3R - 431

2013 AGWMR

03 / 21 / 2014

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ConocoPhillips

Mr. Glenn von Gonten
New Mexico Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

March 21, 2014

Re: NMOCD Case No. 3RP-431, 2013 Annual Groundwater Monitoring Report

Dear Mr. von Gonten:

Enclosed is the 2013 Annual Groundwater Monitoring Report for the Howell K No. 1 site. This report, prepared by Conestoga-Rovers & Associates (CRA), contains the results of groundwater monitoring conducted during September 2013.

Please let me know if you have any questions.

Sincerely,

Terry S. Lauck

Enc

CONESTOGA-ROVERS & ASSOCIATES

www.CRAworld.com

2013 Annual Groundwater Monitoring Report

ConocoPhillips Howell K No. 1
San Juan County, New Mexico
API# 30-045-09313
NMOCD # 3R-431

Prepared for: ConocoPhillips Risk Management and Remediation

Conestoga-Rovers & Associates
6121 Indian School Road, NE Suite 200
Albuquerque, New Mexico 87110

December 2013 • 074928 • Report No. 5

Partners in Sustainability

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Section 1.0 Introduction

This report details the results of the annual groundwater monitoring event, as well as, a supplemental groundwater sampling event for a metals treatability study conducted by Conestoga-Rovers & Associates, Inc. (CRA) on September 17th and October 1st 2013, respectively, at the ConocoPhillips Company (ConocoPhillips) Howell K No. 1 site (Site), located on Bureau of Land Management (BLM) land, approximately ½ mile southeast of Navajo Lake State Park and 10 miles east of Aztec in Unit Letter K, Section 21, Township 30N, Range 8W of San Juan County, New Mexico. Geographical coordinates for the Site are 36º 47' 40.34" North, 107º 41' 4.70" West. The Site consists of a natural gas well and associated equipment and installations. The location and general features of the Site are shown on **Figures 1** and **2**, respectively.

1.1 Background

The environmental investigation at the Site began in August 2005 with the excavation of approximately 4,000 cubic yards of hydrocarbon impacted soil from an area southwest of the Howell K No. 1 wellhead. The hydrocarbon impacted soil was discovered in the area during below grade tank removal activities. The final dimensions of the excavation were 70 feet by 50 feet by 36 feet deep. Groundwater was encountered at a depth of approximately 34 feet below ground surface (bgs). Once this extent had been reached, the excavation was stopped due to the inability of the equipment to operate safely; however, the limits of the hydrocarbon impact had not been delineated. The excavation was backfilled with clean soil. In March 2006, one groundwater monitor well (MW-1) was installed by Envirotech in the area of the backfilled excavation. The location of this monitor well is shown on **Figure 2**.

Due to the transition of Site consulting responsibilities from Lode Star LLC of Farmington, NM, to Tetra Tech, Inc. (Tetra Tech) following the acquisition of Burlington Resources by ConocoPhillips in March 2006, groundwater monitoring was not performed at the Site in March or June 2007. Tetra Tech began sampling groundwater at the Howell K No. 1 site in November 2007 using MW-1 and continued to do so until August of 2008, when 3 additional monitor wells were installed at the Site by WDC Exploration and Wells of Peralta, NM under Tetra Tech supervision. The additional wells were installed in response to a request by the New Mexico Oil Conservation Division (NMOCD) for Site characterization and enhanced laboratory analyses. This request was communicated to Tetra Tech during an April 2008 meeting conducted in Santa Fe, New Mexico with Glenn von Gonten, NMOCD Environmental Bureau Hydrologist.

Groundwater Monitor Well MW-2 was installed upgradient of MW-1 and Monitor Wells MW-3 and MW-4 were installed downgradient of MW-1 (**Figure 2**).

A generalized geologic cross section was compiled using subsurface data collected from each boring location during installation of Monitor Wells MW-2, MW-3 and MW-4. Monitor Wells MW-2 and MW-4 are represented on the cross section which is presented in **Figure 3**.

October 2008 marked the first quarterly groundwater monitoring event to include all 4 monitor wells for groundwater monitoring at the Site. BTEX analysis was discontinued following the December 2010 sampling event which represented eight consecutive quarters of BTEX constituents being below laboratory detection limits in samples from all Site monitor wells. Analysis for dissolved iron, dissolved manganese, sulfate, and fluoride were continued quarterly through October 2011. Sampling for these constituents is currently conducted on an annual basis.

On June 15, 2011, Site consulting responsibilities were transferred from Tetra Tech to CRA of Albuquerque, NM.

Due to settling of soil around the area of Monitor Well MW-1 and resulting damage to the subsurface screen, it was properly plugged and abandoned and a replacement well, MW-1R, was installed during August of 2013 under CRA supervision.

A summary of the Howell K No. 1 site history can be seen in **Table 1**.

Section 2.0 Groundwater Monitoring Summary, Methodology, and Analytical Results

2.1 Groundwater Monitoring Summary

Annual groundwater sampling was conducted by CRA on September 17, 2013. This represents the second annual monitoring event since quarterly monitoring was discontinued. The groundwater sampling event included samples from Monitor Wells MW-1R, MW-2, MW-3, and MW-4. Groundwater levels were measured using an oil/water interface probe prior to sampling and can be found in **Table 2**. Groundwater elevations for Site monitor wells are calculated from top of casing elevations, which were derived from survey data collected by Tetra Tech on August 14, 2008. The groundwater elevation for MW-1R cannot be calculated since the well has not been surveyed in yet. Based on September 2013 groundwater elevation data, groundwater flow direction continues to be to the west. A groundwater potentiometric surface map is presented in **Figure 4**.

Additional groundwater sampling was conducted at the Site on October 1, 2013 to collect groundwater from Monitor Well MW-1 for the purpose of conducting a metals treatability study.

The sample was sent to CRA's Innovative Technology Group (ITG) to assess potential in situ technologies to address solubilization of iron and manganese in the reducing groundwater of the Site.

2.2 Groundwater Monitoring Methodology

Prior to September 2013 sample collection, Monitor Wells MW-1R, MW-2, MW-3, and MW-4 were purged of at least three casing volumes of water. A 1.5-inch, polyethylene, dedicated bailer was used to purge and to collect the groundwater samples. Field parameters of pH, conductivity, dissolved oxygen, temperature and oxidation/reduction potential were measured periodically during purging and recorded. The purge water generated during the event was disposed of in the on-Site produced water tank. The groundwater samples were placed in laboratory prepared bottles, packed on ice, and shipped under chain-of-custody documentation to Pace Analytical Services, Inc. of Lenexa, KS. All groundwater samples collected were analyzed for dissolved iron and dissolved manganese by EPA Method 6010, and fluoride and sulfate by EPA method 300.0.

The metals treatability sample, collected from Monitor Well MW-1 on October 1, 2013, was collected after the same purging and field parameter measurement protocol employed for the annual sampling event conducted in September 2013. The sample was shipped to the ITG for evaluation for potential groundwater treatment by pH adjustment, biosparging and oxidant injection.

2.3 Groundwater Monitoring Analytical Results

The New Mexico Water Quality Control Commission (NMWQCC) mandates that groundwater quality in New Mexico be protected, and has issued groundwater quality standards in Title 20, Chapter 6, Part 2, Section 3103 of the New Mexico Administrative Code (20.6.2.3103 NMAC). Groundwater quality standards have been set for the protection of human health, domestic water supply, and irrigation use. Above-standard results of the September 2013 annual sampling event are discussed below:

- **Dissolved Iron**
  - The NMWQCC groundwater quality standard for dissolved iron is 1.0 mg/L. Groundwater samples collected from Monitor Wells MW-1R and MW-4 were found to contain dissolved iron at concentrations of 2.8 mg/L and 1.2 mg/L, respectively.

- **Dissolved Manganese**
  - The NMWQCC groundwater quality standard for dissolved manganese is 0.2 mg/L. Groundwater samples collected from Monitor Wells MW-1R, MW-3 and MW-4 were found to contain dissolved manganese at concentrations of 3.8 mg/L, 0.32 mg/L, and 16.7 mg/L, respectively.

- **Sulfate**
  - The NMWQCC groundwater quality standard for sulfate is 600 mg/L. Groundwater samples collected from Monitor Wells MW-1R, MW-2, MW-3 and MW-4 were found to contain sulfate at concentrations of 5,100 mg/L, 2,420 mg/L, 2,740 mg/L, and 4,040 mg/L, respectively.

- **Fluoride**
  - The NMWQCC domestic water supply groundwater quality standard for fluoride is 1.6 mg/L. Groundwater sample collected from Monitor Well MW-4 exceeded this standard with a concentration of 2.2 mg/L.

Table 3 summarizes the analytical results from groundwater sampling completed during September of 2013. Groundwater sampling field forms detailing collected field parameters can be found in **Appendix A** and the corresponding laboratory analytical report, including quality control summaries, can be found in **Appendix B**.

Section 3.0 Conclusions and Recommendations

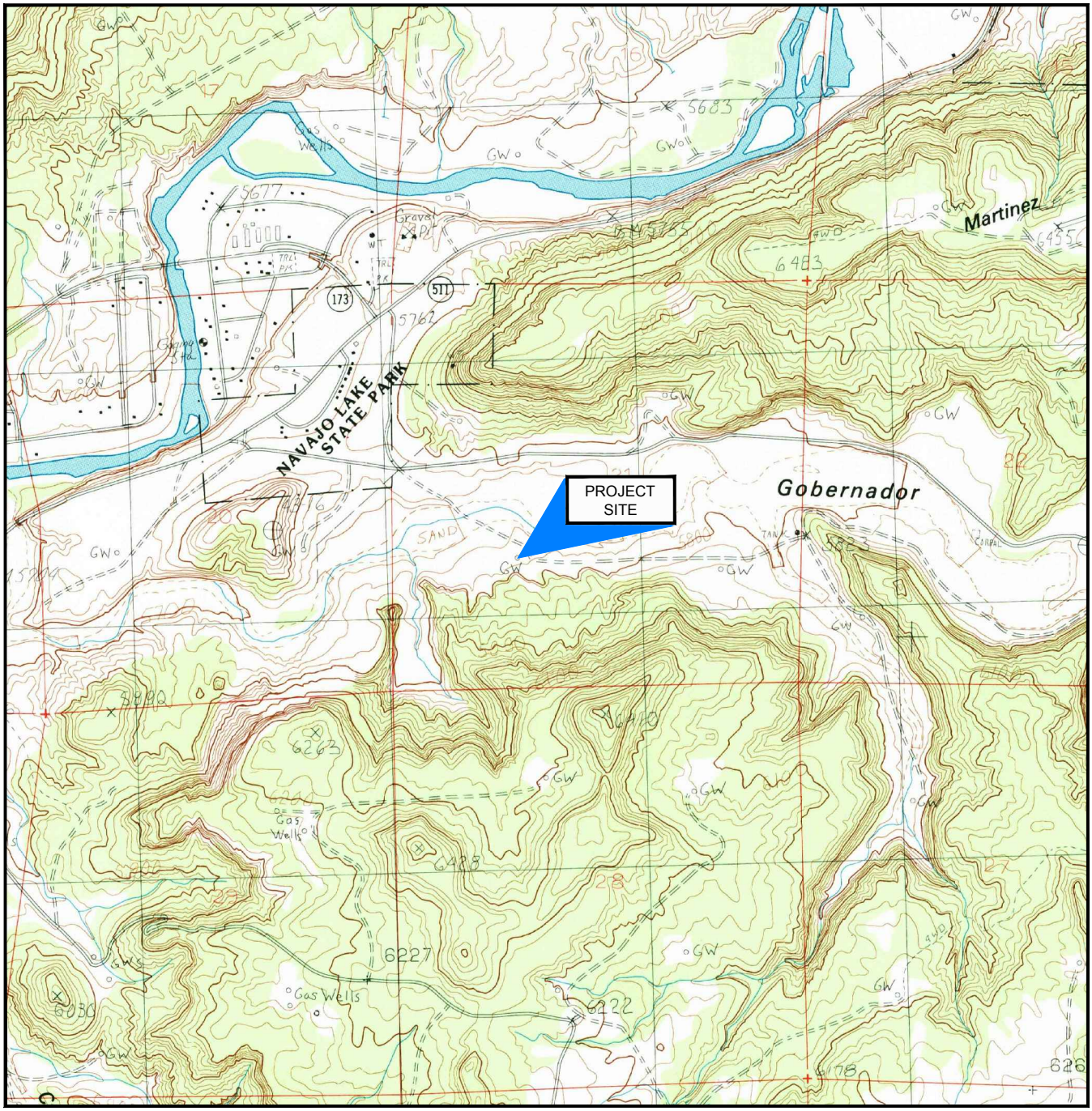
BTEX compounds in Site groundwater have been below NMWQCC standards since groundwater sampling began in 2006. Analyses for these constituents was discontinued following the December 2010 sampling event. Hydrocarbon impacts were found in soil below the groundwater table during the initial Site investigation soil removal. The anaerobic conditions caused by the biodegradation of hydrocarbons in groundwater may have led to the solubilization of iron and manganese. Dissolved-phase iron and manganese occur in Site groundwater at concentrations above NMWQCC standards. The groundwater treatability study conducted by the ITG determined that pH adjustment would be the most cost-effective method for dissolved metals remediation. Details of the ITG's findings and the specific recommendations for implementation of this remedial technology at the Site are included in **Appendix C**. CRA recommends implementation of the pH adjustment technology to address elevated concentrations of iron and manganese in groundwater.

