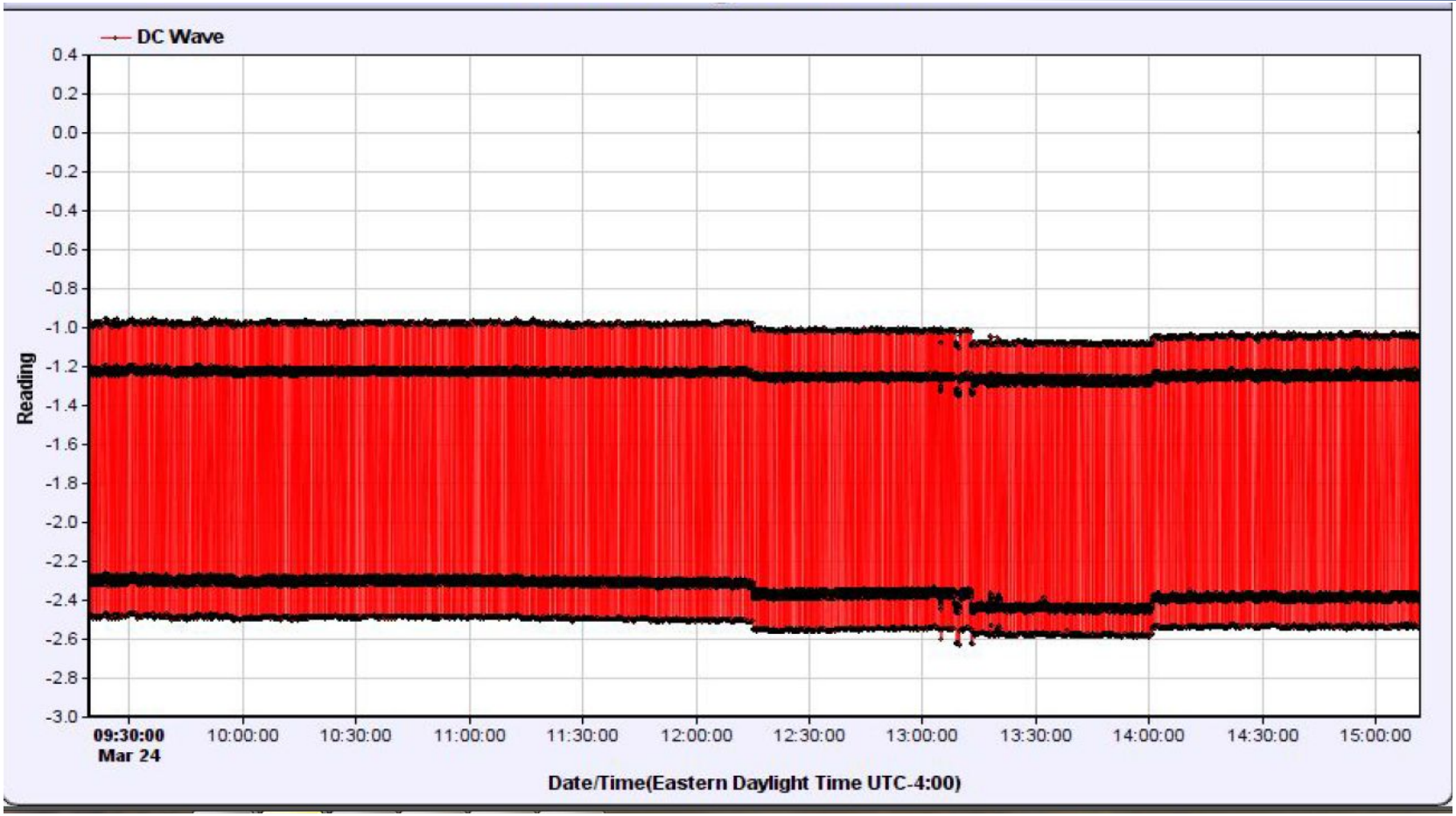
SURVEY CONSIDERATON

- Survey Specifications cont'd:
  - Measuring and Stationing
    - GPS / Slope Chain / Wire Counters
    - Permanent Landmarks / Appurtenance / Other Features
  - Wave Prints
    - Predetermined specified intervals / Survey Irregularities
    - Used to help filter "spiking" and identify Interrupter Sync Issues.
    - Help determine delay time needed on data loggers for accurate data collection
  - Stationary Data Loggers that continuous monitor potential measurements during field data collection

