



THE **LEADER** IN ENERGY INFRASTRUCTURE

# Asbury Well #10 CP Testing Report

**Work Order: 112733848**

Developed for



Rev	Date	Originated By	Reviewed By	Approved By
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## 1 Background

Xcel Energy (“Xcel”) engaged Campos EPC (“Campos”) to perform cathodic protection (“CP”) testing in response to a theorized gas generation issue at Asbury Well #10. This testing was planned to assess the following assets in the Grand Junction, CO area:

- a) Asbury Well #10;
- b) Asbury Well #15; and
- c) 625090 - 4" Asbury Well No 10.

Testing was requested to better understand the requirements of the assets as well as further investigate the interaction between Asbury Well #10 and the kml\_57 ground bed.

An overview of the assets can be found in [Figure 1] below.

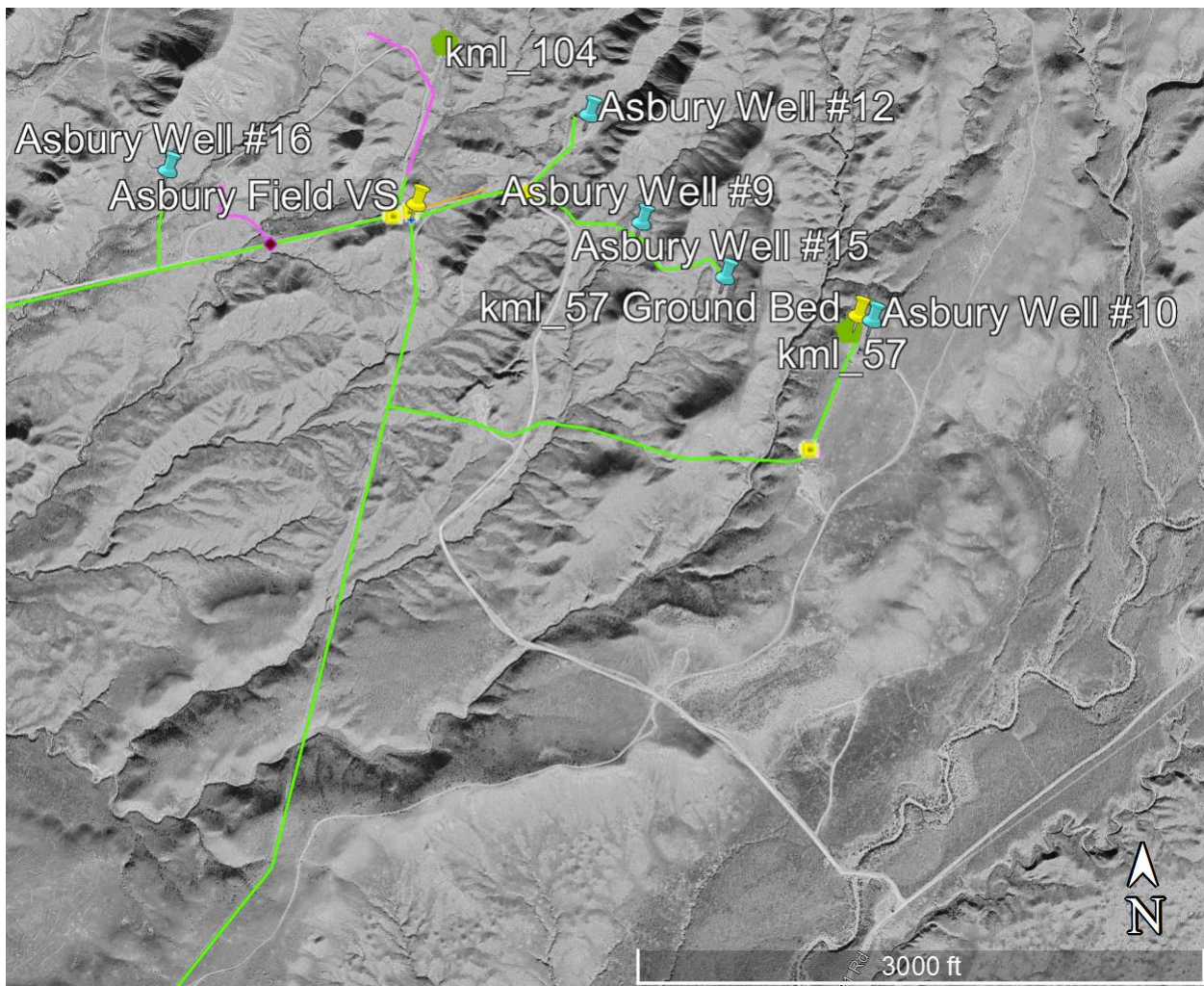


Figure 1 – Asbury Location Map

Asbury Well #10 was originally found to have excessive building pressure within the surface casing. This pressure was vented with an initial gas sample [Figure 3] being collected at the onset of venting. This sample was found to contain more than 95% hydrogen. Additional testing was performed by a second

laboratory to confirm the lack of methane in the surface casing [Figure 4]. The second laboratory was not capable of confirming hydrogen, however a sample of the actual production tubing gas was also sampled to use as a comparison [Figure 5].

The installation record of Asbury well #10 is provided in Appendix C – Asbury Well #10 Documentation.

## 2 Testing

Testing was conducted 10/21/24-10/23/24. The weather was clear and sunny with highs reaching 71° F and lows falling to 34° F.

Several test point surveys were conducted throughout the Asbury system as part of the overall testing. Potentials were captured at each well site on the well piping, the station piping and the pipeline piping.

The following system conditions were recorded:

1. With the ICCP system operating while the individual station bonding jumpers were removed;
2. With the ICCP system not operating and depolarized for 12 hours; and
3. With the ICCP system operating while the individual station bonding jumpers were connected.

