1R - 428-76

WORKPLANS

DATE:
9-9-08

September 9, 2008

Hobbs M-4 Vent
NMOCD Case #: 1R-428-76

Corrective Action Plan

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104

Katie Lee

From: Katie Lee [katie@rthicksconsult.com]

Sent: Tuesday, September 09, 2008 4:07 PM

To: Edward J. EMNRD Hansen (edwardj.hansen@state.nm.us); Wayne Price (wayne.price@state.nm.us)

Cc: Randall Hicks (Randall Hicks); Hack Conder (hconder@riceswd.com); Marvin Burrows; 'Dale Littlejohn' (dale@rthicksconsult.com)

Subject: Hobbs M-4, NMOCD # 1R428-76

Mr. Hansen,

On behalf of Rice Operating Company, R.T. Hicks Consultants is pleased to submit the attached Corrective Action Plan for the Hobbs M-4 Vent Site, NMOCD Case #1R428-76. A hard copy and a cd containing an electronic copy will follow via FedEx. This Corrective Action Plan is being submitted in response to your August 12, 2008 email request to Hack Conder for a workplan for this site.

As always, if you have any questions, please do not hesitate to contact us at our office in Albuquerque, or Hack Conder at the Rice office in Hobbs.

Best regards,

Katie Lee
Project Scientist
R.T. Hicks Consultants, Ltd.
ph. 505-266-5004
fax 505-266-0745
mobile 505-400-7925

September 9, 2008

Hobbs M-4
NMOCD Case #: 1R-428-76

Corrective Action Plan

prepared for:

Rice Operating Company
122 West Taylor
Hobbs, NM 88240

R.T. Hicks Consultants, Ltd.

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

1.0 EXECUTIVE SUMMARY

This Corrective Action Plan presents the results of the characterization activities and a vadose zone remedy for the M-4 Vent site located in the Hobbs Salt Water Disposal System (SWD). R.T. Hicks Consultants (Hicks Consultants) and Rice Operating Company (ROC) performed the investigations; Hicks Consultants evaluated the data and developed the vadose zone remedy. The results of the characterization show that the M-4 vent site released produced water in the past.

In May 2008, chloride and TDS concentrations at the monitoring well were 332 mg/L and 1,330 mg/L respectively. Although ground water beneath the site exceeds WQCC Standards for chloride and TDS, evaluation of historical aerial photographs shows a long history of oil and gas exploration and production activities at and near this site. Because data are insufficient to determine the source of chloride and TDS in ground water, this CAP proposes a vadose zone remedy only. Two additional quarters of ground water monitoring and additional research of the history of the site and surrounding areas will provide data to help determine if:

- The M-4 Vent site is the source of the observed ground water impact,
- Historic activities are the source of the impact,
- Up-gradient or regional sources may be causing the elevated concentrations of chloride and TDS, or
- Ground water quality improves and obviates the need for additional investigation.

Simulation modeling shows that constituents in the vadose zone do not pose a threat to ground water after grading the surface and re-vegetation of the site. Therefore, the proposed vadose zone remedy for this site is:

A. Grading the site to create a 3-5% slope,
B. Creation of a ponding area where precipitation shed from the sloped surface can accumulate over an area that is not impacted by past leakage from the vent,
C. Importation of clean silty-loam topsoil to place over the prepared surface, and
D. Re-vegetation with a seed mixture acceptable to the landowner.

ROC will provide a Corrective Action Plan to address the documented impairment of ground water at the site before April 1, 2009.

Data Summary

1. ROC excavated a sampling trench at the site in September 2007 and detected evidence of a produced water release at the site (e.g. PID values exceeding 1,000 ppm).