GPS SYNC'D CIS WAVEPRINT



Stationary Logger Graph



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Post Survey Considerations

- Final Reports:
  - Operator Qualification documentation
  - Depth of Cover and areas of exposure
  - Listing of all Rectifiers, Bonds, and Anodes interrupted during Survey
    - Rectifier Output and Tap settings – “As Found” and “As Left
  - List of all permanent Test Stations with all data Information required
    - AC potentials, Far Ground, Structure IR, Near Ground
    - Foreign, Casing, Isolation Point Potentials
    - Damaged (No Contact to pipe)
  - Summary of areas not meeting the CP criteria being evaluated
    - Potentials < -.850V “On” current applied surveys
    - Potentials < -.850V IR Free “Instant Off” Interrupted
    - Areas not meeting 100mv Polarization with respect to Native or Depolarized Surveys.
    - Negative Potentials above the specification (More negative than -1.20vdc instant off potential)

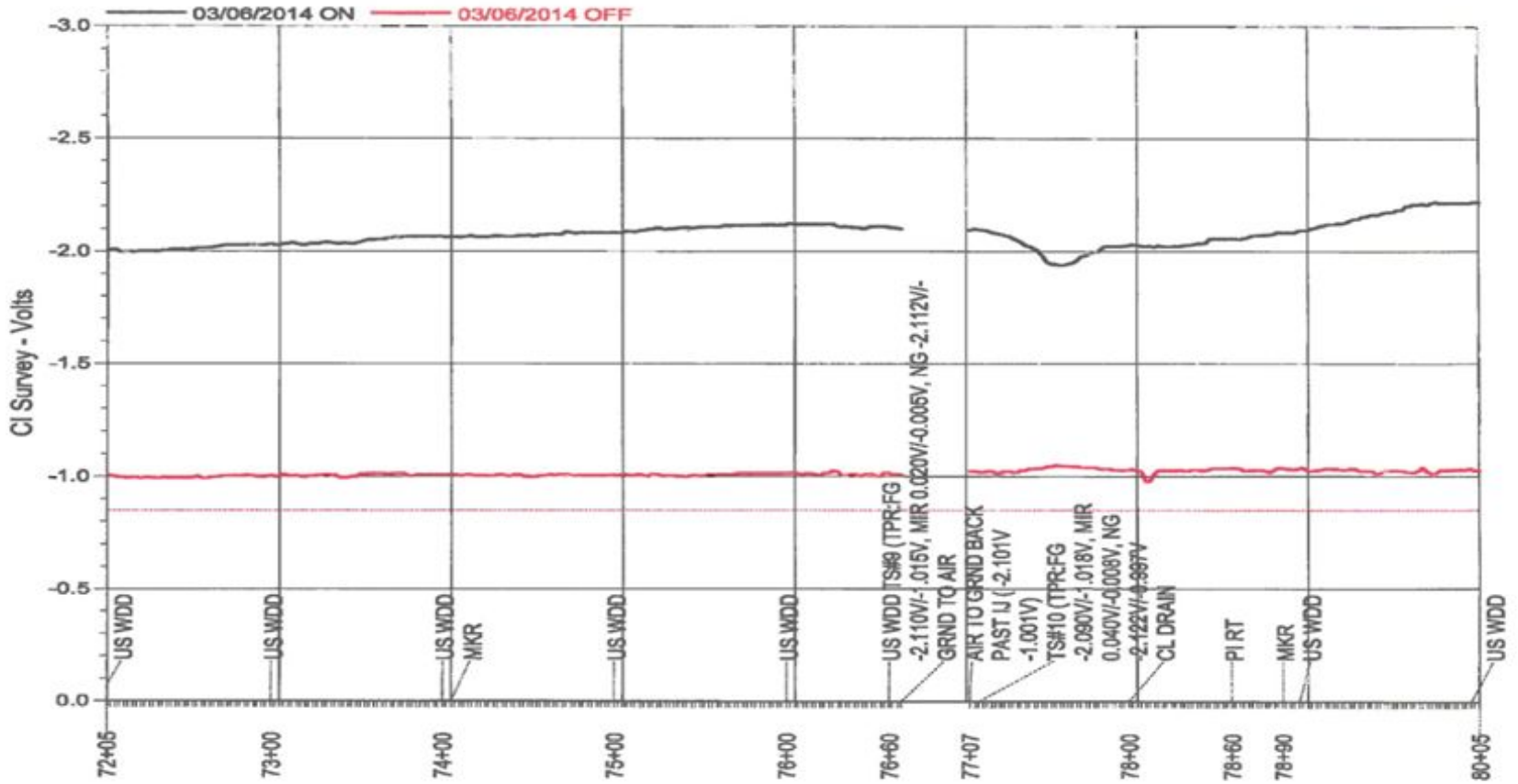
Post Survey Considerations

- Final Report Cont'd:
  - Data Graphs
    - Each type of potential easily distinguished.
      - Usually Color coded
    - Legend may Include:
      - Client / Operator Name, Survey Date
      - Structure or Asset name
      - Interruption Cycle times
      - Surveyor Name
    - Survey measurement: GPS'd – Stationing
      - Test Stations and Above Ground Appurtenances
      - Areas of Skip Potentials – Public Roads, Casings, Bores, Exposures
      - Points of Intersections / Geographical Features

Post Survey Considerations

- Final Report Cont'd
  - Wave Prints
  - Continuous Logging
  - Deliverables:
    - Bounded Reports
    - Electronic Reports
      - File Formatting: (.pdf, .xls, .svy)
- Remedial Recommendations
  - Cathodic Protection Adjustments
  - Criterion change considerations
  - Additional Survey requirements – ACVG / DCVG
  - Confirmation / Repair Digs