Condition 3 was the state the system was left in at the completion of testing.

DC pipe-to-soil (P/S) “ON” and “OFF” potential measurements were collected using a multimeter and a copper/copper-sulfate (CSE) reference electrode. The reference electrode was verified against a calibration [Cu/CuSO<sub>4</sub>] reference electrode prior to testing. “ON” P/S potential measurements were collected while CP was being applied to the structure of interest “OFF” P/S potential measurements were collected while interrupting CP to the structure of interest. Test point survey data is outlined in [Table 1] below.

**Table 1 –Test Point Survey Data**

Pipeline	LAT [DD]	LONG [DD]	ICCP OPERATING STATION BONDING REMOVED		12HR DEPOLARIZED		ICCP OPERATING STATION BONDING RECONNECTED		Current [A]
			ON	OFF	ON	OFF	ON	OFF	
			[V <sub>oc</sub> ]	[V <sub>oc</sub> ]	[V <sub>oc</sub> ]	[V <sub>oc</sub> ]	[V <sub>oc</sub> ]	[V <sub>oc</sub> ]	
Asbury #10 - well casing	39.273471°	-108.617768°	-0.79	-0.88		-0.94	-0.823	-0.9	
Asbury #10 - station piping	39.273233°	-108.617961°	-1.78	-0.63		-0.437	-1.93	-0.972	
Asbury #10 pipeline	39.273233°	-108.617961°	-1.39	-1.01		-0.46			1.27A on station
Asbury #9 - well casing	39.274922°	-108.622058°	-0.8	-0.97		-0.937			
Asbury #9 - station piping	39.274679°	-108.622020°	-1.06	-0.83		-0.947	-1.01	-0.85	
Asbury #9 pipeline	39.274679°	-108.622020°				-0.565	-0.964	-0.886	2.1A on station
Asbury #15 - well casing	39.274118°	-108.620508°	-1.06	-1.01		-0.902			
Asbury #15 - station piping	39.274348°	-108.620512°	-1.3	-0.91		-0.917	-1.04	-0.96	
Asbury #15 pipeline	39.274348°	-108.620512°				-0.647	-1.3	-0.93	1.9A on station
Asbury #12 - well casing	39.276483°	-108.623030°	-1.2	-1.04		-0.797			
Asbury #12 - station piping	39.276637°	-108.623227°	-1.31	-0.95		-0.767	-1.217	-0.91	
Asbury #12 pipeline	39.276637°	-108.623227°				-0.668	-1.27	-0.96	3.75A on station
Asbury #16 - well casing	39.275794°	-108.631092°	-1.05	-0.967		-0.886			
Asbury #16 - station piping	39.275667°	-108.630824°	-1.13	-0.83		-0.835	-1.01	-0.91	
Asbury #16 pipeline	39.275667°	-108.630824°				-0.631	-1.17	-0.81	1.71A on station