2. Hicks Consultants supervised field activities at the M-4 Vent site in February 2008. This involved general reconnaissance as well as supervision of borehole sampling of the vadose zone from ground surface to ground water and the installation of a ground water monitoring well.
3. The most recent of two ground water sampling events show that chloride and TDS concentrations are 332 mg/L and 1330 mg/L respectively.
4. Depth to ground water at the site is about 32 feet below ground surface.
5. Data from vadose zone samples show that the chloride center of mass resides about 16-feet below ground surface (bgs). The maximum chloride concentration is at 16-feet bgs (1760 mg/kg - laboratory) in SB-1. In this same boring (SB-1) the chloride concentration at 11-feet bgs is 605 mg/kg (field analysis) and at 21-feet bgs, the chloride concentration is 963 mg/kg (field analysis).
6. In SB-2, chloride concentrations near the capillary fringe (26 feet bgs) are 700 mg/kg, which suggests that some seepage of produced water from this site has entered ground water.
7. Neither field PID analyses nor observed characteristics of samples (e.g. odor) suggest that hydrocarbons are present in the vadose zone below 12 feet. With the exception of one field test (SB-2 at 16-feet bgs) all field PID analyses from the borings were less than 100 ppm. Laboratory analysis of this sample from 16-feet at SB-2 did not detect benzene. The concentrations of toluene, ethylbenzene and xylene were less than 0.01 mg/kg for each constituent in this sample.
8. Simulation modeling using highly conservative input parameters show that installation of a sloped vegetative cover over the former vent site effectively abates potential impact to ground water posed by residual constituents of concern in the vadose zone.

Conclusions

I. Two quarters of ground water monitoring are not sufficient to determine if the observed impairment is due to:
   a. Releases from the vent site,
   b. Past releases from other on-site activities, or
   c. Regional impairment from an up-gradient source.

II. After installation of the proposed sloped vegetated cap, conservative simulation modeling predicts that the mass of subsurface chloride will migrate to ground water over the next 40 years and cause chloride concentrations to increase below the site by about 60 mg/L in year 29.

III. With the exception of this 1-year period (Year 29), the migration of chloride to ground water will cause an increase in ground water chloride of less than 25 mg/L.

IV. After the importation of about 2 feet of silt/loam clean backfill, grading and re- vegetation, the recharge rate to ground water will be very small.

V. Peer-reviewed scientific papers suggest that the expected recharge rate beneath ET Barriers similar to that proposed for the M-4 site is less than 1 mm/year (Scanlon and others, 2005).

VI. Site-specific HYDRUS-1D simulations show that the recharge rate at this site with a sloped vegetation surface is less than or equal to 0.05 mm/day. An El

Nino event within the climate record results in a recharge exceeding 0.05mm/day for a time period of 3 years (peak recharge is 0.3 mm/day).

VII. The chloride mass that resides from 12-feet bgs to the ground surface at the vent site is about 1,200 pounds (65 m^2 at 7.75 kg/m^2). This mass will migrate downward over decades, disperse in the soil column and enter ground water at a very slow rate.

VIII. HYDRUS-1D simulations predict that chloride concentrations in ground water beneath the site will not measurably increase as a result of the very slow migration of the chloride load detected from 10-feet below ground surface to ground surface.

IX. The salinity of ground water at the site is suitable for livestock.

Recommendations

A. Create a 3-5% slope over the area of vadose zone impact composed of imported clean silty-loam topsoil, and re-vegetate the M-4 Vent Site.
B. Continue ground water monitoring for two additional quarters.
C. Six months after NMOCD-approval of this CAP, provide documentation of surface restoration
D. Before April 1, 2009, provide an evaluation of ground water data with an opinion regarding the source of TDS and chloride observed in ground water.
E. At a location where pumping of saline or brackish ground water provides an environmental benefit, remove 1,200 pounds of chloride with ground water. This water may be used for line and well maintenance.

The selected remedy is the creation of an infiltration barrier through surface restoration and re-vegetation of the site. With respect to residual constituents in the vadose zone, this remedy is protective of ground water quality and human health and the environment.

2.0 BACKGROUND

The Hobbs Salt Water Disposal System (SWD), which managed produced water since the late 1950s is now closed. Future releases from the system infrastructure are not possible. Closure of facilities like the M-4 Vent within Hobbs SWD, followed the August 6, 2004 NMOCD-approved investigation plan. This plan calls for delineation of any impact from these sites during the closure process and states:

> If 12 feet vertical delineation at the source reveals Target Concentrations for TPH or BTEX will not meet NMOCD guidelines or TPH and BTEX will meet guidelines but there is not a significant decline vs. depth in chloride concentration, the site-impact is judged to be outside the scope of this work plan and will become a risk-based corrective action (RBCA) project-site.

