

# **Annual Monitor Report**

# DATE: 2009

April 12, 2010



Samson State BD #4 Reserve Pit NMOCD Case # 1RP-474-0

**2009 Annual Monitoring Report** 

**R.T. Hicks Consultants, Ltd.** 

### R. T. HICKS CONSULTANTS, LTD.

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April 12, 2010

Glenn Von Gonten New Mexico Oil Conservation Division 1220 South St. Francis Drive Santa Fe, New Mexico 87505

RE: Samson State BD #4 Reserve Pit, T12S, R33E, Section 2, Unit H; NMOCD Case # 1RP-474-0

Dear Mr. Von Gonten:

Attached is the 2009 Annual Report for the above-referenced site. At the enceof this letter are several issues that Samson would like to bring forward to NMOCD in an effort to move toward regulatory site closure.

#### **Brief Summary**

- The engineered ET infiltration barrier functions as designed; the chloride flux from the vadose zone to ground water is at or near zero.
- The extent and magnitude of ground water impairment is generally defined
- The average chloride concentration of the plume is changing slightly and down gradient migration is minimal.
- Natural restoration has improved ground water quality of the upper portion of the aquifer, but the source area well (MW-3) remains above ground water standards for TDS and chloride.
- While pumping ground water from MW-3 is beneficial with respect to the removal of contaminant mass, monitoring data suggest meaningful improvement of ground water quality will require long-term pumping.
- In our opinion, there is no reasonable relationship between the economic and social costs and benefits of a ground water restoration strategy that calls for pumping the water and:
  - Treating the water sufficiently to permit use for agriculture or E&P operations
  - o Treating the water sufficiently to permit site re-injection
  - Deep well disposal

In 2007, Samson attempted a pump-and-use restoration strategy and found that neither drillers, earthwork contractors nor any water user would accept water pumped from the site in its present condition. We also evaluated the potential of treating the water to remove the contaminants completely at the point of extraction, but because fresh water is available in the immediate area and at locations that are more convenient for commercial or agricultural uses this option was considered not

#### Page 2

valid. Finally, we considered the addition of salt to create brine for drilling, but the economics of this solution are not favorable.

In light of this, Samson requests input from NMOCD regarding possible pathways to close the regulatory file. We believe that a 10<sup>+</sup>acre area (the former pit) is not "a place of withdrawal for present or reasonably foreseeable future use". Although concurrence with this opinion on the part of NMOCD and the surface owner would be required to insure that the site complies with NMOCD Rules.

Some of the questions of concern for Samson include the following:

- 1. In light of the WQCC decision in the Phelps-Dodge hearing, what data or evaluation would NMOCD require to define the so-called "point of compliance", which some maintain is "a place of withdrawal for present or reasonably foreseeable future use"?
- 2. Should Samson provide arguments to NMOCD to support a finding that a certain area (e.g. 10 acres around the site) is not a "place of withdrawal for present or reasonably foreseeable future use"?
- 3. Because the site might become subject to the Abatement Plan requirements, if NMOCD finds that the area is a place of reasonably foreseeable future use, under what circumstances would NMOCD support a petition for alternative abatement standards appropriate?

Samson will continue to monitor ground water in all wells on a quarterly basis until directed otherwise.

Sincerely, R.T. Hicks Consultants, Ltd.

Randall Hicks Principal

Copy: Hobbs NMOCD office; Samson Resources Merchant Cattle Company

April 12, 2010

## Samson State BD #4 Reserve Pit NMOCD Case # 1RP-474-0

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## **2009 Annual Monitoring Report**

prepared for: Samson

## R.T. Hicks Consultants, Ltd.

Location: T-12-S, R-33-E, Sec 2, Unit H Latitude: North 33° 18' 35.2" Longitude: West 103° 34' 39.2" NMOCD#: 1RP-474-0

#### 1.0 EXECUTIVE SUMMARY

The State BD #4 site, which is operated by Samson Resources Company (Samson), is located approximately 16 miles west of Tatum, New Mexico. Directions to the site are documented in previous submissions. The data presented in this 2009 Annual Monitoring Report permits us to conclude:

- The extent and magnitude of ground water impairment is defined and does not extend beyond the footprint of the former drilling pit on the north, west or south sides.
- Ground water exceeds state standards for chloride and TDS for a distance of about 40 feet east (down gradient) of the former pit.
- The extent of impairment is generally stable and natural dilution and dispersion is reducing the magnitude of impact.
- While pumping ground water from MW-3 from February to July 2007 was beneficial with respect to the removal of contaminant mass, monitoring data suggest meaningful improvement of ground water quality beneath the former drilling pit will require long-term pumping.
- The engineered ET infiltration barrier functions as designed; the chloride flux from the vadose zone to ground water is at or near zero.
- A ground water restoration strategy that calls for using the water in E&P operations or other uses does not create a reasonable relationship between the economic and social costs and benefits.
- Samson requests input from NMOCD regarding possible pathways to close the regulatory file including a decision on the part of NMOCD and the surface owner that a 10-acre area that includes the former pit and production pad is not "a place of withdrawal for present or reasonably foreseeable future use".
- Samson will continue to monitor ground water in all wells on a quarterly basis.

This report is consistent with the commitments and recommendations made in all previous correspondence including the 2008 Annual Ground Water Monitoring Report submitted to the NMOCD on January 22, 2009.

#### 2.0 WORK ELEMENTS PERFORMED

Appendix A presents a table (Table 1) containing results of all historic soil sampling. A table of the historic ground water gauging and laboratory results (Table 2) is also provided in Appendix A. The ground water monitoring laboratory reports and chain-of-custody documents for recent sampling events are included in Appendix B, and Appendix C provides graphs that depict the historic ground water impairment for each monitoring well.

Since November 2008, the site activities at the Samson State BD #4 site included:

- The quarterly ground water sampling of the shallow and deep monitoring wells
- Monitoring of the soil moisture, both background and below the ET Barrier
- The performance of residual drawdown and calculated recovery tests in MW-1, MW-2, MW-4, and MW-4d



#### 3.0 CONCLUSIONS

#### 3.1 ET Barrier Performing as Predicted

Plate 1 is a topographic map of the ET barrier surface which was designed to direct the precipitation runoff toward the less impacted areas of the former pit. Soil moisture monitoring ports and the location of monitoring wells are also plotted on Plate 1. Soil moisture monitoring, as shown on Table 3, demonstrates that the moisture content within the ET Barrier is very low relative to the background values. This result confirms the performance expectations of the ET Barrier.

Vadose Zone	ET Cov	/er Moisture P	orts	Background Cluster Moisture Ports			
Measurement	No. 1	No. 2	No. 3	No. 1	No. 2 Center	No. 3	
Date	West 2.4-foot	Center 5-foot	East 8-foot	West 13.9-foot	9.8-foot	East 6.5-foot	
4/17/07	0	1	1	15	29	18	
5/21/07	0	1	1	15	30	20	
6/21/07	1	1	1	16	31	22	
7/18/07	0	1	1	16	34	22	
8/22/07	0	. 1	1	17	36	23	
9/28/07	0	0	1	17	37	22	
10/24/07	0	0	1	17	37	21	
2/11/08	0	0	0	16	32	17	
5/5/08	0	0	1	16	31	18	
8/20/08	0	0	1	17	32	18	
11/21/08	0	0	0		29	16	
2/17/09	0	0	0		26	14	
5/26/09	0	0	1	16	24	14	
8/24/09	0	0	1	16	20	12	
11/2/09	0	0	1	16	19	11	
2/26/10	0	0	1	14	17	9	

Table 3. Results of Moisture Port Measurements

As discussed below, ground water monitoring results also demonstrate that the chloride concentration of the upper portion of the aquifer beneath and adjacent to the ET cover is stable or declining over time. This observation supports a conclusion that the flux of chloride from the vadose zone to ground water beneath the cover is very low or nil.

#### 3.2 Ground Water Flow Direction is Constant

Hicks Consultants gauged and sampled each of the monitoring wells on a quarterly basis during 2009 and early 2010. Ground water gradient maps (Plates 2A - 2E) indicate essentially no change in the gradient direction and an average gradient slope of 0.0072 ft/ft, which corresponds to the historic gradient for the life of the project.

#### 3.3 Hydraulic Conductivity Increases with Depth

On February 26, 2010, residual drawdown and calculated recovery tests (Theis, 1935) were performed on the shallow (MW-4s) and deep (MW-4d) monitoring wells located on the down gradient edge of the former reserve pit. The methodology and results of these tests are presented in Appendix D. They indicate that the upper portion of the aquifer at this location has a hydraulic conductivity (K) of 3.2 ft/day and the deeper portion of the aquifer has a K of 8.3 ft/day.

Mussharrafieh and Chudnoff (1999) estimated the hydraulic conductivity of the Ogallala Aquifer at the site as 21-40 ft/day. Because this published estimate represents the entire saturated thickness of the Ogallala, which is about 100 feet at the site location (Tillery, 2008), and the Ogallala is often coarser grained at the base and finer grained at the top of the unit (see <a href="http://www.npwd.org/new\_page\_2.htm">http://www.npwd.org/new\_page\_2.htm</a>) the relatively low values of hydraulic conductivity obtained from the recovery tests are within reason.

A calculation of ground water velocity at the site was performed using the measured K values, the average ground water gradient (0.0072 ft/ft), and the estimated porosity (0.25) as follows:

*Ground Water Velocity(ft/yr)* = *Effective Flow Rate(ft/day) x 365(days/yr),* where as

Effective Flow Rate(ft/day) = Ground Water Flow Rate (ft/day)/0.25(unitless) and

Ground Water Flow Rate(ft/day) x 0.0072(ft/ft)

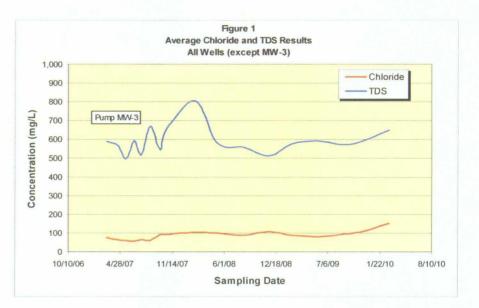
The results indicate that the ground water velocity is 33.6 ft/yr in upper portion of the aquifer and 87.3 ft/yr in the lower portion of the aquifer. This differential in ground water velocity with depth will cause the chloride plume to spread unevenly but dilute more rapidly.

#### 3.4 Pumping & Disposal Is a Marginally Effective Abatement Strategy

A total of 235,000 gallons of impaired ground water (3.7 tons chloride / 6.3 tons TDS) have been removed for disposal from the site to date. No ground water removal has been conducted since July 2007.

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Plate 3 depicts the laboratory results for both the shallow and deep zones for the 2009 and early 2010 sampling events. Figure 1 depicts the average chloride and TDS concentrations for all monitoring wells except MW-3 over time. In Figure 1, the width of the text box describing the pumping is equivalent to the duration of the pumping event.



#### The data shows that

the average site TDS concentration increased independently of the chloride concentration during the year after termination of the pumping operation. The average site TDS concentration then returned to the initial concentration of 500-600 mg/L in mid 2008. Since 2008, the TDS and chloride concentrations have remained stable except for a gradual increase observed in the most recent samples attributable to recently increased salinity in MW-4d (see Appendix C). These results suggest that the removal of saline water from MW-3 has produced no measurable benefit to the overall quality of the ground water relative to natural processes (2007-2010). We conclude that long-term continual pumping at MW-3 would remove additional chloride mass from ground water but is a marginally effective abatement strategy for the site. Because the water from MW-3 will not be used by drilling fluid engineers, cementing companies or other contractors, all water pumped goes to disposal or must be treated prior to use. We do not believe the waste of this resource (disposal) or treatment of the water for subsequent use creates a reasonable relationship between the costs and benefits.

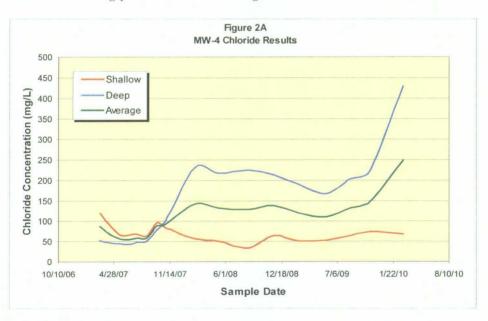
#### 3.5 Chloride Fate and Transport is Dynamic but Contained

Plate 4 indicates the locations of the soil and ground water monitoring points relative to the original configuration of the reserve pit. Plate 5A shows the site during excavation and 5B shows sampling results of chloride concentrations at a depth of approximately 28 feet below the surface (10 feet above the ground water). Due to the lack of any low-permeability layers between the base of the pit and the water table, seepage from the pit would move vertically downward with little horizontal spreading. Therefore, the area of highest chloride concentrations in ground water due to pit seepage should exist below the area of highest impact defined by the trench soil samples.

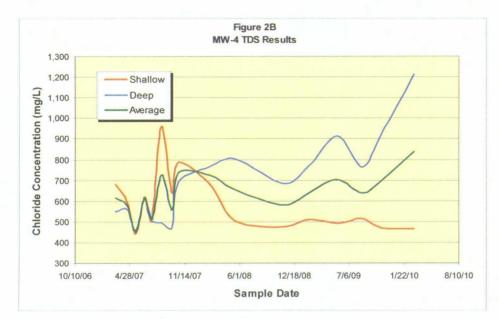
A conceptual model that explains the chloride migration from January 2007 to November 2009 across the site is provided in map view (Plate 6A-6D) and crosssection view (Plates 7A-7D). It utilizes the historic laboratory chloride results from the shallow and deep monitoring wells with plume distributions that conform to the ground water velocities determined from the residual drawdown and calculated recovery tests performed in February 2010.

Based on this information, we believe that the primary ground water impact occurred due to saturated flow through the vadose zone below the northwestern edge of the former reserve pit. Pumping from MW-3 removed some of the chloride mass and caused the zone of highest chloride to move south. Over time the higher chloride concentrations (creating slightly denser water) sank lower into the aquifer where it was subject to greater ground water velocities (higher hydraulic conductivity values). At the same time, fresh water (precipitation) from the ET cover run-off was added to the upper portion of the aquifer which diluted the chloride between MW-3 and MW-4.

As a result, the chloride (and TDS) concentrations at MW-4 changed from being slightly higher in the shallow zone to being significantly higher in the deep zone over the monitoring period as shown in Figure 2A and 2B below:



Presently, the chloride and TDS concentration are below the WQCC standards in both of the cross gradient monitoring wells (MW-1 and MW-2). As of the most recent monitoring events the average chloride and TDS concentrations at MW-4s and 4d remain below WQCC standards, however chloride and TDS in samples from MW-4d are slightly above the standards.



From these data, we conclude that an abatement strategy that employs natural restoration supplemented with the fresh water run-off from the ET cover surface is effective but may result in a short-term exceedance of the regulatory standard outside of the footprint of the former drilling pit. Beneath the pit footprint a linear regression analysis of the last two years of ground water data suggests that this area may exceed standards for 10-20 years.

#### 3.6 A Pump-and-Use Abatement Strategy is Problematic

After speaking to several individuals who routinely use water for E&P operations (e.g. mud engineers, well cementing contractors), we conclude that E&P contractors will not use water from the site without treatment. Drilling mud and casing cement demand that one of the primary ingredients, water, is of a known and constant quality. A failure of drilling mud or cement caused by constituents in the ground water from MW-3 is unacceptable.

Additionally, we explored the feasibility of pumping water from MW-3 to tank and adding salt to create saturated brine for drilling. This would involve creating a brine station with the capacity and access suitable for area drilling operations. Costs associated with building the station, transporting salt, and supplying the additional water to satisfy the potential demand are prohibitive relative to benefit.

Treating the water to create a source of stock water provides no benefit since several suitable water wells are already present in the surrounding area to adequately serve this purpose. Treating water produced from MW-3 in the absence of a defined need does not create a reasonable relationship between the social and economic costs and benefits.

#### 3.7 Options for Closing the Regulatory File Are Limited

We have identified two options for closure of the regulatory file. Of these, option No. 1 is the most appropriate for the site, based on future land use and available ground water resources. Once further monitoring has established a completely stable plume, file closure may be pursued based upon:

- 1. A finding by NMOCD and the surface owner that a 10-acre area at and down gradient of the site is not a place of withdrawal for present or reasonably foreseeable future use, or
- 2. A successful petition for alternative abatement standards under Part 30 of NMOCD Rules

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#### 4.0 **RECOMMENDATIONS**

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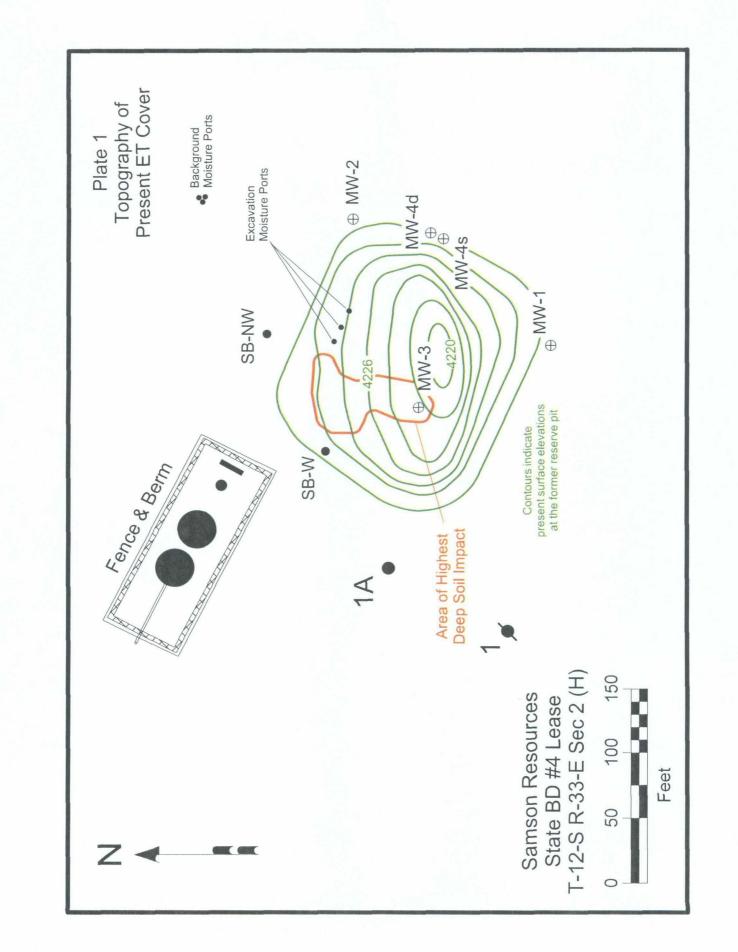
- Continue to collect and analyze ground water samples on quarterly basis for chloride, TDS and field specific conductance from MW-3, MW-4d and MW-4s.
- Obtain a response from NMOCD regarding closure options