## 2.1 E-Log-I Testing

E-log-I testing was performed on the Asbury Well #10 in order to determine the required current for cathodic protection. E-log-I testing results were plotted on a semi-logarithmic curve in order to obtain the Tafle slope, which allows for determination of required current for cathodic protection. E-log-I testing results can be found in [Table 2] below.

**Table 2 – E-log-I Testing Results**

CURRENT [A]	ON [V <sub>DC</sub> ]	OFF [V <sub>DC</sub> ]
1	-0.9	-0.892
1.5	-0.908	-0.894
2.4	-0.923	-0.896
3.24	-0.934	-0.899
3.8	-0.942	-0.901
4.25	-0.95	-0.902
5.25	-0.965	-0.905
6.35	-0.98	-0.909
7.35	-0.995	-0.911
8.35	-1.011	-0.915
9.45	-1.027	-0.918
10.5	-1.043	-0.922
11.4	-1.058	-0.925
12.6	-1.074	-0.93
13.6	-1.09	-0.933
14.6	-1.107	-0.939
15.8	-1.123	-0.941
16.9	-1.139	-0.945
17.9	-1.156	-0.95
18.5	-1.165	-0.953
19.5	-1.181	-0.958
21	-1.203	-0.961
22.1	-1.219	-0.966
23.3	-1.24	-0.973
24.1	-1.255	-0.979
25.2	-1.271	-0.979
26.5	-1.286	-0.981
27.3	-1.302	-0.988
28.2	-1.308	-0.981
29.9	-1.335	-0.991

The semi-logarithmic curve showing the Tafle slope for the E-log-I testing can be found in [Figure 2] below.



Figure 2 – E-log-I Plot

## 2.2 Soil Resistivity Testing

Soil resistivity measurements were collected in the immediate area of the rectifier groundbed using the Wenner four-pin method. Pin spacing varied from 5 [FT] spacing to 200 [FT] spacing. Soil resistivity survey methodology can be found in Appendix A – Survey Methodology. Soil resistivity data is outlined in [Table 3] below.

Table 3 - Soil Resistivity Data

Location			5	10	15	20	25	50	75	100	125	150	175
	Lat	Long	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]
Soil Res 1			Resistivity Reading	6.5	1.5	2	1.5	1.2	0.8	0.5	0.5	0.5	0.5
Axis 1	39.273053°	-108.617260°	Ohm-cm	6224	1436	3830	4309	4596	3830	4788	7181	9575	9575
90°			[MΩ, KΩ or Ω]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

### 3 Additional Findings

The following additional information was collected while onsite.

#### 3.1 Carbon Monoxide

The anode junction box for kml\_57 exhibited some severe corrosion internally. A 4-gas monitor was placed in the box and the door was closed to test for potential H<sub>2</sub>S. The 4-gas monitor alarmed with the door closed, however when collected it had alarmed on CO. Further gas testing was performed on the surface casing of the anode ground bed and the relief valve of the injection well surface casing. Both had high concentrations of CO indicated. Local operations and CP staff were present for testing and notified of the potential dangers.

#### 3.2 Well CP

Pipe-to-soil (P/S) potentials on the isolated Asbury #10 well indicated that some level of CP was still present. With the ICCP system operating a temporary bond was made between the station piping and the injection well casing. This bond was measured to have 3.5 [A] returning to the ICCP system from the injection well. With the ICCP system not operating the same temporary bond was made. This bond was measured to have 1.73 [A] of current returning to the well from the station. This testing successfully demonstrated that there is some level of galvanic CP on the injection well or casing.

### 4 Testing Results Summary

The following test results summary is presented for consideration with the recommendations made in this report.

Current shift testing indicated that at all stations the pipeline isolation flanges were non-functional regardless of the bond status (connected or disconnected).

Depolarized test point survey demonstrated that -100mV shift is occurring on the Asbury system.