CRA also recommends continued annual monitoring of fluoride, sulfate, dissolved manganese, and dissolved iron.

If groundwater pH adjustment is implemented, more frequent (quarterly) sampling and analysis of iron and manganese may be warranted to evaluate the effectiveness of the remedial action. The next annual sampling event is scheduled for September 2014.

As discussed with Glenn von Gonten of the NMOCD Environmental Bureau in November of 2012, installation of a replacement well for MW-1 was completed in August of 2013. An attempt to install additional downgradient monitor wells was initiated in June of 2013. An agreement between the Bureau of Land Management and ConocoPhillips regarding land access is in progress, but has yet to be established. Installation of additional downgradient monitor wells to monitor potential migration of dissolved metals from the Site will be evaluated again during 2014.

Figures



SOURCE: USGS 7.5 MINUTE QUAD
"ARCHULETA, NEW MEXICO"

N

0 1000 2000ft

Figure 1

SITE VICINITY MAP
HOWELL K No. 1, NATURAL GAS WELL SITE
UNIT K. SECTION 21, T30N-R8W, SAN JUAN COUNTY, N.M.
ConocoPhillips Company

CRA

074928-95(005)GN-DL004_TOPO DEC 12/2013

ConocoPhillips high resolution aerial imagery 2008.

Figure 2

SITE PLAN
HOWELL K No. 1 NATURAL GAS WELL SITE
UNIT LETTER K, SECTION 21, T30N-R8W, SAN JUAN COUNTY, NEW MEXICO
ConocoPhillips Company

CRA

074928-95(005)GN-DL001_SD DEC 12/2013

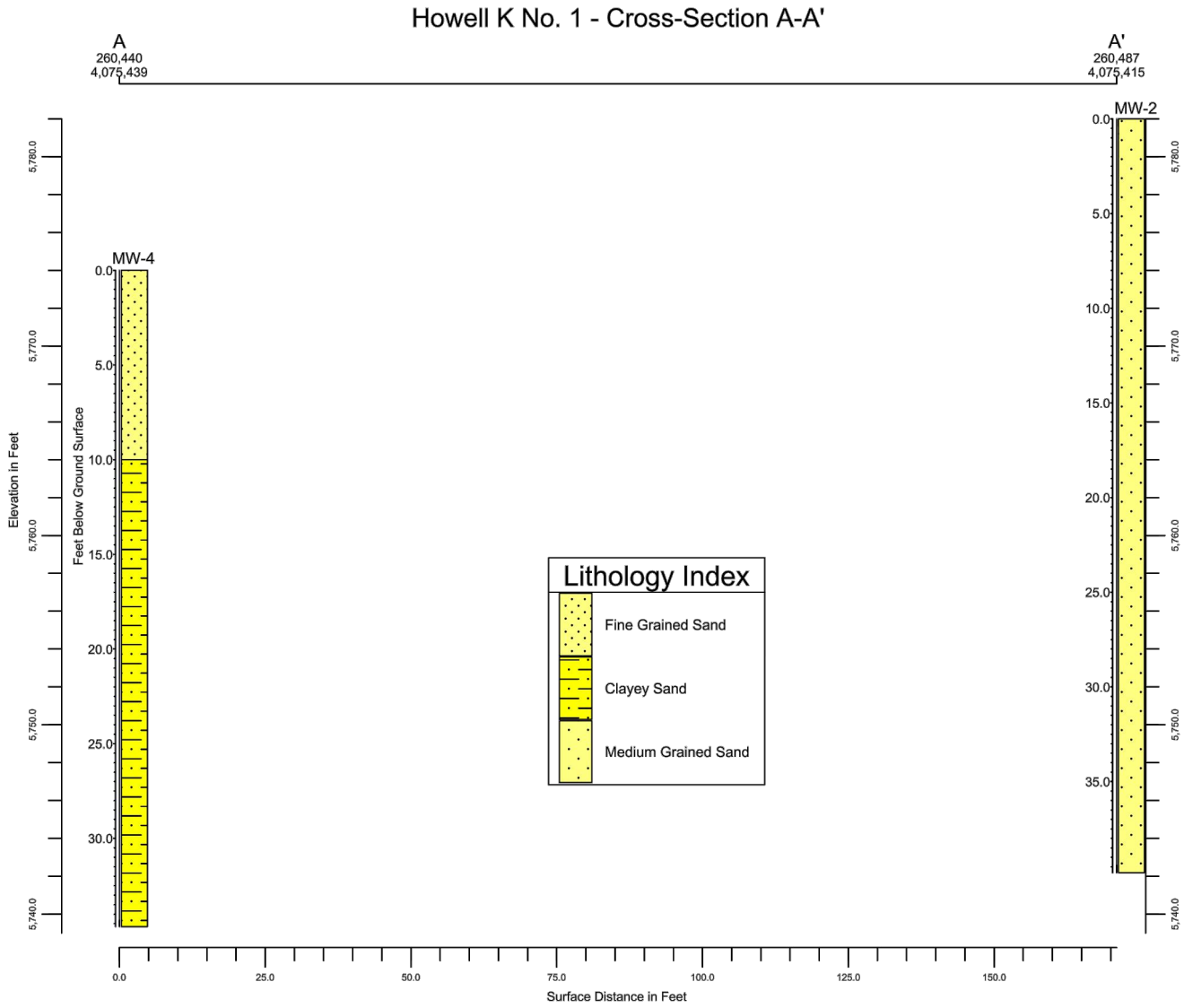
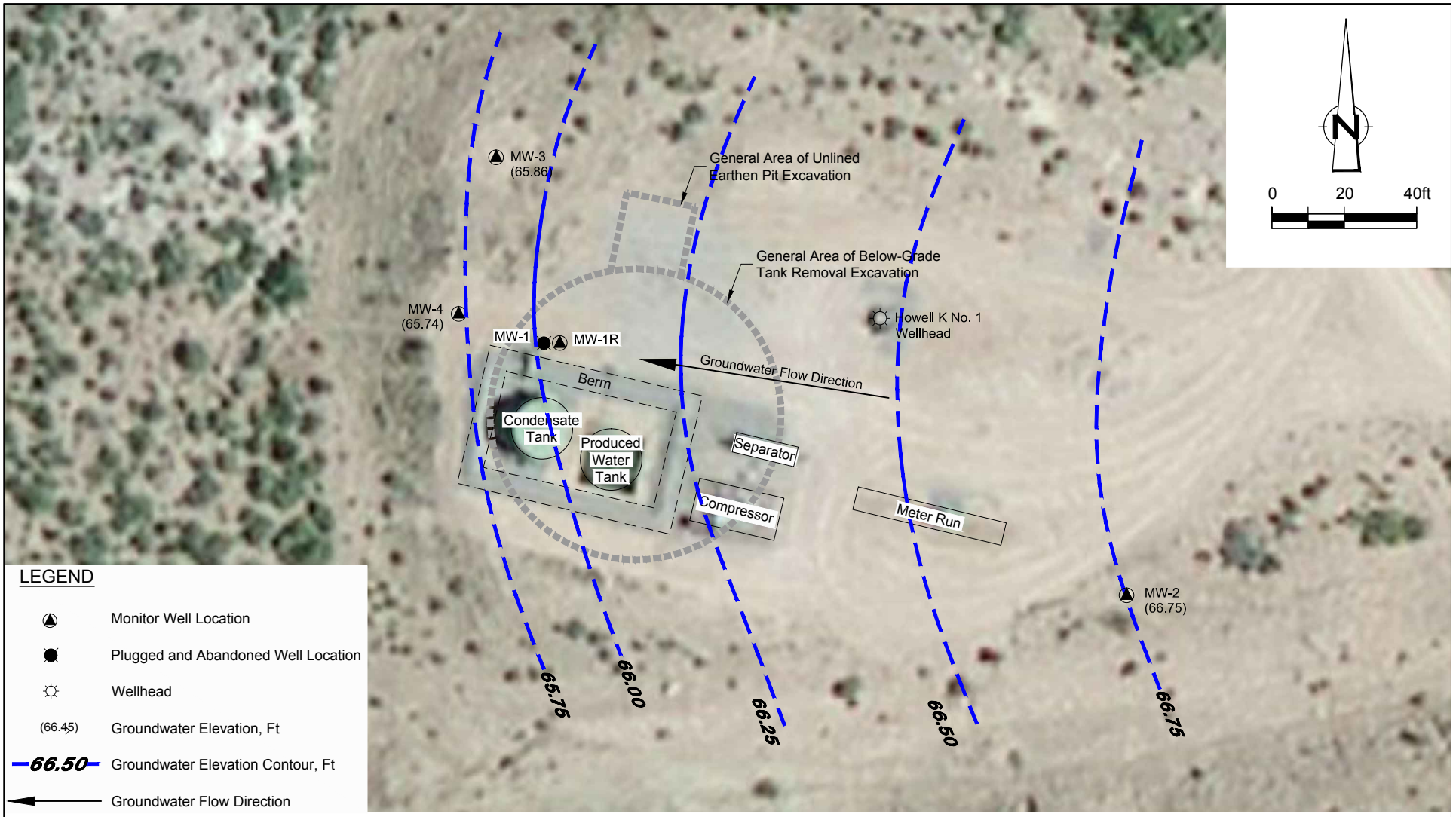


Figure 3

GEOLOGICAL CROSS SECTION
HOWELL K No. 1 NATURAL GAS WELL SITE
UNIT LETTER K, SECTION 21, T30N-R8W, SAN JUAN COUNTY, NEW MEXICO
ConocoPhillips Company



ConocoPhillips high resolution aerial imagery 2008.

Figure 4

SEPTEMBER 2013 GROUNDWATER POTENTIOMETRIC SURFACE MAP
HOWELL K NO. 1 NATURAL GAS WELL SITE
UNIT LETTER K, SECTION 21, T30N-R8W, SAN JUAN COUNTY, NEW MEXICO
ConocoPhillips Company