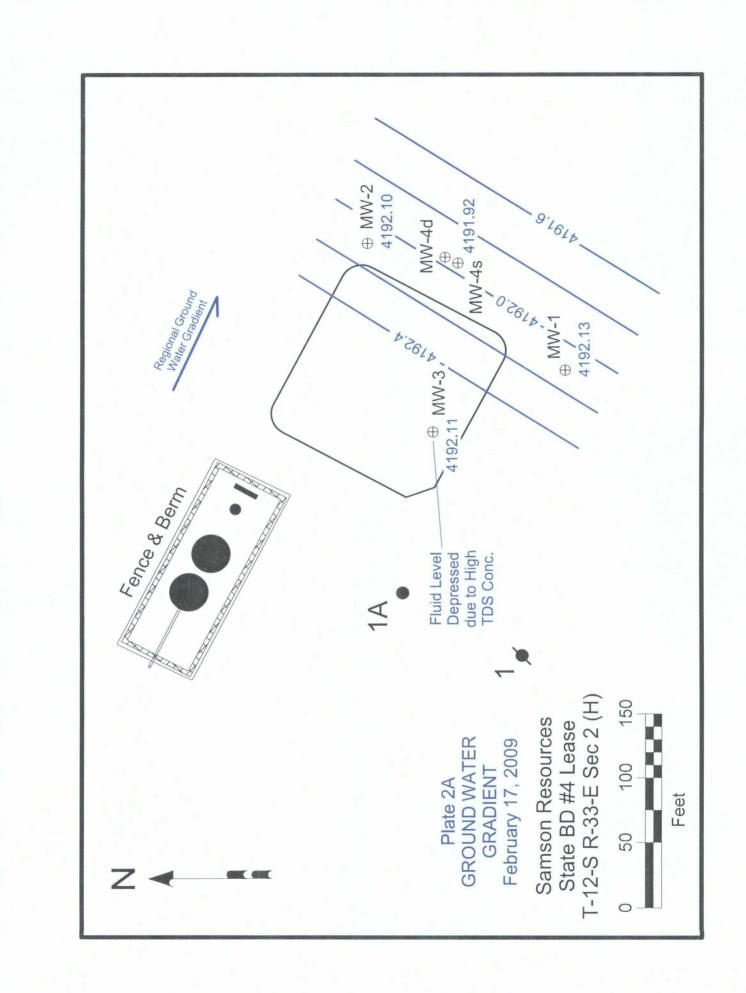


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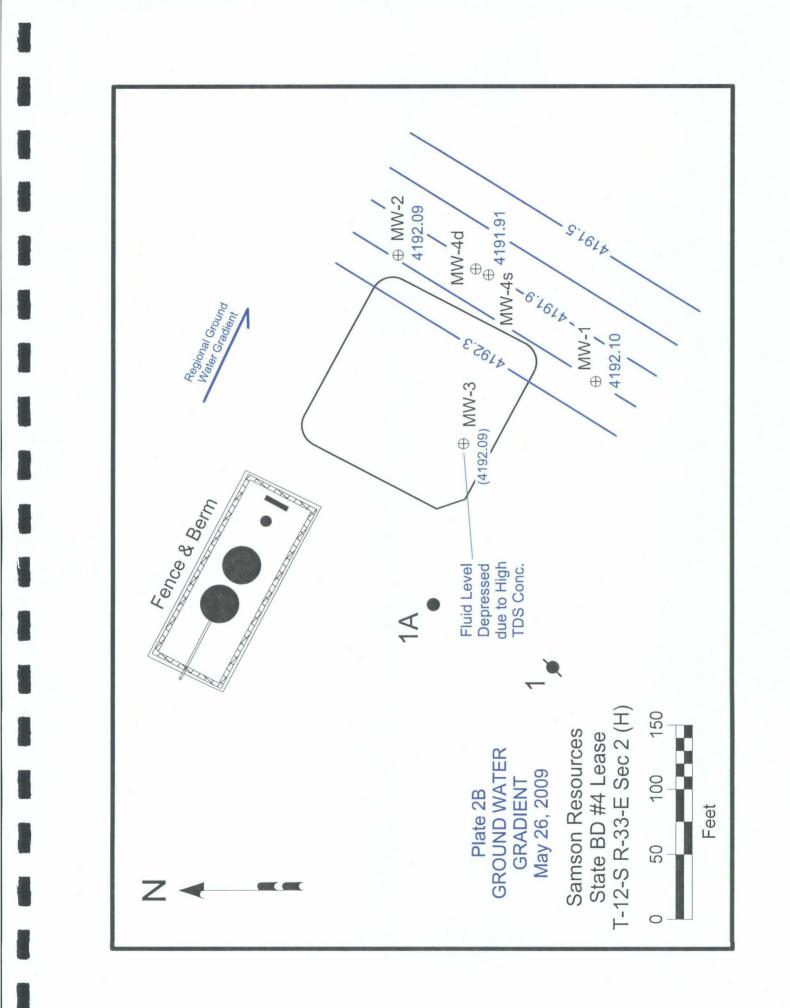
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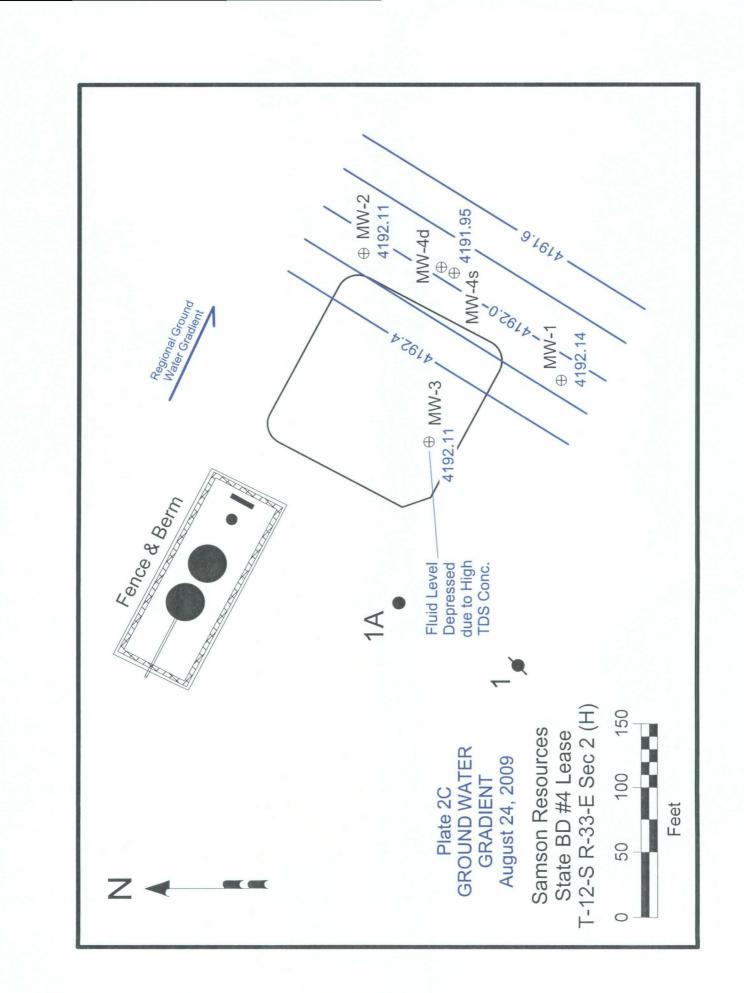
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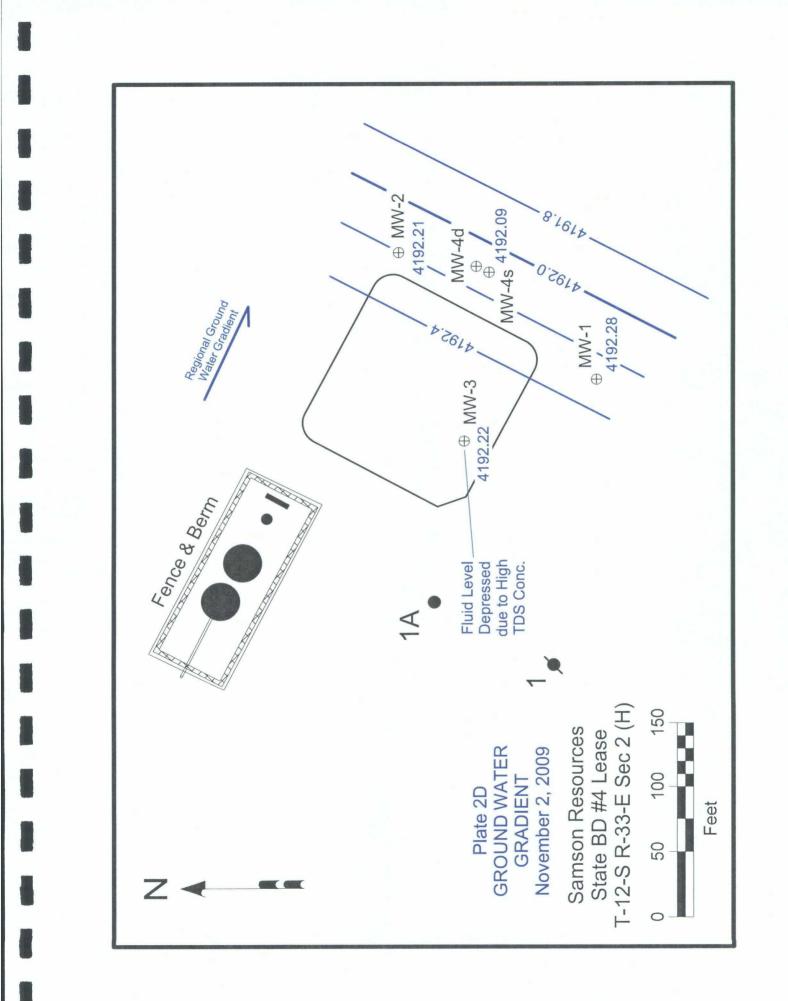


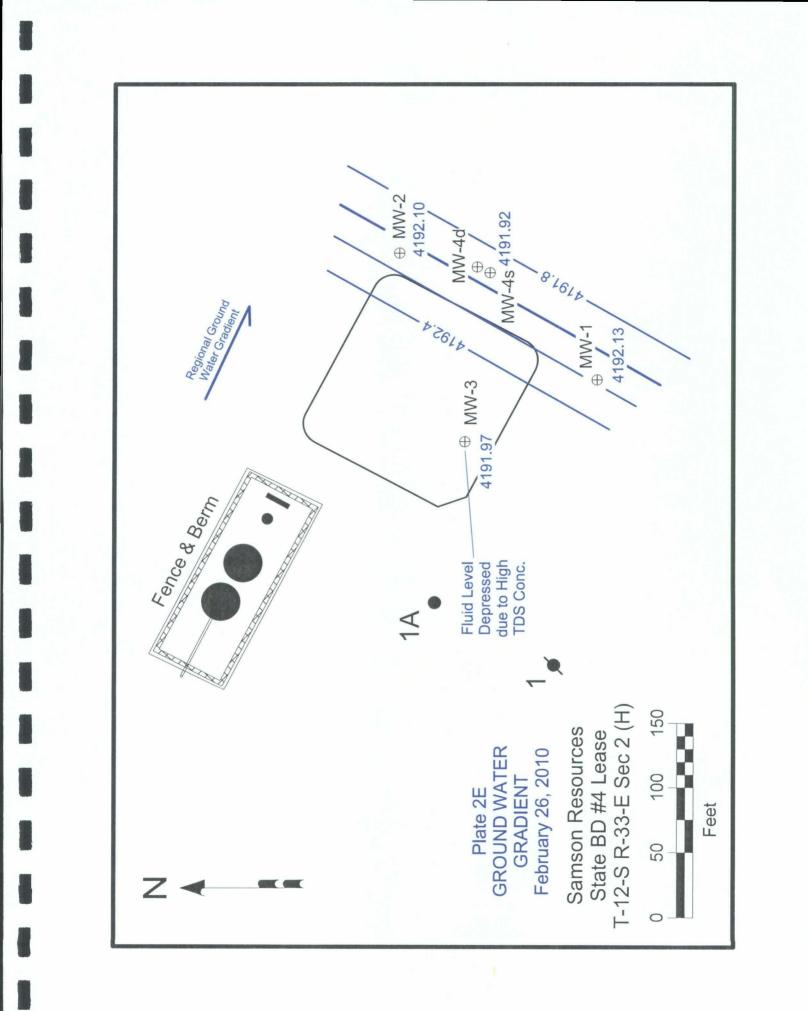


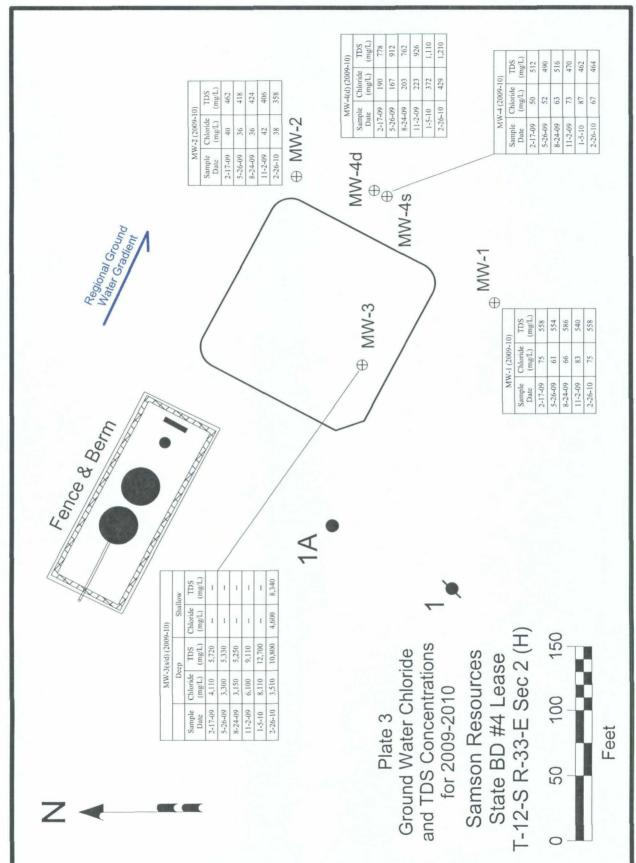
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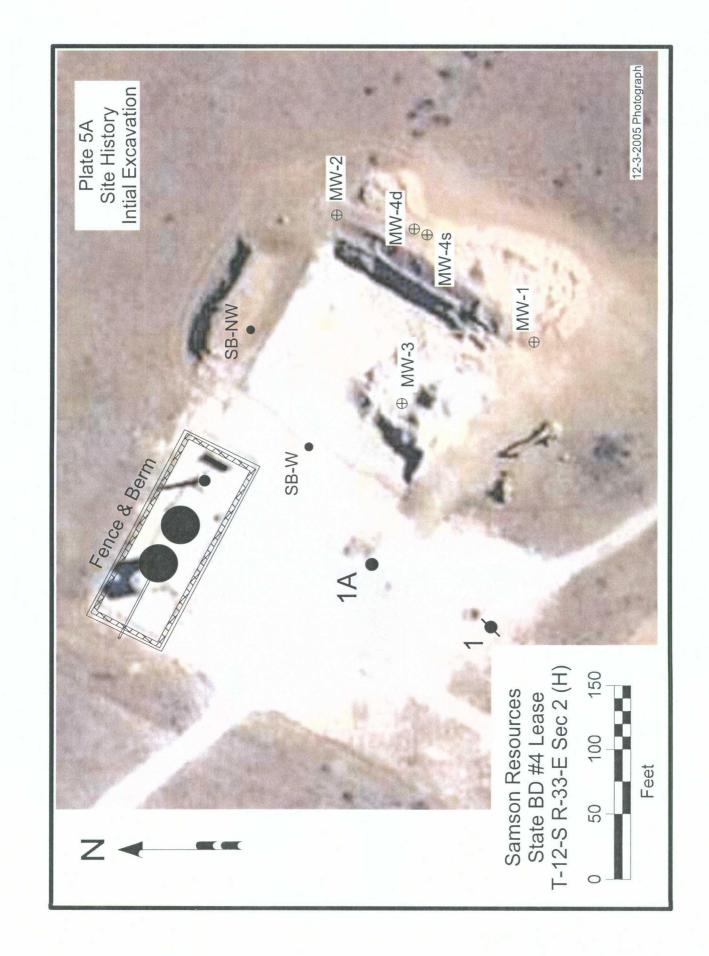