The M-4 Vent site met these criteria.

3.1 Location

Plate 1 is a location map showing the location of the site relative to selected other components of the Hobbs SWD system and public roads. Plate 2 is an aerial photograph of the site showing the principal streets of Marland and S. Grimes.

The site is within unit letter M, Section 4, Township 19S Range 38E. To access the site from the intersection of Marland Street and Grimes Street in Hobbs, proceed south on Grimes 1.0 mile and turn right onto Stanolind Road. Travel west 0.6 miles and turn right on an unpaved lease road. Travel northwest 0.3 miles and turn left on another lease road and proceed less than 0.1 miles through locked gate. Turn right (north) onto lease road, travel 0.2 miles, then turn left (west) on lease road, travel 0.15 miles, then turn left (south) on lease road and travel 0.25 miles to the site on the left (east) side of the road.

3.2 Characterization Activities

In February 2008, R. T. Hicks Consultants, ROC, and Harrison Cooper Drilling mobilized to the site. The investigation and characterization used the same protocols as described in the NMOCD-approved work plan for the Section 29 sites and was consistent with the Investigation Characterization Plan (ICP) submitted for the site (see Appendix A).

On February 19, 2008, SB-1 was advanced to a depth of 27 feet bgs at a location immediately west-southwest of the open excavation, approximately 15 feet from the release site. In the field, ROC evaluated samples from each depth for chloride and used the heated headspace method to measure total organic vapors by PID. Two samples were submitted to the laboratory from depths showing the highest field chloride measurements (15-17 feet bgs) and from the capillary fringe (25-27 feet bgs). The chloride field tests indicated levels above the threshold specified in the ICP (250 mg/kg) with the exception of the capillary fringe sample.

MW-1 was installed approximately 50 feet southeast of the release site. ROC performed field chloride and hydrocarbon screening but given the well's distance from the site, and the low levels of chloride and hydrocarbons in the boring, no soil samples were submitted to the laboratory for analysis from the monitoring well boring (see lithologic log for field measurements, Appendix C). The well was completed with 2-inch PVC casing and screened from 19 to 39 feet bgs.

On February 20, 2008, ROC backfilled the excavation and installed a conductor pipe through the fill at the release source area to a depth of 6 feet. On February 21, 2008, SB-2 was advanced to a depth of 27 feet through the conductor pipe. ROC performed field chloride and hydrocarbon screening and three samples were submitted to the laboratory from depths showing the highest field hydrocarbon measurements (15 -17 feet bgs), the highest field chloride measurements (20 – 22 feet bgs), and from the capillary fringe (25 – 27 feet bgs).

3.0 REGIONAL GEOLOGY AND HYDROGEOLOGY

Appendix B is a series of maps that describe the hydrogeology of the area of the Hobbs SWD system.

4.0 CHARACTERISTICS OF THE VADOSE ZONE

The upper 4 to 5 feet of the 27-foot thick vadose zone at the site is composed primarily of dark brown silt that is underlain by 10 to 19 feet of caliche. SB-1 encountered a very hard quartzite sandstone from 12 to 15 feet bgs that was not present in either MW-1 or SB-2. Below the caliche and extending to the ground water depth was a fine to medium grain, well sorted, and sub-rounded sand. The lithologic logs of the soil borings and monitoring well are included in Appendix C.

ROC staff performed field chloride measurements and PID measurements every five feet starting at 5 feet bgs at SB-1, 10 feet bgs at MW-1, and 15 feet bgs at SB-2. The peak chloride concentrations were observed at 15-17 feet in SB-1 (1,151 mg/kg), 10-11 feet in MW-1 (317 mg/kg), and 20-22 feet in SB-2 (1,168 mg/kg). Laboratory analyses generally confirm the results of the field tests.