074928-95(005)GN-DL003_GW DEC 12/2013

Tables

TABLE 1

SITE HISTORY TIMELINE
CONOCOPHILLIPS COMPANY
SAN JUAN COUNTY, NEW MEXICO
HOWELL K NO. 1

Date/Time Period	*Event/Action*	*Description/Comments*
July 26, through August 18, 2005	Initial Site assessment	Environmental investigation began with the excavation of approximately 4000 cubic yards of impacted soil from an area southwest of the Howell K No.1 well head. Impacted soils were discovered during the removal activities of a below grade tank. Dimensions of the excavation were approximately 70 feet long by 50 feet wide by 36 feet deep. Groundwater was encountered at approximately 34 feet and soils were still impacted at 36 feet deep, the point at which excavation machinery was stopped at the practical limit for safe operation. The total vertical extent of hydrocarbon impacts were not completely delineated. Soil was treated with approximately 600 gallons of potassium permanganate solution. The excavation area was backfilled with clean soil.
March 10, 2006	Groundwater monitor well installation	One ground water monitor well, MW-1, was installed in the area of the backfilled excavation by Envirotech.
March 31, 2006	Site transfer	ConocoPhillips Company completed acquisition of Burlington Resources.
March and June 2007	Groundwater monitoring not performed	After the acquisition of Burlington Resources by ConocoPhillips, consulting responsibilities were transferred from Lode Star LLC of Farmington New Mexico to Tetra Tech of Albuquerque.
November 9, 2007 through March 19, 2008	Groundwater monitoring	Tetra Tech began sampling the Howell K No. 1 site quarterly in November 2007. Groundwater was sampled from MW-1 and was analyzed for BTEX constituents. No constituents were detected at levels that exceeded the NMWQCC standards.
April 1, 2008	Additional monitoring requested by OCD	Oil Conservation Division of NM Energy, Minerals, and Resources Dept. indicates additional investigation and sampling is necessary for closure consideration during a meeting with Glenn Von Gonten.
July 23, 2008	Groundwater monitoring postponed	Groundwater monitoring of MW-1 was postponed after it was found that there was an obstruction caused by settling and shifting of the MW-1 casing. It was determined that the obstruction could be avoided by using a smaller bailer to collect samples. Sampling was postponed and was set to follow upcoming monitor well installation so that proper sampling materials could be used.
August 13 and 14, 2008	Groundwater monitor well installation and groundwater monitoring	Three additional groundwater monitor wells (MW-2, MW-3 and MW-4) were installed by WDC and overseen by Tetra Tech. MW-2 was installed upgradient of MW-1. Both MW-3 and MW-4 were installed downgradient of MW-1. All wells were developed by purging approximately 80 gallons of water using a surge block and a purge pump. A sample was collected from MW-1 on August 14th. A 1/2-inch disposable bailer was used to avoid an obstruction in MW-1. The sample was analyzed for BTEX constituents. All constituents were below NMWQCC standards.
October 24, 2008	Groundwater monitoring	Third quarter 2008 groundwater monitoring was completed and was the first quarter of sampling to include all four monitor wells on site. A baseline analytical suite was completed including major ions, total metals, semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs) including BTEX, diesel range organics, and gasoline range organics. All BTEX constituents were below NMWQCC standards. All four wells were above the standard for sulfate.
January 30, 2009	4th quarter 2008 groundwater monitoring	Tetra Tech conducted fourth quarter 2008 groundwater monitoring at the site for BTEX constituents in all four monitor wells. All wells were below NMWQCC standards for BTEX .
September 25,2009	2009 annual groundwater monitoring	Tetra Tech conducted 2009 annual groundwater monitoring of MW-2, MW-3 and MW-4 for BTEX, dissoved iron, dissolved manganese, sulfate, and fluoride. All three wells were below NMWQCC standards for BTEX. All three wells were above standard for sulfate. Dissolved manganese was above standard in MW-3 and MW-4 and flouride was above standard in MW-4. Dissolved metals analyses conducted for the first time since standards are based on dissolved metals testing. OCD concurred, allowing total metals testing to be discontinued.

TABLE 1

SITE HISTORY TIMELINE
CONOCOPHILLIPS COMPANY
SAN JUAN COUNTY, NEW MEXICO
HOWELL K NO. 1

Date/Time Period	*Event/Action*	*Description/Comments*
October 18, 2009	Groundwater monitoring	Tetra Tech conducted 2009 annual groundwater monitoring of MW-1 for BTEX, dissoved iron, dissolved manganese, sulfate, and fluoride. MW-1 was below NMWQCC standards for BTEX. Sulfate, dissolved manganese and dissolved iron were above standards in MW-1.
December 15, 2010	Groundwater monitoring	Tetra Tech conducted quarterly groundwater monitoring at the site for BTEX, dissolved iron, dissolved manganese, sulfate and flouride. All four monitor wells were below NMWQCC standards for BTEX . All four monitor wells were above the standard for sulfate. MW-1, MW-3 and MW-4 were above standard for dissolved manganese and MW-1 and MW-3 were also above the standard for dissolved iron.
March 30, 2010	Groundwater monitoring	Tetra Tech conducted quarterly groundwater monitoring at the site for BTEX, dissolved iron, dissolved manganese, and sulfate. All four monitor wells were below NMWQCC standards for BTEX. All four monitor wells were above the standard for sulfate. MW-1, MW-3 and MW-4 were also above the standard for dissolved manganese.
June 8, 2010	Groundwater monitoring	Tetra Tech conducted quarterly groundwater monitoring at the site for BTEX, dissolved iron, dissolved manganese, and sulfate. All four monitor wells were below NMWQCC standards for BTEX. All four monitor wells were above the standard for sulfate. MW-1, MW-3 and MW-4 were above the standard for dissolved manganese. MW-1 was also above the standard for dissolved iron.
September 23,2010	Groundwater monitoring	Tetra Tech conducted quarterly groundwater monitoring at the site for BTEX, dissolved iron, dissolved manganese, fluoride and sulfate. All four monitor wells were below NMWQCC standards for BTEX. All four monitor wells were above the standard for sulfate. MW-1, MW-3 and MW-4 were above the standard for dissolved manganese . MW-1 was also above standard for dissolved iron.
December 15,2010	Groundwater monitoring	Tetra Tech conducted quarterly groundwater monitoring at the site for BTEX, dissolved iron, dissolved manganese, fluoride and sulfate. MW-3 was observed to be dry during this monitoring event, which was likely due to an interface probe malfunction. MW-1, MW-2 and MW-4 were sampled. All three sampled monitor wells are below NMWQCC standards for BTEX . MW-1 and MW-4 were above the the standards for sulfate, dissolved manganese, and dissolved iron. Monitor well MW-4 was also found to be above the the standard for fluoride.
March 15, 2011	Groundwater monitoring	First quarter of groundwater monitoring with BTEX analysis discontinued due to eight consecutive quarters of data below the standards being reached; MW-1, MW-2, MW-3, and MW-4 were sampled and analyzed for dissolved iron, dissolved manganese, fluoride and sulfate.
June 15, 2011	Transfer of site consulting responsibilities	On June 15, 2011, site consulting responsibilities were transferred from Tetra Tech of Albuquerque, NM to Conestoga-Rovers & Associates (CRA) of Albuquerque, NM.
June 23, 2011	Groundwater monitoring	MW-1, MW-2, MW-3, and MW-4 were sampled and analyzed for dissolved iron, dissolved manganese, fluoride and sulfate.
October 11 and 12, 2011	Groundwater monitoring	MW-1, MW-2, MW-3, and MW-4 were sampled and analyzed for dissolved iron, dissolved manganese, fluoride and sulfate.
October 3, 2012	Groundwater monitoring	MW-1, MW-2, MW-3, and MW-4 were sampled and analyzed for dissolved iron, dissolved manganese, fluoride and sulfate.
July 19,2013	Plugging & Abandoning and Well Installation	National EWP, with CRA oversight, plugged and abandoned MW-1 and drilled and installed MW-1R.
September 17, 2013	Groundwater monitoring	MW-1R, MW-2, MW-3, and MW-4 were sampled and analyzed for dissolved iron, dissolved manganese, fluoride and sulfate.
October 1, 2013	Groundwater monitoring	MW-1R sampled and analyzed for metals treatability study.

TABLE 2

MONITOR WELL SPECIFICATIONS AND GROUNDWATER ELEVATIONS
CONOCOPHILLIPS COMPANY
HOWELL K No. 1
SAN JUAN COUNTY, NM

Well ID	*Total Depth (ft bgs)*	*Elevation* (ft) (TOC)*	*Screen Interval (ft below TOC)*	*Date Measured*	*Depth to Groundwater (ft below TOC)*	*Relative Water Level*
MW-1	37.47	97.84	21 - 36	3/22/2006	28.54	69.30
				6/21/2006	29.15	68.69
				10/19/2006	27.83	70.01
				12/12/2006	28.22	69.62
				3/1/2007	NM	NM
				6/1/2007	NM	NM
				11/9/2007	29.03	68.81
				1/15/2008	28.34	69.50
				3/19/2008	NM	NM
				7/23/2008	28.46	69.38
				10/24/2008	29.91	67.93
				1/30/2009	28.37	69.47
				9/25/2009	29.95	67.89
				10/18/2009	29.97	67.87
				12/15/2009	29.51	--(1)
				3/30/2010	28.18	--(1)
				6/8/2010	28.38	--(1)
				9/23/2010	29.51	--(1)
				12/15/2010	28.82	--(1)
				3/15/2011	28.51	--(1)
				6/24/2011	28.92	--(1)
				10/11/2011	30.43	--(1)
				10/3/2012	31.39	--(1)
				7/19/2013	Well Plugged and Abandoned	
MW-1R	43.89	--	22 - 42	9/17/2013	30.83	--(2)
MW-2	39.81	95.28	21 - 36	10/24/2008	25.74	69.54
				1/30/2009	24.74	70.54
				9/25/2009	26.48	68.80
				12/15/2009	25.97	69.31
				3/30/2010	24.67	70.61
				6/8/2010	24.84	70.44
				9/23/2010	26.38	68.90
				12/15/2010	25.68	69.60
				3/15/2011	25.05	70.23
				6/24/2011	26.70	68.58
				10/11/2011	27.10	68.18
				10/3/2012	27.99	67.29
				9/17/2013	28.53	66.75

TABLE 2

MONITOR WELL SPECIFICATIONS AND GROUNDWATER ELEVATIONS
CONOCOPHILLIPS COMPANY
HOWELL K No. 1
SAN JUAN COUNTY, NM

Well ID	*Total Depth (ft bgs)*	*Elevation* (ft) (TOC)*	*Screen Interval (ft below TOC)*	*Date Measured*	*Depth to Groundwater (ft below TOC)*	*Relative Water Level*
MW-3	37.47	95.44	19 - 34	10/24/2008	26.95	68.49
				1/30/2009	25.92	69.52
				9/25/2009	27.57	67.87
				12/15/2009	27.05	68.39
				3/30/2010	25.79	69.65
				6/8/2010	26.02	69.42
				9/23/2010	27.35	68.09
				12/15/2010	DRY	--
				3/15/2011	26.19	69.25
				6/24/2011	26.70	68.74
				10/11/2011	28.15	67.29
				10/3/2012	29.02	66.42
				9/17/2013	29.58	65.86
MW-4	34.66	95.36	17 - 32	10/24/2008	NM	NM
				1/30/2009	26.00	69.36
				9/25/2009	27.64	67.72
				12/15/2009	27.14	68.22
				3/30/2010	25.87	69.49
				6/8/2010	26.09	69.27
				9/23/2010	27.31	68.05
				12/15/2010	26.75	68.61
				3/15/2011	26.26	69.10
				6/24/2011	26.76	68.60
				10/11/2011	28.20	67.16
				10/3/2012	29.06	66.30
				9/17/2013	29.62	65.74

Notes:

*Casing elevations are based on an arbitrary 100 ft relative surface elevation set at the gas well head

ft = Feet

bgs = below ground surface

TOC = Top of casing

NM = Not measured

(1) Groundwater elevations can not be calculated accurately due to continual upward shifting of the PVC casing (see text of section 2.1, Monitoring Summary, of this report for more information).