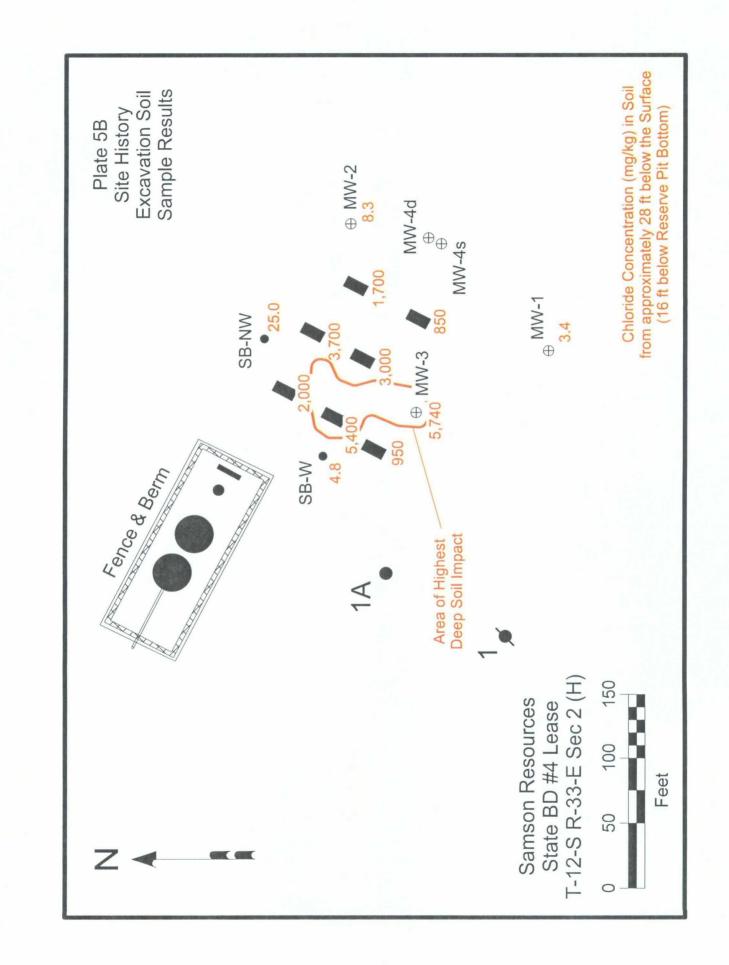


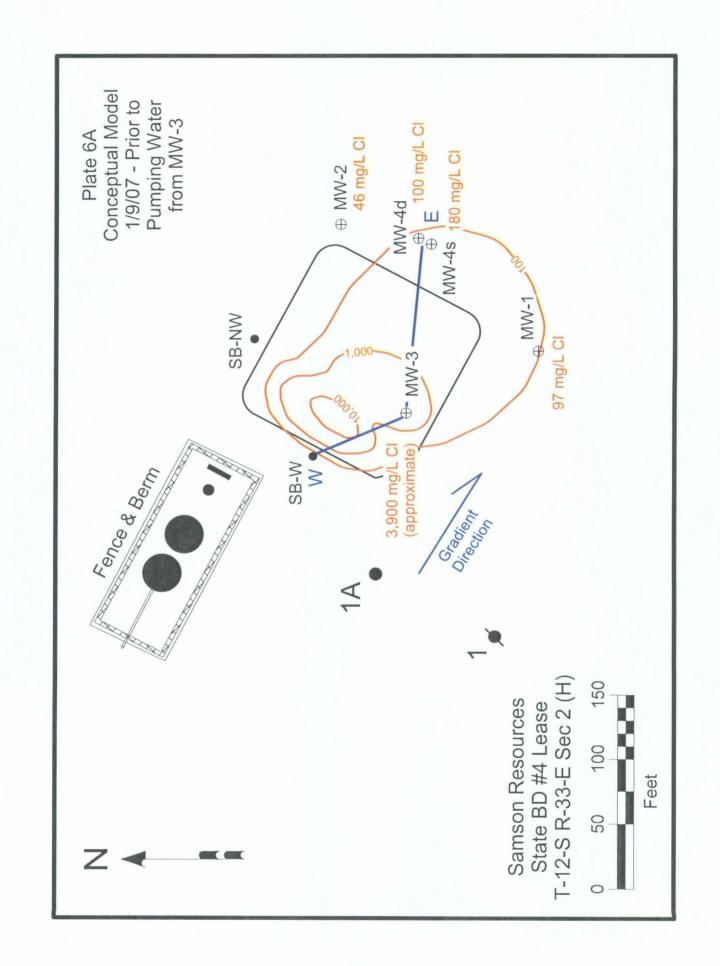


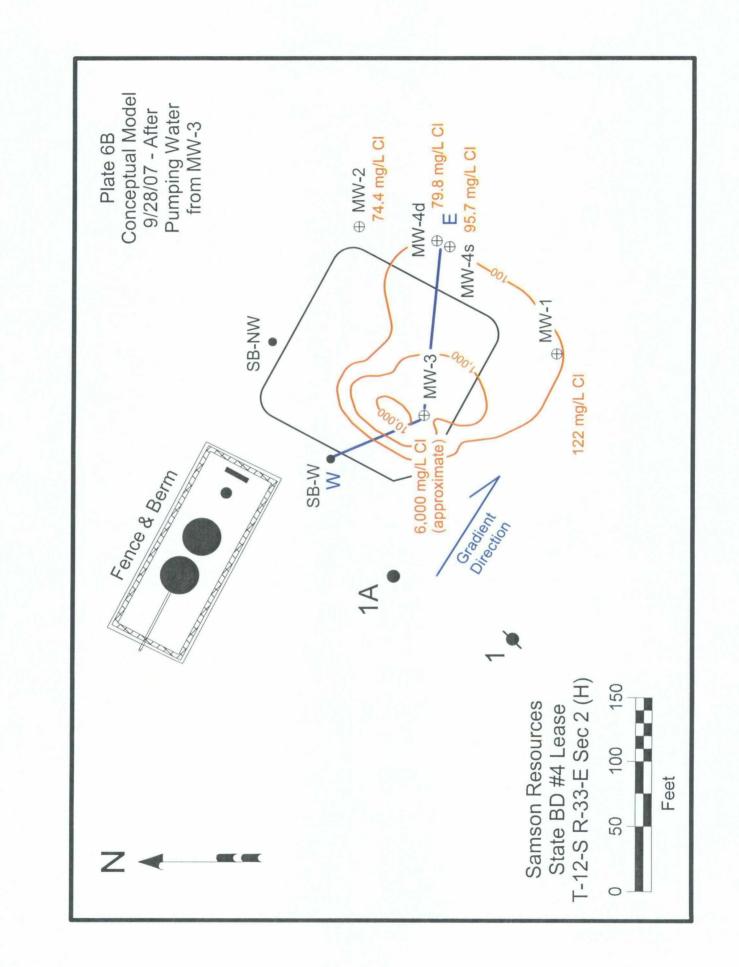


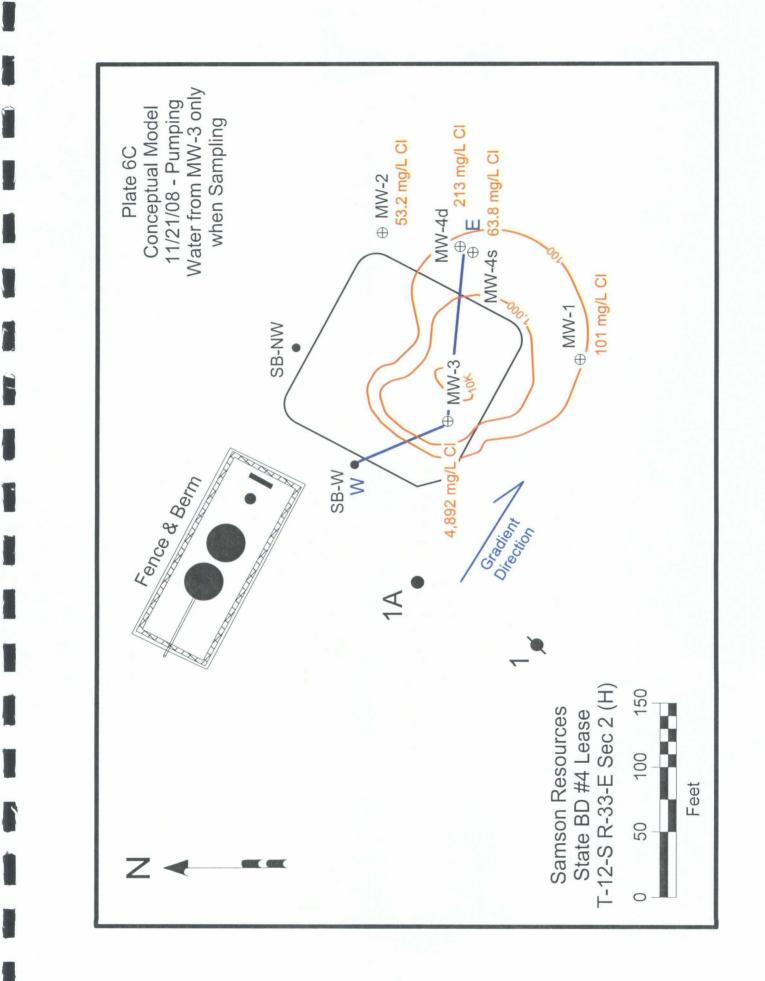


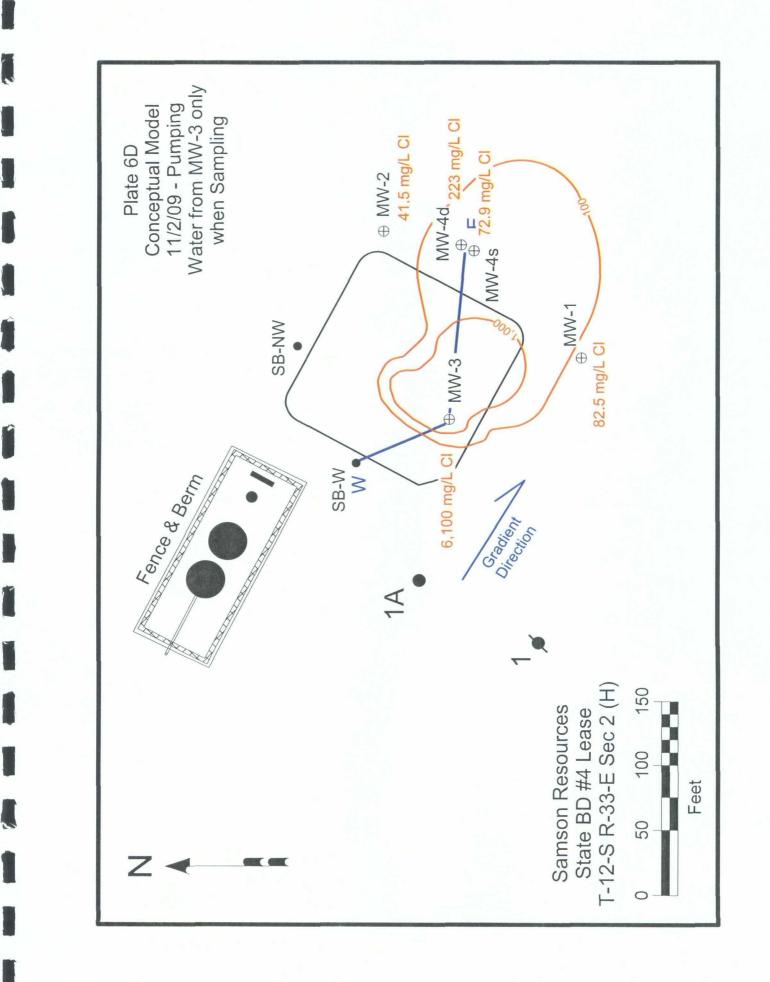


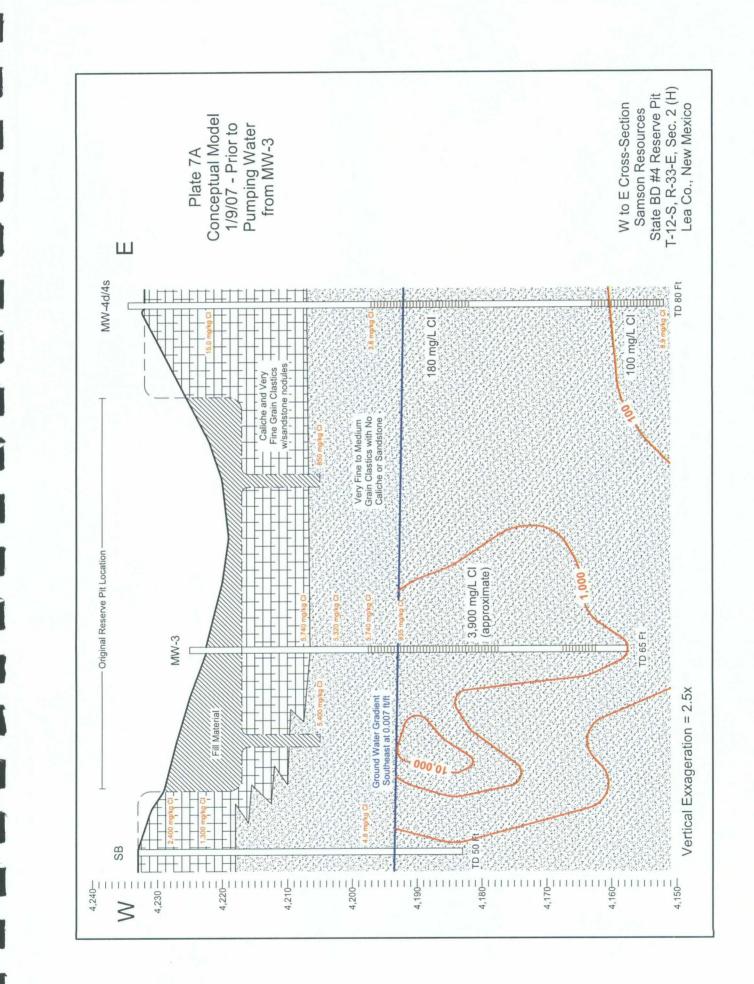


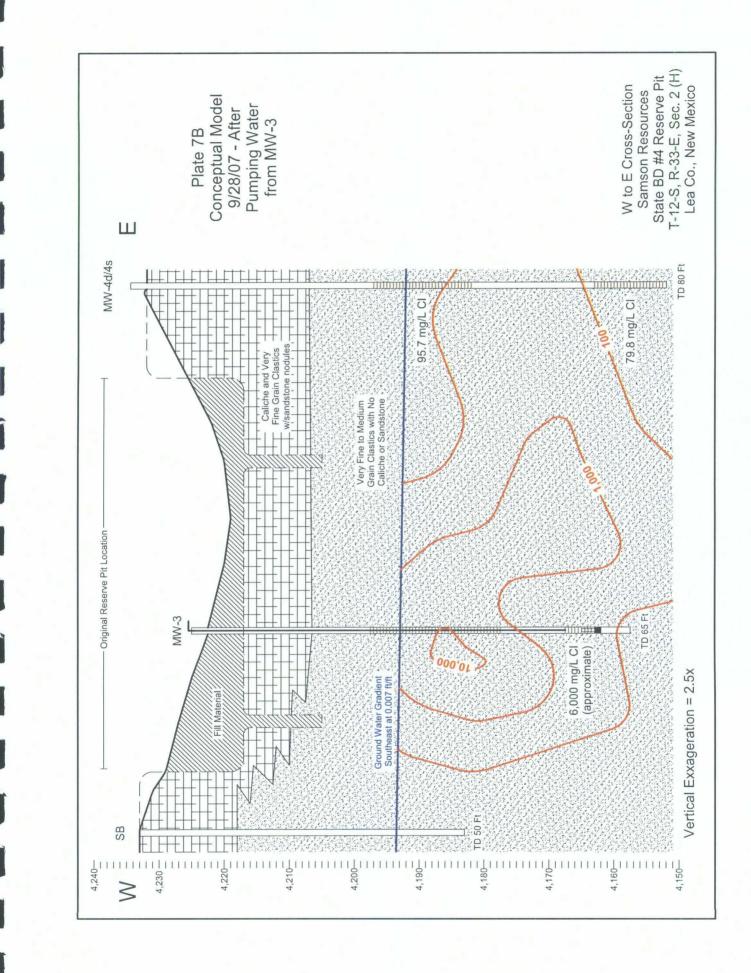


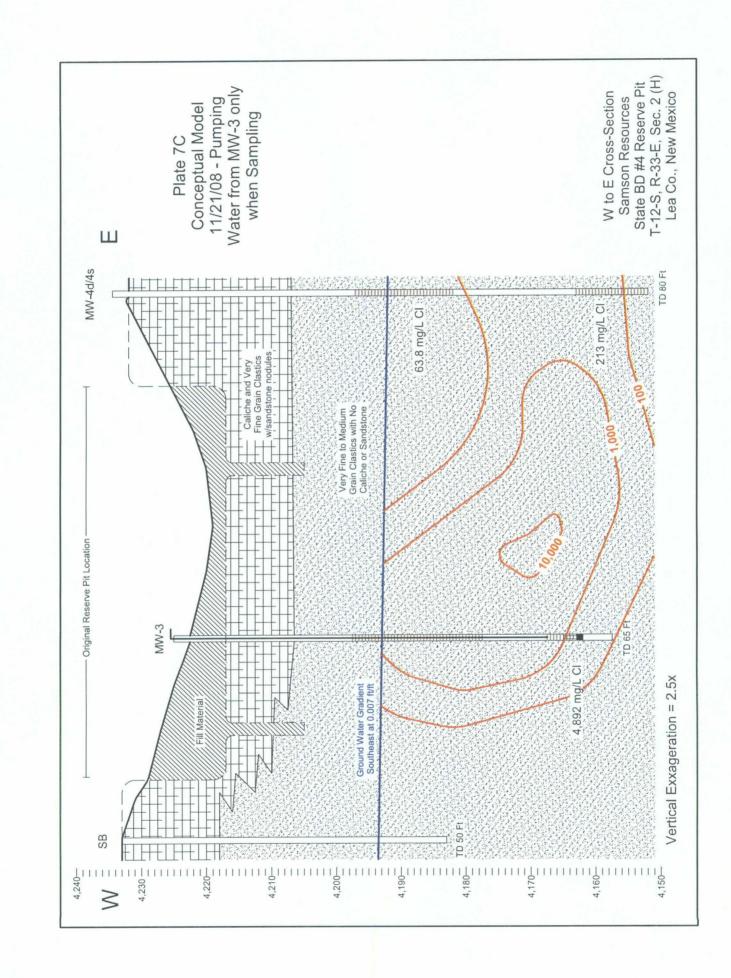


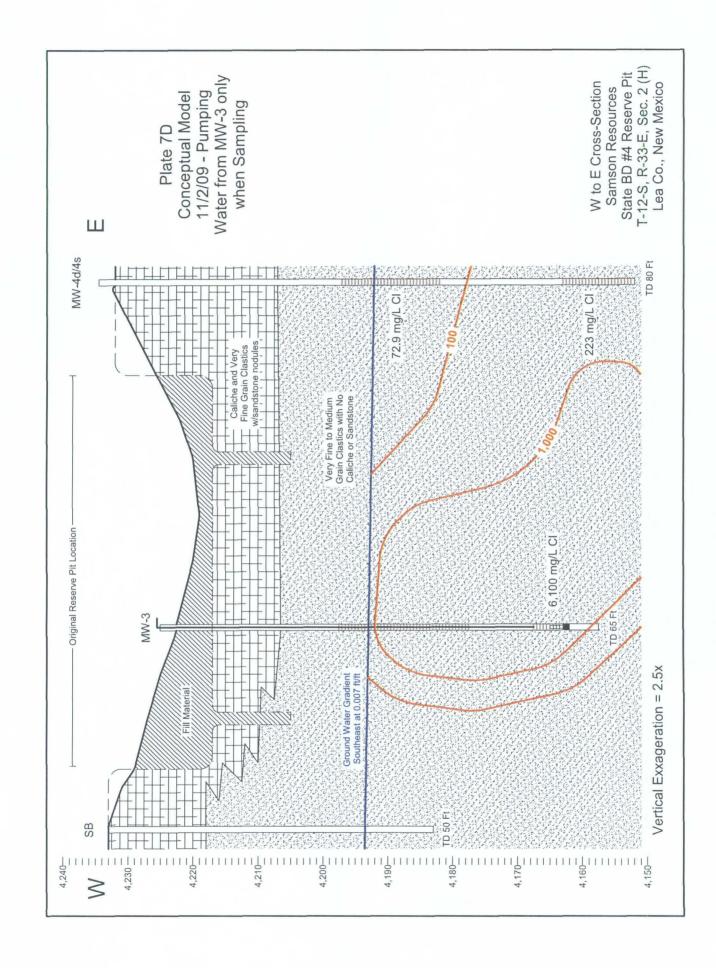












## **Appendix A** Tables of Historic Data

## **R.T. Hicks Consultants, Ltd.**

#### Appendix A - Table 1A Laboratory Results Summary - Pre-RT Hicks Soil Samples Results in mg/kg

Sample Location	Pit Comp.	Pit (max)*	Applicable
Sample Depth (ft)	16 ft (bgs)	28 ft (bgs)	Reg.
Sample Date	12/2/05	12/2/05	Levels
Benzene		····	0.2
Toluene			0.2
Ethyl Benzene			1.01
Total Xylenes			0.167
GRO (C <sub>6</sub> -C <sub>10</sub> )			200
DRO (>C <sub>10</sub> -C <sub>28</sub> )			200
Total Alkalinity	208	96	
Chloride	4,958	6,958	1,000
Carbonate	0	76	
Bicarbonate	254	40	
Sulfate	943	298	
Calcium	128	705	
Magnesium	78	467	
Potassium	136	70	
Sodium	2,928	2,928	
Bromide	-,	_,	

\* - Sample taken from area of highest CI concentration based on HACH kit field screening

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Laboratory Results Summary - Excavation & Soil Boring Samples								
Sample Location (Surface Elevation)		Sample	Depth	Elevation		Br	Chloride	
		Date	(ft)	(ft)		(mg/kg)	(mg/kg)	
MW-1	(4233.0)	5/8/06	9	4,224			49.4	
			19	4,214			7.86	
			29	4,204			3.38	
			34	4,199		<0.1	5.02	
MW-2	(4230.5)	5/9/06	9	4,222			10.0	
			19	4,212	}		7.30	
			29	4,202			8.27	
			34	4,197			7.77	
			39	4,192		0.187	12.0	
NE "side" o	of Pit	7/12/06	28	4,205		<3.0	3,700	
East "corne	er" of Pit	7/12/06	28	4,205		<3.0	1,700	
North "corner" of Pit		7/12/06	28	4,205		<3.0	2,000	
Center of Pit		7/12/06	28	4,205		<3.0	3,000	
SE "side" of Pit		7/12/06	28	4,205		<3.0	850	
NW "side" of Pit		7/12/06	28	4,205		<3.0	5,400	
Avg. Clean Stockpile		7/12/06	surface	4,233			208	
Avg. Dirty Stockpile		7/12/06	surface	4,233			1,768	
East "corner" of Pit		7/12/06	28	4,205			950	
MW-3	(4222.0)	12/11/06	15	4,207			5,740	
	. ,		20	4,202			5,320	
1		1	25	4,197	1 1		5,740	
			30	4,192			936	
MW-4d	(4232.0)	1/8/07	10	4,222			15.0	
	, <i>,</i> ,		35	4,197			3.6	
			80	4,152			8.9	
NW Soil Boring		1/8/07	10	4,224			1,900	
	5		15	4,219			1,100	
			35	4,199			25.0	
West Soil Boring		1/9/07	10	4,224			2,400	
			15	4,219	ļ		1,300	
			35	4,199			4.8	

#### Appendix A - Table 1B

### Laboratory Results Summary - Excavation & Soil Boring Samples

NMOCD Landfarm Closure Standard

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Bold Text indicate concentration exceeds Regulatory Standards

c:\Samson\State BD-4\BD #4 Project Data

Monitor Well	Sample	Water Depth	Water	pH (unitless)	Cond. (uS/cm)	Chloride	TDS (mg/l)	% CI of TDS
TOC Elev.	Date	Depth	Elevation	(unitiess)	(uS/cm)	(mg/L)	(mg/L)	
MW-1	5/11/06	41.18	4,192.05	7.41	1.17			
4,233.23	5/12/06	41.24	4,191.99	7.15	0.88	131	838	16%
	8/2/06	41.22	4,192.01	7.07	0.99	115	648	18%
	10/17/06	41.14	4,192.09					
	12/12/06	41.09	4,192.14					
	1/9/07	41.07	4,192.16			97		
	2/6/07	41.32	4,191.91					
	2/6/07	41.25	4,191.98					
	2/16/07	41.37	4,191.86		0.985			
	3/8/07	41.39	4,191.84	1		83	620	13%
	3/13/07	41.36	4,191.87		1.025			
	4/17/07	41.13	4,192.10	7.41	0.82	89.6	674	13%
	5/21/07	40.99	4,192.24	7.96	0.79	83.8	630	13%
	6/21/07	41.02	4,192.21	7.52	0.74	76.5	632	12%
	7/18/07	41.05	4,192.18	7.50	0.80	102	650	16%
	8/22/07	40.96	4,192.27	7.26	0.86	88.0	672	13%
	9/28/07	40.94	4,192.29	7.62	0.94	122	606	20%
	10/24/07	41.00	4,192.23	7.75	0.93	117	710	16%
	2/11/08	41.01	4,192.22	7.60	1.00	84.7	1020	8%
	3/13/08	41.01	4,192.22					
	5/5/08	41.03	4,192.20	7.26	1.22	96.3	596	16%
	8/20/08	41.10	4,192.13	7.19	0.96	72.3	568	13%
	11/21/08	41.11	4,192.12	7.14	1.01	101	498	20%
	2/17/09	41.10	4,192.13	7.17	1.14	75.4	558	14%
	5/26/09	41.13	4,192.10	7.43	0.89	60.9	554	11%
	8/24/09	41.09	4,192.14	7.27	0.99	65.5	586	11%
	11/2/09	40.95	4,192.28	7.23	1.00	82.5	540	15%
	2/26/10	41.10	4,192.13	7.19	1.00	74.5	558	13%
MW-2	5/11/06	41.85	4,192.02	7.80	0.81			
4,233.87	5/12/06	41.88	4,191.99	7.50	0.60	44.5	530	8%
	8/2/06	41.88	4,191.99	7.38	0.67	42.2	444	10%
	10/17/06	41.82	4,192.05					
	12/12/06	41.77	4,192.10			10.0		
	1/9/07	41.75	4,192.12			46.0		
	2/6/07	41.93	4,191.94					
	2/6/07	41.88	4,191.99 4,191.90		0.004			
	2/16/07 3/8/07	41.97 42.03	4,191.90 4,191.84		0.924	15	510	00/
	3/13/07				0.663	45	510	9%
	4/17/07	41.99 41.81	4,191.88 4,192.06	7.93	0.663 0.65	41.5	436	10%
	5/21/07	41.01	4,192.08 4,192.14	8.31				
	6/21/07	41.73	4,192.14 4,192.14	6.31 7.72	0.63	38.6	452 516	9%
	7/18/07	41.73	4,192.14 4,192.15		0.57	39.7	516	8%
				8.16 7.60	0.56	41.7	388	11%
	8/22/07 9/28/07	41.66 41.65	4,192.21	7.60	0.68	40.9	550	7%
		41.65 41.67	4,192.22	7.82	0.66	74.4	452	16%
	10/24/07 2/11/08	41.67 41.68	4,192.20 4,192.19	7.64 7.56	0.73	74.4	430	17%
	2/11/00	41.00	4,192.19	7.56	0.78	39.8	744	5%

### Appendix A - Table 2 Laboratory Results Summary - Groundwater Samples

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Appendix A - Table 2
Laboratory Results Summary - Groundwater Samples

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Monitor Well	Sample	Water	Water	рН	Cond.	Chloride	TDS	% CI
TOC Elev.	Date	Depth	Elevation	(unitless)	(uS/cm)	(mg/L)	(mg/L)	of TDS
	0/40/00	44.00				· · · · · · · · · · · · · · · · · · ·		
	3/13/08	41.68	4,192.19					 10%
	5/5/08	41.68	4,192.19	7.37	0.77	40.1	406	7%
	8/20/08	41.75	4,192.12	7.51	0.71	28.7	440	14%
	11/21/08	41.78 41.77	4,192.09 4,192.10	7.40 7.43	0.77 0.87	53.2 39.7	388 462	9%
	2/17/09 5/26/09	41.77		7.43		35.8	402	9%
	8/24/09	41.76	4,192.09	7.63	0.66	35.8	410	9% 8%
	8/24/09 11/2/09	41.76	4,192.11 4,192.21	7.80	0.75 0.75	41.5	424 406	10%
	2/26/10	41.00	4,192.21	7.49	0.75	38.2	400 358	11%
MW-3 (S)	12/12/06	32.81	4,192.10	1.49	0.74			1170
	12/12/06	32.81	4,191.71			3,900	5,800	67%
4,224.52	1/9/07	32.82	4,191.70			3,900	5,600	0770
	2/6/07	32.27	4,192.23					
Pump On	2/6/07	44.47	4,191.02	}		2,500	4,400	57%
Fump On	2/16/07	44.45	4,180.07		8.71	2,500	4,400	5176
	3/8/07	40.12	4,184.40		10.31	3,400	6,200	55%
	3/13/07	42.41	4,182.11		10.31	3,400	0,200	0078
	4/17/07	42	4,182.52	8.08	7.45	2,730	4,520	60%
	5/21/07	41	4,183.52	8.20	8.67	3,340	4, <u>32</u> 0 6,430	52%
	6/21/07	42	4,182.52	7.78	10.24	4,750	7,960	60%
Pump Off	7/18/07	32.48	4,192.04	7.45	10.24	5,730	8,730	66%
rumpon	8/22/07	32.22	4,192.30					•
	9/28/07	32.24	4,192.28			07 the pump		
	10/24/07	32.35	4,192.17			d interval. 1		
	2/11/08	32.42	4,192.10	is set a	at a depth o	f 57 feet (so	reen at 55 -	60 ft).
	2/26/10	32.55	4,191.97	7.73	17.33	4,600	8,340	55%
MW-3 (D)	12/18/06			- 1.10	0.87	2,000	3,700	54%
4,224.52	3/8/07				10.28	3,500	6,200	56%
.,	3/13/07	42.41	4,182.11		10.06	0,000	0,200	0070
	3/13/08	32.45	4,192.07			7,730	12,400	62%
	5/5/08	32.50	4,192.02	6.60	19.70	9,680	15,200	64%
	8/20/08	32.42	4,192.10	7.14	12.76	5,300	7,550	70%
	11/21/08	32.42	4,192.10	7.21	10.30	4,892	6,330	77%
	2/17/09	32.41	4,192.11	7.24	12.04	4,110	5,720	72%
	5/26/09	32.43	4,192.09	8.01	10.50	3,300	5,330	62%
	8/24/09	32.41	4,192.11	8.13	10.62	3,150	5,250	60%
	11/2/09	32.30	4,192.22	7.25	17.59	6,100	9,110	67%
	1/5/10	32.40	4,192.12	7.47	>20	8,110	12,700	64%
	2/26/10	32.55	4,191.97	7.80	>20	3,510	10,800	33%
MW-4(S)	1/9/07					180		
4,233.52	2/6/07	41.73	4,191.79					
	2/6/07	41.80	4,191.72					
	2/16/07	41.84	4,191.68		0.98			
	3/8/07	41.85	4,191.67			120	680	18%
	3/13/07	41.82	4,191.70		0.99			
	4/17/07	41.61	4,191.91	7.78	0.79	84.8	598	14%
	5/21/07	41.50	4,192.02	8.16	0.73	65.7	442	15%

l	Laborato	ory Resu	ults Sumr	mary - Gi	roundwa	ater Sam	ples	
Monitor Well TOC Elev.	Sample Date	Water Depth	Water Elevation	pH (unitless)	Cond. (uS/cm)	Chloride (mg/L)	TDS (mg/L)	% CI of TDS
	6/21/07	41.51	4,192.01	7.79	0.65	65.8	618	11%
	7/18/07	41.54	4,191.98	7.81	0.68	67.5	514	13%
	8/22/07	41.44	4,192.08	7.46	0.78	64.0	960	7%
	9/28/07	41.43	4,192.09	7.89	0.77	95.7	640	15%
	10/24/07	41.48	4,192.04	7.97	0.84	85.1	786	11%
	2/11/08	41.50	4,192.02	7.44	0.90	55.2	688	8%
	3/13/08	41.50	4,192.02					
	5/5/08	41.51	4,192.01	7.35	0.86	49.5	514	10%
	8/20/08	41.58	4,191.94	7.35	0.77	32.5	476	7%
	11/21/08	41.60	4,191.92	7.23	0.83	63.8	478	13%
	2/17/09	41.60	4,191.92	7.26	0.97	50.1	512	10%
	5/26/09	41.61	4,191.91	7.62	0.75	52.2	490	11%
	8/24/09	41.57	4,191.95	7.45	0.87	63.2	516	12%
	11/2/09	41.43	4,192.09	7.43	0.88	72.9	470	16%
	1/5/10	41.53	4,191.99	7.41	0.88	87.4	462	19%
	2/26/10	41.60	4,191.92	7.39	0.89	67.0	464	14%
MW-4(D)	1/9/07					100		
4,233.38	2/6/07	41.61	4,191.77					
	2/6/07	41.53	4,191.85					
	2/16/07	41.64	4,191.74		0.95			
	3/8/07	41.65	4,191.73			52.0	550	9%
	3/13/07	41.63	4,191.75		0.78			
	4/17/07	41.42	4,191.96	7.87	0.70	45.7	562	8%
	5/21/07	41.32	4,192.06	8.33	0.69	44.8	458	10%
	6/21/07	41.33	4,192.05	7.72	0.61	42.4	610	7%
	7/18/07	41.34	4,192.04	7.93	0.62	48.2	508	9%
	8/22/07	41.26	4,192.12	7.53	0.74	50.4	494	10%
	9/28/07	41.24	4,192.14	7.79	0.75	79.8	474	17%
	10/24/07	41.29	4,192.09	7.94	0.87	95.7	690	14%
	2/11/08	41.30	4,192.08	7.42	1.31	231	764	30%
	3/13/08	41.32	4,192.06					
	5/5/08	41.32	4,192.06	7.26	1.22	217	804	27%
	8/20/08	41.39	4,191.99	7.33	1.16	225	736	31%
	11/21/08	41.41	4,191.97	7.22	1.25	213	682	31%
	2/17/09	41.40	4,191.98	7.22	1.48	190	778	24%
	5/26/09	41.42	4,191.96	7.50	1.12	167	912	18%
	8/24/09	41.39	4,191.99	7.35	1.35	203	762	27%
	11/2/09 1/5/10	41.25 41.35	4,192.13	7.35 7.27	1.35	223	926	24%
	2/26/10	41.35	4,192.03 4,191.97	7.27	1.82 2.02	372 429	1110 1210	34% 35%
	2/20/10	41.41	4,191.97	1.22	2.02	and the second	1210	

