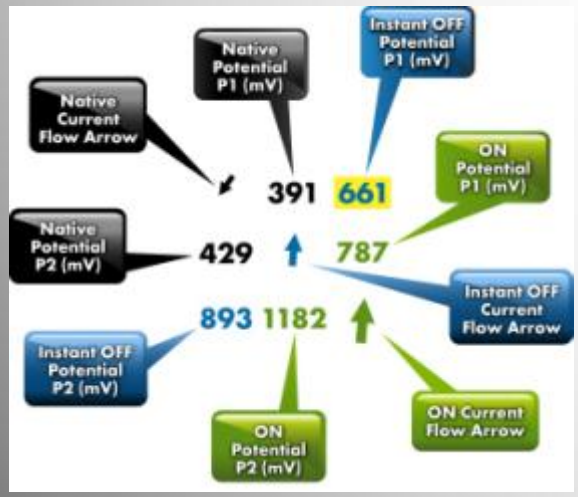
The Advancement of Direct Assessment Methodologies for Difficult-to-Assess Piping

Area Potential Earth Current Inspections for station piping



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Presentation Overview

- Direct Assessment for Difficult-to-Assess Piping
- Review of Cathodic Protection Measurement and Indirect Inspection Principles
- Area Potential - Earth Current (APEC) Survey Overview
- APEC Planning and Logistics
- APEC Survey Data Collection Process
- Review Example of APEC Survey Results

Direct Assessment

- DA is one of the four pipeline integrity methods used to verify pipeline integrity as mandated by DOT
  - Hydrostatic testing
  - In-Line Inspection (pigging)
  - Direct Assessment (DA)
  - Other Technologies
- Based upon the threats of concern for a pipe segment, DA can be used to assess pipe integrity in regards to:
  - External Corrosion
  - Internal Corrosion
  - Stress Corrosion Cracking
- DA is an applied engineering practice consisting of four well documented steps
  - Pre-Assessment
  - Indirect Inspections
  - Direct Inspections
  - Post-Assessment

DA for Difficult-to-Assess Piping

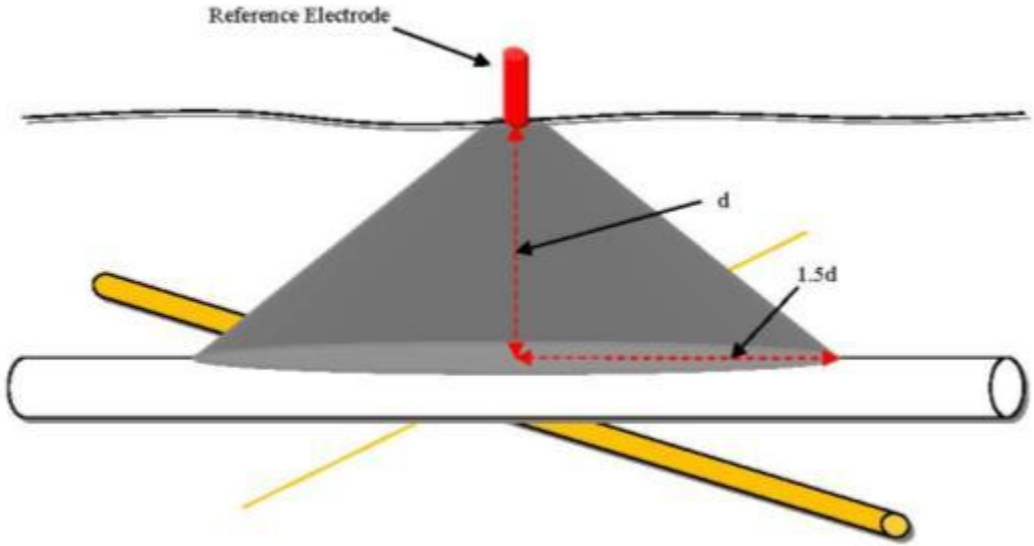
- Questions for Today
  - What is Difficult-to-Assess Piping?
  - What limitations on traditional assessment techniques must be addressed?
  - How can we successfully apply Direct Assessment?
  - Is Direct Assessment feasible??

Difficult-to-Assess Piping

- Difficult-to-Assess Piping consists of locations where traditional indirect inspection tools such as CIS, DCVG and ACCA are limited in their ability to differentiate locations where corrosion control systems are functioning or inadequate
- Examples include
  - Plants or stations that are tied to the common grounding system
  - Locations of congested piping
  - Multiple pipeline corridors
  - Casing....
  - Any location where electrical continuity adversely effects indirect inspection results

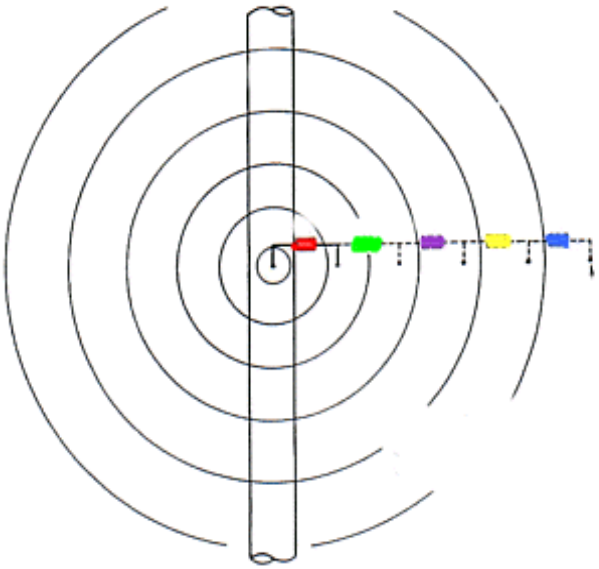
Half Cell Measurements and Mixed Potentials

- A half cell measurement is actually an area measurement of mixed potentials consisting of the soil and all subsurface structures that are exposed to the environment
  - For example, the steel piping below may have a native potential of around -400mV, but the copper may be closer to -200mV
  - The resulting area potential will most likely be closer to -300mV
  - Analysis of this location by potentials alone could lead to erroneous conclusions regarding active corrosion cells



Direct Current Voltage Gradient Surveys

- Walking over pipeline
- IR drop creates voltage gradient in soil
- Gradient leads to epicenter
- Soil contact important
- One surveyor
- Voltage gradient fields are established in the soil around a defect.
- The current source is interrupted at a signature frequency and an analog or digital voltmeter with 2 reference probes is used to locate the coating holidays.