Figure 1
M-4 Chloride v. Depth

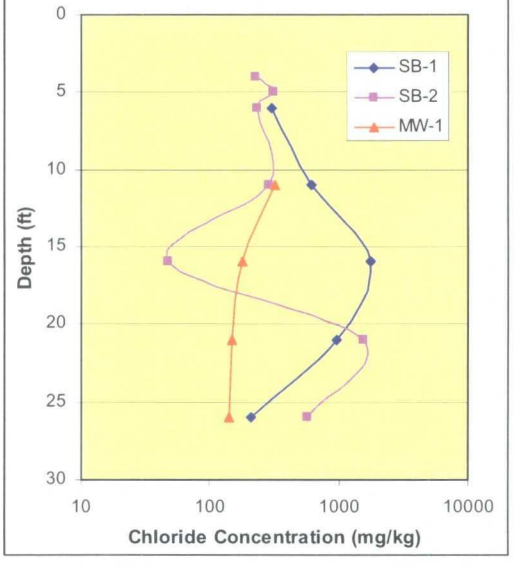


Figure 1 indicates the chloride profile for each boring location. Original excavation values were included for the top 12 feet of SB-2 and the laboratory results were substituted for the field result where available. Below the center of mass, chloride concentrations declined to approximately 50% or less at 27 feet bgs, which is immediately above or within the capillary fringe.

An averaged chloride profile using the data from the excavation and the borings SB-1 and SB-2, when integrated (summed over depth), yields a chloride loading of 7.75 kg/m^2.

Neither hydrocarbon odors nor PID measurements above 2 ppm were detected in the boring completed as MW-1 (Appendix C); therefore, no laboratory analyses for petroleum hydrocarbons were necessary.

5.0 CHARACTERISTICS OF THE SATURATED ZONE

At the M-4 Vent site, moist soil was observed at about 27 feet bgs and depth to water at MW-1 is about 27 feet bgs.

Ground water sampling showed that chloride and TDS concentrations exceeded WQCC standards for the first two sampling events. Field data and lab data are summarized in the table below.

Depth to Water	Sample Date	Cl	TDS	Benzene	Toluene	Ethyl Benzene	Total Xylenes
26.78	3/7/2008	432	1520	<0.001	<0.001	<0.001	<0.003
27.02	5/2/2008	332	1330	<0.002	<0.002	<0.002	<0.006

Data displayed in Appendix B shows that some water supply wells in the general area also exceed WQCC Standards.

6.0 EVALUATION OF VERTICAL CHLORIDE FLUX

Empirical evidence from borings shows chloride concentrations above background levels throughout the vadose zone. The center of chloride mass lies between 16 and 22 feet bgs in SB-1 and SB-2 respectively. These data support a conclusion that produced water has migrated through the vadose zone via unsaturated flow and reached ground water.

We believe the following release/transport scenario is consistent with the empirical data. At the M-4 site, periodic releases created sufficient soil moisture to allow chloride transport to the water table, perhaps under saturated or near-saturated flow. After the releases (closure of the system or implementation of different management practices), evaporation of soil moisture and drying of the upper vadose zone reduced soil moisture and hydraulic conductivity temporarily "stranding" the residual chloride mass above ground water. Unsaturated flow allows continued downward chloride transport through the entire vadose zone, albeit at a very slow rate/flux.