(2) No survey data available

TABLE 3

GROUNDWATER LABORATORY ANALYTICAL RESULTS SUMMARY
CONOCOPHILLIPS COMPANY
HOWELL K No. 1
SAN JUAN COUNTY, NM

Well ID	*Sample ID*	*Date*	*Benzene (mg/L)*	*Toluene (mg/L)*	*Ethylbenzene (mg/L)*	*Xylenes (total) (mg/L)*	*Fluoride (mg/L)*	*Sulfate (mg/L)*	*Iron (dissolved) (mg/L)*	*Manganese (dissolved) (mg/L)*
MW-1	MW-1	3/22/2006	ND	ND	0.001	0.002	--	--	--	--
	MW-1	6/21/2006	0.0014	0.0014	ND	0.0106	--	--	--	--
	MW-1	10/19/2006	ND	ND	ND	0.0011	--	--	--	--
	MW-1	12/12/2006	ND	0.0005	0.0004	0.0021	--	--	--	--
	MW-1	11/9/2007	< 0.0005	< 0.0007	< 0.0008	< 0.0009	--	--	--	--
	MW-1	1/15/2008	< 0.0005	< 0.0007	< 0.0008	< 0.0008	--	--	--	--
	MW-1	3/19/2008	< 0.0005	< 0.0005	< 0.0005	< 0.0005	--	--	--	--
	MW-1	8/14/2008	< 0.0005	< 0.0005	< 0.0005	< 0.0005	--	--	--	--
	MW-1	10/24/2008	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 2.0	**2390**	--	--
	MW-1	1/30/2009	< 0.0005	< 0.0005	< 0.0005	< 0.0005	--	--	--	--
	MW-1	10/18/2009	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.88	**3840**	**2.24**	**17.40**
	MW-1	12/15/2009	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 50	**3290**	**1.70**	**16.50**
	MW-1	3/30/2010	< 0.0005	< 0.0005	< 0.0005	< 0.0005	--	**2950**	0.87	**14.90**
	MW-1	6/8/2010	< 0.0005	< 0.0005	< 0.0005	< 0.0005	--	**2570**	**11.20**	**14.70**
	MW-1	9/23/2010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.5	**2740**	**4.43**	**13.4**
	MW-1	12/15/2010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.5	**2230**	**9.72**	**11.1**
	MW-1	3/15/2011	--	--	--	--	0.654	**2360**	**20**	**11.4**
	GW-74928-062311-PG-04	6/23/2011	--	--	--	--	< 0.50	**2970**	< 0.1	**10.7**
	GW-074928-101211-CM-006	10/12/2011	--	--	--	--	0.28	**2940**	< 0.05	**9.6**
	GW-074928-100312-CM-MW-1	10/3/2012	--	--	--	--	0.56	**3280**	**16.7**	**6.1**
MW-1R	GW-074928-091713-CM-MW-1R	9/17/2013	--	--	--	--	1.1	**5100**	**2.8**	**3.8**
MW-2	MW-2	10/24/2008	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 2	**1480**	--	--
	MW-2	1/30/2009	< 0.0005	< 0.0005	< 0.0005	< 0.0005	--	--	--	--
	MW-2	9/25/2009	< 0.0005	< 0.0005	< 0.0005	< 0.0005	1.09	**1700**	< 0.02	< 0.005
	MW-2	12/15/2009	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 100	**1570**	< 0.02	< 0.005
	MW-2	3/30/2010	< 0.0005	< 0.0005	< 0.0005	< 0.0005	--	**1410**	< 0.02	0.14
	MW-2	6/8/2010	< 0.0005	< 0.0005	< 0.0005	< 0.0005	--	**1460**	0.0544	0.00930
	MW-2	9/23/2010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.5	**1760**	< 0.02	< 0.005
	MW-2	12/15/2010	< 0.001	< 0.001	< 0.001	< 0.001	1.01	**1890**	< 0.02	< 0.005
	MW-2	3/15/2011	--	--	--	--	1.21	**1680**	< 0.02	0.0096
	GW-74928-062311-PG-01	6/23/2011	--	--	--	--	1.3	**1990**	< 0.1	< 0.015
	GW-074928-101211-CM-007	10/12/2011	--	--	--	--	0.93	**1680**	0.873	0.0297
	GW-074928-100312-CM-MW-2	10/3/2012	--	--	--	--	1.1	**1850**	< 0.05	0.0055
	GW-074928-091713-CM-MW-2	9/17/2013	--	--	--	--	1.1	**2420**	< 0.05	< 0.005
MW-3	MW-3	10/24/2008	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 2	**1480**	--	--
	MW-3	1/30/2009	< 0.0005	< 0.0005	< 0.0005	< 0.0005	--	--	--	--
	MW-3	9/25/2009	< 0.0005	< 0.0005	< 0.0005	< 0.0005	1.00	**1840**	< 0.02	**0.38**
	MW-3	12/15/2009	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 50	**2500**	**1.35**	**0.32**
	MW-3	3/30/2010	< 0.0005	< 0.0005	< 0.0005	< 0.0005	--	**1890**	< 0.02	**0.43**
	MW-3	6/8/2010	< 0.0005	< 0.0005	< 0.0005	< 0.0005	--	**1630**	0.0573	**0.383**
	MW-3	9/23/2010	< 0.001	< 0.001	< 0.001	< 0.001	0.751	**1960**	< 0.02	**0.35**
	MW-3	3/15/2011	--	--	--	--	1.11	**1890**	< 0.02	**0.572**
	GW-74928-062311-PG-02	6/23/2011	--	--	--	--	1.2	**2190**	< 0.1	**0.846**
	GW-074928-101211-CM-008	10/12/2011	--	--	--	--	0.81	**1980**	< 0.05	**0.254**
	GW-074928-100312-CM-MW-3	10/3/2012	--	--	--	--	0.95	**2080**	< 0.05	**0.25**
	GW-074928-091713-CM-MW-3	9/17/2013	--	--	--	--	0.91	**2740**	< 0.05	**0.32**
MW-4	MW-4	10/24/2008	< 0.0005	< 0.0005	< 0.0005	< 0.0005	**2.43**	**3400**	--	--
	MW-4	1/30/2009	< 0.0005	< 0.0005	< 0.0005	< 0.0005	--	--	--	--
	MW-4	9/25/2009	< 0.001	< 0.001	< 0.001	< 0.001	**2.47**	**3860**	< 0.02	**7.80**
	MW-4	12/15/2009	< 0.001	< 0.001	< 0.001	< 0.001	< 50	**4540**	0.03	**7.40**
	MW-4	3/30/2010	< 0.001	< 0.001	< 0.001	< 0.001	--	**3970**	< 0.02	**7.83**
	MW-4	6/8/2010	< 0.001	< 0.001	< 0.001	< 0.001	--	**3490**	0.0607	**7.97**
	MW-4	9/23/2010	< 0.001	< 0.001	< 0.001	< 0.001	**1.81**	**3750**	< 0.02	**9.73**
	MW-4	12/15/2010	0.0011	< 0.001	< 0.001	< 0.001	**2.47**	**4310**	0.223	**8.64**
	MW-4	3/15/2011	--	--	--	--	**2.76**	**3990**	0.522	**11**
	GW-74928-062311-PG-03	6/23/2011	--	--	--	--	**2.4**	**4400**	0.492	**11.1**
	GW-074928-101211-CM-005	10/12/2011	--	--	--	--	**1.9**	**4120**	**2.75**	**15.6**
	GW-074928-100312-CM-MW-4	10/3/2012	--	--	--	--	**2.1**	**4280**	**2.0**	**18.0**
	GW-074928-100312-CM-DUP	10/3/2012	--	--	--	--	**--**	**--**	**2.2**	**18.4**
	GW-074928-091713-CM-MW-4	9/17/2013	--	--	--	--	**2.2**	**4040**	**1.1**	**15.6**
	GW-074928-091713-CM-DUP	9/17/2013	--	--	--	--	**--**	**--**	**1.2**	**16.7**
NMWQCC Groundwater Quality Standards			**0.01**	**0.75**	**0.75**	**0.62**	**1.6**	**600**	**1**	**0.2**

Notes:
MW = monitoring well
NMWQCC = New Mexico Water Quality Control Commission
Constituents in **BOLD** are in excess of NMWQCC groundwater quality standards
mg/L = milligrams per liter (parts per million)
< 1.0 = below laboratory detection limit of 1.0 mg/L
-- = not analyzed
ND = not detected

Appendix A

September 2013 Annual Groundwater Sampling Field Forms

WELL SAMPLING FIELD INFORMATION FORM

SITE/PROJECT NAME: Howell K No.1 JOB# 074928

SAMPLE ID: GW-074928-091713-CM-MW-1R WELL# MW-1R

WELL PURGING INFORMATION

PURGE DATE (MM DD YY)	SAMPLE DATE (MM DD YY)	SAMPLE TIME (24 HOUR)	WATER VOL. IN CASING (GALLONS)	ACTUAL VOL. PURGED (GALLONS)
9/17/13	9/17/13	1355	2.612	8.0

PURGING AND SAMPLING EQUIPMENT

PURGING EQUIPMENT.....DEDICATED (Y) N (CIRCLE ONE)

SAMPLING EQUIPMENT.....DEDICATED (Y) N (CIRCLE ONE)

PURGING DEVICE	G	A - SUBMERSIBLE PUMP	D - GAS LIFT PUMP	G - BAILER	X= PURGING DEVICE OTHER (SPECIFY)
		B - PERISTALTIC PUMP	E - PURGE PUMP	H - WATERRA®	
SAMPLING DEVICE	G	C - BLADDER PUMP	F - DIPPER BOTTLE	X - OTHER	X= SAMPLING DEVICE OTHER (SPECIFY)
PURGING MATERIAL	E	A - TEFLON	D - PVC		X= PURGING MATERIAL OTHER (SPECIFY)
		B - STAINLESS STEEL	E - POLYETHYLENE		
SAMPLING MATERIAL	E	C - POLYPROPYLENE	X - OTHER		X= SAMPLING MATERIAL OTHER (SPECIFY)
PURGE TUBING	C	A - TEFLON	D - POLYPROPYLENE	G - COMBINATION TEFLON/POLYPROPYLENE	X= PURGE TUBING OTHER (SPECIFY)
		B - TYGON	E - POLYETHYLENE		
SAMPLING TUBING	C	C - ROPE	F - SILICONE	X - OTHER	X= SAMPLING TUBING OTHER (SPECIFY)
FILTERING DEVICES 0.45	A	A - IN-LINE DISPOSABLE	B - PRESSURE	0.45 for metals only	

FIELD MEASUREMENTS

DEPTH TO WATER 30.83 (feet) WELL ELEVATION (feet)

WELL DEPTH 43.89 (feet) GROUNDWATER ELEVATION (feet)

TEMPERATURE	pH	TDS	SC	DO	ORP	VOLUME
15.79 (°C)	6.41 (std)	2.677 (g/L)	4118 (µS/cm)	2.82 (mg/L)	-176.7 (mV)	2.0 (gal)
15.59 (°C)	6.85 (std)	2.709 (g/L)	4173 (µS/cm)	1.87 (mg/L)	-238.6 (mV)	2.5 (gal)
15.45 (°C)	6.92 (std)	2.771 (g/L)	4220 (µS/cm)	1.73 (mg/L)	-283.9 (mV)	2.0 (gal)
(°C)	(std)	(g/L)	(µS/cm)	(mg/L)	(mV)	(gal)
(°C)	(std)	(g/L)	(µS/cm)	(mg/L)	(mV)	(gal)

FIELD COMMENTS

SAMPLE APPEARANCE: CLOUDY ODOR: NONE COLOR: BROWN SHEEN Y/N N

WEATHER CONDITIONS: TEMPERATURE 90s WINDY Y/N N PRECIPITATION Y/N (IF Y TYPE) N

SPECIFIC COMMENTS:

I CERTIFY THAT SAMPLING PROCEDURES WERE IN ACCORDANCE WITH APPLICABLE CRA PROTOCOLS

DATE 9/17/13 PRINT Christine Mathews SIGNATURE Christine Mathews

WELL SAMPLING FIELD INFORMATION FORM

SITE/PROJECT NAME: Howell K No. 1 JOB# 074928

SAMPLE ID: GW-074928-091713-CM-MW-2 WELL# MW-2

WELL PURGING INFORMATION

PURGE DATE (MM DD YY)	SAMPLE DATE (MM DD YY)	SAMPLE TIME (24 HOUR)	WATER VOL. IN CASING (GALLONS)	ACTUAL VOL. PURGED (GALLONS)
9/17/13	9/17/13	1340	1.732	5.25

PURGING AND SAMPLING EQUIPMENT

PURGING EQUIPMENT.....DEDICATED (Y) N (CIRCLE ONE)

SAMPLING EQUIPMENT.....DEDICATED (Y) N (CIRCLE ONE)

PURGING DEVICE	G	A - SUBMERSIBLE PUMP	D - GAS LIFT PUMP	G - BAILER	X= PURGING DEVICE OTHER (SPECIFY)
		B - PERISTALTIC PUMP	E - PURGE PUMP	H - WATERRA®	
SAMPLING DEVICE	G	C - BLADDER PUMP	F - DIPPER BOTTLE	X - OTHER	X= SAMPLING DEVICE OTHER (SPECIFY)
PURGING MATERIAL	E	A - TEFLON	D - PVC		X= PURGING MATERIAL OTHER (SPECIFY)
		B - STAINLESS STEEL	E - POLYETHYLENE		
SAMPLING MATERIAL	E	C - POLYPROPYLENE	X - OTHER		X= SAMPLING MATERIAL OTHER (SPECIFY)
PURGE TUBING	C	A - TEFLON	D - POLYPROPYLENE	G - COMBINATION TEFLON/POLYPROPYLENE	X= PURGE TUBING OTHER (SPECIFY)
		B - TYGON	E - POLYETHYLENE		
SAMPLING TUBING	C	C - ROPE	F - SILICONE	X - OTHER	X= SAMPLING TUBING OTHER (SPECIFY)
FILTERING DEVICES 0.45	A	A - IN-LINE DISPOSABLE	B - PRESSURE	0.45 for metals only	

FIELD MEASUREMENTS

DEPTH TO WATER 28.53 (feet) WELL ELEVATION (feet)

WELL DEPTH 39.36 (feet) GROUNDWATER ELEVATION (feet)

TEMPERATURE	pH	TDS	SC	DO	ORP	VOLUME
15.55 (°C)	6.07 (std)	1.791 (g/L)	2759 (µS/cm)	10.73 (mg/L)	-22.7 (mV)	4.25 (gal)
14.79 (°C)	6.18 (std)	1.829 (g/L)	2814 (µS/cm)	4.62 (mg/L)	-119.3 (mV)	4.75 (gal)
14.49 (°C)	6.20 (std)	1.852 (g/L)	2850 (µS/cm)	3.38 (mg/L)	-158.2 (mV)	5.25 (gal)
(°C)	(std)	(g/L)	(µS/cm)	(mg/L)	(mV)	(gal)
(°C)	(std)	(g/L)	(µS/cm)	(mg/L)	(mV)	(gal)