Limitations of Traditional Techniques

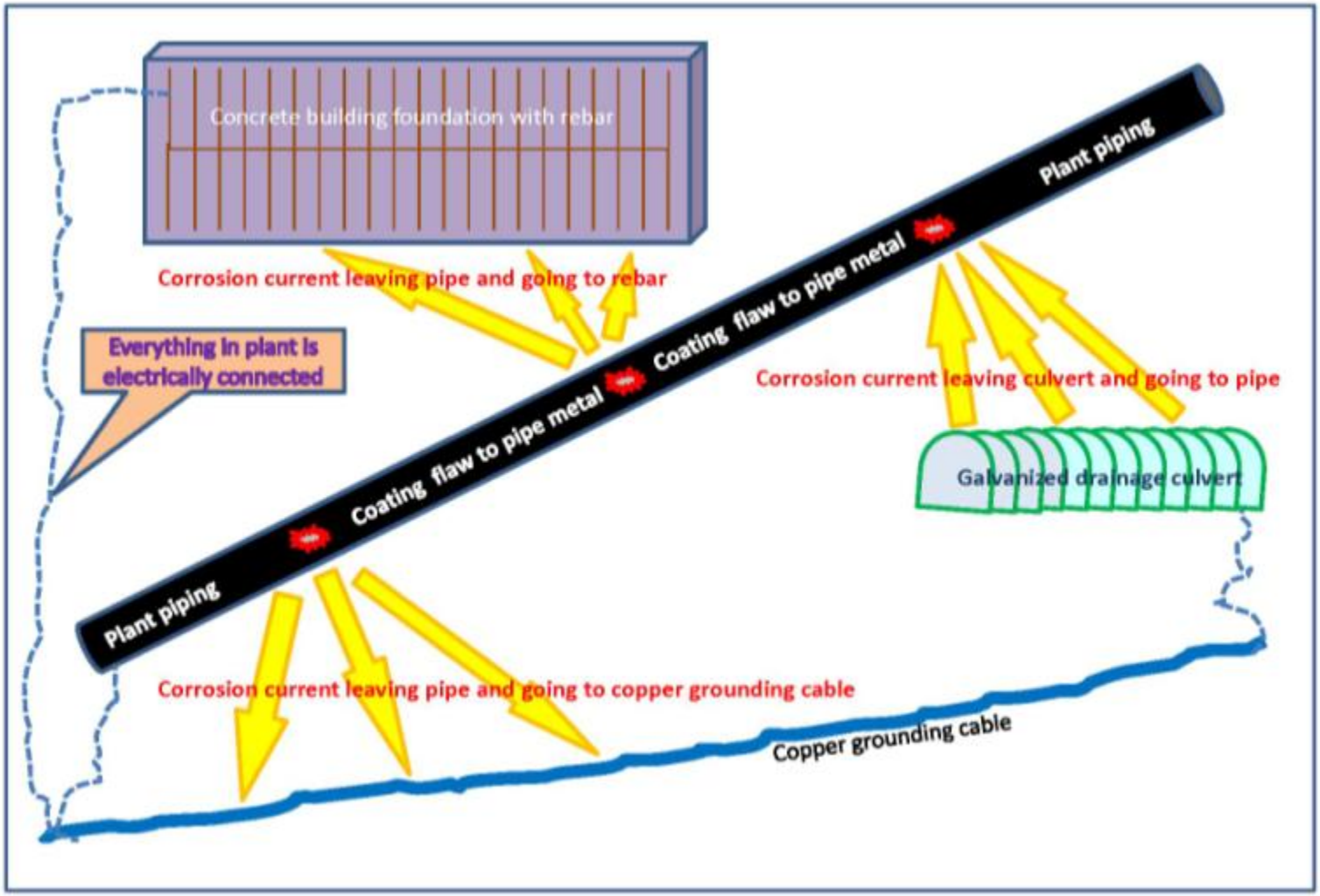
CIS

- Additional structures drastically influence the potential measurements of the structure intended for assessment.
- Low potential indications may be a factor of adjacent structures, not a lack coating or cathodic protection.