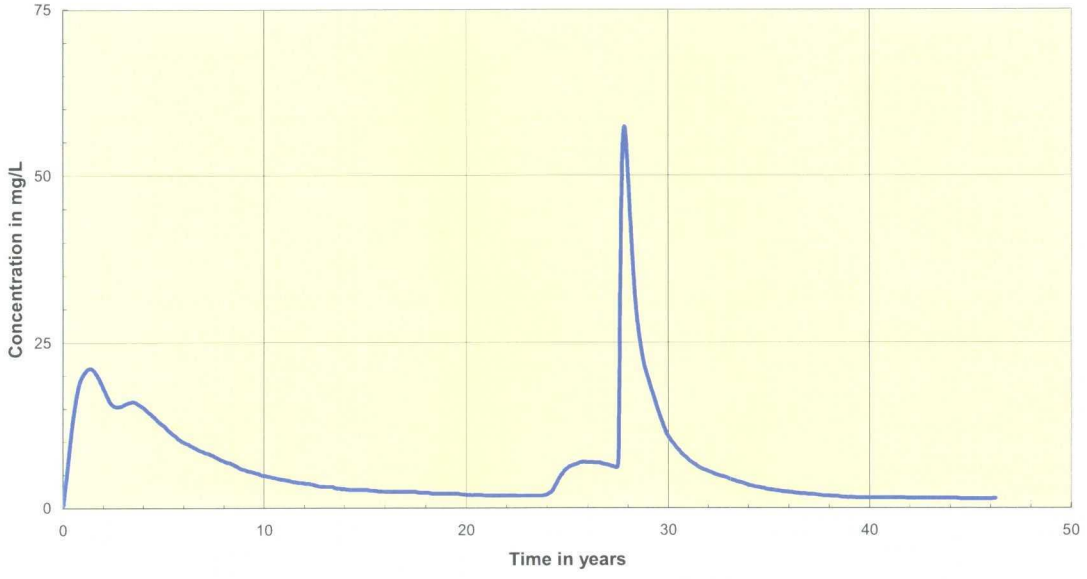
We elected to conduct a HYDRUS-1D modeling experiment to design an effective infiltration barrier to abate any threat to fresh water posed by residual chloride in the vadose zone. In this experiment, a HYDRUS 1-D model was constructed with site specific data as detailed in Appendix D. The model assumes that ROC installs an infiltration barrier consisting of:

1. Vegetation at the ground surface,
2. Two feet of silty-loam topsoil sloped 3-5% to a small depression adjacent to the former vent site,
3. One foot of clean fine-grained soil/backfill beneath the topsoil,
4. A permeable geotextile material that separates the topsoil from,
5. Six inches of caliche gravel that overlies the material impacted by chloride from the former vent site

The predicted vadose zone solute flux to ground water was used as an input to a simple ground water mixing model. Predicted chloride concentration in a monitoring well at the down-gradient edge of the site is shown in Figure 2. The model assumes a vegetative root zone within the upper two feet of silt loam at the site and that ground water

chloride concentration is 0.0 mg/L in order to show only the impact to ground water of the chloride at the M-4 site.

Figure 2: Predicted Chloride Concentration in the Aquifer, M-4 Site with an ET Cap



As can be seen in Figure 2, chloride in the lower vadose zone enters ground water raising chloride concentration close to 25 mg/L as vegetation is being established at the site. The establishment of vegetation lowers infiltration. With "drying" out of the vadose zone soil materials, hydraulic conductivities are reduced. The resultant vadose zone chloride flux to ground water is lowered such that ground water chloride concentration does not rise more than 10 mg/L except during an El Nino event within the climate record. This event results in a chloride flux sufficient to raise chloride concentration in ground water by 25 mg/L for about a year and by 50 mg/L for about three months during this year (see Appendix D).

7.0 PROPOSED REMEDY

Experience at similar sites and HYDRUS-1D simulations of the conditions similar to those observed at this site support simple re-vegetation of the surface as an effective corrective action.

This corrective action plan calls for two additional ground water monitoring events and an examination of past activities at the site and regional data. Before April 1, 2009, ROC will submit a report summarizing the historical and ground water data with an opinion regarding the source of chloride and TDS in ground water or the need to determine a source if ground water concentrations decline below standards.

ROC will remove sufficient ground water from another nearby location such that 1,200 pounds of chloride are removed from the aquifer. Hicks Consultants does not

recommend removing this water from the M-4 site as ground water at this location marginally exceeds WQCC standards and is suitable for livestock.

8.0 REFERENCES

Ash, S.R., 1963, Ground water conditions in northern Lea County, U.S. Geological Survey Hydrologic Investigations Atlas HA-62

Hendrickx, J., Rodriguez, G., Hicks, R. T., and Simunek, January 2005, Modeling Study of Produced Water Release Scenarios, API Publication Number 4734, 11 pp.

Intera Incorporated, July 8, 2003, Windmill Oil Site Ground Water Sampling Results, prepared for the New Mexico Oil Conservation Division, 3 pp.