Desired Results "Impressed Current" CIS Graph



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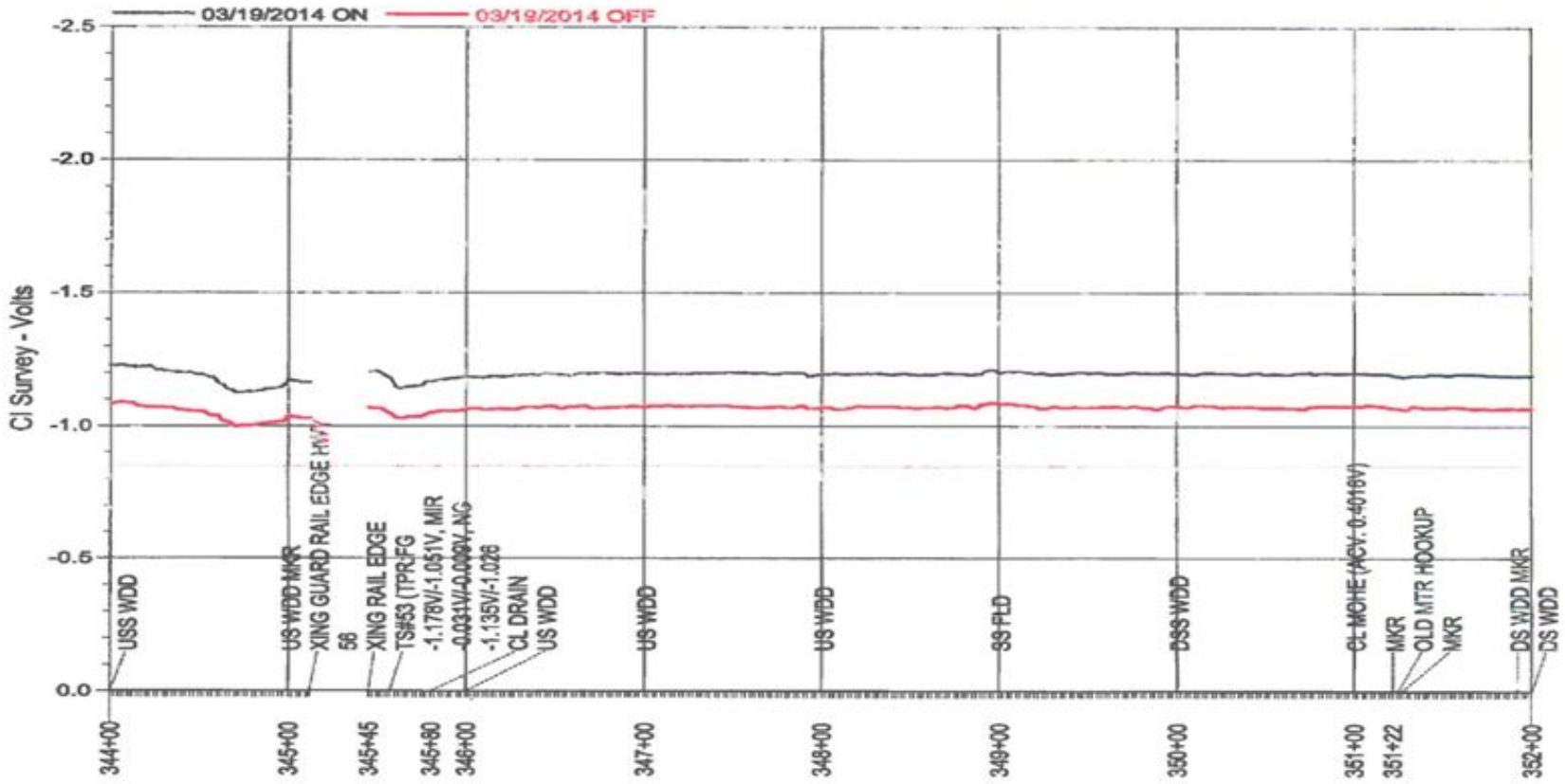
Desired Result "Galvanic Protection" CIS Graph