DCVG

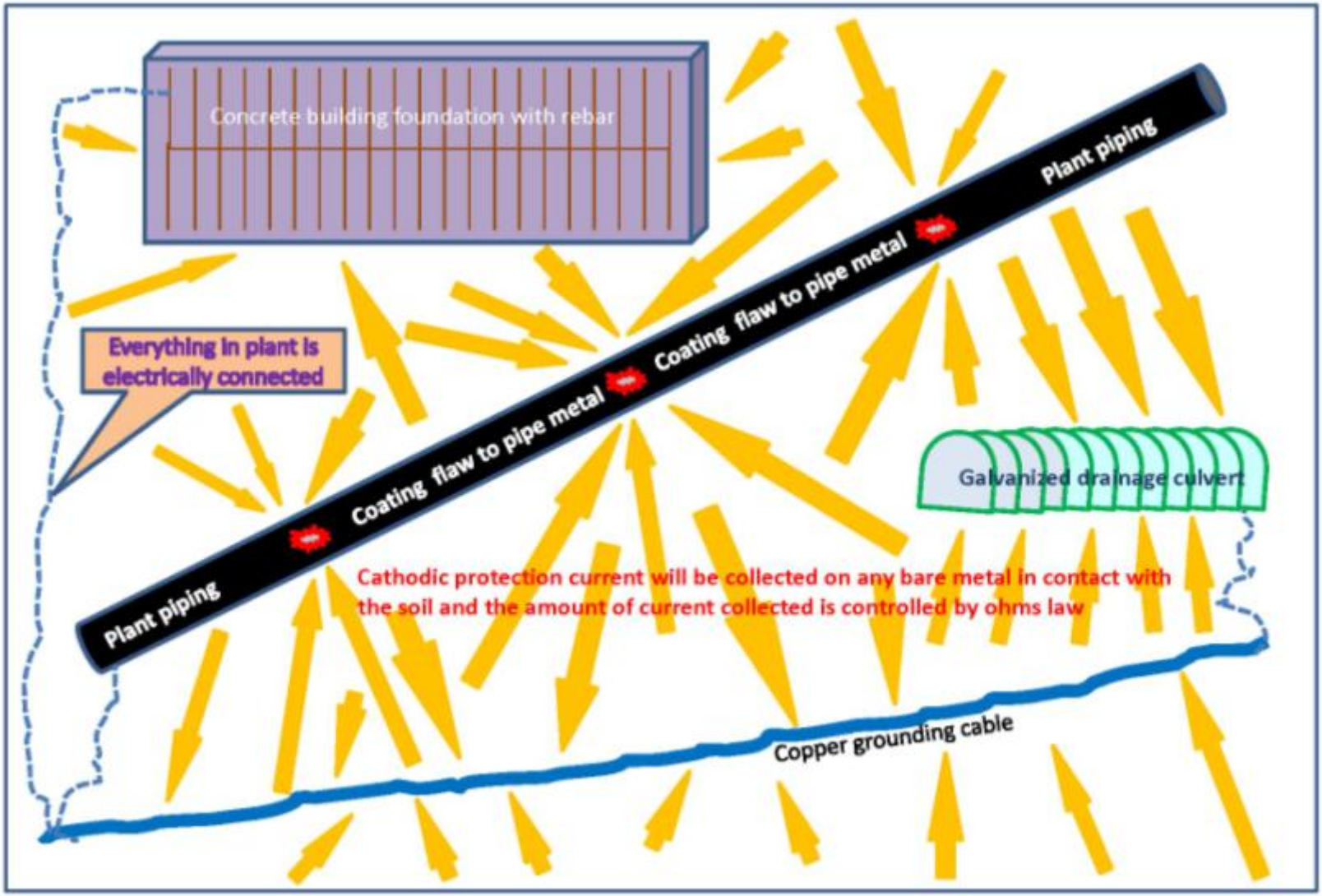
- Voltage gradient indications may be masked by adjacent coating holidays or structures.
- Locating coating holidays and remote earth measurements may be infeasible.

Native Conditions



POSSIBLE SCENARIO OF NATIVE CORROSION CURRENT MIGRATION BETWEEN VARIOUS BURIED PLANT STRUCTURES

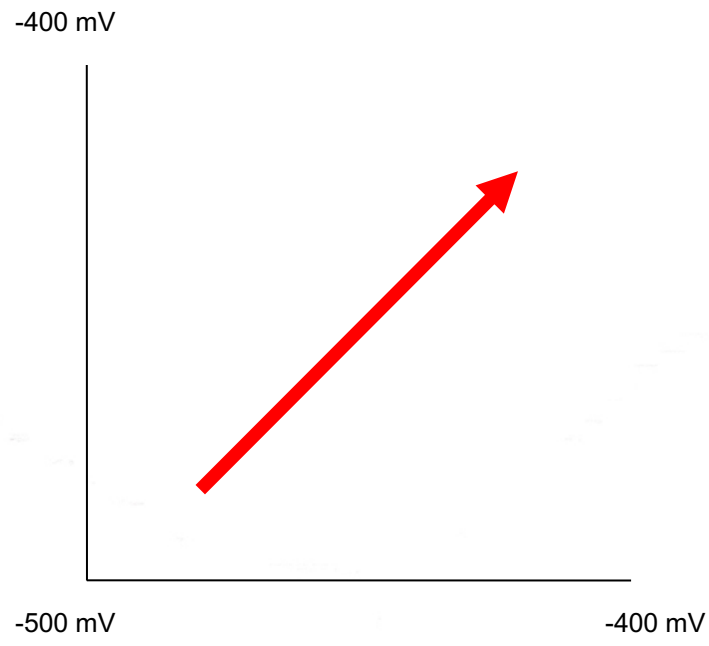
With CP System On



POSSIBLE SCENARIO OF CP CURRENT MIGRATION TO VARIOUS BURIED PLANT STRUCTURES

Voltage Gradients and Earth Current Vectors

- By collecting three half cell readings simultaneously in a grid pattern, voltage gradients can be measured between the half cell
- These voltage gradients can then be converted into earth current vectors in a polar coordinate system, allowing for easier data interpretation in a real world environment
- In the example on the right, the area potentials measured result in 100 mV gradients in the x and y coordinate directions, resulting in a 45 degree earth current gradient

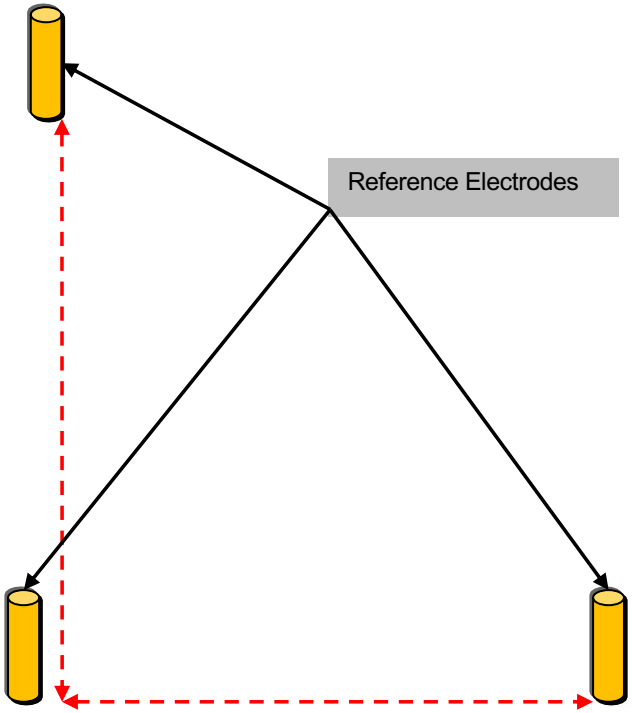


The objectives of an APEC inspection are to:

- Identify where polarization levels are present, indicating adequate cathodic
- Identify localized changes in the measured potentials, relative to surrounding readings, as a means to locate potential areas containing corrosion cells,
- Identify localized variations in earth currents, relative to surrounding readings, that would imply coating degradation,
- Identify how to mitigate the risk of further corrosion,
- Identify prioritized areas where direct examination of the piping may be warranted

APEC Overview

- Uses industry standard equipment
- Employs principles of both Close Interval Survey - CIS (used to gauge CP system effectiveness in controlling pipe corrosion) and Voltage Gradient Surveys - (used to identify coating degradation)
- The novelty is that we are using three half-cells simultaneously during the cell-to-cell survey. This permits the observation of corrosion currents within a highly congested area – which is an indication of the relative corrosion activity.