#### Appendix A - Table 2 Laboratory Results Summary - Groundwater Samples

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# Appendix B Laboratory Reports

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## **R.T. Hicks Consultants, Ltd.**

901 Rio Grande Blvd. NW, Suite F-142 Albuquerque, NM 87104

### Analytical Report 325220

for

### **R.T. Hicks Consultants, LTD**

**Project Manager: Dale Littlejohn** 

Samson State BD No. 4 L-126-0209

19-FEB-09

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12600 West I-20 East Odessa, Texas 79765

Texas certification numbers: Houston, TX T104704215-08B-TX - Odessa/Midland, TX T104704400-08-TX

Florida certification numbers: Houston, TX E871002 - Miami, FL E86678 - Tampa, FL E86675 Norcross(Atlanta), GA E87429

> South Carolina certification numbers: Norcross(Atlanta), GA 98015

> North Carolina certification numbers: Norcross(Atlanta), GA 483

Houston - Dallas - San Antonio - Tampa - Miami - Latin America Midland - Corpus Christi - Atlanta



19-FEB-09



Project Manager: Dale Littlejohn R.T. Hicks Consultants, LTD 901 Rio Grande Blvd. NW, Suite F-142 Albuquerque, NM 87104

Reference: XENCO Report No: 325220 Samson State BD No. 4 Project Address: Lea Co., NM

#### Dale Littlejohn:

We are reporting to you the results of the analyses performed on the samples received under the project name referenced above and identified with the XENCO Report Number 325220. All results being reported under this Report Number apply to the samples analyzed and properly identified with a Laboratory ID number. Subcontracted analyses are identified in this report with either the NELAC certification number of the subcontract lab in the analyst ID field, or the complete subcontracted report attached to this report.

Unless otherwise noted in a Case Narrative, all data reported in this Analytical Report are in compliance with NELAC standards. Estimation of data uncertainty for this report is found in the quality control section of this report unless otherwise noted. Should insufficient sample be provided to the laboratory to meet the method and NELAC Matrix Duplicate and Matrix Spike requirements, then the data will be analyzed, evaluated and reported using all other available quality control measures.

The validity and integrity of this report will remain intact as long as it is accompanied by this letter and reproduced in full, unless written approval is granted by XENCO Laboratories. This report will be filed for at least 5 years in our archives after which time it will be destroyed without further notice, unless otherwise arranged with you. The samples received, and described as recorded in Report No. 325220 will be filed for 60 days, and after that time they will be properly disposed without further notice, unless otherwise arranged with you. We reserve the right to return to you any unused samples, extracts or solutions related to them if we consider so necessary (e.g., samples identified as hazardous waste, sample sizes exceeding analytical standard practices, controlled substances under regulated protocols, etc).

We thank you for selecting XENCO Laboratories to serve your analytical needs. If you have any questions concerning this report, please feel free to contact us at any time.

Respectfully,

Brent Barron, II Odessa Laboratory Manager

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### Sample Cross Reference 325220

### R.T. Hicks Consultants, LTD, Albuquerque, NM

Samson State BD No. 4

Sample Id	Matrix	Date Collected	Sample Depth	Lab Sample Id
MW-1	W	Feb-17-09 09:55		325220-001
MW-2	W	Feb-17-09 08:46		325220-002
MW-3	W	Feb-17-09 10:10		325220-003
MW-4 (D)	W	Feb-17-09 09:30		325220-004
MW-4 (S)	W	Feb-17-09 09:23		325220-005

XGNCO International

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Project Id: L-126-0209 Contact: Dale Littlejohn Project Location: Lea Co, NM

Certificate of Analysis Summary 325220 R.T. Hicks Consultants, LTD, Albuquerque, NM

Project Name: Samson State BD No. 4



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Date Received in Lab: Tue Feb-17-09 03:30 pm

Report Date: 19-FEB-09

					Project Manager: Brent Barron, II	Brent Barron, II	
	Lab Id:	325220-001	325220-002	325220-003	325220-004	325220-005	
Analysis Roanastad	Field Id:	I-WM	MW-2	MW-3	MW-4 (D)	MW-4 (S)	
naisanhay ciclimite	Depth:						
	Matrix:	WATER	WATER	WATER	WATER	WATER	
	Sampled:	Feb-17-09 09:55	Feb-17-09 08:46	Feb-17-09 10:10	Feb-17-09 09:30	Feb-17-09 09:23	
Anions by EPA 300	Extracted:						
	Analyzed:	Feb-19-09 01:00	Fcb-19-09 01:00	Fcb-19-09 01:00	Fcb-19-09 01:00	Feb-19-09 01:00	
	Units/RL:	mg/L RL	L mg/L RL	mg/L RL	mg/L RL	mg/L RL	
Chloride		75.4 5.00	0 39.7 5.00	4110 100	190 5.00	50.1 5.00	
TDS by SM2540C	Extracted:						
	Analyzed:	Feb-18-09 15:41	Feb-18-09 15:41	Feb-18-09 15:41	Feb-18-09 15:41	Feb-18-09 15:41	
	Units/RL:	mg/L R	RL mg/L RL	mg/L RL	mg/L RL	mg/L RL	
Total dissolved solids		558 5.00	0 462 5.00	5720 5.00	778 5.00	512 5.00	

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This analytical report, and the entire data package it represents, has been made for your exclusive and confidential use. The interpretations and results expressed throughou this analytical report reports each the bar planem of XENCO Laboratorias assumes no responsibility and makes no warranty to the end use of the data hareby presented. Our fiability is limited to the amount invoiced for this work order unless otherwise agreed to in writing.

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Odessa Laboratory Director Brent Barron

Page 4 of 10





- X In our quality control review of the data a QC deficiency was observed and flagged as noted. MS/MSD recoveries were found to be outside of the laboratory control limits due to possible matrix /chemical interference, or a concentration of target analyte high enough to effect the recovery of the spike concentration. This condition could also effect the relative percent difference in the MS/MSD.
- **B** A target analyte or common laboratory contaminant was identified in the method blank. Its presence indicates possible field or laboratory contamination.
- **D** The sample(s) were diluted due to targets detected over the highest point of the calibration curve, or due to matrix interference. Dilution factors are included in the final results. The result is from a diluted sample.
- E The data exceeds the upper calibration limit; therefore, the concentration is reported as estimated.
- F RPD exceeded lab control limits.
- J The target analyte was positively identified below the MQL and above the SQL.
- U Analyte was not detected.
- L The LCS data for this analytical batch was reported below the laboratory control limits for this analyte. The department supervisor and QA Director reviewed data. The samples were either reanalyzed or flagged as estimated concentrations.
- **H** The LCS data for this analytical batch was reported above the laboratory control limits. Supporting QC Data were reviewed by the Department Supervisor and QA Director. Data were determined to be valid for reporting.
- K Sample analyzed outside of recommended hold time.
- **JN** A combination of the "N" and the "J" qualifier. The analysis indicates that the analyte is "tentatively identified" and the associated numerical value may not be consistent with the amount actually present in the environmental sample.
- \* Outside XENCO's scope of NELAC Accreditation.

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### Project Name: Samson State BD No. 4

Project ID:

L-126-0209

Lab Batch #: 750052 Date Analyzed: 02/19/2009	Sample: 750052- Date Prepared: 02/19/20			ix: Water st: LATCO	OR	
Reporting Units: mg/L	Batch #: 1	BLANK /	BLANK SPI	KE REC	COVERY S	STUDY
Anions by EPA 300	Blank Result	Spike Added	Blank Spike Result	Blank Spike %R	Control Limits %R	Flags
Analytes	[A]	[B]	[C]	[D]	78K	
Chloride	ND	10.0	10.3	103	90-110	

Blank Spike Recovery [D] = 100\*[C]/[B] All results are based on MDL and validated for QC purposes.



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### Form 3 - MS Recoveries



#### Project Name: Samson State BD No. 4

Work Order #: 325220 Lab Batch #: 750052 Date Analyzed: 02/19/2009

### Date Prepared: 02/19/2009

Project ID: L-126-0209 Analyst: LATCOR

QC- Sample ID: 325202-001 S Reporting Units: mg/L	Batch #:	I RIX / MA	TRIX SPIKE	Matrix:	Water	DY
Inorganic Anions by EPA 300	Parent Sample Result	Spike Added	Spiked Sample Result [C]		Control Limits %R	Flag
Analytes	[A]	[B]		(-)		
Chloride	66.6	100	173	106	80-120	

Matrix Spike Percent Recovery  $[D] = 100^{\circ}(C-A)/B$ Relative Percent Difference  $[E] = 200^{\circ}(C-A)/(C+B)$ All Results are based on MDL and Validated for QC Purposes



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### Sample Duplicate Recovery



Work Order #: 325220 Project Name: Samson State BD No. 4

Lab Batch #: 750052 Date Analyzed: 02/19/2009 QC- Sample ID: 325202-001 D Reporting Units: mg/L	Date Pre Bi	atch #: 1	9/2009	Analy Matr	D: L-126-02 st: LATCOF ix: Water ATE REC	₹. 		
Anions by EPA 300 Analyte		Parent Sample Result [A]	Sample Duplicate Result [B]	RPD	Control Limits %RPD	Flag		
Chloride		66.6	64.9	3	20			
Lab Batch #: 750117 Date Analyzed: 02/18/2009 QC- Sample ID: 325202-001 D	Date Pre B:	pared: 02/1 atch #: 1	8/2009	Analyst: WRU Matrix: Water				
Reporting Units: mg/L	[		SAMPLE			OVERY		
TDS by SM2540C Analyte		Parent Sample Result [A]	Sample Duplicate Result [B]	RPD	Control Limits %RPD	Flag		
Total dissolved solids		760	812	7	30			

Spike Relative Difference RPD 200 \* | (B-A)/(B+A) | All Results are based on MDL and validated for QC purposes.

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#### Environmental Lab of Texas Variance/ Corrective Action Report- Sample Log-In

RT HICKS Client: 2 17 09 1530 Date/ Time:

325220

CIL

Lab ID # :

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Initials:

#### Sample Receipt Checklist

	Sample Receipt	Checklist		Client Ini
#1	Temperature of container/ cooler?	Yes	No	H <sub>a</sub> C °C
#2	Shipping container in good condition?	(es)	No	
#3	Custody Seals intact on shipping container/ cooler?	Yes	No	Not Present
#4	Custody Seals intact on sample bottles/ container?	Yes	No	Not Present>
#5	Chain of Custody present?	Yes:	No	
#6	Sample instructions complete of Chain of Custody?	Yes/	No	
#7	Chain of Custody signed when relinquished/ received?	Yes	No	
#8	Chain of Custody agrees with sample label(s)?	Yes ;	No	ID written on Cont./ Lid
#9	Container label(s) legible and intact?	Yes-	No	Not Applicable
#10	Sample matrix/ properties agree with Chain of Custody?	Yes	No	
#11	Containers supplied by ELOT?	Yes	No	
#12	Samples in proper container/ bottle?	(Tes	No	See Below
#13	Samples properly preserved?	Yes	No	See Below
#14	Sample bottles intact?	Yes/	No	
#15	Preservations documented on Chain of Custody?	Yes	No	
#16	Containers documented on Chain of Custody?	Yes	No	
#17	Sufficient sample amount for indicated test(s)?	Yes	No	See Below
#18	All samples received within sufficient hold time?	Yes	No	See Below
#19	Subcontract of sample(s)?	Yes	No	Not Applicable
#20	VOC samples have zero headspace?	Yes	No	Not Applicable

#### Variance Documentation

### Analytical Report 333727

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for

### **R.T. Hicks Consultants, LTD**

**Project Manager: Dale Littlejohn** 

Samson State BD No. 4 L-126-0509

10-JUN-09



12600 West I-20 East Odessa, Texas 79765

Texas certification numbers: Houston, TX T104704215-08B-TX - Odessa/Midland, TX T104704400-08-TX Corpus Christi, TX T104704370-08-TX - Dallas, TX T104704295-08-TX

Florida certification numbers: Houston, TX E871002 - Miami, FL E86678 - Tampa, FL E86675 Miramar, FL E86349 Norcross(Atlanta), GA E87429

> South Carolina certification numbers: Norcross(Atlanta), GA 98015

North Carolina certification numbers: Norcross(Atlanta), GA 483

Houston - Dallas - San Antonio - Tampa - Miami - Latin America Midland - Corpus Christi - Atlanta



10-JUN-09



Project Manager: Dale Littlejohn R.T. Hicks Consultants, LTD 901 Rio Grande Blvd. NW, Suite F-142 Albuquerque, NM 87104

Reference: XENCO Report No: 333727 Samson State BD No. 4 Project Address: Lea Co., NM

#### Dale Littlejohn:

We are reporting to you the results of the analyses performed on the samples received under the project name referenced above and identified with the XENCO Report Number 333727. All results being reported under this Report Number apply to the samples analyzed and properly identified with a Laboratory ID number. Subcontracted analyses are identified in this report with either the NELAC certification number of the subcontract lab in the analyst ID field, or the complete subcontracted report attached to this report.

Unless otherwise noted in a Case Narrative, all data reported in this Analytical Report are in compliance with NELAC standards. Estimation of data uncertainty for this report is found in the quality control section of this report unless otherwise noted. Should insufficient sample be provided to the laboratory to meet the method and NELAC Matrix Duplicate and Matrix Spike requirements, then the data will be analyzed, evaluated and reported using all other available quality control measures.

The validity and integrity of this report will remain intact as long as it is accompanied by this letter and reproduced in full, unless written approval is granted by XENCO Laboratories. This report will be filed for at least 5 years in our archives after which time it will be destroyed without further notice, unless otherwise arranged with you. The samples received, and described as recorded in Report No. 333727 will be filed for 60 days, and after that time they will be properly disposed without further notice, unless otherwise arranged with you. We reserve the right to return to you any unused samples, extracts or solutions related to them if we consider so necessary (e.g., samples identified as hazardous waste, sample sizes exceeding analytical standard practices, controlled substances under regulated protocols, etc).

We thank you for selecting XENCO Laboratories to serve your analytical needs. If you have any questions concerning this report, please feel free to contact us at any time.

Respectfully,

Brent Barron, II Odessa Laboratory Manager

Recipient of the Prestigious Small Business Administration Award of Excellence in 1994. Certified and approved by numerous States and Agencies. A Small Business and Minority Status Company that delivers SERVICE and QUALITY Houston - Dallas - San Antonio - Austin - Tampa - Miami - Atlanta - Corpus Christi - Latin America



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2010 1000

### Sample Cross Reference 333727



### R.T. Hicks Consultants, LTD, Albuquerque, NM

Samson State BD No. 4

Sample Id	Matrix	Date Collected	Sample Depth	Lab Sample Id
MW-1	W	May-26-09 15:32		333727-001
MW-2	W	May-26-09 14:25		333727-002
MW-3	W	May-26-09 15:55		333727-003
MW-4 (S)	W	May-26-09 15:06		333727-004
MW-4 (D)	W	May-26-09 15:03		333727-005

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Client Name: R.T. Hicks Consultants, LTD Project Name: Samson State BD No. 4

Project ID: L-126-0509 Work Order Number: 333727 Report Date: 10-JUN-09 Date Received: 05/27/2009

#### Sample receipt non conformances and Comments:

Samples MW-4(D) (Chain of custody line item 4) and MW-4 (S) (Chain of custody line item 5) were incorrectly labled by the techs in sample receiving. This was noticed by the client and brought to our attention. The laboratory ids have been corrected, however MW-4(D) has now been assigned sample ID 333727-005 and MW-4 (S) has been assigned sample ID 333727-004. A corrective action has been issued in this case.

Sample receipt Non Conformances and Comments per Sample:

None

#### Analytical Non Conformances and Comments:

Batch: LBA-760251 Inorganic Anions by EPA 300 None

Batch: LBA-760281 TDS by SM2540C None

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Certificate of Analysis Summary 333727 R.T. Hicks Consultants, LTD, Albuquerque, NM

Project Name: Samson State BD No. 4



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States.

Project Id: L-126-0509 Contact: Dale Littlejohn Project Location: Lea Co., NM

Date Received in Lab: Wed May-27-09 08:42 am Report Date: 10-JUN-09

					Project Manager: Brent Barron, II	srent Barron, II	
	Lab Id:	333727-001	333727-002	333727-003	333727-004	333727-005	
Analysis Dogustad	Field Id:	I-WM	MW-2	MW-3	MW-4 (S)	MW-4 (D)	
. naicanhavi ciclinuiv	Depth:						
	Matrix:	WATER	WATER	WATER	WATER	WATER	
	Sampled:	May-26-09 15:32	May-26-09 14:25	May-26-09 15:55	May-26-09 15:06	May-26-09 15:03	
Anions by EPA 300	Extracted:				-		
	Analyzed:	May-27-09 13:50	May-27-09 13:50	May-27-09 13:50	May-27-09 13:50	May-27-09 13:50	
	Units/RL:	mg/L RL	mg/L RL	mg/L RL	mg/L RL	mg/L RL	
Chloride *		60.9 5.00	35.8 5.00	3300 100	52.2 5.00	167 5.00	
TDS hv SM2540C	Extracted:						
	Analyzed:	May-27-09 16:00	May-27-09 16:00	May-27-09 16:00	May-27-09 16:00	May-27-09 16:00	
	Units/RL:	mg/L RL	mg/L RL	mg/L RL	mg/L RL	mg/L RL	
Total dissolved solids		554 5.00	418 5.00	5330 5.00	490 5.00	912 5.00	
							]

This analytical report, and the entite data package it represents, has been made for your exclusive and confidential use. The interpretations and results expressed throughout the analytical report reports the base in thement of XENCO Laboratories assumes no responsibility and makes no varranty on the end use of the data hereby presented. Our liability is limited to the amount invoiced for this work order unless otherwise agreed to in writing.

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Brent Barron Odessa Laboratory Director





- X In our quality control review of the data a QC deficiency was observed and flagged as noted. MS/MSD recoveries were found to be outside of the laboratory control limits due to possible matrix /chemical interference, or a concentration of target analyte high enough to effect the recovery of the spike concentration. This condition could also effect the relative percent difference in the MS/MSD.
- **B** A target analyte or common laboratory contaminant was identified in the method blank. Its presence indicates possible field or laboratory contamination.
- **D** The sample(s) were diluted due to targets detected over the highest point of the calibration curve, or due to matrix interference. Dilution factors are included in the final results. The result is from a diluted sample.
- E The data exceeds the upper calibration limit; therefore, the concentration is reported as estimated.
- F RPD exceeded lab control limits.
- J The target analyte was positively identified below the MQL and above the SQL.
- U Analyte was not detected.
- L The LCS data for this analytical batch was reported below the laboratory control limits for this analyte. The department supervisor and QA Director reviewed data. The samples were either reanalyzed or flagged as estimated concentrations.
- **H** The LCS data for this analytical batch was reported above the laboratory control limits. Supporting QC Data were reviewed by the Department Supervisor and QA Director. Data were determined to be valid for reporting.
- K Sample analyzed outside of recommended hold time.
- JN A combination of the "N" and the "J" qualifier. The analysis indicates that the analyte is "tentatively identified" and the associated numerical value may not be consistent with the amount actually present in the environmental sample.

BRL Below Reporting Limit.

RL Reporting Limit

\* Outside XENCO's scope of NELAC Accreditation.