McAda, D.P., 1985, Projected water-level declines in the Ogallala aquifer in Lea County, New Mexico, US Geological Survey Water-Resources Investigations Report 84-4062, 84 pp.

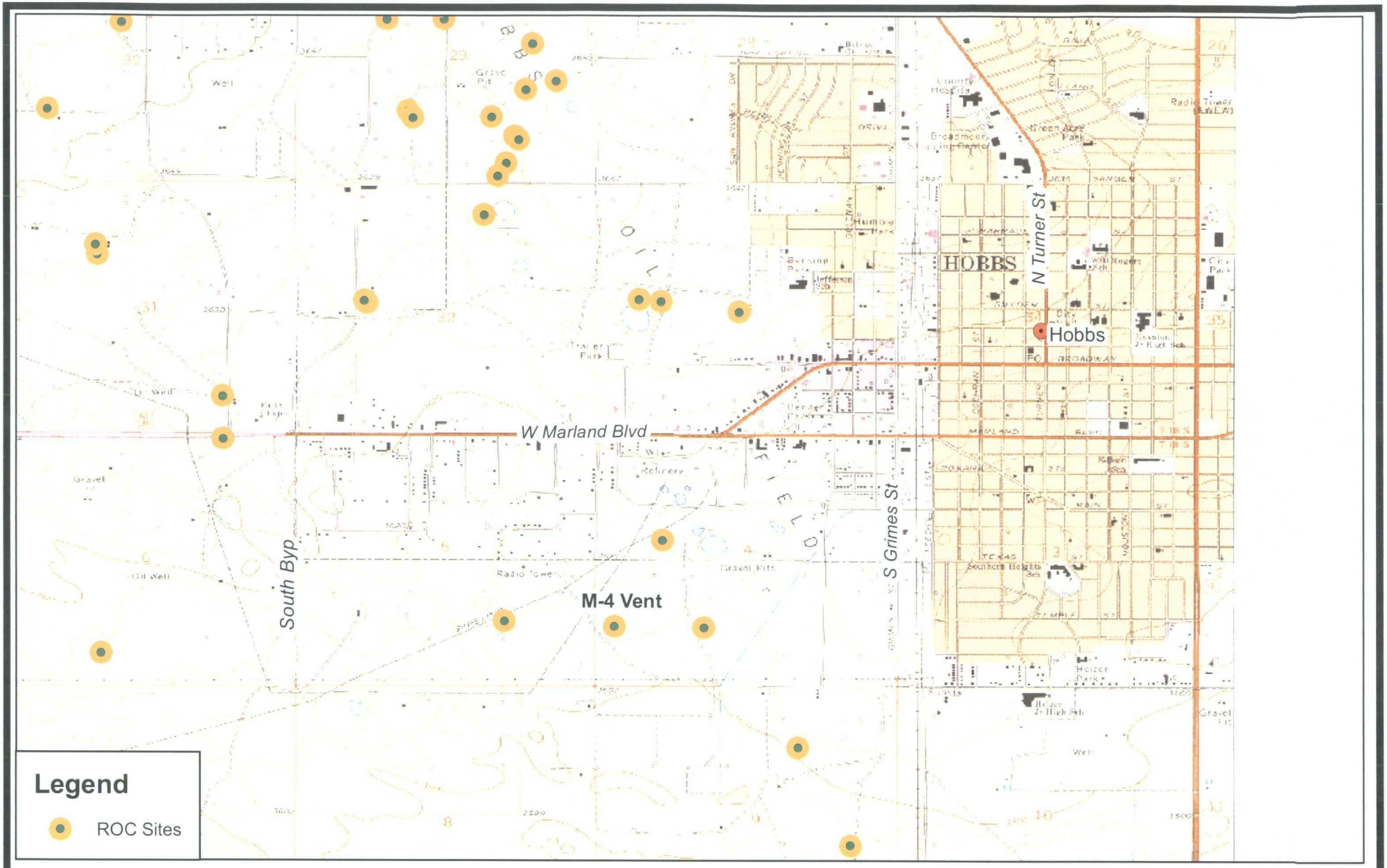
Musharrafieh, G. and Chudnoff, M., January 1999, Numerical Simulation of Groundwater Flow for Water Rights Administration in the Lea County Underground Water Basin New Mexico, New Mexico Office of the State Engineer Technical Report 99-1, 6 pp.