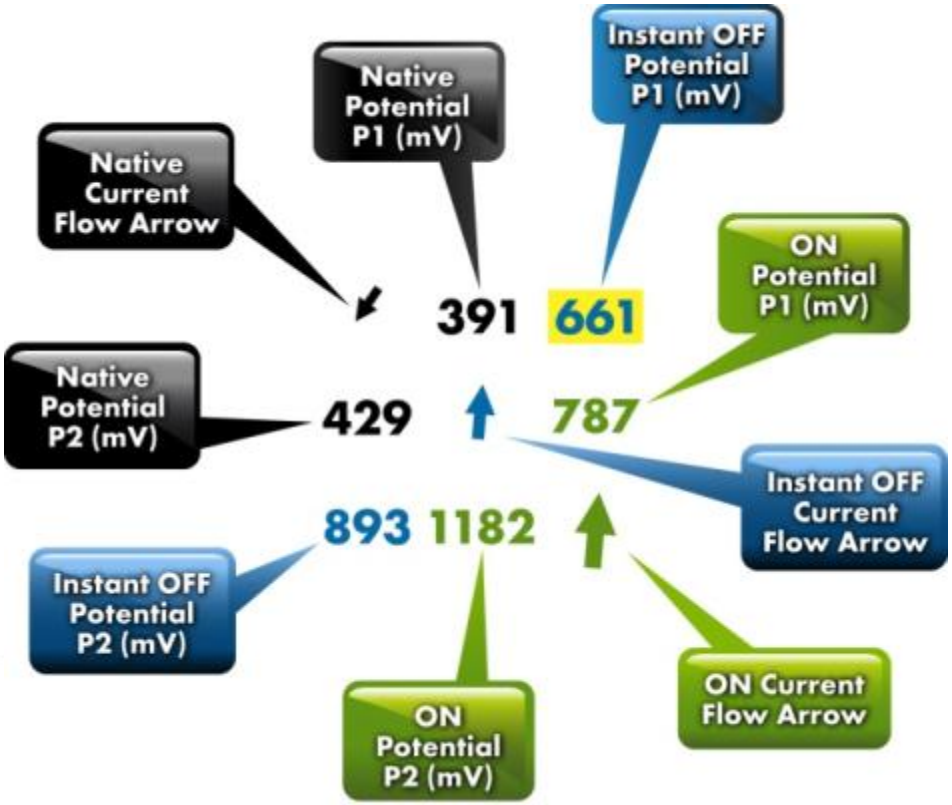


Area Potentials and Earth Current Gradients

Some possible analysis conclusions for localized areas in a station or plant may include:

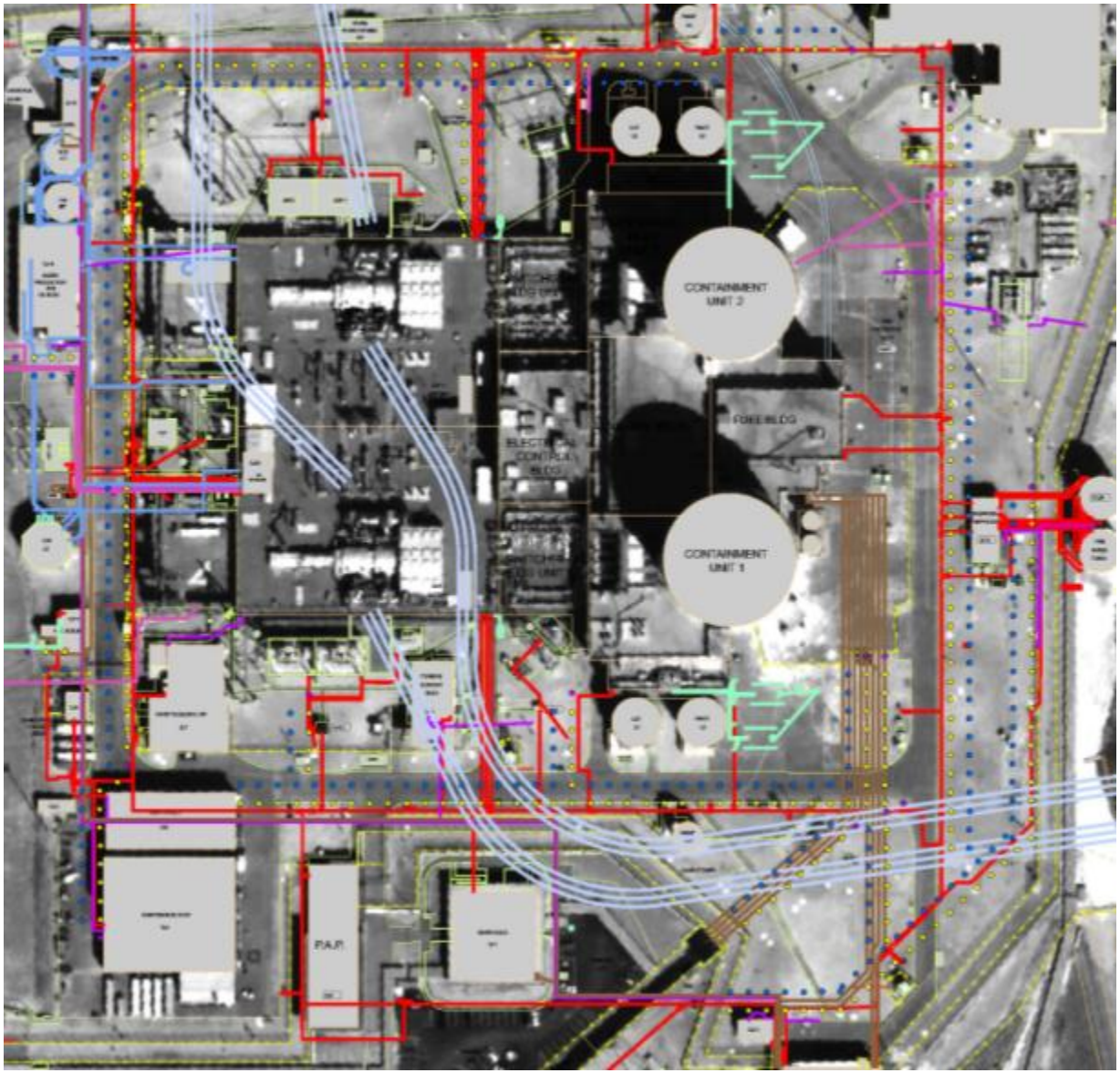
1. AP values not meeting polarization levels with large EC flow may be associated with locations of coating degradation requiring remediation
2. AP values not meeting polarization levels with small EC flow may be associated with locations requiring CP remediation to provide supplemental current to provide adequate CP
3. AP values meeting polarization levels with large EC flows may be associated with locations of coating degradation requiring future monitoring
4. AP values meeting polarization levels with small EC flows may be associated with locations of adequate CP current and coating