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### Project Name: Samson State BD No. 4

Work Ord	ler #: 33372	27
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#### **Project ID:**

L-126-0509

Lab Batch #: 760251 Date Analyzed: 05/27/2009	Sample: 760251- Date Prepared: 05/27/20		Matrix: Water Analyst: LATCOR			
Reporting Units: mg/L	Batch #: 1	BLANK /	BLANK SPI	KE REC	COVERY S	STUDY
Anions by EPA 300	Blank Result	Spike Added	Blank Spike	Blank Spike	Control Limits	Flags
Analytes	[A]	[B]	Result [C]	%R [D]	%R	
Chloride	ND	10.0	9.68	97	90-110	

Blank Spike Recovery [D] = 100\*[C]/[B] All results are based on MDL and validated for QC purposes. BRL - Below Reporting Limit

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**BS / BSD Recoveries** 



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Project Name: Samson State BD No. 4

Work Order #: 333727 Analyst: WRU Lab Batch ID: 760281 Unite: m9/L	Sample: 760281-1-BKS		te Prepar Batcl BLAN	Date Prepared:       05/27/2009         Date Prepared:       05/27/2009         Batch #:       1         BLANK /BLANK SPIKE / BLANK SPIKE DUPLICATE RECOVERY STUDY	9 SPIKE / B	LANK S	PIKE DUPL	Proj Date Ai <u>JCATE J</u>	ect ID: L-126 nalyzed: 05/27/ Matrix: Water RECOVERY	Project ID: L-126-0509 Date Analyzed: 05/27/2009 Matrix: Water ATE RECOVERY STUD)
TDS by SM2540C Analytes	540C	Blank Sample Result [A]	Spike Added [B]	Blank Spike Result [C]	Blank Spike %R [D]	Spike Added {E]	Blank Spike Duplicate Result [F]	Blk. Spk Dup. %R [G]	RPD %	Control Limits %R

Flag

Control Limits %RPD

30

80-120

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97

972

1000

92

924

1000

g

Total dissolved solids

Relative Percent Difference RPD = 200\*[(C-F)/(C+F)] Blank Spike Recovery [D] = 100\*(C)/[B] Blank Spike Duplicate Recovery [G] = 100\*(F)/[E] All results are based on MDL and Validated for QC Purposes



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### Form 3 - MS Recoveries



Project Name: Samson State BD No. 4

Lab Batch #: 760251		05/07/2000		-	L-126-0509	9
Date Analyzed: 05/27/2009 QC- Sample ID: 333690-001 S	Date Prepared: Batch #:	05/27/2009	-	Analyst: Matrix:		
Reporting Units: mg/L	MAT	RIX / MA	TRIX SPIKE	RECO	VERY STU	DY
Inorganic Anions by EPA 300	Parent Sample Result	Spike Added	Spiked Sample Result [C]	%R [D]	Control Limits %R	Flag
Analytes	[A]	[B]		(-1		
Chloride	52.0	100	150	98	80-120	1

Matrix Spike Percent Recovery  $[D] = 100^{*}(C-A)/B$ Relative Percent Difference  $[E] = 200^{*}(C-A)/(C+B)$ All Results are based on MDL and Validated for QC Purposes

BRL - Below Reporting Limit

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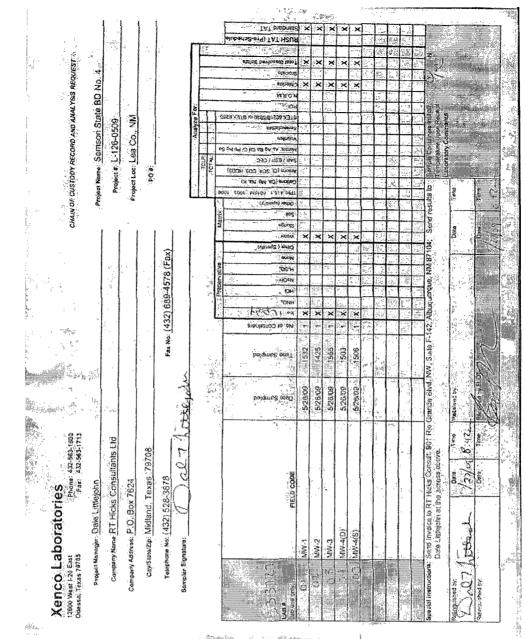
### **Sample Duplicate Recovery**



Work Order #: 333727

Lab Batch #: 760251				Project I	D: L-126-05	09
Date Analyzed: 05/27/2009	Date Prepared	<b>1:</b> 05/2	27/2009	Analy	st: LATCOF	٤
QC- Sample ID: 333690-001 D	Batch #	#: I	l	Matr	ix: Water	
Reporting Units: mg/L	SA	MPLE	/ SAMPLE	DUPLIC	ATE REC	OVERY
Anions by EPA 300	R	t Sample esult [A]	Duplicate Result	RPD	Control Limits %RPD	Flag
Analyte			(B)			
Chloride	5	2.0	52.7	1	20	
Lab Batch #: 760281						
Date Analyzed: 05/27/2009	Date Prepare	<b>i:</b> 05/2	27/2009	Analy	st: WRU	
QC- Sample ID: 333727-001 D	Batch #	¥: 1	l	Matr	ix: Water	
Reporting Units: mg/L	SA	MPLE	/ SAMPLE	DUPLIC	CATE REC	OVERY
TDS by SM2540C	R	t Sample esult [A]	Duplicate Result	RPD	Control Limits %RPD	Flag
Analyte			[B]			
Total dissolved solids		554	564	2	30	

Spike Relative Difference RPD 200 \* | (B-A)/(B+A) | All Results are based on MDL and validated for QC purposes. BRL - Below Reporting Limit



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illais AL						
	ample Receipt C	hecklist			a the second	
1 Temperature of container/ cooler?		(Yes)	No		Client Initi	ala ]
2. Shipping container in good condition?		(Tes)	No		220090302	
3 Custody Seals intact on shipping container 4 Custody Seals intact on sample bottles/ co	and the second	Yes Yes	<u>No</u>	Not Present	<u>*X:-</u>	400000
5 Charo of Custody present?		Ves)	No	CIUCITIE acity		
6 Sample Instructions complete of Chain of		<u>(es</u> )	No		<u>, a casta</u>	3
<ol> <li>Chain of Custody signed when relinquishe</li> <li>Chain of Custody agrees with sample labe</li> </ol>		Yes)	<u>No</u>			
8 Chain of Custody egrees with sample table 9 Container tabel(s) legible and intact?		(Yes) (Yes	No No	ID written on Cont./. Not Applicable		
10 Sample matrix/ properties agree with Cha		(Ye)	No		C ISANYARA	
13 Containers supplied by ELOT7	Conversion and Second	Yes	No		AB STRACT	3.2.2
12 Samples in proper container/ bottle?	1000 C	<u>(1</u> 29 (1285	No	See Below	*******	_
13 Samples properly preserved?     14 Sample bottles intact?		Yes	No No	See Below		
15 Preservations documented on Chain of C	ustody?	X(Y69	No		2020 (2220) 2020 (2280)	
16 Containers documented on Chain of Cust		· Yes	No			
17 Sufficient sample amount for indicated le		Yee	No	See Below		
18 All samples received within sufficient hold 19 Subcontract of sample(s)?	. omer	Yes Yes	No	See Balow		
20 VOC samplos have zero headepace?		Yes	No	CNot Applicable	and the second se	
	Variance Docum	entation				
Contact Contac	Ned by:			Date/ Time		<u> </u>
Regarding:		SUE	Sec. flow	and the part of the		50.3
		2.55				
		**************************************				
Corrective Action Taken:						
	<u></u>	Ar (N), Br (S), Ar (S)	3v		<u> 1</u>	
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Check all that Apply: [] See attach	ed e-mail/ fax		•*	지 것같다.		
	erstands and would	like to prov	nin win	analysis		134

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### Analytical Report 342171

for

### **R.T. Hicks Consultants, LTD**

**Project Manager: Dale Littlejohn** 

Samson State BD No. 4

L-126-0809

27-AUG-09





12600 West I-20 East Odessa, Texas 79765

Xenco-Houston (EPA Lab code: TX00122):

Texas (T104704215-08-TX), Arizona (AZ0738), Arkansas (08-039-0), Connecticut (PH-0102), Florida (E871002) Illinois (002082), Indiana (C-TX-02), Iowa (392), Kansas (E-10380), Kentucky (45), Louisiana (03054) New Hampshire (297408), New Jersey (TX007), New York (11763), Oklahoma (9218), Pennsylvania (68-03610) Rhode Island (LAO00308), USDA (S-44102)

Xenco-Atlanta (EPA Lab Code: GA00046): Florida (E87428), North Carolina (483), South Carolina (98015), Utah (AALII), West Virginia (362), Kentucky (85) Louisiana (04176), USDA (P330-07-00105)

> Xenco-Miami (EPA Lab code: FL01152): Florida (E86678), Maryland (330) Xenco-Tampa Mobile (EPA Lab code: FL01212): Florida (E84900) Xenco-Odessa (EPA Lab code: TX00158): Texas (T104704400-08-TX) Xenco-Dallas (EPA Lab code: TX01468): Texas (T104704295-08-TX) Xenco-Corpus Christi (EPA Lab code: TX02613): Texas (T104704370-08-TX) Xenco-Boca Raton (EPA Lab Code: FL00449): Florida(E86240), South Carolina(96031001), Louisiana(04154), Georgia(917)



27-AUG-09



Project Manager: **Dale Littlejohn R.T. Hicks Consultants, LTD** 901 Rio Grande Blvd. NW, Suite F-142 Albuquerque, NM 87104

Reference: XENCO Report No: 342171 Samson State BD No. 4 Project Address: Lea Co., NM

#### Dale Littlejohn:

We are reporting to you the results of the analyses performed on the samples received under the project name referenced above and identified with the XENCO Report Number 342171. All results being reported under this Report Number apply to the samples analyzed and properly identified with a Laboratory ID number. Subcontracted analyses are identified in this report with either the NELAC certification number of the subcontract lab in the analyst ID field, or the complete subcontracted report attached to this report.

Unless otherwise noted in a Case Narrative, all data reported in this Analytical Report are in compliance with NELAC standards. Estimation of data uncertainty for this report is found in the quality control section of this report unless otherwise noted. Should insufficient sample be provided to the laboratory to meet the method and NELAC Matrix Duplicate and Matrix Spike requirements, then the data will be analyzed, evaluated and reported using all other available quality control measures.

The validity and integrity of this report will remain intact as long as it is accompanied by this letter and reproduced in full, unless written approval is granted by XENCO Laboratories. This report will be filed for at least 5 years in our archives after which time it will be destroyed without further notice, unless otherwise arranged with you. The samples received, and described as recorded in Report No. 342171 will be filed for 60 days, and after that time they will be properly disposed without further notice, unless otherwise arranged with you. We reserve the right to return to you any unused samples, extracts or solutions related to them if we consider so necessary (e.g., samples identified as hazardous waste, sample sizes exceeding analytical standard practices, controlled substances under regulated protocols, etc).

We thank you for selecting XENCO Laboratories to serve your analytical needs. If you have any questions concerning this report, please feel free to contact us at any time.

Respectfully,

Brent Barron, II Odessa Laboratory Manager

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### Sample Cross Reference 342171



### R.T. Hicks Consultants, LTD, Albuquerque, NM

Samson State BD No. 4

Sample Id	Matrix	Date Collected	Sample Depth	Lab Sample Id
MW-1	W	Aug-24-09 11:17		342171-001
MW-2	W	Aug-24-09 10:08		342171-002
MW-3	W	Aug-24-09 11:33		342171-003
MW-4 (D)	W	Aug-24-09 10:45		342171-004
MW-4 (S)	W	Aug-24-09 10:50		342171-005

1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -

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### CASE NARRATIVE

Client Name: R.T. Hicks Consultants, LTD Project Name: Samson State BD No. 4

Project ID:L-126-0809Work Order Number:342171

Report Date: 27-AUG-09 Date Received: 08/25/2009

Sample receipt non conformances and Comments: None

Sample receipt Non Conformances and Comments per Sample:

None

Analytical Non Conformances and Comments:

Batch: LBA-769775 Inorganic Anions by EPA 300 None

Batch: LBA-769958 TDS by SM2540C None

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XaN

Contact: Dale Littlejohn

**Project Id:** L-126-0809

Project Location: Lea Co., NM

Certificate of Analysis Summary 342171 R.T. Hicks Consultants, LTD, Albuquerque, NM Project Name: Samson State BD No. 4



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Date Received in Lab: Tue Aug-25-09 10:00 am Report Date: 27-AUG-09

I DECK FOCATION. ECA CO., MAL					Project Manager: Brent Barron, II	3rent Barron, II
	Lab Id:	342171-001	342171-002	342171-003	342171-004	342171-005
Analysis Pannestad	Field Id:	I-WM	MW-2	MW-3	MW-4 (D)	MW-4 (S)
naisan have ciclinuc	Depth:					
	Matrix:	WATER	WATER	. WATER	WATER	WATER
	Sampled:	Aug-24-09 11:17	Aug-24-09 10:08	Aug-24-09 11:33	Aug-24-09 10:45	Aug-24-09 10:50
TDS by SM2540C	Extracted:					
	Analyzed:	Aug-25-09 16:30	Aug-25-09 16:30	Aug-25-09 16:30	Aug-25-09 16:30	Aug-25-09 16:30
•	Units/RL:	mg/L RL	mg/L RL	mg/L RL	mg/L RL	mg/L RL
Total dissolved solids		586 5.00	424 5.00	5250 5.00	762 5.00	516 5.00

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Odessa Laboratory Manager Brefit Barron, II

<b>O</b> is
XGN

Contact: Dale Littlejohn

**Project Id:** L-126-0809

Project Location: Lea Co., NM

Certificate of Analysis Summary 342171 R.T. Hicks Consultants, LTD, Albuquerque, NM

Project Name: Samson State BD No. 4



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Date Received in Lab: Tue Aug-25-09 10:00 am Report Date: 27-AUG-09

					Project Manager: Brent Barron, II	brent Barron, II	
	Lab Id:	342171-001	342171-002	342171-003	342171-004	342171-005	
Analyseis Dogradad	Field Id:	I-WM	MW-2	MW-3	MW-4 (D)	MW-4 (S)	
noiconhout ciclimity	Depth:						
	Matrix:	WATER	WATER	WATER	WATER	WATER	
	Sampled:	Aug-24-09 11:17	Aug-24-09 10:08	Aug-24-09 11:33	Aug-24-09 10:45	Aug-24-09 10:50	
Anions by EPA 300	Extracted:						
	Analyzed:	Aug-25-09 12:59	Aug-25-09 12:59	Aug-25-09 12:59	Aug-25-09 12:59	Aug-25-09 12:59	
	Units/RL:	mg/L RL	mg/L RL	mg/L RL	mg/L RL	mg/L RL	
Chloride		65.5 5.00	35.8 5.00	3150 50.0	203 5.00	63.2 5.00	
		-			-		

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Odessa Laboratory Manager Brefit Barron, II





- X In our quality control review of the data a QC deficiency was observed and flagged as noted. MS/MSD recoveries were found to be outside of the laboratory control limits due to possible matrix /chemical interference, or a concentration of target analyte high enough to effect the recovery of the spike concentration. This condition could also effect the relative percent difference in the MS/MSD.
- **B** A target analyte or common laboratory contaminant was identified in the method blank. Its presence indicates possible field or laboratory contamination.
- **D** The sample(s) were diluted due to targets detected over the highest point of the calibration curve, or due to matrix interference. Dilution factors are included in the final results. The result is from a diluted sample.
- E The data exceeds the upper calibration limit; therefore, the concentration is reported as estimated.
- F RPD exceeded lab control limits.
- J The target analyte was positively identified below the MQL and above the SQL.
- U Analyte was not detected.
- L The LCS data for this analytical batch was reported below the laboratory control limits for this analyte. The department supervisor and QA Director reviewed data. The samples were either reanalyzed or flagged as estimated concentrations.
- **H** The LCS data for this analytical batch was reported above the laboratory control limits. Supporting QC Data were reviewed by the Department Supervisor and QA Director. Data were determined to be valid for reporting.
- K Sample analyzed outside of recommended hold time.
- JN A combination of the "N" and the "J" qualifier. The analysis indicates that the analyte is "tentatively identified" and the associated numerical value may not be consistent with the amount actually present in the environmental sample.

BRL Below Reporting Limit.

RL Reporting Limit

\* Outside XENCO's scope of NELAC Accreditation.

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### Project Name: Samson State BD No. 4

#### Work Order #: 342171

#### Project ID:

L-126-0809

Lab Batch #: 769775 Date Analyzed: 08/25/2009	Sample: 769775 Date Prepared: 08/25/20		Matrix: Water Analyst: LATCOR			
Reporting Units: mg/L	Batch #: 1	BLANK /	BLANK SPI	KE REC	OVERY S	STUDY
Anions by EPA 300	Blank Result	Spike Added	Blank Spike	Blank Spike	Control Limits	Flags
Analytes	[A]	[B]	Result [C]	%R [D]	%R	
Chloride	ND	10.0	9.33	93	80-120	

Blank Spike Recovery [D] = 100\*[C]/[B] All results are based on MDL and validated for QC purposes. BRL - Below Reporting Limit



**BS / BSD Recoveries** 



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Project Name: Samson State BD No. 4

Sample: 769958-1-BKS Work Order #: 342171 Lab Batch ID: 769958 Analyst: WRU

Date Prepared: 08/25/2009 Batch #: 1

**Project ID:** L-126-0809 Date Analyzed: 08/25/2009 Matrix: Water

Units: mg/L		BLANH	K /BLANK S	PIKE / B	LANK S	<b>BLANK /BLANK SPIKE / BLANK SPIKE DUPLICATE RECOVERY STUD</b>	ICATE H	LECOVE	RY STUD	Y	
TDS by SM2540C	Blank Sample Result [A]	Spike Added	Blank Spike Result	Blank Spike %R	Spike Added	Blank Spike Duplicate	Bik. Spk Dup. %R	RPD %	Control Limits %R	Control Limits %RPD	Flag
Analytes		[B]	[C]	<u>a</u>	[E]	Result [F]	<u></u>				
Total dissolved solids	DN	1000	932	93	1000	936	94	0	80-120	30	

.

Relative Percent Difference RPD = 200\*[(C-F)/(C+F)] Blank Spike Recovery [D] = 100\*(C)/[B] Blank Spike Duplicate Recovery [G] = 100\*(F)/[E] All results are based on MDL and Validated for QC Purposes



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### Form 3 - MS Recoveries



### Project Name: Samson State BD No. 4

Lab Batch #: 769775 Date Analyzed: 08/25/2009	Date Prepared: 08/25	/2009			L-126-0809 ATCOR	)
QC- Sample ID: 342088-001 S	Batch #: 1		N	1atrix: V	Vater	
Reporting Units: mg/L	MATR	IX / MA	TRIX SPIKE	RECO	VERY STU	DY
Inorganic Anions by EPA 300	Parent Sample Result	Spike Added	Spiked Sample Result [C]	%R [D]	Control Limits %R	Flag
Analytes	[A]	[B]		[12]		
Chloride	139	100	230	91	80-120	

Matrix Spike Percent Recovery [D] = 100\*(C-A)/B Relative Percent Difference [E] = 200\*(C-A)/(C+B) All Results are based on MDL and Validated for QC Purposes

BRL - Below Reporting Limit

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# Sample Duplicate Recovery



### Project Name: Samson State BD No. 4

Work Order #: 342171

Lab Batch #: 769775 Date Analyzed: 08/25/2009 QC- Sample ID: 342088-001 D Reporting Units: mg/L	Date Prepar Batch		Ana	lyst: LATC rix: Water		
Anions by EPA 300 Analyte		Parent Sample Result [A]	Sample Duplicate Result [B]	RPD	Control Limits %RPD	Flag
Chloride		139	142	2	20	
Lab Batch #: 769958 Date Analyzed: 08/25/2009 QC- Sample [D: 342171-001 D	Date Prepar Batcł	ed: 08/25/2009		lyst: WRU rix: Water		
Reporting Units: mg/L		SAMPLE	/ SAMPLE	DUPLIC	ATE REC	OVERY
TDS by SM2540C Analyte		Parent Sample Result [A]	Sample Duplicate Result [B]	RPD	Control Limits %RPD	Flag
Total dissolved solids		586	576	2	30	

Spike Relative Difference RPD 200 \* | (B-A)/(B+A) | All Results are based on MDL and validated for QC purposes. BRL - Below Reporting Limit

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Xenco Laboratories	Project Namager: Dâlê Littlejohn	Company Name RT Hicks Consultants Ltd	Company Address: P.O. BOX 7624	CaySule/Zip: Midland, Texas 79708	Telephone No. (432) 528-3878	1														special instructions. Servid invisions to RT(Hicks: Constitut, 501, RNb) Gainste Birkal YAW, Suith F-1427, Albuctus request NM 87104. Date triated and strict actives actives accover.	1.	
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ala/Tima: <u>8.755.09.10:00</u>				ĸ	
ab ID#					
ullais <u>a</u> L			3		
Sample Recolpt	Checklist			al Lauris Autor	
1. Temperature of container/ cooler?	1000	No	3.1	Client Init	
2 Shipping container in good condition?	Tress !	, No	<u>it «1.5.6201139</u> 43	1	
3 Custody Seals intact on shipping contained cooler?	Yes	No	Not Present		
4 Custody Seals intact on sample bottles/ container?	Yes	No	CNot Presents		
5 Chain of Custody present? 6 Sample Instructions complete of Chain of Custody?	Yes.	No: No:			
7. Chain of Custody signed when relinquished/ received?	Yes	» No	S. S. S. S. S. S. S.	5	
Bis Chain of Custody agrees with sample label(s)2.	Yes	No:	D written on Cont./.	D and the state	
9/Container label(s) legible and intact?	ં ૪૨૭	No	Not Applicable		김야, 영상 -
10 Sample matrix/ properties agree with Chain of Custody?	L COES	No	No. 19 Sec. 19		
11. Containers supplied by ELOT?	(Yes)	No			
/12 Samples in proper container/ bottle?	Yes Yes	No /	See Bulow		
13 Samples propeny preserved /	Yes	NO	Sos Below	New Colory	
115 Preservations documented on Chain of Custody?	Yes	No	A CARLES AND A CARLES	0.12 (1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
116 Containers documented on Chain of Custody?	Ves	No	i na serie de la companya de la comp		
17 Sufficient sample amount for indicated test(s)?	Yes	Note	See Below.	<ul> <li>Section</li> </ul>	
18 All samples received within sufficient hold time?	(Yes)	No	See Below	XONAV	30
119 Subcontract of sample(s)?	Yes	No	Not Applicable	See Contraction	
20 VOC samples have zero headspace?	Yes	No	CNot Applicable	<u> </u>	
Variance Docu	nentation	di juni. Serte			
Contacted by:	· · · · · ·		Date/Time:	11 - 1 	
	***************************************	÷ .	Manager Chicago		
Regarding:	· ·			<u></u> .	<u></u>
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# Analytical Report 350773

for

# **R.T. Hicks Consultants, LTD**

**Project Manager: Dale Littlejohn** 

Samson State BD No. 4

L-126-1109

### 16-NOV-09



#### 12600 West I-20 East Odessa, Texas 79765

Xenco-Houston (EPA Lab code: TX00122):

 Texas (T104704215-08-TX), Arizona (AZ0738), Arkansas (08-039-0), Connecticut (PH-0102), Florida (E871002) Illinois (002082), Indiana (C-TX-02), Iowa (392), Kansas (E-10380), Kentucky (45), Louisiana (03054)
 New Hampshire (297408), New Jersey (TX007), New York (11763), Oklahoma (9218), Pennsylvania (68-03610) Rhode Island (LAO00308), USDA (S-44102)

Xenco-Atlanta (EPA Lab Code: GA00046): Florida (E87428), North Carolina (483), South Carolina (98015), Utah (AALI1), West Virginia (362), Kentucky (85) Louisiana (04176), USDA (P330-07-00105)

> Xenco-Miami (EPA Lab code: FL01152): Florida (E86678), Maryland (330) Xenco-Tampa Mobile (EPA Lab code: FL01212): Florida (E84900)
> Xenco-Odessa (EPA Lab code: TX00158): Texas (T104704400-08-TX)
> Xenco-Dallas (EPA Lab code: TX01468): Texas (T104704295-08-TX)
> Xenco-Corpus Christi (EPA Lab code: TX02613): Texas (T104704370-08-TX)
> Xenco-Boca Raton (EPA Lab Code: FL00449): Florida(E86240), South Carolina(96031001), Louisiana(04154), Georgia(917)



16-NOV-09

Project Manager: **Dale Littlejohn R.T. Hicks Consultants, LTD** 901 Rio Grande Blvd. NW, Suite F-142 Albuquerque, NM 87104

Reference: XENCO Report No: **350773 Samson State BD No. 4** Project Address: Lea Co., NM

#### Dale Littlejohn:

We are reporting to you the results of the analyses performed on the samples received under the project name referenced above and identified with the XENCO Report Number 350773. All results being reported under this Report Number apply to the samples analyzed and properly identified with a Laboratory ID number. Subcontracted analyses are identified in this report with either the NELAC certification number of the subcontract lab in the analyst ID field, or the complete subcontracted report attached to this report.