Using Asbury #10 well as typical, it is assumed that all production wells and/or casings have some level of galvanic CP.

The station and injection wells/casings account for nearly 11 [A] of CP current from the ICCP system.

E-LOG-I testing indicates between 9 [A] and 12 [A] of CP current required for protection, however the presence of galvanic anodes on these structures may have resulted in test error.

Soil resistivity is in line with the known geography of the area and is favorable for deepwell anode installations.

Kml\_57 ground bed is producing or conducting CO gas to the surface.

### 5 Recommendations

The following recommendations are made based on the data presented in this report:

1. Isolate the remaining production wells on the Asbury system from the gathering pipeline.
2. Replace the anode junction box at kml\_57. When replaced consider either a non-metallic junction box, or installing conduit seals on the anode cable conduits to prevent the migration of CO gas.
3. Consider installing independent CP systems for each production well casing based on the 9 [A] to 12 [A] current requirement per well.

## Appendix A – Survey Methodology

### Soil Resistivity Methodology

Soil Resistivity (SR) measurements shall be collected using the Wenner four-pin method at pin spacings as indicated. When practical, measurements shall be taken with the pins perpendicular to the pipeline. If measurements must be taken with the pins parallel to the pipeline, the pins shall be placed offset from the pipeline.

Soil resistance ( $\Omega$ ), which is measured in the field, is converted to soil resistivity ( $\rho$ ) using the following:

$$\rho = 191.5 \times \Omega \times a$$

where:

$\Omega$  = measured soil resistance [ohms]; and

$a$  = pin spacing [ft].

Appendix B – Gas Samples



NATURAL GAS ANALYSIS

CUSTOMER PROJECT #:	NAME/DESCRIP :	ASBURY #10
SN/PRIMARY DB KEY:		WELLHEAD CASING
FIELD/AREA:		
PROJECT NO. :	202406055	ANALYSIS NO. : 01
COMPANY NAME :	XCEL ENERGY	ANALYSIS DATE: JUNE 17, 2024 11:47
OFFICE / BRANCH:	GRAND JUNCTION, CO	SAMPLE DATE : JUNE 12, 2024
CUSTOMER REF:		TO:
PRODUCER :		EFFECTIVE DATE:
***FIELD DATA***		
SAMPLE CYCLE:		SAMPLE TYPE: SPOT
SAMPLE PRES. :	20 psig	PROBE : NO
FLOW PRES. :	psig	CYLINDER NO. : 0499
LAB PRES:	psig	SAMPLED BY : GALE MCENDREE
SAMPLE TEMP. :	92 °f	SAMPLING COMPANY: EMPACT
AMBIENT TEMP.:	°f	H2S BY STAIN TUBE: — ppm mol
H2O BY STAIN TUBE:	#/mmcf	CO2 BY STAIN TUBE: — Mol %
FIELD COMMENTS:		
LAB COMMENTS:		

COMPONENTS	NORM. MOLE%	GPM @ 14.696	GPM @ 14.73
HELIUM	0.00	-	-
HYDROGEN	95.88	-	-
OXYGEN/ARGON	0.46	-	-
NITROGEN	3.54	-	-
CARBON DIOXIDE	0.07	-	-
METHANE	0.04	-	-
ETHANE	0.01	0.003	0.003
PROPANE	0.00	0.000	0.000
ISOBUTANE	0.00	0.000	0.000
N-BUTANE	0.00	0.000	0.000
ISOPENTANE	0.00	0.000	0.000
N-PENTANE	0.00	0.000	0.000
HEXANES PLUS	0.00	0.000	0.000
TOTAL	100.00	0.003	0.003
BTU @ 60 DEG F		14.696	14.73
LHV NET DRY REAL=		263.1 /scf	263.7 /scf
NET SATURATED REAL=		258.5 /scf	259.1 /scf
HHV GROSS DRY REAL =		311.4 /scf	312.1 /scf
GROSS SATURATED REAL =		306.0 /scf	306.7 /scf
NET DRY IDEAL =		263.1 /scf	
GROSS DRY IDEAL =		311.4 /scf	
NET HEATING VALUE (60 °F, ideal reaction):		32061.5 Btu/lbm	
GROSS HEATING VALUE (60 °F, ideal reaction):		37958.3 Btu/lbm	
SPECIFIC GRAVITY ( AIR=1 @14.696 PSIA 60F) :		0.1074	
DENSITY (lbm/scf)		0.00820	
COMPRESSIBILITY FACTOR :		1.0000	
REGULAR WOBBE INDEX (14.696)		950.2	