Difficult-to-Assess Piping



Planning & Logistics

- Data from client
  - Isometrics, yard drawings, schematics, pipe specifications, etc.
- Digitization of data
  - All data received from client is reviewed, organized and digitized into MAPProView™
  - Preliminary APEC Survey grids are laid out to provide the most effective coverage of buried piping within the plant
- Site visit
  - Lead engineer meets with client on-site for Q&A and a walk-down of the facilities
  - A final APEC Survey plan is completed and sent to the client for permitting and planning



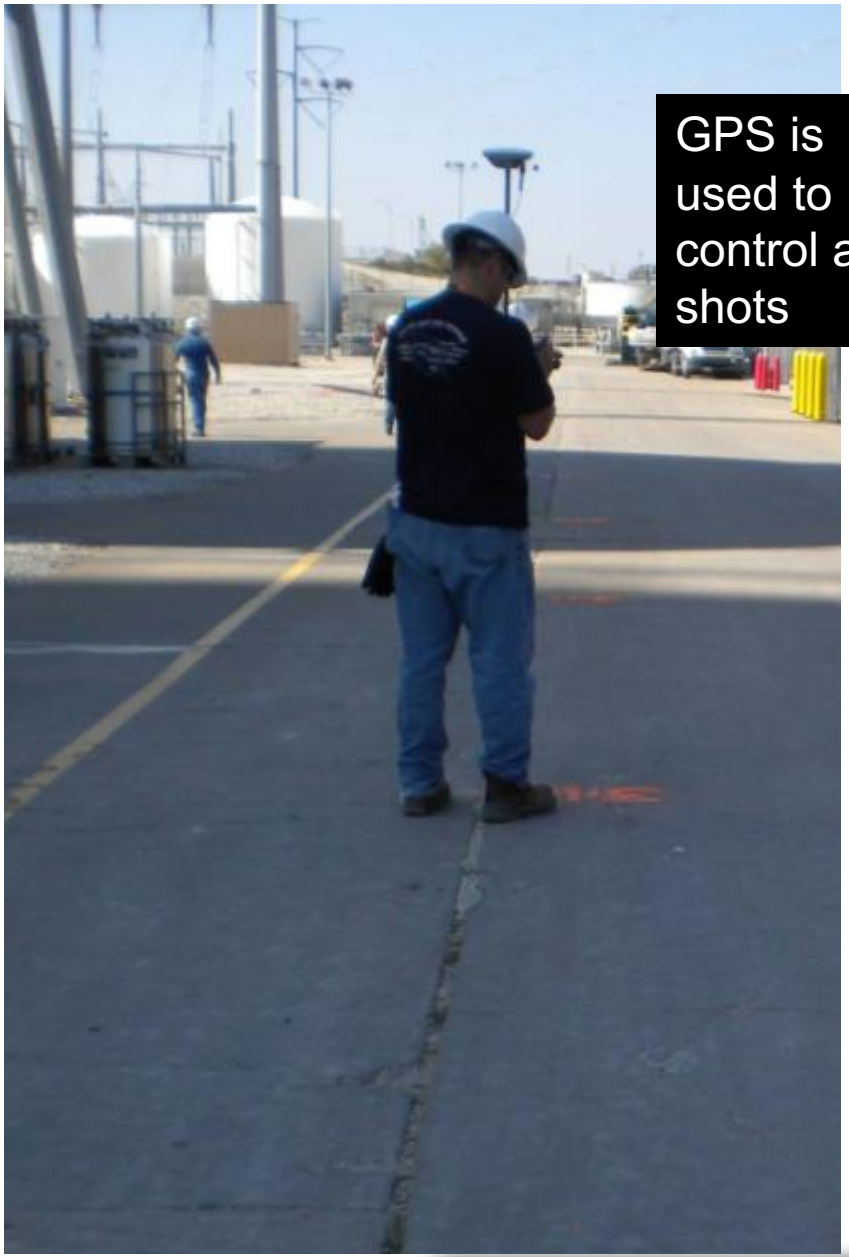
APEC Survey Plan Overview

APEC Survey

1. Turn off rectifiers to allow system to depolarize
2. Mark sites for measurements
3. Drill access holes (if applicable)
4. Perform native potential survey

APEC Survey

5. Install GPS synchronized interrupters at rectifiers
6. Reactivate rectifiers
7. Perform interrupted (On-Off) potential surveys
8. Remove & disassemble all inspection equipment