FIELD COMMENTS

SAMPLE APPEARANCE: CLOUDY ODOR: NONE COLOR: BROWN SHEEN Y/N Y

WEATHER CONDITIONS: TEMPERATURE 90s WINDY Y/N N PRECIPITATION Y/N (IF Y TYPE) N

SPECIFIC COMMENTS:

I CERTIFY THAT SAMPLING PROCEDURES WERE IN ACCORDANCE WITH APPLICABLE ERA PROTOCOLS

DATE 9/17/13 PRINT Christine Matheus SIGNATURE Christine Matheus

WELL SAMPLING FIELD INFORMATION FORM

SITE/PROJECT NAME: G Havel K No. 1 JOB# 074928

SAMPLE ID: GW-074928-091713-CM-MW-3 WELL# MW-3

WELL PURGING INFORMATION

PURGE DATE (MM DD YY)	SAMPLE DATE (MM DD YY)	SAMPLE TIME (24 HOUR)	WATER VOL. IN CASING (GALLONS)	ACTUAL VOL. PURGED (GALLONS)
9/17/13	9/17/13	1420	1.424	4.5

PURGING AND SAMPLING EQUIPMENT

PURGING EQUIPMENT.....DEDICATED Y (N) (CIRCLE ONE)

SAMPLING EQUIPMENT.....DEDICATED (Y) N (CIRCLE ONE)

PURGING DEVICE	A	A - SUBMERSIBLE PUMP	D - GAS LIFT PUMP	G - BAILER	X= PURGING DEVICE OTHER (SPECIFY)
		B - PERISTALTIC PUMP	E - PURGE PUMP	H - WATERRA®	
SAMPLING DEVICE	C	C - BLADDER PUMP	F - DIPPER BOTTLE	X - OTHER	X= SAMPLING DEVICE OTHER (SPECIFY)
PURGING MATERIAL	E	A - TEFLON	D - PVC		X= PURGING MATERIAL OTHER (SPECIFY)
		B - STAINLESS STEEL	E - POLYETHYLENE		
SAMPLING MATERIAL	E	C - POLYPROPYLENE	X - OTHER		X= SAMPLING MATERIAL OTHER (SPECIFY)
PURGE TUBING	C	A - TEFLON	D - POLYPROPYLENE	G - COMBINATION TEFLON/POLYPROPYLENE	X= PURGE TUBING OTHER (SPECIFY)
		B - TYGON	E - POLYETHYLENE		
SAMPLING TUBING	C	C - ROPE	F - SILICONE	X - OTHER	X= SAMPLING TUBING OTHER (SPECIFY)
FILTERING DEVICES 0.45	A	A - IN-LINE DISPOSABLE	B - PRESSURE	0.45 for metals only	

FIELD MEASUREMENTS

DEPTH TO WATER 29.58 (feet) WELL ELEVATION (feet)

WELL DEPTH 36.70 (feet) GROUNDWATER ELEVATION (feet)

TEMPERATURE	pH	TDS	SC	DO	ORP	VOLUME
15.40 (°C)	7.34 (std)	2.248 (g/L)	3457 (µS/cm)	2.84 (mg/L)	-256.6 (mV)	~~3.5~~ (gal) 2.5
15.24 (°C)	7.16 (std)	2.219 (g/L)	3413 (µS/cm)	2.31 (mg/L)	-269.0 (mV)	~~4.0~~ 3.0 (gal)
15.19 (°C)	6.94 (std)	2.210 (g/L)	3400 (µS/cm)	2.67 (mg/L)	-242.5 (mV)	~~4.5~~ 3.5 (gal)
15.33 (°C)	6.93 (std)	2.204 (g/L)	3392 (µS/cm)	2.79 (mg/L)	-233.0 (mV)	4.0 (gal)
15.18 (°C)	6.91 (std)	2.205 (g/L)	3392 (µS/cm)	3.04 (mg/L)	-226.9 (mV)	4.5 (gal)

FIELD COMMENTS

SAMPLE APPEARANCE: cloudy ODOR: none COLOR: LT Brown SHEEN Y/N no

WEATHER CONDITIONS: TEMPERATURE 90° WINDY Y/N NO PRECIPITATION Y/N (IF Y TYPE) no

SPECIFIC COMMENTS:

I CERTIFY THAT SAMPLING PROCEDURES WERE IN ACCORDANCE WITH APPLICABLE CRA PROTOCOLS

DATE 9/17/13 PRINT Christine Matthews SIGNATURE Christine Matthews

WELL SAMPLING FIELD INFORMATION FORM

SITE/PROJECT NAME: Howell K. No. 1 JOB# 074928

SAMPLE ID: GW-074928-091713-CM-MW-4 WELL# MW-4

WELL PURGING INFORMATION

PURGE DATE (MM DD YY)	SAMPLE DATE (MM DD YY)	SAMPLE TIME (24 HOUR)	WATER VOL. IN CASING (GALLONS)	ACTUAL VOL. PURGED (GALLONS)
9/17/13	9/17/13	1405	0.786	2.5

PURGING AND SAMPLING EQUIPMENT

PURGING EQUIPMENT.....DEDICATED (Y) N (CIRCLE ONE)

SAMPLING EQUIPMENT.....DEDICATED (Y) N (CIRCLE ONE)

PURGING DEVICE	G	A - SUBMERSIBLE PUMP	D - GAS LIFT PUMP	G - BAILER	X= PURGING DEVICE OTHER (SPECIFY)
		B - PERISTALTIC PUMP	E - PURGE PUMP	H - WATERRA®	
SAMPLING DEVICE	G	C - BLADDER PUMP	F - DIPPER BOTTLE	X - OTHER	X= SAMPLING DEVICE OTHER (SPECIFY)
PURGING MATERIAL	E	A - TEFLON	D - PVC		X= PURGING MATERIAL OTHER (SPECIFY)
		B - STAINLESS STEEL	E - POLYETHYLENE		
SAMPLING MATERIAL	E	C - POLYPROPYLENE	X - OTHER		X= SAMPLING MATERIAL OTHER (SPECIFY)
PURGE TUBING	C	A - TEFLON	D - POLYPROPYLENE	G - COMBINATION TEFLON/POLYPROPYLENE	X= PURGE TUBING OTHER (SPECIFY)
		B - TYGON	E - POLYETHYLENE		
SAMPLING TUBING	C	C - ROPE	F - SILICONE	X - OTHER	X= SAMPLING TUBING OTHER (SPECIFY)
FILTERING DEVICES 0.45	A	A - IN-LINE DISPOSABLE	B - PRESSURE	0.45 for metals only	

FIELD MEASUREMENTS

DEPTH TO WATER 29.62 (feet) WELL ELEVATION (feet)

WELL DEPTH 34.53 (feet) GROUNDWATER ELEVATION (feet)

TEMPERATURE	pH	TDS	SC	DO	ORP	VOLUME
15.54 (°C)	6.70 (std)	4.588 (g/L)	7060 (µS/cm)	3.93 (mg/L)	-288.6 (mV)	1.5 (gal)
15.26 (°C)	6.68 (std)	4.573 (g/L)	7030 (µS/cm)	3.92 (mg/L)	-316.0 (mV)	2.0 (gal)
15.15 (°C)	6.70 (std)	4.528 (g/L)	7/6967 (µS/cm)	3.82 (mg/L)	-312.1 (mV)	2.5 (gal)
(°C)	(std)	(g/L)	(µS/cm)	(mg/L)	(mV)	(gal)
(°C)	(std)	(g/L)	(µS/cm)	(mg/L)	(mV)	(gal)

FIELD COMMENTS

SAMPLE APPEARANCE: CLOUDY ODOR: NONE COLOR: LIGHT BROWN SHEEN Y/N N

WEATHER CONDITIONS: TEMPERATURE 90's WINDY Y/N N PRECIPITATION Y/N (IF Y TYPE) N

SPECIFIC COMMENTS:

DUP COLLECTED @ 1410
GW-074928-091713-CM-DUP

I CERTIFY THAT SAMPLING PROCEDURES WERE IN ACCORDANCE WITH APPLICABLE CRA PROTOCOLS

DATE 9/17/13 PRINT Christine Mathews SIGNATURE Christine Mathews

Appendix B

September 2013 Annual Groundwater Laboratory Analytical Report

Pace Analytical Services, Inc.
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

August 07, 2013

Christine Matthews
CRA
6121 Indian School Rd NE
Suite 200
Albuquerque, NM 87110

RE: Project: 074928 HOWELL K NO 1
Pace Project No.: 60149575

Dear Christine Matthews:
Enclosed are the analytical results for sample(s) received by the laboratory on July 25, 2013. The results relate only to the samples included in this report. Results reported herein conform to the most current TNI standards and the laboratory's Quality Assurance Manual, where applicable, unless otherwise noted in the body of the report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Alice Flanagan

alice.flanagan@pacelabs.com
Project Manager

Enclosures

cc: Kelly Blanchard, COP Conestoga-Rovers & Associa
Angela Bown, COP Conestoga-Rovers & Associa
Cassie Brown, COP Conestoga-Rovers & Associa
Jason Ploss, COP Conestoga-Rovers & Associa

Pace Analytical Services, Inc.
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

CERTIFICATIONS

Project: 074928 HOWELL K NO 1
Pace Project No.: 60149575

Kansas Certification IDs
9608 Loiret Boulevard, Lenexa, KS 66219
WY STR Certification #: 2456.01
Arkansas Certification #: 13-012-0
Illinois Certification #: 003097
Iowa Certification #: 118
Kansas/NELAP Certification #: E-10116
Louisiana Certification #: 03055
Nevada Certification #: KS000212008A
Oklahoma Certification #: 9205/9935
Texas Certification #: T104704407-13-4
Utah Certification #: KS000212013-3
Illinois Certification #: 003097

Pace Analytical Services, Inc.
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

SAMPLE SUMMARY

Project: 074928 HOWELL K NO 1
Pace Project No.: 60149575

Lab ID	Sample ID	Matrix	Date Collected	Date Received
60149575001	**SS-074928-071913-JC-MW1R-25**	Solid	07/19/13 12:15	07/25/13 07:20

Pace Analytical Services, Inc.
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Lenexa, KS 66219
(913)599-5665

SAMPLE ANALYTE COUNT

Project: 074928 HOWELL K NO 1
Pace Project No.: 60149575

Lab ID	Sample ID	Method	Analysts	Analytes Reported
60149575001	**SS-074928-071913-JC-MW1R-25**	EPA 6010	JGP	2
		ASTM D2974	DWC	1
		EPA 300.0	OL	2

Pace Analytical Services, Inc.
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Lenexa, KS 66219
(913)599-5665

PROJECT NARRATIVE

Project: 074928 HOWELL K NO 1
Pace Project No.: 60149575

Method: **EPA 6010**
Description: 6010 MET ICP Red. Interference
Client: COP Conestoga-Rovers & Associates, Inc. NM
Date: August 07, 2013

General Information:
1 sample was analyzed for EPA 6010. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 3050 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

QC Batch: MPRP/23634

A matrix spike and matrix spike duplicate (MS/MSD) were performed on the following sample(s): 60149503003

M1: Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

- MS (Lab ID: 1226230)
  - Iron
  - Manganese
- MSD (Lab ID: 1226231)
  - Iron

Additional Comments:

Analyte Comments:

QC Batch: MPRP/23634

1e: Post Digestion Spike Performed - 76% Recovery

- SS-074928-071913-JC-MW1R-25 (Lab ID: 60149575001)
  - Manganese

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, Inc.
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

PROJECT NARRATIVE

Project: 074928 HOWELL K NO 1
Pace Project No.: 60149575

Method: **EPA 300.0**
Description: 300.0 IC Anions 28 Days
Client: COP Conestoga-Rovers & Associates, Inc. NM
Date: August 07, 2013

General Information:
1 sample was analyzed for EPA 300.0. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 300.0 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Additional Comments:

This data package has been reviewed for quality and completeness and is approved for release.