Unless otherwise noted in a Case Narrative, all data reported in this Analytical Report are in compliance with NELAC standards. Estimation of data uncertainty for this report is found in the quality control section of this report unless otherwise noted. Should insufficient sample be provided to the laboratory to meet the method and NELAC Matrix Duplicate and Matrix Spike requirements, then the data will be analyzed, evaluated and reported using all other available quality control measures.

The validity and integrity of this report will remain intact as long as it is accompanied by this letter and reproduced in full, unless written approval is granted by XENCO Laboratories. This report will be filed for at least 5 years in our archives after which time it will be destroyed without further notice, unless otherwise arranged with you. The samples received, and described as recorded in Report No. 350773 will be filed for 60 days, and after that time they will be properly disposed without further notice, unless otherwise arranged with you. We reserve the right to return to you any unused samples, extracts or solutions related to them if we consider so necessary (e.g., samples identified as hazardous waste, sample sizes exceeding analytical standard practices, controlled substances under regulated protocols, etc).

We thank you for selecting XENCO Laboratories to serve your analytical needs. If you have any questions concerning this report, please feel free to contact us at any time.

Respectfully,

Brent Barron, II Odessa Laboratory Manager

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# Sample Cross Reference 350773



# R.T. Hicks Consultants, LTD, Albuquerque, NM

144 A.

Samson State BD No. 4

Sample Id	Matrix	Date Collected S	ample Depth	Lab Sample Id
MW-1	W	Nov-02-09 15:33		350773-001
MW-2	W	Nov-02-09 14:23		350773-002
MW-3	W	Nov-02-09 15:53		350773-003
MW-4 (D)	W	Nov-02-09 14:55		350773-004
MW-4 (S)	W	Nov-02-09 15:07	-	350773-005

### **CASE NARRATIVE**



Client Name: R.T. Hicks Consultants, LTD Project Name: Samson State BD No. 4

Project ID: L-126-1109 Work Order Number: 350773 Report Date: 16-NOV-09 Date Received: 11/03/2009

#### Sample receipt non conformances and Comments: None

Sample receipt Non Conformances and Comments per Sample:

None

Analytical Non Conformances and Comments: Batch: LBA-780328 Anions by E300

None

Batch: LBA-780417 TDS by SM2540C None

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Contact: Dale Littlejohn

Project Id: L-126-1109

Project Location: Lea Co., NM

Certificate of Analysis Summary 350773

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R.T. Hicks Consultants, LTD, Albuquerque, NM

Project Name: Samson State BD No. 4

Date Received in Lab: Tue Nov-03-09 04:03 pm

Report Date: 16-NOV-09

					Project Manager: Brent Barron, II	srent Barron, II
	Lab Id:	350773-001	350773-002	350773-003	350773-004	350773-005
Analysis Doguested	Field Id:	I-WM	MW-2	MW-3	MW-4 (D)	MW-4 (S)
vinity in the second	Depth:					
	Matrix:	WATER	WATER	WATER	WATER	WATER
	Sampled:	Nov-02-09 15:33	Nov-02-09 14:23	Nov-02-09 15:53	Nov-02-09 14:55	Nov-02-09 15:07
Anions by E300	Extracted:					
	Analyzed:	Nov-04-09 22:36	Nov-04-09 22:36	Nov-04-09 22:36	Nov-04-09 22:36	Nov-04-09 22:36
	Units/RL:	mg/L RL	mg/L RL	mg/L RL	mg/L RL	mg/L RL
Chloride		82.5 5.00	41.5 5.00	6100 100	223 5.00	72.9 5.00
TDS by SM2540C	Extracted:					
	Analyzed:	Nov-04-09 15:42	Nov-04-09 15:42	Nov-04-09 15:42	Nov-04-09 15:42	Nov-04-09 15:42
	Units/RL:	mg/L RL	mg/L RL	mg/L RL	mg/L RL	mg/L RL
Total dissolved solids		540 5.00	406 5.00	9110 5.00	926 5.00	470 5.00

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This analytical report, and the entire data package it represents, has been made for your exclusive and confidential use. The interpretations and results expressed throughout this analytical report reportes the best jugment of XENCO Laboratories. XENCO Laboratories assumes to responsibility and makes no warranty to the end use of the data hereby presented. Our liability is limited to the amount invoiced for this work order unless otherwise agreed to in writing.

Since 1990 Houston - Dallas - San Antonio - Austin - Tampa - Miami - Latin America - Atlanta - Corpus Christi

Odessa Laboratory Manager Brefit Barron, II



- X In our quality control review of the data a QC deficiency was observed and flagged as noted. MS/MSD recoveries were found to be outside of the laboratory control limits due to possible matrix /chemical interference, or a concentration of target analyte high enough to effect the recovery of the spike concentration. This condition could also effect the relative percent difference in the MS/MSD.
- **B** A target analyte or common laboratory contaminant was identified in the method blank. Its presence indicates possible field or laboratory contamination.
- **D** The sample(s) were diluted due to targets detected over the highest point of the calibration curve, or due to matrix interference. Dilution factors are included in the final results. The result is from a diluted sample.
- E The data exceeds the upper calibration limit; therefore, the concentration is reported as estimated.
- F RPD exceeded lab control limits.
- J The target analyte was positively identified below the MQL and above the SQL.
- U Analyte was not detected.
- L The LCS data for this analytical batch was reported below the laboratory control limits for this analyte. The department supervisor and QA Director reviewed data. The samples were either reanalyzed or flagged as estimated concentrations.
- H The LCS data for this analytical batch was reported above the laboratory control limits. Supporting QC Data were reviewed by the Department Supervisor and QA Director. Data were determined to be valid for reporting.
- K Sample analyzed outside of recommended hold time.
- **JN** A combination of the "N" and the "J" qualifier. The analysis indicates that the analyte is "tentatively identified" and the associated numerical value may not be consistent with the amount actually present in the environmental sample.

BRL Below Reporting Limit.

**RL** Reporting Limit

\* Outside XENCO's scope of NELAC Accreditation.

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# Project Name: Samson State BD No. 4

Work	Order #:	350773
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### **Project ID:**

L-126-1109

Lab Batch #: 780328 Date Analyzed: 11/04/2009	<b>Sample:</b> 780328 <b>Date Prepared:</b> 11/04/20			: Water : LATCOF	R	
<b>Reporting Units:</b> mg/L	Batch #: 1	BLANK /	BLANK SPI	KE REC	COVERY S	STUDY
Anions by E300	Blank Result	Spike Added	Blank Spike	Blank Spike	Control Limits	Flags
Analytes	[A]	[B]	Result [C]	%R [D]	%R	
Chloride	ND	10.0	10.5	105	90-110	L

Blank Spike Recovery [D] = 100\*[C]/[B] All results are based on MDL and validated for QC purposes. BRL - Below Reporting Limit

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**BS / BSD Recoveries** 



Project Name: Samson State BD No. 4

Date Prepared: 11/04/2009	Sample: 780417-1-BKS Batch #: 1 Materia Batch #: 1	BLANK /BLANK SPIKE / BLANK SPIKE DUPLICATE RECOVERY STUDY	. Blank Spike Blank Blank Spike	Sample Result Added Spike Spike Added Spike Dup. RPD	Result %R Duplicate %R %	[D] [E] I
		B	. Blank	Sample Result	[A]	
	Lab Batch ID: 780417	Units: mg/L	TDS by SM2540C			Analytes

Flag

Control Limits %RPD

30

80-120

2

91

914

1000

6

900

1000

Q

Total dissolved solids

Relative Percent Difference RPD = 200\*((C-F)/(C+F)) Blank Spike Recovery [D] = 100\*(C)/[B] Blank Spike Duplicate Recovery [G] = 100\*(F)/[E] All results are based on MDL and Validated for QC Purposes

Page 8 of 12



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# Form 3 - MS Recoveries



### Project Name: Samson State BD No. 4

Lab Batch #: 780328 Date Analyzed: 11/04/2009	Date Prepared: 11/04/2	009			L-126-1109 ATCOR	)
QC- Sample ID: 350773-001 S	Batch #: 1		N	latrix: W	/ater	
Reporting Units: mg/L	MATRIX	( / MA	TRIX SPIKE	RECO	VERY STU	DY
Inorganic Anions by EPA 300		Spike Added	Spiked Sample Result [C]	%R [D]	Control Limits %R	Flag
Analytes	[A]	[ <b>B</b> ]		1-1		
Chloride	82.5	100	183	101	90-110	

Matrix Spike Percent Recovery  $[D] = 100^{\circ}(C-A)/B$ Relative Percent Difference  $[E] = 200^{\circ}(C-A)/(C+B)$ All Results are based on MDL and Validated for QC Purposes

BRL - Below Reporting Limit



27 State 1

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# Sample Duplicate Recovery

### Project Name: Samson State BD No. 4

Work Order #: 350773

Lab Batch #: 780328				Project I	<b>D:</b> L-126-11	09
Date Analyzed: 11/04/2009	Date Prepar	ed: 11/04/2009	) Anal	lyst: LATC	OR	
QC- Sample ID: 350773-001 D	Batch	n#: 1	Mat	rix: Water		
Reporting Units: mg/L		SAMPLE	SAMPLE	DUPLIC	ATE REC	OVER
Anions by E300		Parent Sample Result [A]	Duplicate Result	RPD	Control Limits %RPD	Flag
Analyte			[B]			
Chloride		82.5	75.7	9	20	
Lab Batch #: 780417		· · · · · · · · · · · · · · · · · · ·				
Date Analyzed: 11/04/2009	Date Prepar	ed: 11/04/2009	) Ana	lyst: WRU		
QC- Sample ID: 350773-001 D	Batch	ı#: 1	Mat	rix: Water		
Reporting Units: mg/L		SAMPLE	/ SAMPLE	DUPLIC	ATE RECO	OVER
TDS by SM2540C		Parent Sample Result [A]	Sample Duplicate Result	RPD	Control Limits %RPD	Flag
Analyte			[B]			-
Total dissolved solids		540	584	8	30	

Spike Relative Difference RPD 200 \* | (B-A)/(B+A) | All Results are based on MDL and validated for QC purposes. BRL - Below Reporting Limit

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UES	4	•											Bromide										1	3		al thi Stead	
REQ	ġ				·								Chloride	×	×	×	×	×									:
I SIS I													.M.A.O.N														
ΓX	Project Name: Samson State BD No			1				ö					BCI			_		-		-	$\downarrow$			Sample Containers Intact? Temperature Upon Receipt:			
ANA	lat	ი		Σ				Analyze For	_	<u> </u>	< 8560	030 or BTE)	BTEX 80218/5											Sample Containers Intact? Temperature Upon Receip	aboratory Comments:		
Q	Ś	Project #: L-126-1109	7	Project Loc: Lea Co., NM				<u>laly</u>					selitstovime2											ners	E		·
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borat	Project Manager: Dale Littlejohn	company Name RT Hicks Consultants Ltd		Company Address: P.O. BOX 7624	city/state/Zip: Midland, Texas	Telephone No: (432) 528-3878	. or te							MW-1	C-WW	MW-3	MW-4(D)	MW-4(S)						Special Instructions: Send Invoice to RT Hicks Consult. 901 Rio Grand	Date Littlejonn at the adress above.	shed by: Jal Thittight	
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# Environmental Lab of Texas

Variance/ Corrective Action Report- Sample Log-In

Client:	R.T. Hicks
Date/ Time:	11.3.09 16:03
Lab ID # :	350773
Initials	. Ai

No. of Concession, Name

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### Sample Receipt Checklist

#1	Temperature of container/ cooler?	Yes	No	• <b>1</b> • C
ŧ2	Shipping container in good condition?	(Yes)	No	
#3	Custody Seals intact on shipping container/ cooler?	Yes	No	Not Present>
#4	Custody Seals intact on sample bottles/ container?	Yes	No	Not Present
<i>‡</i> 5	Chain of Custody present?	Tes	No	
<i>#</i> 6	Sample instructions complete of Chain of Custody?	(Yes)	No	
ŧ7	Chain of Custody signed when relinquished/ received?	(Yes)	No	
<b>#8</b>	Chain of Custody agrees with sample label(s)?	(Yes)	No	ID written on Cont./ Lid
<b>#9</b>	Container label(s) legible and intact?	Tes	No	Not Applicable
<b>#10</b>	Sample matrix/ properties agree with Chain of Custody?	Yes	No	
¥11	Containers supplied by ELOT?	Yes	No	
#12	Samples in proper container/ bottle?	( Cer	No	See Below
#13	Samples properly preserved?	(Yes)	No	See Below
#14	Sample bottles intact?	(res)	No	
#15	Preservations documented on Chain of Custody?	res	No	
<b>¥16</b>	Containers documented on Chain of Custody?	Yes	No	
#17	Sufficient sample amount for indicated test(s)?	Yes	No	See Below
#18	All samples received within sufficient hold time?	(Yes)	No	See Below
#19	Subcontract of sample(s)?	Yes	No	Not Applicable
#20	VOC samples have zero headspace?	Yes	No	Not Applicable

			Date/ Time:	
Regarding:				
Corrective Action Taker	n:			
Check all that Apply:		See attached e-mail/ fax		
		Client understands and would like t Cooling process had begun shortly		

# Analytical Report 357607

for

# **RT Hicks Consultants Ltd. (Midland)**

**Project Manager: Dale Littlejohn** 

Samson State BD No. 4

L-126-0110

### 11-JAN-10





12600 West I-20 East Odessa, Texas 79765

Xenco-Houston (EPA Lab code: TX00122): Texas (T104704215-08-TX), Arizona (AZ0738), Arkansas (08-039-0), Connecticut (PH-0102), Florida (E871002) Illinois (002082), Indiana (C-TX-02), Iowa (392), Kansas (E-10380), Kentucky (45), Louisiana (03054) New Hampshire (297408), New Jersey (TX007), New York (11763), Oklahoma (9218), Pennsylvania (68-03610) Rhode Island (LAO00308), USDA (S-44102)

Xenco-Atlanta (EPA Lab Code: GA00046): Florida (E87429), North Carolina (483), South Carolina (98015), Utah (AAL11), West Virginia (362), Kentucky (85) Louisiana (04176), USDA (P330-07-00105)

> Xenco-Miami (EPA Lab code: FL01152): Florida (E86678), Maryland (330) Xenco-Tampa Mobile (EPA Lab code: FL01212): Florida (E84900) Xenco-Odessa (EPA Lab code: TX00158): Texas (T104704400-08-TX) Xenco-Dallas (EPA Lab code: TX01468): Texas (T104704295-08-TX) Xenco-Corpus Christi (EPA Lab code: TX02613): Texas (T104704370-08-TX) Xenco-Boca Raton (EPA Lab Code: FL00449): Florida(E86240), South Carolina(96031001), Louisiana(04154), Georgia(917)



11-JAN-10



Project Manager: Dale Littlejohn RT Hicks Consultants Ltd. (Midland) P.O. Box 7624

Midland, TX 79708

Reference: XENCO Report No: 357607 Samson State BD No. 4 Project Address: Lea Co., NM

#### Dale Littlejohn:

We are reporting to you the results of the analyses performed on the samples received under the project name referenced above and identified with the XENCO Report Number 357607. All results being reported under this Report Number apply to the samples analyzed and properly identified with a Laboratory ID number. Subcontracted analyses are identified in this report with either the NELAC certification number of the subcontract lab in the analyst ID field, or the complete subcontracted report attached to this report.

Unless otherwise noted in a Case Narrative, all data reported in this Analytical Report are in compliance with NELAC standards. Estimation of data uncertainty for this report is found in the quality control section of this report unless otherwise noted. Should insufficient sample be provided to the laboratory to meet the method and NELAC Matrix Duplicate and Matrix Spike requirements, then the data will be analyzed, evaluated and reported using all other available quality control measures.

The validity and integrity of this report will remain intact as long as it is accompanied by this letter and reproduced in full, unless written approval is granted by XENCO Laboratories. This report will be filed for at least 5 years in our archives after which time it will be destroyed without further notice, unless otherwise arranged with you. The samples received, and described as recorded in Report No. 357607 will be filed for 60 days, and after that time they will be properly disposed without further notice, unless otherwise arranged with you. We reserve the right to return to you any unused samples, extracts or solutions related to them if we consider so necessary (e.g., samples identified as hazardous waste, sample sizes exceeding analytical standard practices, controlled substances under regulated protocols, etc).

We thank you for selecting XENCO Laboratories to serve your analytical needs. If you have any questions concerning this report, please feel free to contact us at any time.

Respectfully

Brent Barron, II Odessa Laboratory Manager

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# Sample Cross Reference 357607



# RT Hicks Consultants Ltd. (Midland), Midland, TX

Samson State BD No. 4

Sample Id	Matrix	Date Collected	Sample Depth	Lab Sample Id
MW-3	W	Jan-05-10 14:30		357607-001
MW-4 s	W	Jan-05-10 13:42		357607-002
MW-4 d	W	Jan-05-10 14:24		357607-003

## CASE NARRATIVE



Client Name: RT Hicks Consultants Ltd. (Midland) Project Name: Samson State BD No. 4

Project ID:L-126-0110Work Order Number:357607

Report Date: 11-JAN-10 Date Received: 01/06/2010

Sample receipt non conformances and Comments: None

Sample receipt Non Conformances and Comments per Sample:

None

### Analytical Non Conformances and Comments:

Batch: LBA-788426 Inorganic Anions by EPA 300 None

Batch: LBA-788826 TDS by SM2540C None

XENCO Laboratorites	Ceri RT I	tificate of A Hicks Consultar	nalysis Sum nts Ltd. (Midlan	Certificate of Analysis Summary 357607 RT Hicks Consultants Ltd. (Midland), Midland, TX	
<b>Project Id:</b> L-126-0110		Project Nam	Project Name: Samson State BD No. 4	BD No. 4	
Contact: Dale Littlejohn				Dat	Date Recei
Project Location: Lea Co., NM			1		R Projee
	Lab Id:	357607-001	357607-002	357607-003	
Analysis Roginstad	Field Id:	MW-3	MW-4 s	MW-4 d	
nates and statistic	Depth:				
	Matrix:	WATER	WATER	WATER	

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ate Received in Lab: Wed Jan-06-10 10:07 am Report Date: 11-JAN-10

I OJCCI FUCATION. FCA CO., INVI				Pro	Project Manager: Brent Barron, II
	Lab Id:	357607-001	357607-002	357607-003	
Analysis Donnoctod	Field Id:	MW-3	MW-4 s	MW-4 d	
narcanhaw ciclimuw	Depth:				
	Matrix:	WATER	WATER	WATER	
	Sampled:	Jan-05-10 14:30	Jan-05-10 13:42	Jan-05-10 14:24	
Anions by E300	Extracted:				
	Analyzed:	Jan-06-10 17:14	Jan-06-10 17:14	Jan-06-10 17:14	
	Units/RL:	ING/L RL	mg/L RL	mg/L RL	
Chloride		8110 250	87.4 5.00	372 5.00	
TDS by SM2540C	Extracted:				
	Analyzed:	Jan-08-10 12:40	Jan-08-10 12:40	Jan-08-10 12:40	
	Units/RL:	mg/L RL	mg/L RL	mg/L RL	
Total dissolved solids		12700 5.00	462 5.00	1110 5.00	

This analytical report, and the entire data package it represents, has been made for your exclusive and confidential use. The interpretations and results expressed throughout this analytical report represent the best juggment of XENCO Laboratories. XENCO Laboratories assumes no responsibility and makes no warrany to the end use of the data hereby presented. Our liability is limited to the amount invoiced for this work order unless otherwise agreed to in writing.