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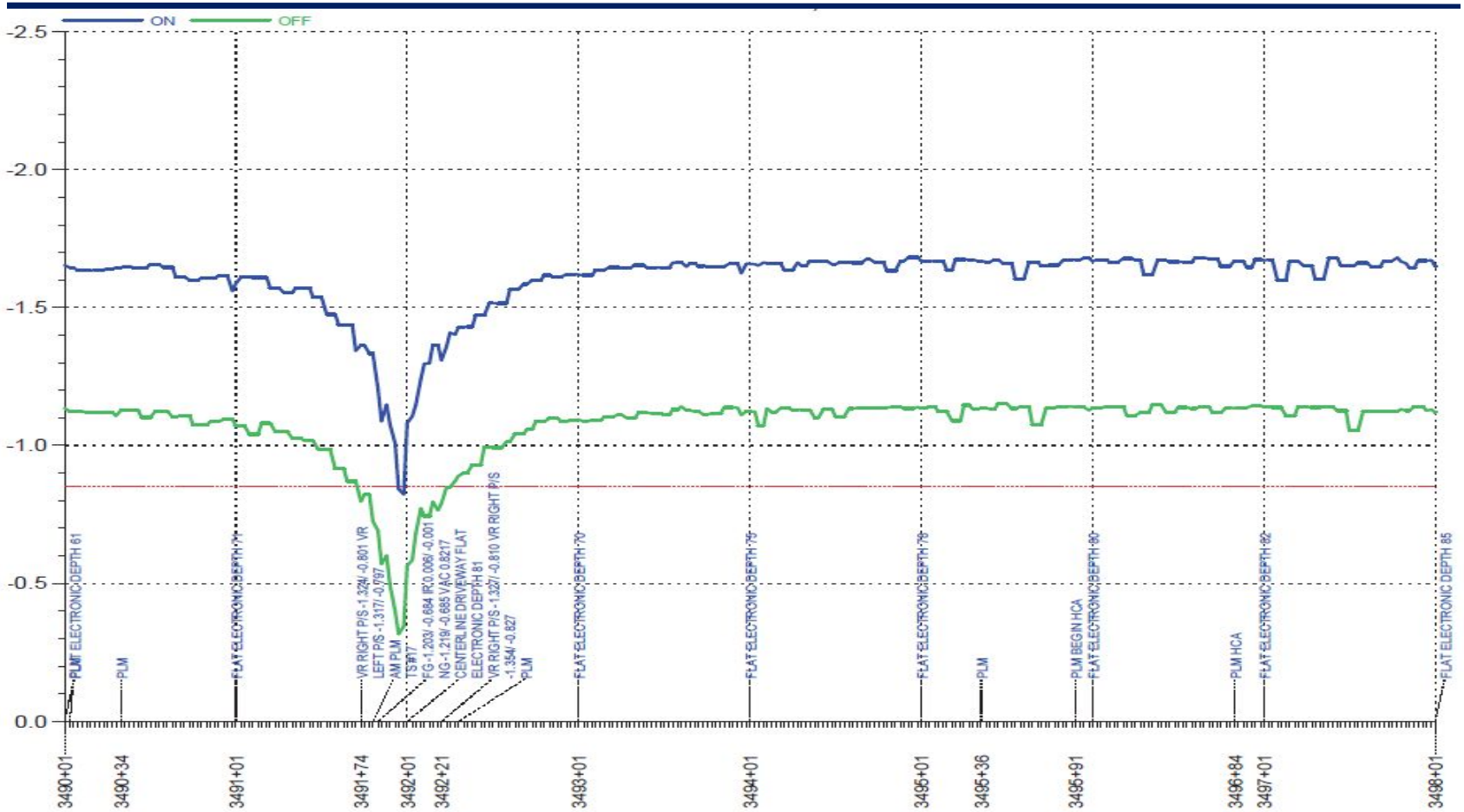
CIS Data Evaluation

Let's look at a unique CIS low potential area and what steps were taken to evaluated and remediate.

Positive Shift in Potentials/Concern?