GPS is used to control all shots

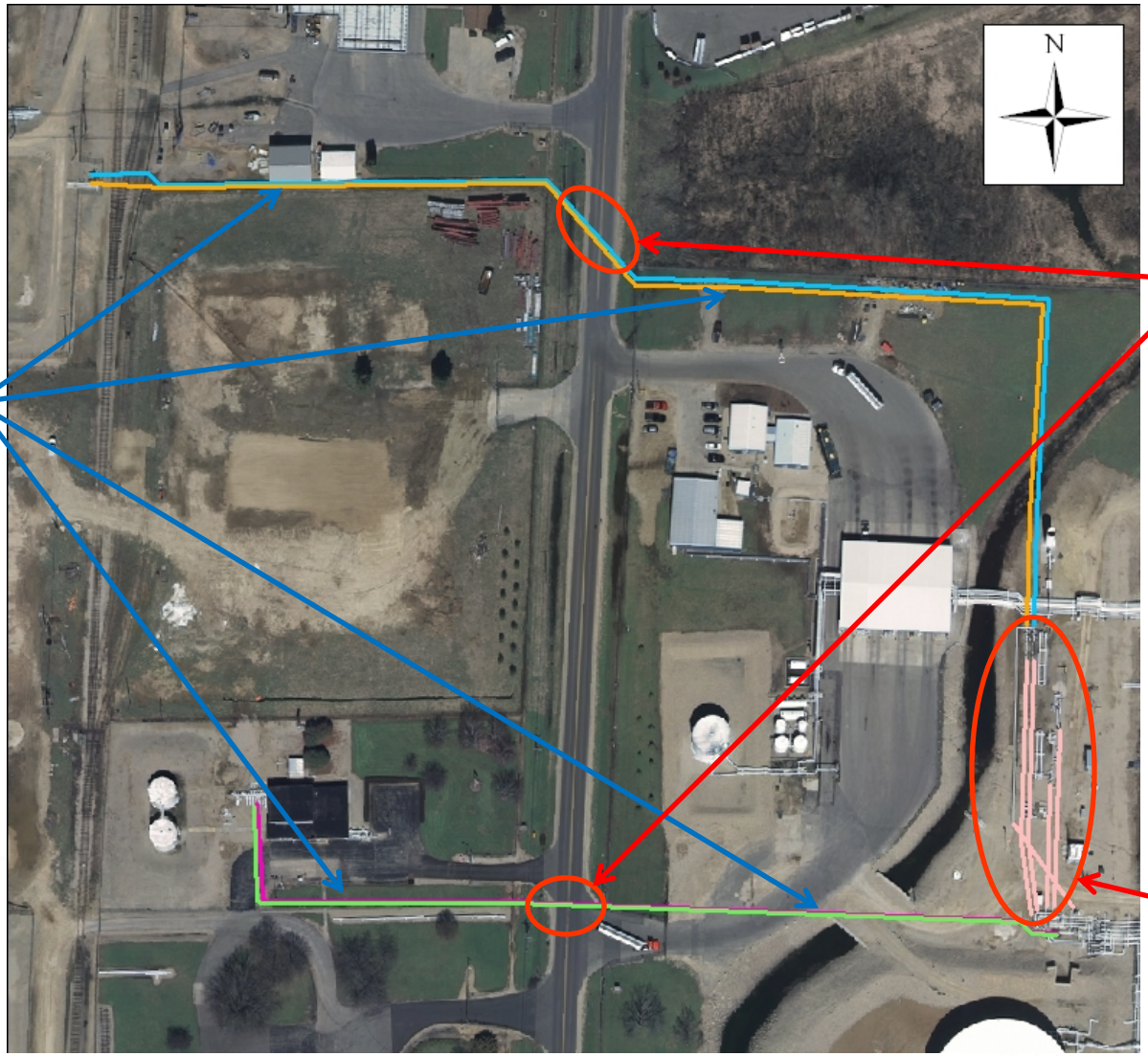
Case Study

- SI completed a corrosion assessment at fuel terminal in October of 2009
- Four regions were identified by the pre-assessment
  - Region 1 – Non-Cased buried piping for delivery lines
  - Region 2 – Above grade piping for the delivery lines
  - Region 3 – Cased buried piping for the delivery lines
  - Region 4 – Buried piping in the vicinity of the manifold
- The indirect inspections included:
  - Close Interval Pipe-to-Soil Potential Survey (CIS) and Direct Current Voltage Gradient Survey (DCVG) for Region 1
  - Area Potential Earth Current Gradient (APEC) for Region 4
  - Guided Wave Ultrasonic Testing (GWT) for Regions 2 and 3 (to be completed in September of 2010)

Case Study

- Results
  - No Immediate or Scheduled indications were identified
  - The indirect inspections showed no signs of active corrosion for any buried piping included in the testing (Regions 1 & 4)
  - Eight excavations were recommended for direct examination (Scheduled for September 2010)
    - Four for Region 1 (traditional buried piping)
    - Two for Region 3 (cased piping)
    - Two for Region 4 (piping located in the manifold)