NOTE: REFERENCE GPA 2261(ASM D1945 & ASME-PTC) with Calc from 2145, 2172 & D3588 CURRENT PUBLICATIONS

Reference: Per GPA 2172-14 sec 9 The C6+ is derived from the following ratios of C6, C7 & C8+ respectively: 60% 30% 10%

The data presented herein has been acquired by means of current analytical techniques and represents the judicious conclusion EMPACT Analytical Systems, Inc. Results of the analysis can be affected by the sampling conditions, therefore, are only warranted through proper lab protocol. EMPACT assumes no responsibility for interpretation or any consequences from application of the reported information and is the sole liability of the user. The reproduction in any media of this reported information may not be made, in portion or as a whole, without the written permission of EMPACT Analytical Systems, Inc.

EMPACT Analytical Systems Inc. 365 S Main St Brighton, CO 80601 303-637-0150

Figure 3 – Initial Gas Sample

Brown's Instrumentation  
649 Allegheny Dr.  
Grand Junction, CO 81504  
970-623-6209  
Print Date Time: 06/27/2024 08:48

Analyzed By: Chris Brown  
Meter ID: GS0121 Brayden  
Asbury Well 10 Brayden  
Analysis Time: 06/27/2024 08:43  
Flowing Temp.: 68 Deg. F  
Calibration Elevation: 4735 ft  
Sample Type: Spot  
Flowing Pressure: 49 psig  
Location Elevation: 5214 ft

Comp	UnNorm %	Normal %	Liquids (USgal/MCF)	Ideal (Btu/SCF)	Rel. Density
Propane	0.00224	0.04466	0.01230	1.12364	0.00068
Hydrogen Sulfide	0.00000	0.00000	0.00000	0.00000	0.00000
IsoButane	0.00000	0.00000	0.00000	0.00000	0.00000
Butane	0.00170	0.03385	0.01067	1.10425	0.00068
NeoPentane	0.00000	0.00000	0.00000	0.00000	0.00000
IsoPentane	0.00088	0.01760	0.00644	0.70413	0.00044
Pentane	0.00079	0.01585	0.00575	0.63550	0.00039
Hexane+	0.03588	0.71567	0.00000	0.00000	0.00000
Nitrogen	4.97142	99.17236	10.91214	0.00000	0.95922
Methane	0.00000	0.00000	0.00000	0.00000	0.00000
Carbon Dioxide	0.00000	0.00000	0.00000	0.00000	0.00000
Ethylene	0.00000	0.00000	0.00000	0.00000	0.00000
Ethane	0.00000	0.00000	0.00000	0.00000	0.00000
Hexane	0.00000	0.71567	0.29434	34.03667	0.02129
Heptane	0.00000	0.00000	0.00000	0.00000	0.00000
Heptane	0.00000	0.00000	0.00000	0.00000	0.00000
Octane	0.00000	0.00000	0.00000	0.00000	0.00000
Nonane	0.00000	0.00000	0.00000	0.00000	0.00000
Nonane	0.00000	0.00000	0.00000	0.00000	0.00000
Decane	0.00000	0.00000	0.00000	0.00000	0.00000
Undecane	0.00000	0.00000	0.00000	0.00000	0.00000
Ethane-	0.00000	0.00000	0.00000	0.00000	0.00000
Propane +	0.00000	0.00000	0.00000	0.00000	0.00000
Oxygen	0.00000	0.00000	0.00000	0.00000	0.00000
Water	0.00000	1.74067	0.00000	0.00000	0.00000
Helium	0.00000	0.00000	0.00000	0.00000	0.00000
Hydrogen	0.00000	0.00000	0.00000	0.00000	0.00000
Total	5.01291	100.00000	11.24164	37.60420	0.98274
Elevation (-479ft)	0.74483				