Pace Analytical Services, Inc.
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

ANALYTICAL RESULTS

Project: 074928 HOWELL K NO 1
Pace Project No.: 60149575

Sample: SS-074928-071913-JC-MW1R-25 **Lab ID: 60149575001** Collected: 07/19/13 12:15 Received: 07/25/13 07:20 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	Report Limit	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP Red. Interference	Analytical Method: EPA 6010 Preparation Method: EPA 3050								
Iron	**7350**	mg/kg	5.1	1.6	1	07/26/13 13:45	07/29/13 14:04	7439-89-6	
Manganese	**180**	mg/kg	0.51	0.021	1	07/26/13 13:45	07/29/13 14:04	7439-96-5	1e
Percent Moisture	Analytical Method: ASTM D2974								
Percent Moisture	**9.7**	%	0.50	0.50	1		07/26/13 00:00		
300.0 IC Anions 28 Days	Analytical Method: EPA 300.0 Preparation Method: EPA 300.0								
Fluoride	ND	mg/kg	22.1	0.93	10	08/01/13 10:00	08/01/13 15:30	16984-48-8	
Sulfate	**367**	mg/kg	111	6.0	10	08/01/13 10:00	08/01/13 15:30	14808-79-8	

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, Inc.
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(913)599-5665

QUALITY CONTROL DATA

Project: 074928 HOWELL K NO 1
Pace Project No.: 60149575

QC Batch: MPRP/23634
QC Batch Method: EPA 3050
Analysis Method: EPA 6010
Analysis Description: 6010 MET
Associated Lab Samples: 60149575001

METHOD BLANK: 1226228 Matrix: Solid
Associated Lab Samples: 60149575001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Iron	mg/kg	ND	5.0	07/29/13 12:47	
Manganese	mg/kg	0.50	0.50	07/29/13 12:47	

LABORATORY CONTROL SAMPLE: 1226229

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Iron	mg/kg	1000	956	96	80-120	
Manganese	mg/kg	100	93.5	94	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1226230 1226231

Parameter	Units	60149503003 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Iron	mg/kg	13700	1110	1200	15200	16400	128	221	75-125	8	20	M1
Manganese	mg/kg	149	111	120	227	241	70	77	75-125	6	20	M1

REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: 074928 HOWELL K NO 1
Pace Project No.: 60149575

QC Batch: PMST/8747
QC Batch Method: ASTM D2974
Analysis Method: ASTM D2974
Analysis Description: Dry Weight/Percent Moisture
Associated Lab Samples: 60149575001

METHOD BLANK: 1226105 Matrix: Solid
Associated Lab Samples: 60149575001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Percent Moisture	%	ND	0.50	07/26/13 00:00	

SAMPLE DUPLICATE: 1226106

Parameter	Units	60149503003 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	19.8	19.3	3	20	

REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: 074928 HOWELL K NO 1
Pace Project No.: 60149575

QC Batch: WETA/25646
QC Batch Method: EPA 300.0
Analysis Method: EPA 300.0
Analysis Description: 300.0 IC Anions
Associated Lab Samples: 60149575001

METHOD BLANK: 1229044 Matrix: Solid
Associated Lab Samples: 60149575001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Fluoride	mg/kg	ND	20.0	08/01/13 14:11	
Sulfate	mg/kg	ND	100	08/01/13 14:11	

LABORATORY CONTROL SAMPLE: 1229045

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Fluoride	mg/kg	250	252	101	90-110	
Sulfate	mg/kg	500	508	102	90-110	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1229046 1229047

Parameter	Units	60149723010 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Fluoride	mg/kg	23.6			39.9	45.9				14	20	
Sulfate	mg/kg	340	250	250	604	600	105	104	67-127			

REPORT OF LABORATORY ANALYSIS

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QUALIFIERS

Project: 074928 HOWELL K NO 1
Pace Project No.: 60149575

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to changes in sample preparation, dilution of the sample aliquot, or moisture content.

ND - Not Detected at or above adjusted reporting limit.

J - Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

PRL - Pace Reporting Limit.

RL - Reporting Limit.

S - Surrogate

1,2-Diphenylhydrazine (8270 listed analyte) decomposes to Azobenzene.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.

TNI - The NELAC Institute.

ANALYTE QUALIFIERS

1e	Post Digestion Spike Performed - 76% Recovery
M1	Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

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QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: 074928 HOWELL K NO 1
Pace Project No.: 60149575

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
60149575001	**SS-074928-071913-JC-MW1R-25**	EPA 3050	MPRP/23634	EPA 6010	ICP/18548
60149575001	**SS-074928-071913-JC-MW1R-25**	ASTM D2974	PMST/8747		
60149575001	**SS-074928-071913-JC-MW1R-25**	EPA 300.0	WETA/25646	EPA 300.0	WETA/25647

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Sample Condition Upon Receipt
ESI Tech Spec Client

WO# : 60149575

60149575

Client Name: COP CRA_NM

Optional
Proj Due Date:
Proj Name:

Courier: Fed Ex ☑ UPS ☐ USPS ☐ Client ☐ Commercial ☐ Pace ☐ Other ☐

Tracking #: 7963 0460 2844 Pace Shipping Label Used? Yes ☐ No ☑

Custody Seal on Cooler/Box Present: Yes ☑ No ☐ Seals intact: Yes ☑ No ☐

Packing Material: Bubble Wrap ☐ Bubble Bags ☑ Foam ☐ None ☐ Other ☑ ZPLC

Thermometer Used: T-112 / T-194 **Type of Ice:** (Wet) Blue None ☐ Samples received on ice, cooling process has begun
(circle one)

Cooler Temperature: 3.3

Temperature should be above freezing to 6°C

Date and initials of person examining contents: 7-25-13 BA

Chain of Custody present:	☑Yes ☐No ☐N/A	1.
Chain of Custody filled out:	☑Yes ☐No ☐N/A	2.
Chain of Custody relinquished:	☐Yes ☑No ☐N/A	3.
Sampler name & signature on COC:	☑Yes ☐No ☐N/A	4.
Samples arrived within holding time:	☑Yes ☐No ☐N/A	5.
Short Hold Time analyses (<72hr):	☐Yes ☑No ☐N/A	6.
Rush Turn Around Time requested:	☐Yes ☑No ☐N/A	7.
Sufficient volume:	☑Yes ☐No ☐N/A	8.
Correct containers used:	☑Yes ☐No ☐N/A	
Pace containers used:	☑Yes ☐No ☐N/A	9.
Containers intact:	☑Yes ☐No ☐N/A	10.
Unpreserved 5035A soils frozen w/in 48hrs?	☐Yes ☐No ☑N/A	11.
Filtered volume received for dissolved tests?	☐Yes ☐No ☑N/A	12.
Sample labels match COC:	☑Yes ☐No ☐N/A	
Includes date/time/ID/analyses Matrix: SL		13.
All containers needing preservation have been checked.	☐Yes ☐No ☑N/A	
All containers needing preservation are found to be in compliance with EPA recommendation.	☐Yes ☐No ☑N/A	14.
Exceptions: VOA, coliform, TOC, O&G, WI-DRO (water), Phenolics	☐Yes ☑No	Initial when completed / Lot # of added preservative
Trip Blank present:	☑Yes ☐No ☑N/A	BA 7-25-13
Pace Trip Blank lot # (if purchased):		15.
Headspace in VOA vials (>6mm):	☐Yes ☐No ☑N/A	16.
Project sampled in USDA Regulated Area:	☐Yes ☑No ☐N/A	17. List State: NM

Client Notification/ Resolution: Copy COC to Client? Y / N Field Data Required? Y / N

Person Contacted: _____ Date/Time: _____

Comments/ Resolution: _____

Temp Log: Record start and finish times when unpacking cooler, if >20 min, recheck sample temps.	
Start: 0825	Start:
End: 0830	End:
Temp:	Temp:

Project Manager Review: [signature] Date: 7/25/13

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CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page: 1 of 1

Section A Required Client Information:

Company:	COP CRA NM
Address:	6121 Indian School Rd NE, Ste 200
	Albequerque, NM 87110
Email To:	cmathews@craworld.com
Phone: (505)884-0672	Fax: (505)884-4932
Requested Due Date/TAT:	

Section B Required Project Information:

Report To:	Christine Mathews
Copy To:	Kelly Blanchard, Angela Bown
Purchase Order No.:	4517898447
Project Name:	Howell K No. 1
Project Number:	74928

Section C Invoice Information:

Attention:	COP epayables
Company Name:	
Address:	
Pace Quote Reference:	
Pace Project Manager:	Alice Flanagan
Pace Profile #:	5514, TS NT

REGULATORY AGENCY

☐ NPDES ☐ GROUND WATER ☐ DRINKING WATER
☐ UST ☐ RCRA ☐ OTHER _____

Site Location STATE: NM

Section D Required Client Information

SAMPLE ID
(A-Z, 0-9 / ,-)
Sample IDs MUST BE UNIQUE

Valid Matrix Codes

MATRIX	CODE
DRINKING WATER	DW
WATER	WT
WASTE WATER	WW
PRODUCT	P
SOIL/SOLID	SL
OIL	OL
WIPE	WP
AIR	AR
OTHER	OT
TISSUE	TS

Requested Analysis Filtered (Y/N)

ITEM #	SAMPLE ID	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED COMPOSITE START DATE	COLLECTED COMPOSITE START TIME	COLLECTED COMPOSITE END/GRAB DATE	COLLECTED COMPOSITE END/GRAB TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Preservatives: Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	Analysis Test Y/N: 6010 ~~Dissolved~~ Fe & Mn	300.0 Sulfate, Fluoride	Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
1	SS-074928-07193-JC-MWIR-25	SO	G			7.19.13	1215		2	X							X	X			2WGFU (M)
2																					2VGAU (TB) (M)
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					
11																					
12																					

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS			
				[signature] PACE	7-25-13	0720	3.3	Y	Y	Y

SAMPLER NAME AND SIGNATURE

PRINT Name of SAMPLER: [signature]

SIGNATURE of SAMPLER: Josh Kilgore DATE Signed (MM/DD/YY): 7/24/13

Temp in °C | Received on Ice (Y/N) | Custody Sealed Cooler (Y/N) | Samples Intact (Y/N)

*Important Note: By signing this form you are accepting Pace's NET 30 day payment terms and agreeing to late charges of 1.5% per month for any invoices not paid within 30 days.

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October 07, 2013

Christine Matthews
CRA
6121 Indian School Rd NE
Suite 200
Albuquerque, NM 87110

RE: Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

Dear Christine Matthews:
Enclosed are the analytical results for sample(s) received by the laboratory on September 20, 2013. The results relate only to the samples included in this report. Results reported herein conform to the most current TNI standards and the laboratory's Quality Assurance Manual, where applicable, unless otherwise noted in the body of the report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Alice Flanagan

alice.flanagan@pacelabs.com
Project Manager

Enclosures

cc: Angela Bown, COP Conestoga-Rovers & Associa
Jeff Walker, COP Conestoga-Rovers & Associa

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CERTIFICATIONS

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

Kansas Certification IDs
9608 Loiret Boulevard, Lenexa, KS 66219
WY STR Certification #: 2456.01
Arkansas Certification #: 13-012-0
Illinois Certification #: 003097
Iowa Certification #: 118
Kansas/NELAP Certification #: E-10116
Louisiana Certification #: 03055
Nevada Certification #: KS000212008A
Oklahoma Certification #: 9205/9935
Texas Certification #: T104704407-13-4
Utah Certification #: KS000212013-3
Illinois Certification #: 003097

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SAMPLE SUMMARY

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

Lab ID	Sample ID	Matrix	Date Collected	Date Received
60153646001	**GW-074928-091713-CM-MW-1R**	Water	09/17/13 13:55	09/20/13 08:30
60153646002	**GW-074928-091713-CM-MW-2**	Water	09/17/13 13:40	09/20/13 08:30
60153646003	**GW-074928-091713-CM-MW-3**	Water	09/17/13 14:20	09/20/13 08:30
60153646004	**GW-074928-091713-CM-MW-4**	Water	09/17/13 14:05	09/20/13 08:30
60153646005	**GW-074928-091713-CM-MW-DUP**	Water	09/17/13 14:01	09/20/13 08:30

REPORT OF LABORATORY ANALYSIS

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SAMPLE ANALYTE COUNT

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

Lab ID	Sample ID	Method	Analysts	Analytes Reported
60153646001	**GW-074928-091713-CM-MW-1R**	EPA 6010	NDJ	2
		EPA 300.0	OL	2
60153646002	**GW-074928-091713-CM-MW-2**	EPA 6010	NDJ	2
		EPA 300.0	OL	2
60153646003	**GW-074928-091713-CM-MW-3**	EPA 6010	NDJ	2
		EPA 300.0	OL	2
60153646004	**GW-074928-091713-CM-MW-4**	EPA 6010	NDJ	2
		EPA 300.0	OL	2
60153646005	**GW-074928-091713-CM-MW-DUP**	EPA 6010	NDJ	2

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PROJECT NARRATIVE

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

Method: **EPA 6010**
Description: 6010 MET ICP, Dissolved
Client: COP Conestoga-Rovers & Associates, Inc. NM
Date: October 07, 2013

General Information:
5 samples were analyzed for EPA 6010. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 3010 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

Method: **EPA 300.0**
Description: 300.0 IC Anions 28 Days
Client: COP Conestoga-Rovers & Associates, Inc. NM
Date: October 07, 2013

General Information:
4 samples were analyzed for EPA 300.0. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

QC Batch: WETA/26476

A matrix spike and/or matrix spike duplicate (MS/MSD) were performed on the following sample(s): 60153603001,60153603002

M1: Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

- MS (Lab ID: 1265089)
  - Fluoride

Additional Comments:

This data package has been reviewed for quality and completeness and is approved for release.