Difficult-to-Assess Piping

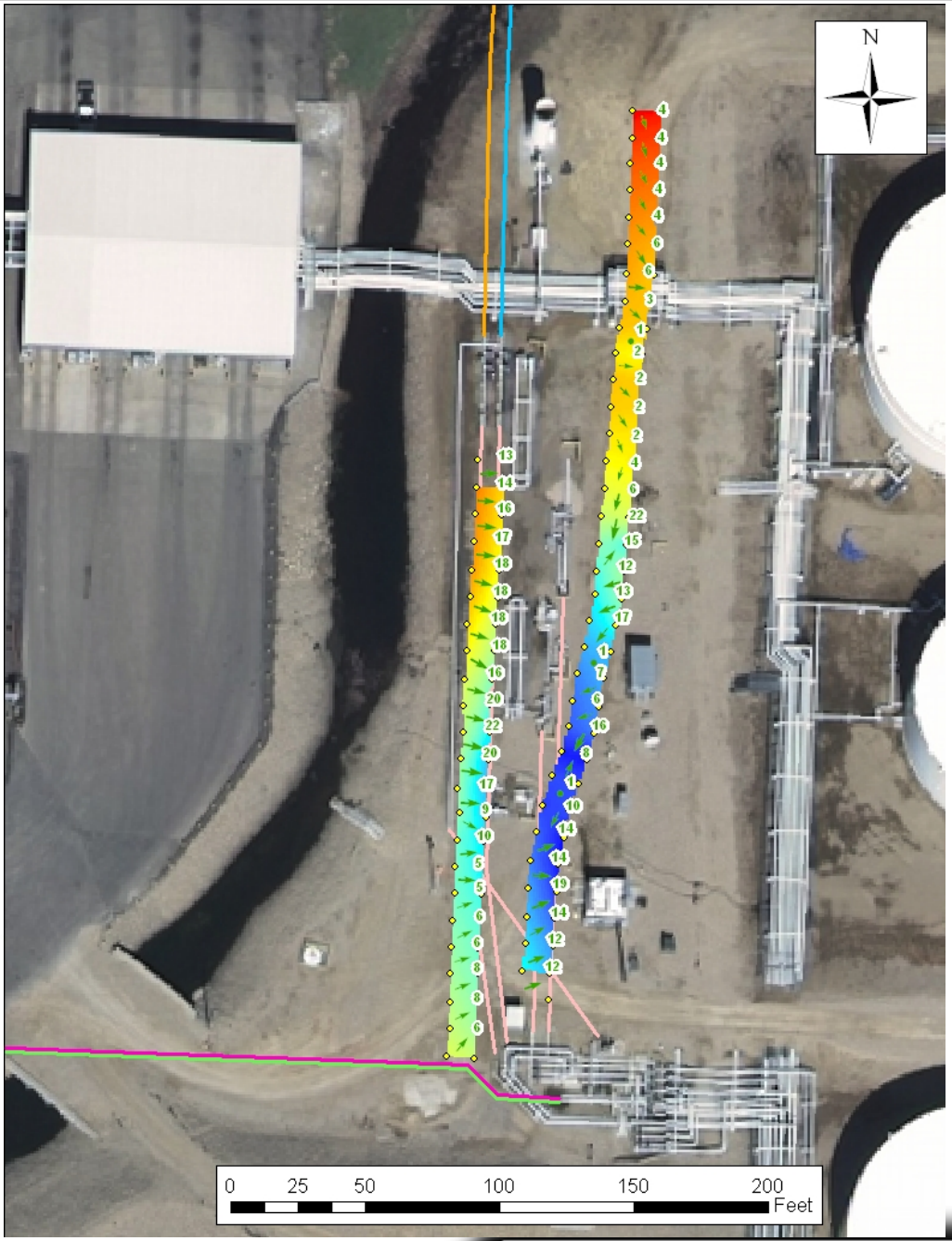


Case Study – APEC

- Four pipelines in Region 1
  - 4,055 feet of CIS & DCVG conducted
  - No On or Instant Off potentials were more positive than -0.850 Volts
  - 798 feet of pipe were designated as Minor CIS indications due to localized potential minimums (“dips”)
  - 20 DCVG indications were located
    - 19 classified as Minor (≤15% %IR)
    - 1 classified as Moderate (>15% and ≤35% %IR)
- 55 APEC grids were completed to inspect the buried manifold piping in Region 4
  - Six locations were identified as a Monitored ECDA Category
  - 17 grids displayed atypical current patterns associated with possible coating damage