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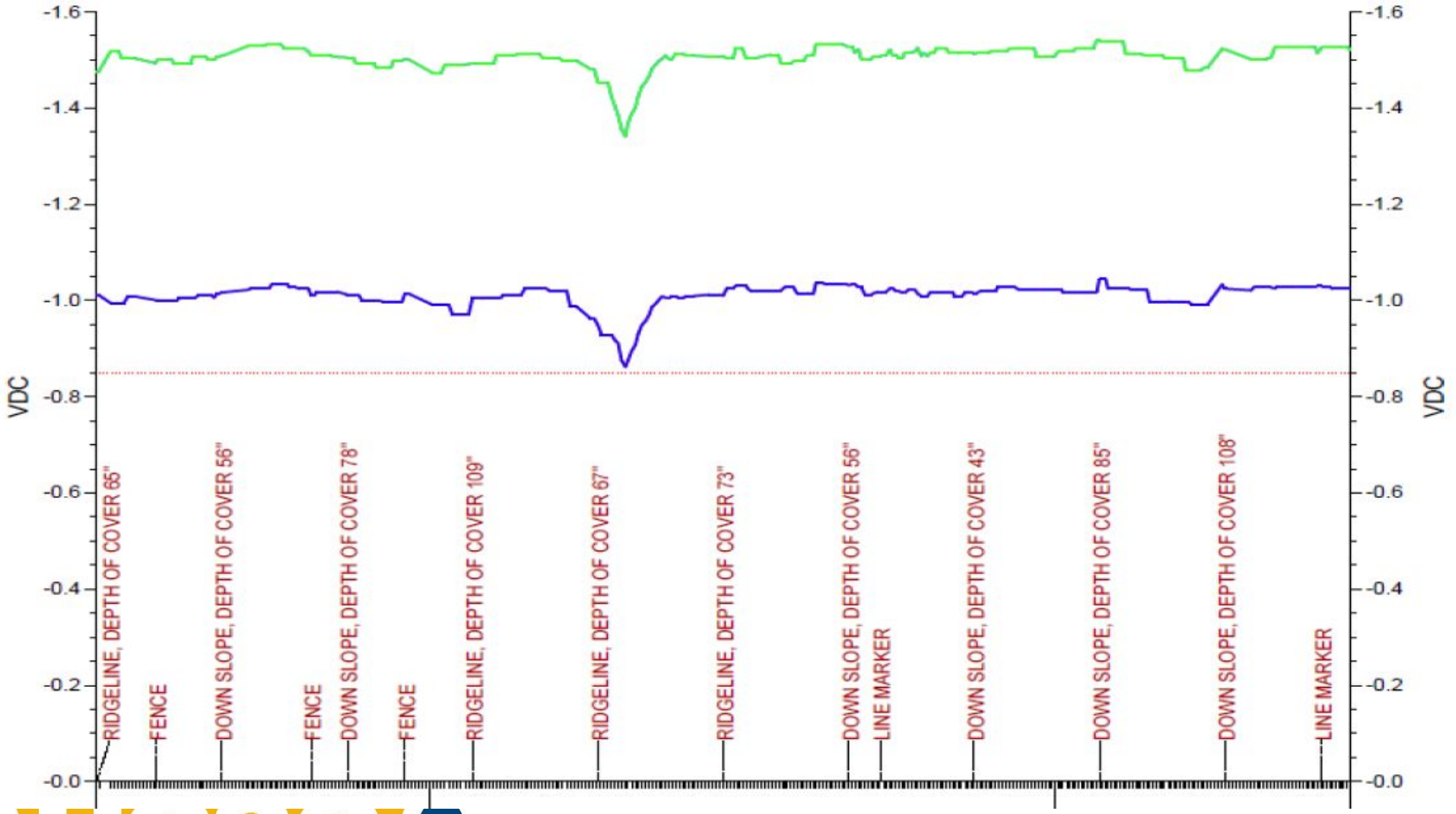
Positive Shift in Potentials/Concern?