Inferior Wobbe	37.4949	(Btu/SCF)	Superior Wobbe	38.0357	(Btu/SCF)
Compressibility	0.9996		Density	0.0752	(lbm/ft3)
Real Rel. Density	0.9827		Ideal CV	37.6042	(Btu/SCF)
Wet CV	37.0521	(Btu/SCF)	Dry CV	37.7060	(Btu/SCF)
Contract Temp.	60.0000	(deg F)	Contract Press.	14.7300	(psia)
Number of Cycles	1		Connected Stream	1	
Atmospheric Pressure	12.1				

Figure 4 – Confirmation Testing Gas Sample

Brown's Instrumentation  
649 Allegheny Dr.  
Grand Junction, CO 81504  
970-623-6209  
Print Date Time: 06/27/2024 08:58

Analyzed By: Chris Brown  
Meter ID: GS0121 Asbury 10 Tubing  
Asbury Well 10 Tubing  
Analysis Time: 06/27/2024 08:52 Sample Type: Spot  
Flowing Temp.: 68 Deg. F Flowing Pressure: 577 psig  
Calibration Elevation: 4735 ft Location Elevation: 5214 ft

Comp	UnNorm %	Normal %	Liquids (USgal/MCF)	Ideal (Btu/SCF)	Rel. Density
Propane	0.45992	0.45619	0.12594	11.47818	0.00695
Hydrogen Sulfide	0.00000	0.00000	0.00000	0.00000	0.00000
IsoButane	0.05536	0.05491	0.01800	1.78548	0.00110
Butane	0.06302	0.06251	0.01975	2.03934	0.00125
NeoPentane	0.00000	0.00000	0.00000	0.00000	0.00000
IsoPentane	0.02050	0.02034	0.00745	0.81372	0.00051
Pentane	0.01474	0.01462	0.00531	0.58616	0.00036
Hexane+	0.02461	0.02441	0.00000	0.00000	0.00000
Nitrogen	0.50244	0.49836	0.05494	0.00000	0.00482
Methane	91.56237	90.81896	15.42834	917.27155	0.50305
Carbon Dioxide	2.79907	2.77634	0.47479	0.00000	0.04219
Ethylene	0.00000	0.00000	0.00000	0.00000	0.00000
Ethane	5.31652	5.27336	1.41320	93.32260	0.05475
Hexane	0.00000	0.02441	0.01006	1.16081	0.00073
Heptane	0.00000	0.00000	0.00000	0.00000	0.00000
Heptane	0.00000	0.00000	0.00000	0.00000	0.00000
Octane	0.00000	0.00000	0.00000	0.00000	0.00000
Nonane	0.00000	0.00000	0.00000	0.00000	0.00000
Nonane	0.00000	0.00000	0.00000	0.00000	0.00000
Decane	0.00000	0.00000	0.00000	0.00000	0.00000
Undecane	0.00000	0.00000	0.00000	0.00000	0.00000
Ethane-	0.00000	0.00000	0.00000	0.00000	0.00000
Propane +	0.00000	0.00000	0.00000	0.00000	0.00000
Oxygen	0.00000	0.00000	0.00000	0.00000	0.00000
Water	0.00000	1.74067	0.00000	0.00000	0.00000
Helium	0.00000	0.00000	0.00000	0.00000	0.00000
Hydrogen	0.00000	0.00000	0.00000	0.00000	0.00000
Total	100.81857	100.00000	17.55779	1028.45789	0.61691
Elevation (-479ft)	0.74483				

Inferior Wobbe	1292.4977 (Btu/SCF)	Superior Wobbe	1315.4849 (Btu/SCF)
Compressibility	0.9977	Density	0.0472 (lbm/ft3)
Real Rel. Density	0.6169	Ideal CV	1028.4579 (Btu/SCF)
Wet CV	1015.2837 (Btu/SCF)	Dry CV	1033.2273 (Btu/SCF)
Contract Temp.	60.0000 (deg F)	Contract Press.	14.7300 (psia)
Number of Cycles	1	Connected Stream	1
Atmospheric Pressure	12.1		

Figure 5 – Comparative Production Tubing Sample

**Appendix C – Asbury Well #10 Documentation**