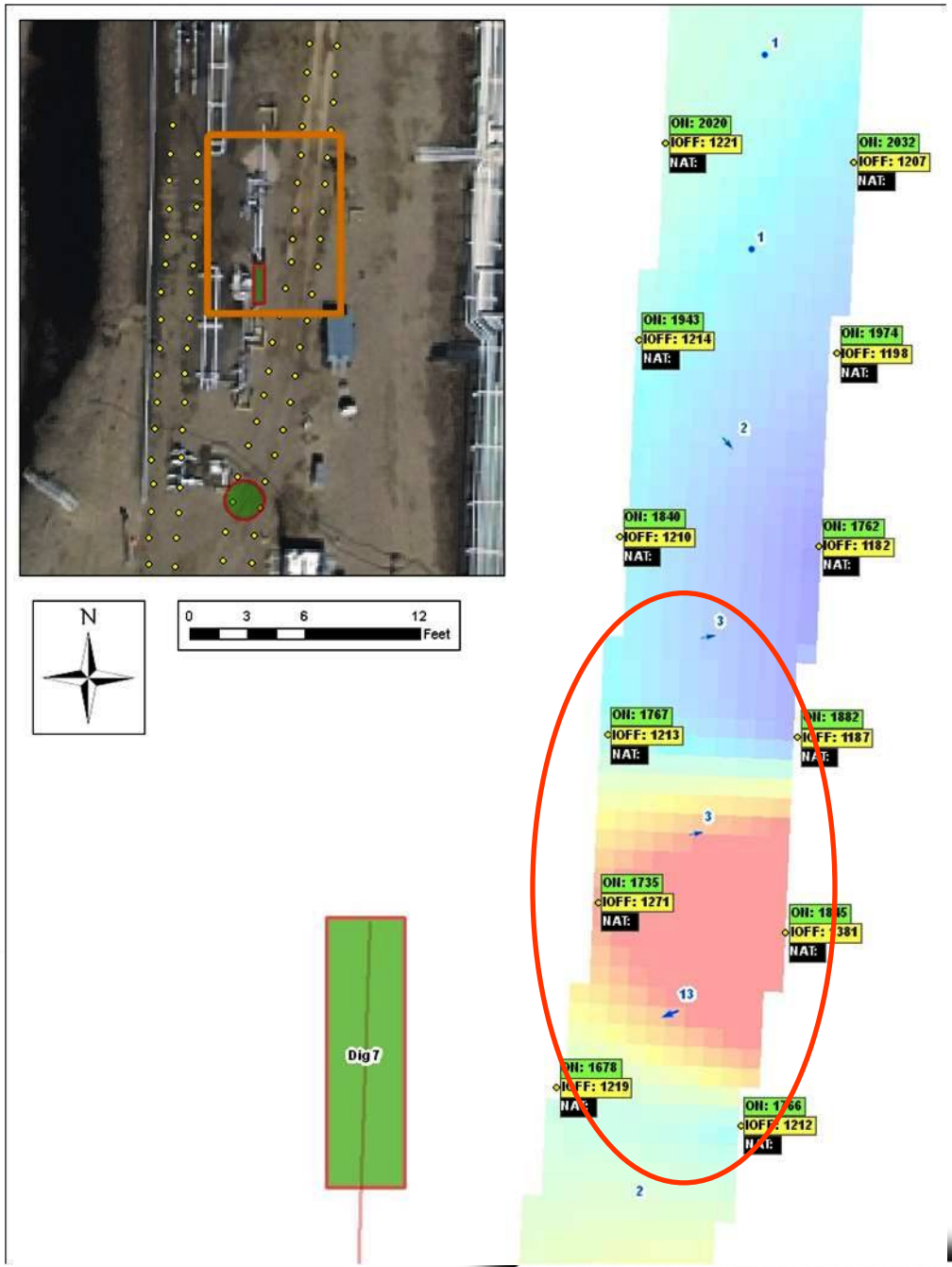
Case Study – APEC Results

- The figure to the right displays results of the Instant Off APEC measurements
- The arrows represent the earth current vectors
  - The larger the arrow, the larger the amount of earth current
- The color spectrum represents the range of potentials
  - Blue is the more positive values, red to more negative



Case Study – APEC Results

- Here we have an example of one of the recommended dig locations from the APEC Survey
  - The reversal in the current direction by the riser is the type of current pattern that indicates possible coating damage



APEC Potential Log Example

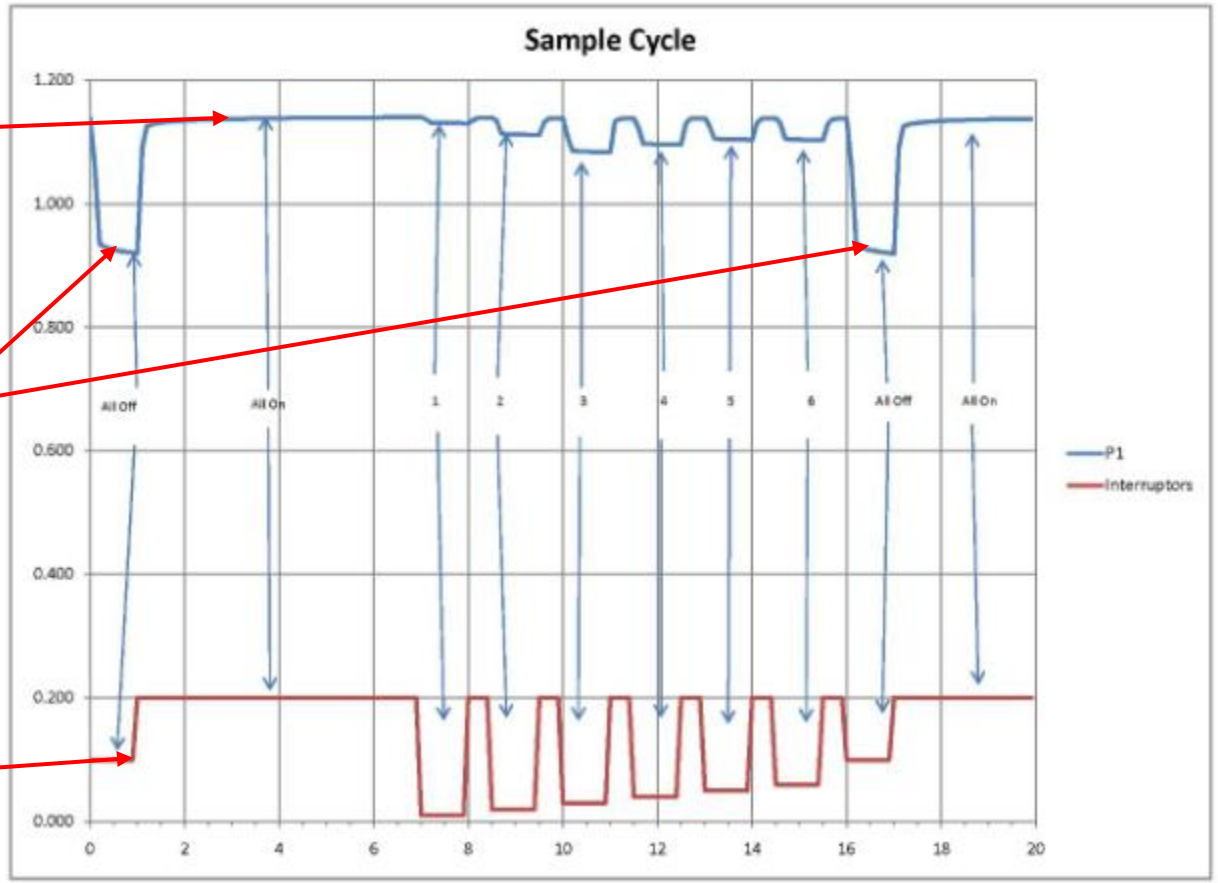
Below is an example of the interruption cycle used at a location with deep well anodes

As seen in the graph, all of the rectifiers are providing current at this location

Potentials plotted vs. time

Off cycles for all 6 rectifiers

Interruption cycle plotted vs. time



Conclusions

- Validating the integrity of pipe in complicated systems requires more than traditional survey methodologies
- APEC is a survey method for assessing buried piping within a congested network of piping and buried structures typically found in a plant
- Understanding current distribution will facilitate targeting locations with potential coating degradation and corrosion cells for direct examinations
- Direct Assessment, if properly conducted, is feasible for Difficult-to-Assess piping
- We have come a long way and learned a lot of lessons since the first implementations of RP-0502 – it is now time to use those lessons and continue improving assessment techniques and pipeline integrity

Thank You

Questions?

Structural Integrity Associates, Inc.

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