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ANALYTICAL RESULTS

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

Sample: GW-074928-091713-CM-MW-1R **Lab ID: 60153646001** Collected: 09/17/13 13:55 Received: 09/20/13 08:30 Matrix: Water

Parameters	Results	Units	Report Limit	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP, Dissolved	Analytical Method: EPA 6010 Preparation Method: EPA 3010								
Iron, Dissolved	**2.8**	mg/L	0.050	0.012	1	09/26/13 10:25	09/27/13 10:44	7439-89-6	
Manganese, Dissolved	**3.8**	mg/L	0.0050	0.00049	1	09/26/13 10:25	09/27/13 10:44	7439-96-5	
300.0 IC Anions 28 Days	Analytical Method: EPA 300.0								
Fluoride	**1.1**	mg/L	0.20	0.047	1		10/04/13 20:15	16984-48-8	
Sulfate	**5100**	mg/L	500	80.0	500		10/04/13 20:29	14808-79-8	

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

Sample: GW-074928-091713-CM-MW-2 **Lab ID: 60153646002** Collected: 09/17/13 13:40 Received: 09/20/13 08:30 Matrix: Water

Parameters	Results	Units	Report Limit	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP, Dissolved	Analytical Method: EPA 6010 Preparation Method: EPA 3010								
Iron, Dissolved	ND	mg/L	0.050	0.012	1	09/26/13 10:25	09/27/13 10:53	7439-89-6	
Manganese, Dissolved	ND	mg/L	0.0050	0.00049	1	09/26/13 10:25	09/27/13 10:53	7439-96-5	
300.0 IC Anions 28 Days	Analytical Method: EPA 300.0								
Fluoride	**1.1**	mg/L	0.20	0.047	1		10/04/13 21:13	16984-48-8	
Sulfate	**2420**	mg/L	200	32.0	200		10/04/13 21:27	14808-79-8	

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

Sample: GW-074928-091713-CM-MW-3 **Lab ID: 60153646003** Collected: 09/17/13 14:20 Received: 09/20/13 08:30 Matrix: Water

Parameters	Results	Units	Report Limit	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP, Dissolved	Analytical Method: EPA 6010 Preparation Method: EPA 3010								
Iron, Dissolved	ND	mg/L	0.050	0.012	1	09/26/13 10:25	09/27/13 10:57	7439-89-6	
Manganese, Dissolved	**0.32**	mg/L	0.0050	0.00049	1	09/26/13 10:25	09/27/13 10:57	7439-96-5	
300.0 IC Anions 28 Days	Analytical Method: EPA 300.0								
Fluoride	**0.91**	mg/L	0.20	0.047	1		10/04/13 21:41	16984-48-8	
Sulfate	**2740**	mg/L	200	32.0	200		10/04/13 21:56	14808-79-8	

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

Sample: GW-074928-091713-CM-MW-4 **Lab ID: 60153646004** Collected: 09/17/13 14:05 Received: 09/20/13 08:30 Matrix: Water

Parameters	Results	Units	Report Limit	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP, Dissolved	Analytical Method: EPA 6010 Preparation Method: EPA 3010								
Iron, Dissolved	**1.1**	mg/L	0.050	0.012	1	09/26/13 10:25	09/27/13 11:00	7439-89-6	
Manganese, Dissolved	**15.6**	mg/L	0.0050	0.00049	1	09/26/13 10:25	09/27/13 11:00	7439-96-5	
300.0 IC Anions 28 Days	Analytical Method: EPA 300.0								
Fluoride	**2.2**	mg/L	0.20	0.047	1		10/04/13 22:25	16984-48-8	
Sulfate	**4040**	mg/L	500	80.0	500		10/04/13 22:10	14808-79-8	

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

Sample: GW-074928-091713-CM-MW-DUP **Lab ID: 60153646005** Collected: 09/17/13 14:01 Received: 09/20/13 08:30 Matrix: Water

Parameters	Results	Units	Report Limit	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6010 MET ICP, Dissolved	Analytical Method: EPA 6010 Preparation Method: EPA 3010								
Iron, Dissolved	**1.2**	mg/L	0.050	0.012	1	09/26/13 10:25	09/27/13 11:04	7439-89-6	
Manganese, Dissolved	**16.7**	mg/L	0.0050	0.00049	1	09/26/13 10:25	09/27/13 11:04	7439-96-5	

REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

QC Batch: MPRP/24442 Analysis Method: EPA 6010
QC Batch Method: EPA 3010 Analysis Description: 6010 MET Dissolved
Associated Lab Samples: 60153646001, 60153646002, 60153646003, 60153646004, 60153646005

METHOD BLANK: 1260460 Matrix: Water
Associated Lab Samples: 60153646001, 60153646002, 60153646003, 60153646004, 60153646005

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Iron, Dissolved	mg/L	ND	0.050	09/27/13 10:15	
Manganese, Dissolved	mg/L	ND	0.0050	09/27/13 10:15	

LABORATORY CONTROL SAMPLE: 1260461

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Iron, Dissolved	mg/L	10	10.1	101	80-120	
Manganese, Dissolved	mg/L	1	1.0	101	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1260462 1260463

Parameter	Units	60153641001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Iron, Dissolved	mg/L	ND	10	10	10	9.9	100	99	75-125	0	20	
Manganese, Dissolved	mg/L	0.89	1	1	1.8	1.8	94	95	75-125	1	20	

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, Inc.
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

QUALITY CONTROL DATA

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

QC Batch: WETA/26476 Analysis Method: EPA 300.0
QC Batch Method: EPA 300.0 Analysis Description: 300.0 IC Anions
Associated Lab Samples: 60153646001, 60153646002, 60153646003, 60153646004

METHOD BLANK: 1265087 Matrix: Water
Associated Lab Samples: 60153646001, 60153646002, 60153646003, 60153646004

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Fluoride	mg/L	ND	0.20	10/04/13 17:37	
Sulfate	mg/L	ND	1.0	10/04/13 17:37	

LABORATORY CONTROL SAMPLE: 1265088

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Fluoride	mg/L	2.5	2.3	92	90-110	
Sulfate	mg/L	5	4.8	97	90-110	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1265089 1265090

Parameter	Units	60153603001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Fluoride	mg/L	ND	50	50	39.6	39.9	79	80	80-120	1	15	M1
Sulfate	mg/L	1760	1000	1000	2620	2650	86	89	80-120	1	15	

MATRIX SPIKE SAMPLE: 1265091

Parameter	Units	60153603002 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Fluoride	mg/L	ND	50	45.7	91	80-120	
Sulfate	mg/L	1110	1000	2000	89	80-120	

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, Inc.
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

QUALIFIERS

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to changes in sample preparation, dilution of the sample aliquot, or moisture content.

ND - Not Detected at or above adjusted reporting limit.

J - Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

PRL - Pace Reporting Limit.

RL - Reporting Limit.

S - Surrogate

1,2-Diphenylhydrazine (8270 listed analyte) decomposes to Azobenzene.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.

TNI - The NELAC Institute.

ANALYTE QUALIFIERS

M1 Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

Pace Analytical Services, Inc.
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: 074928 HOWELL K NO. 1
Pace Project No.: 60153646

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
60153646001	**GW-074928-091713-CM-MW-1R**	EPA 3010	MPRP/24442	EPA 6010	ICP/19045
60153646002	**GW-074928-091713-CM-MW-2**	EPA 3010	MPRP/24442	EPA 6010	ICP/19045
60153646003	**GW-074928-091713-CM-MW-3**	EPA 3010	MPRP/24442	EPA 6010	ICP/19045
60153646004	**GW-074928-091713-CM-MW-4**	EPA 3010	MPRP/24442	EPA 6010	ICP/19045
60153646005	**GW-074928-091713-CM-MW-DUP**	EPA 3010	MPRP/24442	EPA 6010	ICP/19045
60153646001	**GW-074928-091713-CM-MW-1R**	EPA 300.0	WETA/26476		
60153646002	**GW-074928-091713-CM-MW-2**	EPA 300.0	WETA/26476		
60153646003	**GW-074928-091713-CM-MW-3**	EPA 300.0	WETA/26476		
60153646004	**GW-074928-091713-CM-MW-4**	EPA 300.0	WETA/26476		

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Sample Condition Upon Receipt
ESI Tech Spec Client

WO# : 60153646

60153646

Client Name: COP CPA NM

Optional
Proj Due Date:
Proj Name:

Courier: Fed Ex ☒ UPS ☐ USPS ☐ Client ☐ Commercial ☐ Pace ☐ Other ☐

Tracking #: 8023 6827 9384 Pace Shipping Label Used? Yes ☒ No ☐

Custody Seal on Cooler/Box Present: Yes ☒ No ☐ Seals intact: Yes ☒ No ☐

Packing Material: Bubble Wrap ☒ Bubble Bags ☐ Foam ☐ None ☐ Other ☐

Thermometer Used: (T-112) T-194 **Type of Ice:** (Wet) Blue None ☐ Samples received on ice, cooling process has begun
(circle one)

Cooler Temperature: 4.3

Temperature should be above freezing to 6°C

Date and initials of person examining contents: DNO 9/20/13 1130

Chain of Custody present:	☒Yes ☐No ☐N/A	1.
Chain of Custody filled out:	☒Yes ☐No ☐N/A	2.
Chain of Custody relinquished:	☒Yes ☐No ☐N/A	3.
Sampler name & signature on COC:	☒Yes ☐No ☐N/A	4.
Samples arrived within holding time:	☒Yes ☐No ☐N/A	5.
Short Hold Time analyses (<72hr):	☐Yes ☒No ☐N/A	6.
Rush Turn Around Time requested:	☐Yes ☒No ☐N/A	7.
Sufficient volume:	☒Yes ☐No ☐N/A	8.
Correct containers used:	☒Yes ☐No ☐N/A	
Pace containers used:	☒Yes ☐No ☐N/A	9.
Containers intact:	☒Yes ☐No ☐N/A	10.
Unpreserved 5035A soils frozen w/in 48hrs?	☐Yes ☐No ☒N/A	11.
Filtered volume received for dissolved tests?	☐Yes ☐No ☒N/A	12.
Sample labels match COC:	☒Yes ☐No ☐N/A	
Includes date/time/ID/analyses Matrix: water		13.
All containers needing preservation have been checked.	☐Yes ☐No ☒N/A	
All containers needing preservation are found to be in compliance with EPA recommendation.	☐Yes ☐No ☒N/A	14.
Exceptions: VOA, coliform, TOC, O&G, WI-DRO (water), Phenolics	☒Yes ☐No	Initial when completed: NA / Lot # of added preservative:
Trip Blank present:	☐Yes ☐No ☒N/A	
Pace Trip Blank lot # (if purchased): NA		15.
Headspace in VOA vials (>6mm):	☐Yes ☐No ☒N/A	16.
Project sampled in USDA Regulated Area:	☐Yes ☐No ☒N/A	17. List State:

AFT

Client Notification/ Resolution: Copy COC to Client? Y / (N) Field Data Required? Y / N

Person Contacted: _____ Date/Time: _____

Comments/ Resolution: _____

Project Manager Review: AAF Date: 9/20/13

Temp Log: Record start and finish times when unpacking cooler, if >20 min, recheck sample temps.