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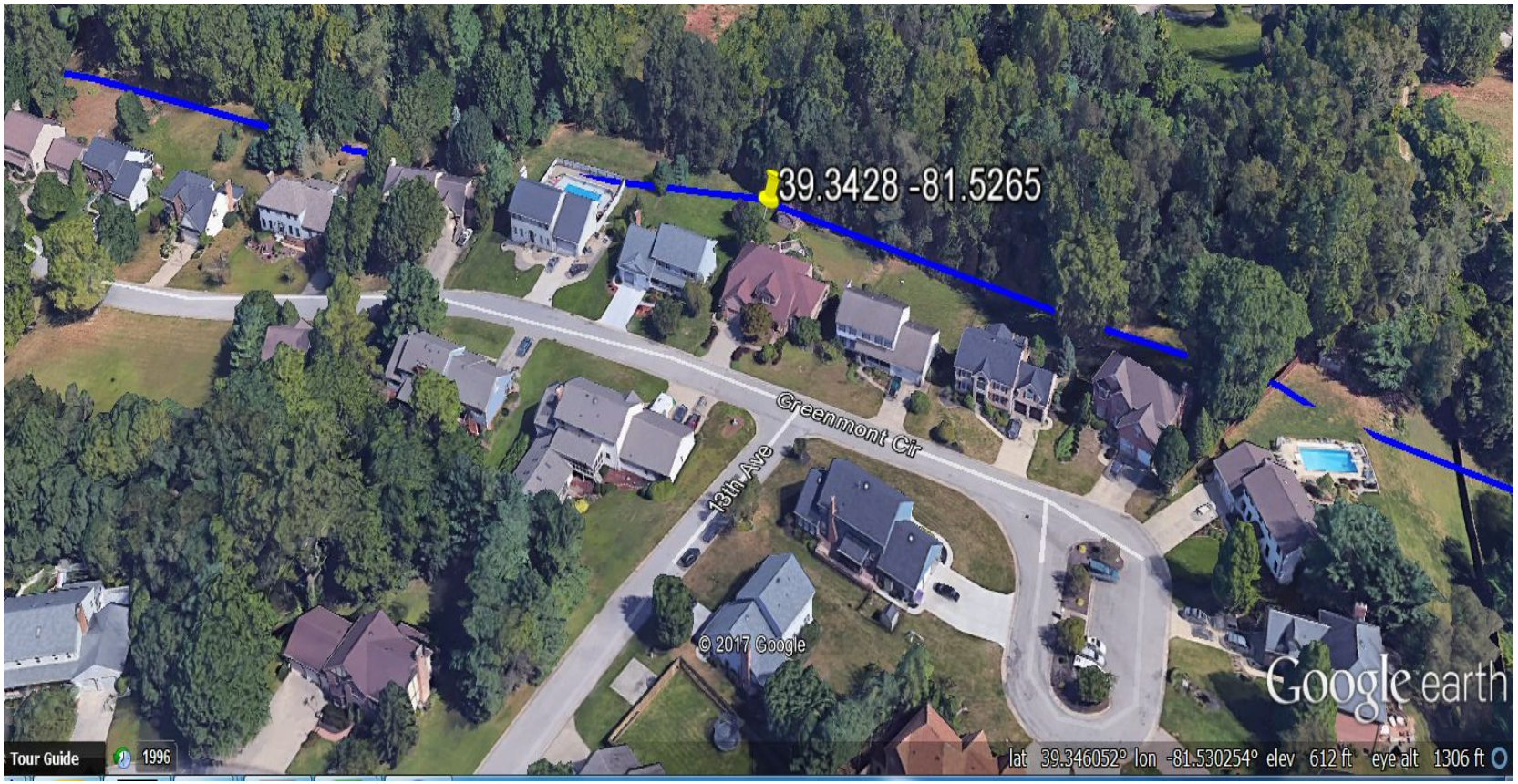
Location/Location/Location



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Field Evaluation Low Potential Areas

- Field verification of data confirmed low potential areas
- Coating quality tests did not reveal any significant coating damage (ACVG)
- Evaluation of stationary data loggers showed no problems with rectifier interruption
- Evaluation of previous CIS data did not show low potential areas
- Plan to excavate pipeline to evaluate

Field Evaluation Low Potential Area

- During excavation found broken telephone cable directly over low potential areas

The DC potential measurements on the telephone cable was **-26.0vdc and 9.0vac**

- Potential at pipe interface **-1.50vdc/-1.10vdc cse**
- Contact telephone company to confirm abandoned cable was still energized.
- Installed epoxy splice kit to isolate cable from ground
- Resurvey low potential areas to confirm remediation/compliance and properly documented findings

Broken Telephone cable

Broken Telephone cable

SUMMARY

- A CIS PROVIDES A CONTINUOUS PIPE-TO-SOIL POTENTIAL PROFILE OF THE PIPELINE
- DETERMINES EFFECTIVENESS OF THE CATHODIC PROTECTION BEING APPLIED TO SYSTEM.
- A POWERFUL ANALYSIS TOOL THAT CAN BE INTEGRATED WITH INLINE INSPECTION DATA
- DATA MUST BE TECHNICALLY ACCURATE TO ENSURE PIPELINE SAFETY AND COMPLIANCE
- REMEMBER: GARBAGE “IN” = GARBAGE “OUT”

Like a Walk in the Park

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