Since 1990 Houston - Dallas - San Antonio - Austin - Tampa - Miami - Latin America - Atlanta - Corpus Christi

Brent Barron, II Odessa Laboratory Manager

Page 5 of 12





- X In our quality control review of the data a OC deficiency was observed and flagged as noted. MS/MSD recoveries were found to be outside of the laboratory control limits due to possible matrix /chemical interference, or a concentration of target analyte high enough to effect the recovery of the spike concentration. This condition could also effect the relative percent difference in the MS/MSD.
- **B** A target analyte or common laboratory contaminant was identified in the method blank. Its presence indicates possible field or laboratory contamination.
- **D** The sample(s) were diluted due to targets detected over the highest point of the calibration curve, or due to matrix interference. Dilution factors are included in the final results. The result is from a diluted sample.
- E The data exceeds the upper calibration limit; therefore, the concentration is reported as estimated.
- F RPD exceeded lab control limits.
- J The target analyte was positively identified below the MQL and above the SQL.
- U Analyte was not detected.
- L The LCS data for this analytical batch was reported below the laboratory control limits for this analyte. The department supervisor and QA Director reviewed data. The samples were either reanalyzed or flagged as estimated concentrations.
- H The LCS data for this analytical batch was reported above the laboratory control limits. Supporting QC Data were reviewed by the Department Supervisor and OA Director. Data were determined to be valid for reporting.
- **K** Sample analyzed outside of recommended hold time.
- JN A combination of the "N" and the "J" qualifier. The analysis indicates that the analyte is "tentatively identified" and the associated numerical value may not be consistent with the amount actually present in the environmental sample.

**BRL** Below Reporting Limit.

**RL** Reporting Limit

\* Outside XENCO's scope of NELAC Accreditation.

842 Cantwell Lane, Corpus Christi, TX 78408

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# Project Name: Samson State BD No. 4

Work Order #: 357607		P	roject ID:		L-1	26-0110
Lab Batch #: 788426 Date Analyzed: 01/06/2010	Sample: 788426- Date Prepared: 01/06/20		Matrix: Analyst:	: Water : LATCOF	t	
Reporting Units: mg/L	Batch #: 1	BLANK /	BLANK SPI	KE REC	OVERY S	STUDY
Anions by E300	Blank Result	Spike Added	Blank Spike	Blank Spike	Control Limits	Flags
Analytes	[A]	[B]	Result [C]	%R [D]	%R	
Chloride	ND	11.0	11.2	102	90-110	

Blank Spike Recovery [D] = 100\*[C]/[B] All results are based on MDL and validated for QC purposes. BRL - Below Reporting Limit

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**BS / BSD Recoveries** 



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Project Name: Samson State BD No. 4

Date Prepared: 01/08/2010 Sample: 788826-1-BKS Work Order #: 357607 Lab Batch ID: 788826 Analyst: WRU

Batch #: ]

**Project ID:** L-126-0110 Date Analyzed: 01/08/2010 Matrix: Water

Units: mg/L		BLANK	<b>BLANK /BLANK SPIKE</b>	PIKE / B	LANK S	/ BLANK SPIKE DUPLICATE		LECOVE	RECOVERY STUDY	Y	
TDS by SM2540C	Blank Sample Result [A]	Spike Added	Blank Spike Result	Blank Spike %R	Spike Added	Blank Spike Duplicate	Blk. Spk Dup. %R	RPD %	Control Limits %R	Control Limits %RPD	Flag
Analytes		[B]	[C]	[ <b>D</b> ]	[]	Result [F]	ত্র				
Total dissolved solids	DN	1000	962	96	1000	952	95	-	80-120	30	

Relative Percent Difference RPD = 200\*((C-F)/(C+F)) Blank Spike Recovery [D] = 100\*(C)/[B] Blank Spike Duplicate Recovery [G] = 100\*(F)/[E] All results are based on MDL and Validated for QC Purposes

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# Form 3 - MS Recoveries



### Project Name: Samson State BD No. 4

#### Work Order #: 357607 Lab Batch #: 788426

#### Project ID: L-126-0110

Date Analyzed: 01/06/2010	Date Prepared: 01/06/2	010	A	nalyst: L	ATCOR	
QC- Sample 1D: 357607-002 S	Batch #: 1		ſ	Matrix: W	ater	
Reporting Units: mg/L	MATRIX	K / MA'	TRIX SPIKE	RECO	VERY STU	DY
Inorganic Anions by EPA 300		Spike Added	Spiked Sample Result [C]	%R [D]	Control Limits %R	Flag
Analytes	[A]	[B]	(-)	(-)		
Chloride	87.4	100	189	102	90-110	

Matrix Spike Percent Recovery  $[D] = 100^{*}(C-A)/B$ Relative Percent Difference  $[E] = 200^{*}(C-A)/(C+B)$ All Results are based on MDL and Validated for QC Purposes

BRL - Below Reporting Limit

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# Sample Duplicate Recovery



### Project Name: Samson State BD No. 4

Work Order #: 357607

Lab Batch #: 788426				Project I	D: L-126-01	10
<b>Date Analyzed:</b> 01/06/2010	Date Prepar	ed:01/06/2010		lyst: LATC		
QC- Sample ID: 357607-002 D	Batch	#: I	Mat	rix: Water		
Reporting Units: mg/L	1	SAMPLE	SAMPLE	DUPLIC	ATE REC	<b>JVERY</b>
Anions by E300		Parent Sample Result [A]	Duplicate Result	RPD	Control Limits %RPD	Flag
Analyte			[ <b>B</b> ]			
Chloride		87.4	83.7	4	20	
Lab Batch #: 788826						
Date Analyzed: 01/08/2010	Date Prepare	ed:01/08/2010	) Anal	lyst: WRU		
QC- Sample ID: 357606-001 D	Batch	#: 1	Mat	rix: Water		
Reporting Units: mg/L		SAMPLE	/ SAMPLE	DUPLIC	ATE REC	<b>OVERY</b>
TDS by SM2540C		Parent Sample Result [A]	Duplicate Result	RPD	Control Limits %RPD	Flag
Analyte			[ <b>B</b> ]			
Total dissolved solids		10300	9690	6	30	[

Spike Relative Difference RPD 200 \* | (B-A)/(B+A) | All Results are based on MDL and validated for QC purposes. BRL - Below Reporting Limit

	1							TAT brebrust2	×	×	×									
								elubert/Pre-Schedule												۰.
																		z		
ST								Total Dissolved Solids	×	×	×									
ant	4							ebimon8										Ð	> 2	
REC	2							Chloride	×	×	×					$\perp$		1 -	ž	
CHAIN OF CUSTODY RECORD AND ANAL YSIS REQUEST	Project Name: Samson State BD No.							.M.F.O.N											contrind	
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Xenco Laboratories 12600 West 1-20 East Odessa, Texas 79765								LAB # 357 (vo) [ab use only]		·				[*	· ·			Special Instructions: Send Invoice to RT Hicks Consult. 901 Rio Grande BI Dale Littlejohn at the adress above.	Relinquished by:	Relinquished by:
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# Environmental Lab of Texas

Variance/ Corrective Action Report- Sample Log-In

Client	RT Hicks
Date/ Time:	1.6.10 10:07
Lab ID # :	357607
Initials:	AL

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#### Sample Receipt Checklist

	<u>.</u>			<u>с</u>	lient Initials
#1	Temperature of container/ cooler?	Yee	No	1.1 °C	
#2	Shipping container in good condition?	(Yes)	No		
#3	Custody Seals intact on shipping container/ cooler?	Yes	No	Not Present	
#4	Custody Seals intact on sample bottles/ container?	Yes	No	Not Present	
#5	Chain of Custody present?	( es	No		
#6	Sample instructions complete of Chain of Custody?	809	No		
#7	Chain of Custody signed when relinquished/ received?	(Yes)	No		
#8	Chain of Custody agrees with sample label(s)?	Yes	No	D written on Cont/ Lid	
#9	Container label(s) legible and intact?	Yes	No	(Not Applicable)	
#10	Sample matrix/ properties agree with Chain of Custody?	(Yes)	No		
#11	Containers supplied by ELOT?	(Yes)	No		
#12	Samples in proper container/ bottle?	Yes	No	See Below	
#13	Samples property preserved?	Yes	No	See Below	
#14	Sample bottles intact?	Yes	No		
#15	Preservations documented on Chain of Custody?	Yes	No	·	
#16	Containers documented on Chain of Custody?	Yes	No		
#17	Sufficient sample amount for indicated test(s)?	Yes	No	See Below	
#18	All samples received within sufficient hold time?	Yes	No	See Below	
#19	Subcontract of sample(s)?	Yes	No	Not Applicable	
#20	VOC samples have zero headspace?	Yes	No	Not Applicable	

#### **Variance** Documentation

Contact:	Contacted by:	Date/ Time:	
Regarding:			
Corrective Action Taken:			·

Check all that Apply:

See attached e-mail/ fax

Client understands and would like to proceed with analysis

Cooling process had begun shortly after sampling event

# Analytical Report 363834

for

# **R.T. Hicks Consultants, LTD**

Project Manager: Dale Littlejohn

Samson State BD No. 4

L-126-0210

## 16-MAR-10



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12600 West I-20 East Odessa, Texas 79765

Xenco-Houston (EPA Lab code: TX00122): Texas (T104704215-TX), Arizona (AZ0738), Arkansas (08-039-0), Connecticut (PH-0102), Florida (E871002) Illinois (002082), Indiana (C-TX-02), Iowa (392), Kansas (E-10380), Kentucky (45), Louisiana (03054) New Hampshire (297408), New Jersey (TX007), New York (11763), Oklahoma (9218), Pennsylvania (68-03610) Rhode Island (LAO00312), USDA (S-44102)

Xenco-Atlanta (EPA Lab Code: GA00046): Florida (E87429), North Carolina (483), South Carolina (98015), Utah (AAL11), West Virginia (362), Kentucky (85) Louisiana (04176), USDA (P330-07-00105)

Xenco-Miami (EPA Lab code: FL01152): Florida (E86678), Maryland (330)
Xenco-Tampa Mobile (EPA Lab code: FL01212): Florida (E84900)
Xenco-Odessa (EPA Lab code: TX00158): Texas (T104704400-TX)
Xenco-Dallas (EPA Lab code: TX01468): Texas (T104704295-TX)
Xenco-Corpus Christi (EPA Lab code: TX02613): Texas (T104704370)
Xenco-Boca Raton (EPA Lab Code: FL00449):
Florida(E86240),South Carolina(96031001), Louisiana(04154), Georgia(917)
North Carolina(444), Texas(T104704468-TX), Illinois(002295)



16-MAR-10



Project Manager: Dale Littlejohn R.T. Hicks Consultants, LTD 901 Rio Grande Blvd. NW, Suite F-142 Albuquerque, NM 87104

Reference: XENCO Report No: 363834 Samson State BD No. 4 Project Address: Lea Co., NM

#### Dale Littlejohn:

We are reporting to you the results of the analyses performed on the samples received under the project name referenced above and identified with the XENCO Report Number 363834. All results being reported under this Report Number apply to the samples analyzed and properly identified with a Laboratory ID number. Subcontracted analyses are identified in this report with either the NELAC certification number of the subcontract lab in the analyst ID field, or the complete subcontracted report attached to this report.

Unless otherwise noted in a Case Narrative, all data reported in this Analytical Report are in compliance with NELAC standards. Estimation of data uncertainty for this report is found in the quality control section of this report unless otherwise noted. Should insufficient sample be provided to the laboratory to meet the method and NELAC Matrix Duplicate and Matrix Spike requirements, then the data will be analyzed, evaluated and reported using all other available quality control measures.

The validity and integrity of this report will remain intact as long as it is accompanied by this letter and reproduced in full, unless written approval is granted by XENCO Laboratories. This report will be filed for at least 5 years in our archives after which time it will be destroyed without further notice, unless otherwise arranged with you. The samples received, and described as recorded in Report No. 363834 will be filed for 60 days, and after that time they will be properly disposed without further notice, unless otherwise arranged with you. We reserve the right to return to you any unused samples, extracts or solutions related to them if we consider so necessary (e.g., samples identified as hazardous waste, sample sizes exceeding analytical standard practices, controlled substances under regulated protocols, etc).

We thank you for selecting XENCO Laboratories to serve your analytical needs. If you have any questions concerning this report, please feel free to contact us at any time.

Respectfully,

Brent Barron, II Odessa Laboratory Manager

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# Sample Cross Reference 363834

## R.T. Hicks Consultants, LTD, Albuquerque, NM

0.1997

Samson State BD No. 4

Sample Id	Matrix	Date Collected Sample Depth	Lab Sample Id
MW-1	W	Feb-26-10 11:41	363834-001
MW-2	W	Feb-26-10 12:49	363834-002
MW-4 D	W	Feb-26-10 09:32	363834-003
MW-4 S	W	Feb-26-10 10:26	363834-004
MW-3 D	W	Feb-26-10 14:05	363834-005
MW-3 S	W	Feb-26-10 14:00	363834-006



# CASE NARRATIVE

Client Name: R.T. Hicks Consultants, LTD Project Name: Samson State BD No. 4



Project ID:L-126-0210Work Order Number:363834

Report Date: 16-MAR-10 Date Received: 03/01/2010

#### Sample receipt non conformances and Comments: None

Sample receipt Non Conformances and Comments per Sample:

None

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Analytical Non Conformances and Comments:

Batch: LBA-796498 Inorganic Anions by EPA 300 None

Batch: LBA-796873 TDS by SM2540C None

Certificate of Analysis Summary 363834 R.T. Hicks Consultants, LTD, Albuquerque, NM



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. 18 of 4

Project 1d: L-126-0210 Contact: Dale Littlejohn

Project Location: Lea Co., NM

Date Received in Lab: Mon Mar-01-10 11:15 am Report Date: 16-MAR-10 Device Monorove: Breat Barrow 11

					Project Manager: Brent Barron, II	srent Barron, II	
	Lab Id:	363834-001	363834-002	363834-003	363834-004	363834-005	363834-006
Audicie Dogusciod	Field Id:	I-WM	MW-2	MW-4 D	MW-4 S	MW-3 D	MW-3 S
naisanhay sisting	Depth:						
	Matrix:	WATER	WATER	WATER	WATER	WATER	WATER
	Sampled:	Fcb-26-10 11:41	Fcb-26-10 12:49	Fcb-26-10 09:32	Feb-26-10 10:26	Fcb-26-10 14:05	Fcb-26-10 14:00
Anions by E300	Extracted:						
	Analyzed:	Mar-15-10 15:05	Mar-15-10 15:05	Mar-15-10 15:05	Mar-15-10 15:05	Mar-15-10 15:05	Mar-15-10 15:05
	Units/RL:	mg/L RL	mg/L RL	mg/L RL	mg/L RL	mg/L RL	mg/L RL
Chloride		74.5 5.00	38.2 5.00	429 5.00	67.0 5.00	3510 250	4600 100
TDS by SM2540C	Extracted:						
	Analyzed:	Mar-03-10 14:50	Mar-03-10 14:50	Mar-03-10 14:50	Mar-03-10 14:50	Mar-03-10 14:50	Mar-03-10 14:50
	Units/RL:	mg/L RL	mg/L RL	mg/L RL	mg/L RL	mg/L RL	mg/L RL
Total dissolved solids		558 5.00	358 5.00	1210 5.00	464 5.00	10800 5.00	8340 5.00
	1						

This analytical report, and the entire data package it represents, has been made for your exclusive and confidential use. The interpretations and results expressed introughout this many/real report represent the besi judgment of XENCO Laboratories. XENCO Laboratorics assumes no responsibility and makes no warranty to the end use of the data hereby presented. Our liability is limited to the amount invoiced for this work order unless otherwise agreed to in writing.

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Odessa Laboratory Manager Brefft Barron, II





- X In our quality control review of the data a QC deficiency was observed and flagged as noted. MS/MSD recoveries were found to be outside of the laboratory control limits due to possible matrix /chemical interference, or a concentration of target analyte high enough to effect the recovery of the spike concentration. This condition could also effect the relative percent difference in the MS/MSD.
- **B** A target analyte or common laboratory contaminant was identified in the method blank. Its presence indicates possible field or laboratory contamination.
- **D** The sample(s) were diluted due to targets detected over the highest point of the calibration curve, or due to matrix interference. Dilution factors are included in the final results. The result is from a diluted sample.
- E The data exceeds the upper calibration limit; therefore, the concentration is reported as estimated.
- F RPD exceeded lab control limits.
- J The target analyte was positively identified below the MQL and above the SQL.
- U Analyte was not detected.
- L The LCS data for this analytical batch was reported below the laboratory control limits for this analyte. The department supervisor and QA Director reviewed data. The samples were either reanalyzed or flagged as estimated concentrations.
- H The LCS data for this analytical batch was reported above the laboratory control limits. Supporting QC Data were reviewed by the Department Supervisor and QA Director. Data were determined to be valid for reporting.
- K Sample analyzed outside of recommended hold time.
- JN A combination of the "N" and the "J" qualifier. The analysis indicates that the analyte is "tentatively identified" and the associated numerical value may not be consistent with the amount actually present in the environmental sample.

BRL Below Reporting Limit.

RL Reporting Limit

\* Outside XENCO's scope of NELAC Accreditation.

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### Project Name: Samson State BD No. 4

#### Work Order #: 363834 L-126-0210 **Project ID:** Lab Batch #: 796498 Sample: 796498-1-BKS Matrix: Water Date Analyzed: 03/03/2010 Date Prepared: 03/03/2010 Analyst: LATCOR Reporting Units: mg/L **BLANK /BLANK SPIKE RECOVERY STUDY** Batch #: 1 Blank Blank Spike Blank Control Anions by E300 Spike %R Result Added Spike Limits Flags Result %R [A] [B] Analytes [C] [D] ND 8.00 7.05 Chloride 88 90-110 L

Blank Spike Recovery [D] = 100\*[C]/[B] All results are based on MDL and validated for QC purposes. BRL - Below Reporting Limit

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**BS / BSD Recoveries** 



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Project Name: Samson State BD No. 4

		<b>Sample:</b> 796873-1-BKS	
Work Order #: 363834	Analyst: WRU	Lab Batch ID: 796873	[]]te. mo/].

Date Prepared: 03/03/2010

Batch #: 1

**Project ID:** L-126-0210 Date Analyzed: 03/03/2010 Matrix: Water

Units: mg/L		BLANF	K/BLANK S	PIKE / B	LANK S	3LANK /BLANK SPIKE / BLANK SPIKE DUPLICATE RECOVERY STUDY	ICATE F	RECOVE	RY STUD	Y	
TDS by SM2540C	Blank Sample Result [A]	Spike Added	Blank Spike Result	Blank Spike %R	Spike Added	Blank Spike Duolicate	Blk. Spk Dup. %R	RPD %	Control Limits %R	Control Limits %RPD	Flag
Analytes		[B]	[c]	[ <b>a</b> ]	Ξ	Result [F]	<u>[</u> ]				
Total dissolved solids	ND	1000	888	89	1000	906	16	2	80-120	30	

.

Relative Percent Difference RPD = 200\*[(C-F)/(C+F)] Blank Spike Recovery [D] = 100\*(C)/[B] Blank Spike Duplicate Recovery [G] = 100\*(F)/[E] All results are based on MDL and Validated for QC Purposes



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# Form 3 - MS Recoveries



### Project Name: Samson State BD No. 4

#### Work Order #: 363834 Lab Batch #: 796498

### Project ID: L-126-0210

Date Analyzed: 03/03/2010 QC- Sample ID: 363833-001 S	Date Prepared: 03/03 Batch #: 1	8/2010		nalyst: L fatrix: W		
Reporting Units: mg/L	MATR	IX / MA	TRIX SPIKE			DY
Inorganic Anions by EPA 300	Parent Sample Result	Spike Added	Spiked Sample Result [C]	%R [D]	Control Limits %R	Flag
Analytes	[A]	[B]		[~]		
Chloride	2570	1000	3610	104	90-110	<u> </u>

Matrix Spike Percent Recovery  $[D] = 100^{*}(C-A)/B$ Relative Percent Difference  $[E] = 200^{*}(C-A)/(C+B)$ All Results are based on MDL and Validated for QC Purposes

BRL - Below Reporting Limit



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## Sample Duplicate Recovery



## Project Name: Samson State BD No. 4

Work Order #: 363834

Lab Batch #: 796498 Date Analyzed: 03/03/2010	Date Prepared: 03/03/2	.010 <b>An</b> :	Project l alyst: LATC	<b>D:</b> L-126-02 COR	:10
QC- Sample ID: 363833-001 D	Batch #: 1	Ma	atrix: Water	r	
Reporting Units: mg/L	SAMPI	LE / SAMPLE	DUPLIC	ATE REC	OVERY
Anions by E300	Parent Sam Result [A]	Duplicate Result	RPD	Control Limits %RPD	Flag
Analyte		[B]			
Chloride	2570	2490	3	20	
Lab Batch #: 796873					
Date Analyzed: 03/03/2010	Date Prepared: 03/03/2	010 An	alyst: WRU		
QC- Sample ID: 363833-001 D	Batch #: 1	Ma	atrix: Water	r	
Reporting Units: mg/L	SAMPI	LE / SAMPLE	DUPLIC	ATE REC	OVERY
TDS by SM2540C Analyte	Parent Sam Result [A]	ple Sample Duplicate Result [B]	RPD	Control Limits %RPD	Flag
Total dissolved solids	7120	7830	9	30	

Spike Relative Difference RPD 200 \* | (B-A)/(B+A) | All Results are based on MDL and validated for QC purposes. BRL - Below Reporting Limit

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CHAIN OF CUSTODY RECORD AND ANAL YSIS REQUEST		4										ebimor8							_			<b>b</b> _	·	
S RE		Project Name: Samson State BD No.										N.G.R.M.	쐰	<u>×</u>	<u>×</u>	<u>×</u>	×	×	-		╉╴	5		
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ANA		tate	0	Σ			Ze For			09	18/2030 of BTEX 82					_					Τ_	I         I         I         I         I           Sample Containers Intact?         Temperature Upon Receipt:           Temperature Comments:         Laboratory Comments:	1.1	
AND		S	Project #: L-126-0210	Project Loc: Lea Co., NM			Analvze				\$ <del>9</del>	telovime2		-	_		$\dashv$	-						
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						Fax No: (432) 689-4578					pəldm	62 əmiT	1141	1249	0932	1026	1405	1400				VW, Suite F-		
							< <				pəjdu	62 əfeQ	2/26/10	2/26/10	2/26/10	2/26/10	2/26/10	2/26/10				Grande Blvd. 1	Received by:	Received by ELOT:
) <b>//ieS</b> Phone: 432-563-1800	Fax: 432-563-1713	<u>ittlejohn</u>	company Name RT Hicks Consultants Ltd	3ox 7624	city/state/zip: Midland, Texas 79708	528-3878	Jal ( mul					FIELD CODE										Special Instructions: Send Invoice to RT Hicks Consult. 901 Rio Grande Blvd. NW, Suite F-142, Albuquerque, NM 87104; Dale Littlejohn at the adress above.	Date Time	Date Time
Xenco Laboratories	765	Project Manager: <u>Dale Littlejohn</u>	any Name RT Hi	Company Address: P.O. BOX 7624	State/Zip: Midlar	Telephone No: (432) 528-3878	Sampler Signature:						1-WM	MW-2	MW-4d	MW-4s	MW-3d	MW-3s			1	s: Send Invoice t Dale Littlejohn	the sh	
Xenco La	Odessa, Texas 79765	Project	Comp	Company	City/	Talec	Sampler \$				1, 20 Z. I		6	W	<i>4</i> 0,	2	Ŕ	100				Special Instruction:	Relinquished by:	Relinquished by:

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Page 11 of 12

Final Ver. 1.000

## Environmental Lab of Texas

Variance/ Corrective Action Report- Sample Log-In

Client	RT Hicks
Date/ Time:	3110 1115
Lab ID # :	363834
Initials:	<u>A</u>

## Sample Receipt Checklist

<u> </u>		· · · · · · · · · · · · · · · · · · ·	_		Client Initial
#1	Temperature of container/ cooler?	Nes	No	Z.1 °C	
#2	Shipping container in good condition?	(Yes)	No		1
#3	Custody Seals intact on shipping container/ cooler?	Yes	No	Not Present	
#4	Custody Seals intact on sample bottles/ container?	Yes	No	(Not Present)	<u> </u>
#5	Chain of Custody present?	res	No		<u> </u>
#6	Sample instructions complete of Chain of Custody?	Yes	No		<b></b> ;;
#7	Chain of Custody signed when relinquished/ received?	Tes	No		┠━━━━┼┼━╸
#8	Chain of Custody agrees with sample label(s)?	Yes	No	KiD written on Comt/ Lid	<b></b> ;;
#9	Container label(s) legible and intact?	Yes	No	Not Applicable	<u> </u>
#10	Sample matrix/ properties agree with Chain of Custody?	(Yes)	No		
#11	Containers supplied by ELOT?	(Yes)	No	+	╉────┾┽─
#12	Samples in proper container/ bottle?	Yes	No	See Below	
#13	Samples property preserved?	Tes	No		
#14	Sample bottles intact?	(Yes)	No	See Below	┢────┤─
#15	Preservations documented on Chain of Custody?	Cree	No		╞────┼─
#16	Containers documented on Chain of Custody?	Tes	The second se	+	
#17	Sufficient sample amount for indicated test(s)?		No		
#18	All samples received within sufficient hold time?	Yes	No	Sea Below	
#19	Subcontract of sample(s)?	Yes	No	See Below	
#20	VOC samples have zero headspace?	Yes	No	Not Applicable	
		Yes	No	Not Applicable	1

## Variance Documentation

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Contact

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Contacted by:

Regarding:

Corrective Action Taken:

Check all that Apply:

П

 See attached e-mail/ fax

Client understands and would like to proceed with analysis Cooling process had begun shortly after sampling event

Final Ver. 1.000

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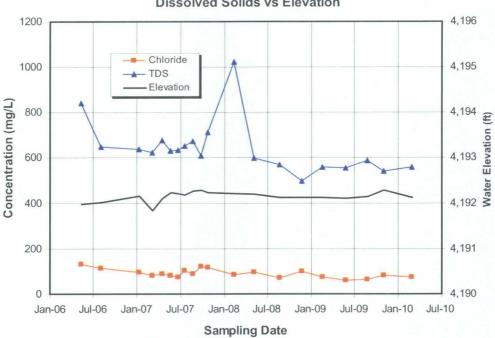
Date/ Time:

# Appendix C Graphs - Historic Ground Water Data

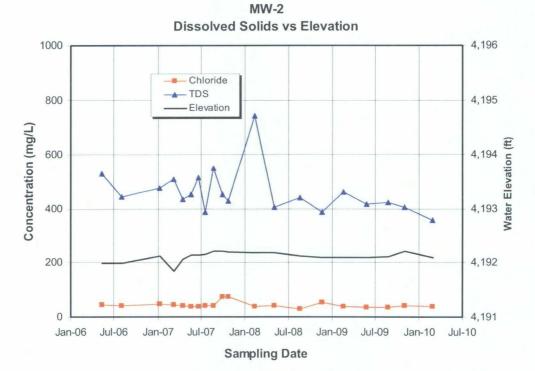
1 0 Tr C.

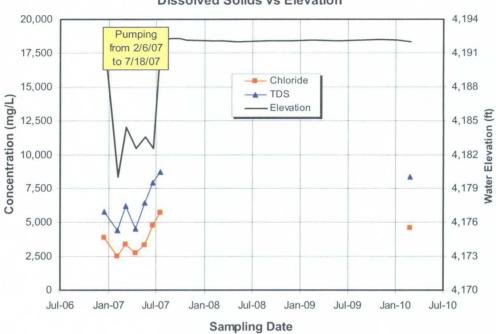
## R.T. Hicks Consultants, Ltd.

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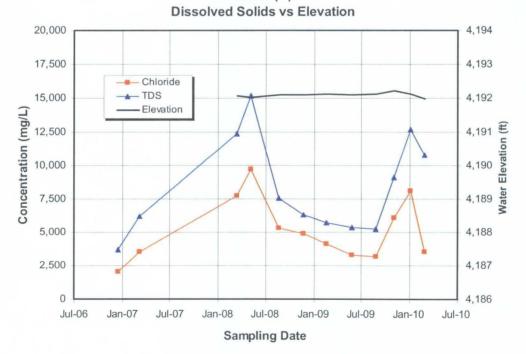
MW-1 Dissolved Solids vs Elevation

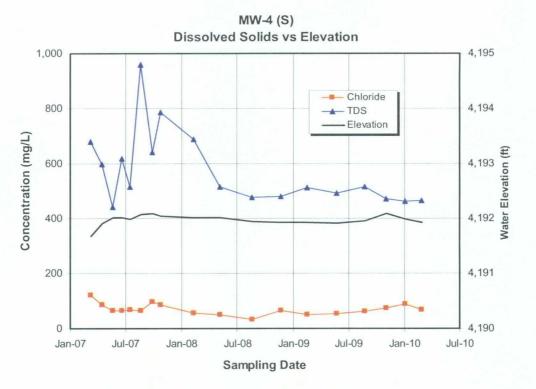




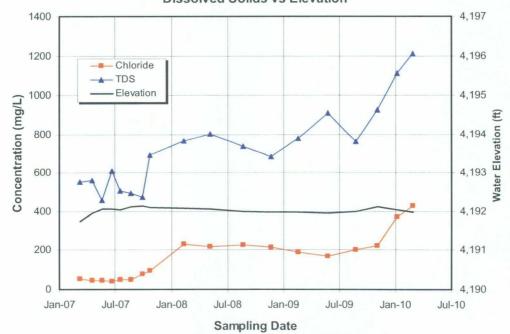
MW-3 (S) Dissolved Solids vs Elevation

MW-3 (D)





MW-4 (D) Dissolved Solids vs Elevation

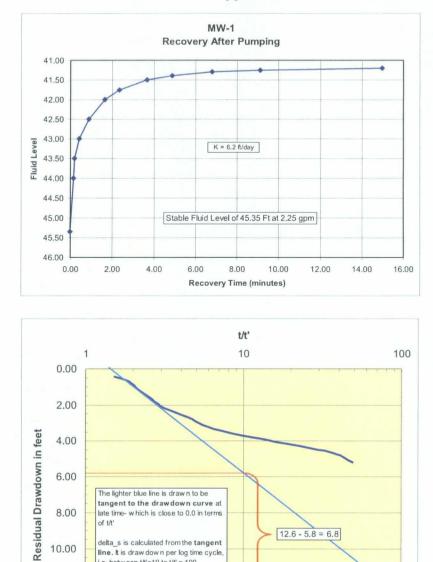


# Appendix D Methodology for Draw Down Tests

Barers at St

## R.T. Hicks Consultants, Ltd.

901 Rio Grande Blvd. NW, Suite F-142 Albuquerque, NM 87104



			delta_s is calcu	lated from graph
Input	Pumping Rate	2.25 [gal/min]	Input	6.8 [feet]
	T = (264*Q)/delta	S	delta s is	
		awdown in feet per log time cy	_	
		Groundwater and Wells)		

12.6 - 5.8 = 6.8

tangent to the drawdown curve at

late time- which is close to 0.0 in terms

delta\_s is calculated from the tangent

line. It is draw dow n per log time cycle, i.e. betw een t/t'=10 to t/t' = 100

8.00

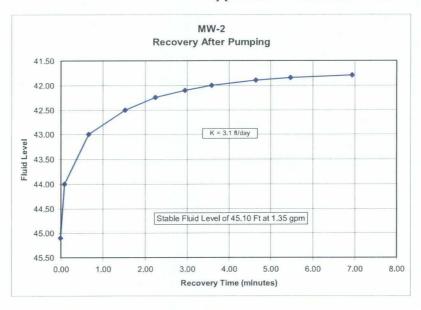
10.00

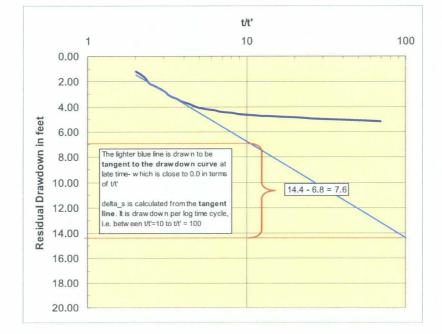
12.00

14.00

of t/t'

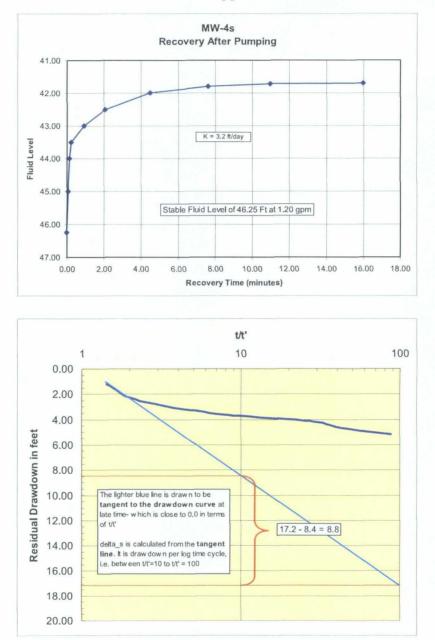
Output	T =	87.35294	[feet^2/day]
Input	Aquifer thickness	14.1	[feet]
Output	Resultant K	6.195244	[feet/day]





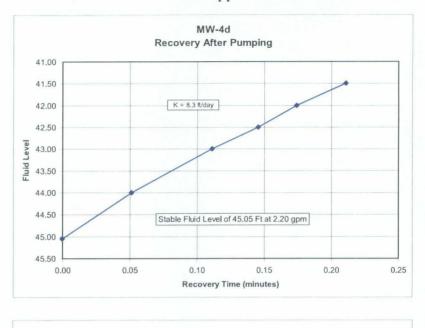
				delta_s is calcul	lated from graph
Input	Pumping Rate	1.35	[gal/min]	Input	7.6 [feet]
	T = (264*Q)/delta	S		delta s is	
	residual dra	awdown ii	n feet per log time cyc	cle (Page 256,	
		Grou	ndwater and Wells)		

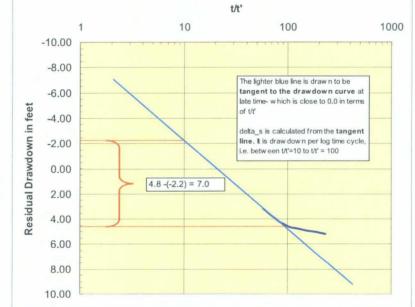
Output	T =	46.89474	[feet^2/day]
Input	Aquifer thickness	15.2	[feet]
Output	Resultant K	3.08518	[feet/day]

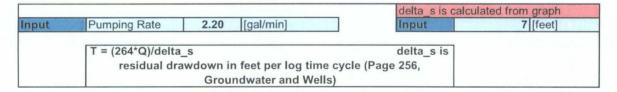


	the second se	delta_s is calcu	lated from graph
Input	Pumping Rate 1.20 [gal/min]	Input	8.8 [feet]
	T = (264*Q)/delta_s	delta_s is	
	residual drawdown in feet per log time	e cycle (Page 256,	
	Groundwater and Well	s)	

Output	T =	36	[feet^2/day]
Input	Aquifer thickness	11.4	[feet]
Output	Resultant K	3.157895	[feet/day]







Output	T =	82.97143	[feet^2/day]
Input	Aquifer thickness	10	[feet]
Output	Resultant K	8.297143	[feet/day]

## 13 Recovery tests

When the pump is shut down after a pumping test, the water levels in the well and the piezometers will start to rise. This rise in water levels is known as residual drawdown, s'. It is expressed as the difference between the original water level before the start of pumping and the water level measured at a time t' after the cessation of pumping. Figure 13.1 shows the change in water level with time during and after a pumping test.

It is always good practice to measure the residual drawdowns during the recovery period. Recovery-test measurements allow the transmissivity of the aquifer to be calculated, thereby providing an independent check on the results of the pumping test, although costing very little in comparison with the pumping test.

Residual drawdown data are more reliable than pumping test data because recovery occurs at a constant rate, whereas a constant discharge during pumping is often difficult to achieve in the field.

The analysis of a recovery test is based on the principle of superposition, which was discussed in Chapter 6. Applying this principle, we assume that, after the pump has been shut down, the well continues to be pumped at the same discharge as before, and that an imaginary recharge, equal to the discharge, is injected into the well. The recharge and the discharge thus cancel each other, resulting in an idle well as is required for the recovery period. For any of the well-flow equations presented in the previous chapters, a corresponding 'recovery equation' can be formulated.

The Theis recovery method (Section 13.1.1) is widely used for the analysis of recovery tests. Strictly speaking, this method is only valid for confined aquifers which are fully penetrated by a well that is pumped at a constant rate. Nevertheless, if additional limiting conditions are satisfied, the Theis method can also be used for leaky aquifers (Section 13.1.2) and unconfined aquifers (Section 13.1.3), and aquifers that are only partially penetrated by a well (Section 13.1.4).

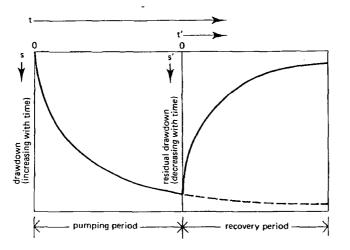


Figure 13.1 Time drawdown and residual drawdown

If the recovery test is conducted in a free-flowing well, the Theis recovery method can also be used (Section 13.2).

If the discharge rate of the pumping test was variable, the Birsoy-Summer recovery method (Section 13.3.1) can be used.

## 13.1 Recovery tests after constant-discharge tests

## 13.1.1 Confined aquifers, Theis's recovery method

According to Theis (1935), the residual drawdown after a pumping test with a constant discharge is

$$s' = \frac{Q}{4\pi KD} \{ W(u) - W(u') \}$$
(13.1)

where

$$u = \frac{r^2S}{4KDt}$$
 and  $u' = \frac{r^2S'}{4KDt'}$ 

When u and u' are sufficiently small (see Section 3.2.2 for the approximation of W(u) for u < 0.01), Equation 13.1 can be approximated by

$$s' = \frac{Q}{4\pi KD} \left( \ln \frac{4KDt}{r^2 S} - \ln \frac{4KDt'}{r^2 S'} \right)$$
(13.2)

where

s'

= residual drawdown in m

r = distance in m from well to piezometer

 $KD = transmissivity of the aquifer in m^2/d$ 

S' =storativity during recovery, dimensionless

S = storativity during pumping, dimensionless

t = time in days since the start of pumping

t' = time in days since the cessation of pumping

Q = rate of recharge = rate of discharge in  $m^3/d$ 

When S and S' are constant and equal and KD is constant, Equation 13.2 can also be written as

$$s' = \frac{2.30Q}{4\pi KD} \log \frac{t}{t'}$$
(13.3)

A plot of s' versus t/t' on semi-log paper (t/t' on logarithmic scale) will yield a straight line. The slope of the line is

$$\Delta s' = \frac{2.30Q}{4\pi KD} \tag{13.4}$$

where  $\Delta s'$  is the residual drawdown difference per log cycle of t/t'.

The Theis recovery method is applicable if the following assumptions and conditions are met:

- The assumptions listed at the beginning of Chapter 3, adjusted for recovery tests. The following conditions are added:

- The flow to the well is in an unsteady state;
- u < 0.01, i.e. pumping time  $t_p > (25 r^2 S)/KD$
- u' < 0.01, i.e.  $t' > (25 r^2S)/KD$ , see also Section 3.2.2.

#### Procedure 13.1

- For each observed value of s', calculate the corresponding value of t/t';
- For one of the piezometers, plot s' versus t/t' on semi-log paper (t/t' on the logarithmic scale);
- Fit a straight line through the plotted points;
- Determine the slope of the straight line, i.e. the residual drawdown difference  $\Delta s'$  per log cycle of t/t';
- Substitute the known values of Q and  $\Delta s'$  into Equation 13.4 and calculate KD.

### Remark

- When S and S' are constant, but unequal, the straight line through the plotted points intercepts the time axis where s' = 0 at a point  $t/t' = (t/t')_0$ . At this point, Equation 13.2 becomes

$$0 = \frac{2.30Q}{4\pi KD} \left[ \log\left(\frac{t}{t'}\right)_{o} - \log\frac{S}{S'} \right]$$

Because 2.30 Q/4 $\pi$ KD # 0, it follows that log (t/t')<sub>o</sub> - log (S/S') = 0. Hence (t/t')<sub>o</sub> = S/S', which determines the relative change of S.

#### 13.1.2 Leaky aquifers, Theis's recovery method

After a constant-discharge test in a leaky aquifer, Hantush (1964), disregarding any storage effects in the confining aquitard, expresses the residual drawdown s' at a distance r from the well as

$$s' = \frac{Q}{4\pi KD} \{ W(u,r/L) - W(u',r/L) \}$$
(13.5)

Taking this equation as his basis and using a digital computer, Vandenberg (1975) devised a least-squares method to determine KD, S, and L. For more information on this method, we refer the reader to the original literature.

If the pumping and recovery times are long, leakage through the confining aquitards will affect the water levels. If the times are short, i.e. if  $t_p + t' \le (L^2S)/20KD$  or  $t_p + t' \le cS/20$ , the Theis recovery method (Section 13.1.1) can be used, but only the leaky aquifer's transmissivity can be determined (Uffink 1982; see also Hantush 1964).

### 13.1.3 Unconfined aquifers, Theis's recovery method

An unconfined aquifer's delayed watertable response to pumping (Chapter 5) is fully reversible according to Neuman's theory of delayed watertable response, because hysteresis effects do not play any part in this theory. Neuman (1975) showed that the Theis recovery method (Section 13.1.1) is applicable in unconfined aquifers, but only for late-time recovery data. At late time, the effects of elastic storage, which set in after pumping stopped, have dissipated. The residual drawdown data will then fall on a straight line in the semi-log s' versus t/t' plot used in the Theis recovery method.

### 13.1.4 Partially penetrating wells, Theis's recovery method

The Theis recovery method (Section 13.1.1) can also be used if the well is only partially penetrating. For long pumping times in such a well, i.e.  $t_p > (D^2S)/2KD$ , the semi-log plot of s versus t yields a straight line with a slope identical to that of a completely penetrating well (Hantush 1961b). Thus, if the straight line portion of the recovery curve is long enough, i.e. if both  $t_p$  and t' are greater than (10 D<sup>2</sup>S)/KD, the Theis recovery method can be applied (Uffink 1982).

## 13.2 Recovery tests after constant-drawdown tests

If the recovery test follows a constant-drawdown test instead of a constant-discharge test, the Theis recovery method (Section 13.1.1) can be applied, provided that the discharge at the moment before the pump is shut down is used in Equation 13.4 (Rushton and Rathod 1980).

## 13.3 Recovery tests after variable-discharge tests

## 13.3.1 Confined aquifers, Birsoy-Summers's recovery method

To analyze the residual drawdown data after a pumping test with step-wise or intermittently changing discharge rates, Birsoy and Summers (1980) proposed the following expression

$$\frac{s'}{Q_n} = \frac{2.30}{4\pi KD} \log \left\{ \beta_{t(n)} \left( \frac{t-t_n}{t-t'_n} \right) \right\}$$
(13.6)

where

s' = residual drawdown at  $t > t'_n$ 

 $Q_n$  = constant discharge during the last (= n-th) pumping period

 $t_n = time at which the n-th pumping period started$ 

 $t-t_n = time since the n-th pumping period started$ 

 $t'_n$  = time at which the n-th pumping period ended

 $t-t'_n$  = time since the n-th pumping period ended

 $\beta_{t(n)}$  is defined according to Equation 12.2

A semi-log plot of s'/ $Q_n$  versus the corresponding adjusted time of recovery:  $\beta_{t(n)}(t-t_n/t-t'_n)$  yields a straight line. The slope of the straight line  $\Delta(s'/Q_n)$  is equal to 2.30/4 $\pi$ KD, from which the transmissivity can be determined.

The Birsoy-Summers recovery method can be used if the following assumptions and conditions are met:

- The assumptions listed at the beginning of Chapter 3, as adjusted for recovery tests, with the exception of the fifth assumption, which is replaced by:

• Prior to the recovery test, the aquifer is pumped at a variable discharge rate. The following conditions are added:

- The flow to the well is in an unsteady state;
- u < 0.01 [ $u = r^2 S/4KD\{\beta_{t(n)}(t_p t_n)\}$ ], see also Section 3.2.2;

 $- u' < 0.01 \qquad [u' = r^2 S/4KD\{\beta_{t(n)}(t-t_n/t-t'_n)\}].$ 

Procedure 13.2

- For a single piezometer, calculate the adjusted time of recovery,  $\beta_{t(n)}(t-t_n/t-t_n)$ , by applying Equation 12.2 for the calculation of  $\beta_{t(n)}$ , and by using all the observed values of the discharge rate and the appropriate values of time;
- On semi-log paper, plot the observed specific residual drawdown s'/ $Q_n$  versus the corresponding values of  $[\beta_{t(n)}(t-t_n/t-t'_n)]$  (the adjusted time of recovery on the logar-ithmic scale);
- Draw a straight line through the plotted points;
- Determine the slope of the straight line,  $\Delta(s'/Q_n)$ , which is the difference of  $s'/Q_n$  per log cycle of adjusted time of recovery;
- Calculate KD from  $\Delta(s'/Q_n) = 2.30/4\pi KD$ .

## Remark

- See Section 12.1 for simplified expressions of  $\beta_{t(n)}(t-t_n)$  which can be introduced into the expression for the adjusted time of recovery.