Start: 1120	Start:
End: 1130	End:
Temp.	Temp:

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CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page: 1 of 1

Section A Required Client Information:

Company:	COP CRA NM
Address:	6121 Indian School Rd NE, Ste 200
	Albequerque, NM 87110
Email To:	cmathews@craworld.com
Phone: (505)884-0672	Fax: (505)884-4932
Requested Due Date/TAT:	

Section B Required Project Information:

Report To:	Christine Mathews
Copy To:	Jeff Walker, Angela Bown
Purchase Order No.:	4517898447
Project Name:	Howell K No. 1
Project Number:	74928

Section C Invoice Information:

Attention:	COP epayables
Company Name:	
Address:	
Pace Quote Reference:	
Pace Project Manager:	Alice Flanagan
Pace Profile #:	5514, 15

REGULATORY AGENCY

☐ NPDES ☒ GROUND WATER ☐ DRINKING WATER
☐ UST ☐ RCRA ☐ OTHER

Site Location STATE: NM

Section D Required Client Information

SAMPLE ID
(A-Z, 0-9 / ,-)
Sample IDs MUST BE UNIQUE

Valid Matrix Codes

MATRIX	CODE
DRINKING WATER	DW
WATER	WT
WASTE WATER	WW
PRODUCT	P
SOIL/SOLID	SL
OIL	OL
WIPE	WP
AIR	AR
OTHER	OT
TISSUE	TS

Requested Analysis Filtered (Y/N)

ITEM #	SAMPLE ID	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED COMPOSITE START DATE	COLLECTED COMPOSITE START TIME	COLLECTED COMPOSITE END/GRAB DATE	COLLECTED COMPOSITE END/GRAB TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Preservatives: Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	Analysis Test Y/N: 300.0 Sulfate, Fluoride	6010 Dissolved Fe & Mn	Residual Chlorine (Y/N)	Pace Project No./ Lab I.D. 60153646
1	GW-074928-091713-CM-MW-1R	WT	G			9-17-13	1355		2	1		1					X	X			(BP3N) (BP3F) wl
2	GW-074928-091713-CM-MW-2	WT	G			9-17-13	1340		2	1		1					X	X			wl2
3	GW-074928-091713-CM-MW-3	WT	G			9-17-13	1420		2	1		1					X	X			wl3
4	GW-074928-091713-CM-MW-4	WT	G			9-17-13	1405		2	1		1					X	X			wl4
5	GW-074928-091713-CM-DUP	WT	G			9-17-13	1410		1			1						X			(BP3F) wl5
6																					
7																					
8																					
9																					
10																					
11																					
12																					

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS			
METALS WERE FIELD FILTERED	CRA	9-17-13	9:00		9/20/13	830	4.3	Y	Y	Y

SAMPLER NAME AND SIGNATURE

PRINT Name of SAMPLER: CALE KANACK

SIGNATURE of SAMPLER: [signature] DATE Signed (MM/DD/YY): 9/17/13

Temp in °C | Received on Ice (Y/N) | Custody Sealed Cooler (Y/N) | Samples Intact (Y/N)

*Important Note: By signing this form you are accepting Pace's NET 30 day payment terms and agreeing to late charges of 1.5% per month for any invoices not paid within 30 days

Appendix C

Conestoga-Rovers & Associates Treatability Study Memo

CONESTOGA-ROVERS & ASSOCIATES

2055 Niagara Falls Blvd., Suite #3
Niagara Falls, New York 14304
Telephone: (716) 297-6150 Fax: (716) 297-2265
www.CRAworld.com

MEMORANDUM

TO:	Jeffrey Walker	REF. NO.:	074928, 074933, 074938
FROM:	Alan Weston/Sophia Dore/adh/2	DATE:	October 22, 2013
CC:	Bernie Bockisch		
RE:	**pH Adjustment for Metals Precipitation, Laboratory Treatability Study Three ConocoPhillips Company Sites in New Mexico**		

INTRODUCTION

Six ConocoPhillips Company Sites located in New Mexico were recently assessed by the Conestoga-Rovers & Associates' (CRA's) Innovative Technology Group (ITG). At these Sites, historic benzene, toluene, ethylbenzene, and xylenes (BTEX) and petroleum hydrocarbon presence has been remediated such that these compounds are no longer detected in groundwater. However, the anaerobic conditions caused by the presence of these compounds in groundwater has potentially led to the solubilization of iron and manganese; therefore, while the organic compounds are no longer an issue at the Sites, the Sites cannot be closed because these metals exceed New Mexico Water Quality Control Commission (NMWQCC) criteria. Both iron and manganese are more soluble in their reduced forms. When they are oxidized, they tend to form ferric or manganese oxides, which are not soluble and precipitate out of groundwater. Information for the six Sites is summarized in the table below:

Site	***Howell K No. 1***	***Faye Burdette No. 1***	***Sategna No. 2E***	***Randleman No. 1***	***San Juan 27-5 No. 34A***	***Farmington B Com No. 1E***
Full Name and Location	Howell K No. 1 Natural Gas Well Site, San Juan County, NM	Faye Burdette No. 1 Gas Well Site, San Juan County, NM	Sategna No. 2E Natural Gas Well Site, Bloomfield, NM	Randleman No. 1 Natural Gas Well Site, San Juan County, NM	San Juan 27-5 No. 34A Natural Gas Well Site, Rio Arriba County, NM	Farmington B-Com No. 1E Natural Gas Well Site, Farmington, NM
NMOCD No.	3R-431	3R-434	3R-428	3R-340	3R-426	3R-084
CRA Project No.	074928	074929	074932	074933	074934	074938
Wells with Fe above Criteria	MW-1, MW-4	None	None	None	None	MW-1
Wells with Mn above Criteria	MW-1, MW-3, MW-4	MW-1	MW-1, MW-2, MW-3	MW-2, MW-3, MW-4, MW-5	MW-1, MW-3	MW-1
pH/ORP	N/A	pH 6.85 S.U. ORP -2.7 mV	pH 5.6-6.5 S.U. ORP 6.4-49.9 mV	pH 6.3-8.3 S.U. ORP -262 to -209 mV	pH 6.2-6.4 S.U. ORP -109 to -96	pH 7.3 S.U. ORP -119 mV
Depth to Groundwater	25-30 feet	8-9 feet	6-9 feet	13-16 feet	21-21 feet	28 feet
Lithology	Sand/clayey sand	Sand/silty sand	Clay; sand/cobbles	Sand/cobbles	Clay; sand	Gravel

Site	*Howell K No. 1*	*Faye Burdette No. 1*	*Sategna No. 2E*	*Randleman No. 1*	*San Juan 27-5 No. 34A*	*Farmington B Com No. 1E*
Other Issues	Sulfate exceeds criteria	N/A	Sulfate, TDS exceed criteria	Sulfate, TDS exceed criteria	N/A	N/A

Notes:

S.U. - Standard unit.
ORP - Oxidation reduction potential.
mV - Millivolts.
Mn - Manganese.
Fe - Iron.
N/A - Not applicable.
TDS - Total dissolved solids.

Based on the ITG assessment, pH adjustment was determined to be the most cost-effective method for metals precipitation; however, it was recommended that the effectiveness of this technology be verified by a treatability study.

A laboratory treatability study was performed on samples from three of the Sites described above (Howell K No. 1, Randleman No. 1, and Farmington B Com No. 1E) to assess the effectiveness of pH adjustment for metals precipitation.

pH Adjustment

One of the main variables in environmental systems that determine the solubility of most metals in water is their pH. Typically, metals are less soluble at higher pH. However, some metals exhibit amphoteric (able to act as either an acid or a base) behavior causing the metal to be soluble at both high and low pH values. High rates of microbial activity can lower groundwater pH due to the production of organic acids and carbon dioxide. The cause of the low pH at these Sites is likely due to this biological activity associated with the biodegradation of BTEX and petroleum hydrocarbons. Both iron and manganese are more soluble under reducing conditions; however, at lower pH levels, they are soluble under less reducing conditions. Iron and manganese will precipitate at a lower ORP if the pH is higher. pH can be adjusted using a base such as sodium hydroxide (NaOH) if the pH is too low, or using an acid such as hydrochloric acid (HCl) if the pH is too high. Proprietary buffers specifically formulated for adjustment of groundwater pH are also commercially available. Increasing the pH could be performed by injecting NaOH or sodium bicarbonate (NaHCO3) or by injecting a commercially available buffer such as CoBupH, which is manufactured by EOS Remediation. Using CoBupH would increase the treatment cost by a factor of at least 5 as compared to NaOH or NaHCO3; therefore, it will not be considered further. The use of NaOH could result in overtreatment to slightly basic conditions while the use of NaHCO3 would not.

LABORATORY TREATABILITY STUDY

Objectives

The objectives of the laboratory treatability study were:

- To assess the effectiveness of increasing the pH for the precipitation of iron and manganese from groundwater
- To determine the most effective reagent and dose for pH adjustment

Sample Acquisition

The treatability study was performed using groundwater samples collected from the Howell K No. 1, Randleman No. 1, and Farmington B Com No. 1E Sites. Two gallons of groundwater from each Site were received in the CRA laboratory located in Niagara Falls, New York on October 2nd and 3rd, 2013.

Task 1 – Initial Characterization

The groundwater sample was analyzed for pH and dissolved iron and manganese. The Howell K No. 1 groundwater sample had a pH of 7.3 S.U. and contained 157 micrograms per liter (µg/L) iron and 3,650 µg/L manganese. The manganese level exceeded the NMWQCC criterion of 200 µg/L. The Randleman No. 1 groundwater sample had a pH of 7.3 S.U. and contained 114 µg/L iron and 1,130 µg/L manganese, which again exceeded the NMWQCC criterion for manganese. The Farmington B Com No. 1E groundwater sample had a pH of 7.5 S.U. and contained 657 µg/L iron and 271 µg/L manganese, which also exceeded the criterion for manganese. These data are shown in Table 1.

Task 2 – pH Adjustment Tests

The pH of the three groundwater samples was adjusted with a target of pH 8.5. Initially, a sodium bicarbonate solution was used for pH adjustment since this reagent was recommended for the safe adjustment of pH in the field; however, testing showed that it was not able to overcome the acidity of the groundwater and was not able to adjust the pH of the water without using a volume that would not be practical in the field. Therefore, a 0.1 N solution of sodium hydroxide (NaOH) was used to adjust the pH of the groundwater. For all three groundwater samples, it was observed that the pH could be adjusted to 8.5 S.U. with a relatively small amount of NaOH; however, upon standing, the pH of the groundwater samples dropped. Several rounds of pH adjustment were required in order to increase the pH of the groundwater samples such that the pH remained at or above 8.5 S.U. After the pH adjustment was complete, the water samples were analyzed for dissolved iron and manganese.

For the Howell K No. 1 groundwater sample, 4.75 milliliters (mL) of 0.1 N NaOH were required to raise the pH above 8.5 S.U. After pH adjustment, a 77-percent reduction in dissolved iron and a 93-percent reduction in dissolved manganese were observed. The dissolved manganese was reduced to 246 µg/L, which is close to the NMWQCC criterion for manganese and would attenuate naturally within a short time.

For the Randleman No. 1 groundwater, 9 mL of 0.1 N NaOH were required to raise the pH above 8.5 S.U. After pH adjustment, a 93-percent reduction in dissolved iron and a 99-percent reduction in dissolved manganese were observed. The dissolved manganese was reduced to 11.3 µg/L, which is well below the NMWQCC criterion for manganese.

For the Farmington B Com No. 1E groundwater, 2.35 mL of 0.1 N NaOH were required to raise the pH above 8.5 S.U. After pH adjustment, a 48-percent reduction in dissolved iron and a 97-percent reduction in dissolved manganese were observed. The dissolved manganese was reduced to 9.33 µg/L, which is well below the NMWQCC criterion for manganese.

SUMMARY

- Increasing the pH to above 8.5 S.U. was an effective treatment for reducing concentrations of dissolved iron and manganese in the Site's groundwater to below or close to NMWQCC criteria.

- Sodium bicarbonate was not an effective treatment for increasing the groundwater pH using volumes that could be applied in the field.
- NaOH was effective for increasing the pH of the groundwater.
- The amounts of NaOH in grams (g) of NaOH per liter (L) of groundwater are shown in the table below:

	Howell K No. 1	*Randleman No. 1*	*Farmington B Com No. 1*
NaOH dose (g NaOH/L groundwater)	0.19	0.36	0.094
NaOH dose (g NaOH/cubic yard saturated matrix)	43.6	82.6	21.6

RECOMMENDATION

The results of this study showed that pH adjustment using NaOH would be an effective treatment for reducing concentrations of iron and manganese in groundwater at the Sites.

For the Howell K No. 1 Site, 43.6 g of NaOH would be required per cubic yard of saturated matrix. This would be applied as approximately 6 gallons of a 0.2-percent solution per cubic yard of saturated matrix.

For the Randleman No. 1 Site, 82.6 g of NaOH would be required per cubic yard of saturated matrix. This would be applied as approximately 6 gallons of a 0.36-percent solution per cubic yard of saturated matrix.

For the Farmington B Com No. 1E Site, 21.6 g of NaOH would be required per cubic yard of saturated matrix. This would be applied as approximately 6 gallons of a 0.09-percent solution per cubic yard of saturated matrix.