Nicholson Jr., A. and Clebsch, A., 1961, Geology and Ground Water Conditions of Southern Lea County, New Mexico, Ground Water Report 6, US Geological Survey, New Mexico Bureau of Mines and Mineral Resources

Scanlon, B. R., R. C. Reedy, K. E. Keese, and S. F. Dwyer, 2005, Evaluation of evapotranspirative covers for waste containment in arid and semiarid regions in the southwestern USA: Vadose Zone Journal, v. 4, p. 55-71.

Plates

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104



R.T. Hicks Consultants, Ltd
901 Rio Grande Blvd NW Suite F-142
Albuquerque, NM 87104
Ph: 505.266.5004

Location of M-4 Vent
Relative to Hobbs, New Mexico

Plate 1

Rice Operating Company: Hobbs SWD System

September 2008

N
W E
S


N
Present Lease Road
Excavation
SB-2
SB-1
MW-1
Water Knock-out
and Electrical
Plate 2A
Site History (Current)
Rice Operating Compar
Hobbs SWD M-4 Jct. Box
T-19-S R-38-E Sec. 4 (M)
Lea County, New Mexico
Scale - Feet
0
90
180
0
30
60
Scale - Meters

Appendix A

Investigation Characterization Plan, Quality Procedures

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104

R. T. HICKS CONSULTANTS, LTD.

901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

April 13, 2007

Mr. Wayne Price
New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Investigation Characterization Plan: T18S R38E
Jct. E-4
Jct. N-4 Vent
Jct. M-4 Vent
Hobbs Salt Water Disposal System

Dear Mr. Price:

On behalf of Rice Operating Company (ROC), R.T. Hicks Consultants, Ltd. is pleased to submit this Investigation Characterization Plan (ICP) for the three (3) junction box sites referenced above within the Hobbs Salt Water Disposal System. Plate 1 is a map showing the location of these three sites relative to major roads in the area and other relevant sites.

The work elements proposed to characterize these sites sufficiently to develop an appropriate corrective action are presented below.

1. ROC will identify and document the location of all current and historic equipment and pipelines associated with each site.
2. ROC and Hicks Consultants will use a backhoe, with a 12-foot vertical reach to install a series of sampling trenches in order to recover soil samples and delineate the lateral extent (and potentially the vertical extent) of impacted soil.
3. Soil samples employed for delineation will be obtained from regular intervals below ground surface in each trench.
4. Representative soil samples will be sent to a laboratory to allow for verification of the field results.
5. General soil texture descriptions will be provided for each sample trench.
6. The criteria to delineate the extent of impact is 5 point chloride decline vs. depth, or:
   a. 250 ppm chloride using field analyses (see attached ROC Quality Procedure in Appendix A) whichever occurs first,
   b. 100 ppm total hydrocarbon vapors using the headspace method analysis (Appendix A).
   c. Soil boring to ground water depth should neither (a) nor (b) apply,
   d. Monitoring well installation if warranted to assess ground water at the site.

Following the site characterization described above, we will submit the data and analysis with a Corrective Action Plan that outlines the procedures for closure of the site.

Rice Operating Company (ROC) is the service provider (agent) for the Hobbs Saltwater Disposal System and has no ownership of any portion of pipeline, well, or facility. A consortium of oil producers who own the Hobbs System (System Partners); provide all operating capital on a percentage ownership/usage basis. Major projects require System Partner authorization for expenditures (AFE) approval and work begins as funds are received. The Hobbs SWD System has been abandoned.

For all environmental projects, ROC will choose a path forward that:

1. Protects public health.
2. Provides the greatest net environmental benefit.
3. Complies with NMOCD Rules.
4. Is supported by good science.

The last criteria employed when evaluating any proposed remedy or investigative work is confirming that there is a reasonable relationship between the benefits created by the proposed remedy or assessment and the economic and social costs.

Each site shall have three submissions or a combination of:

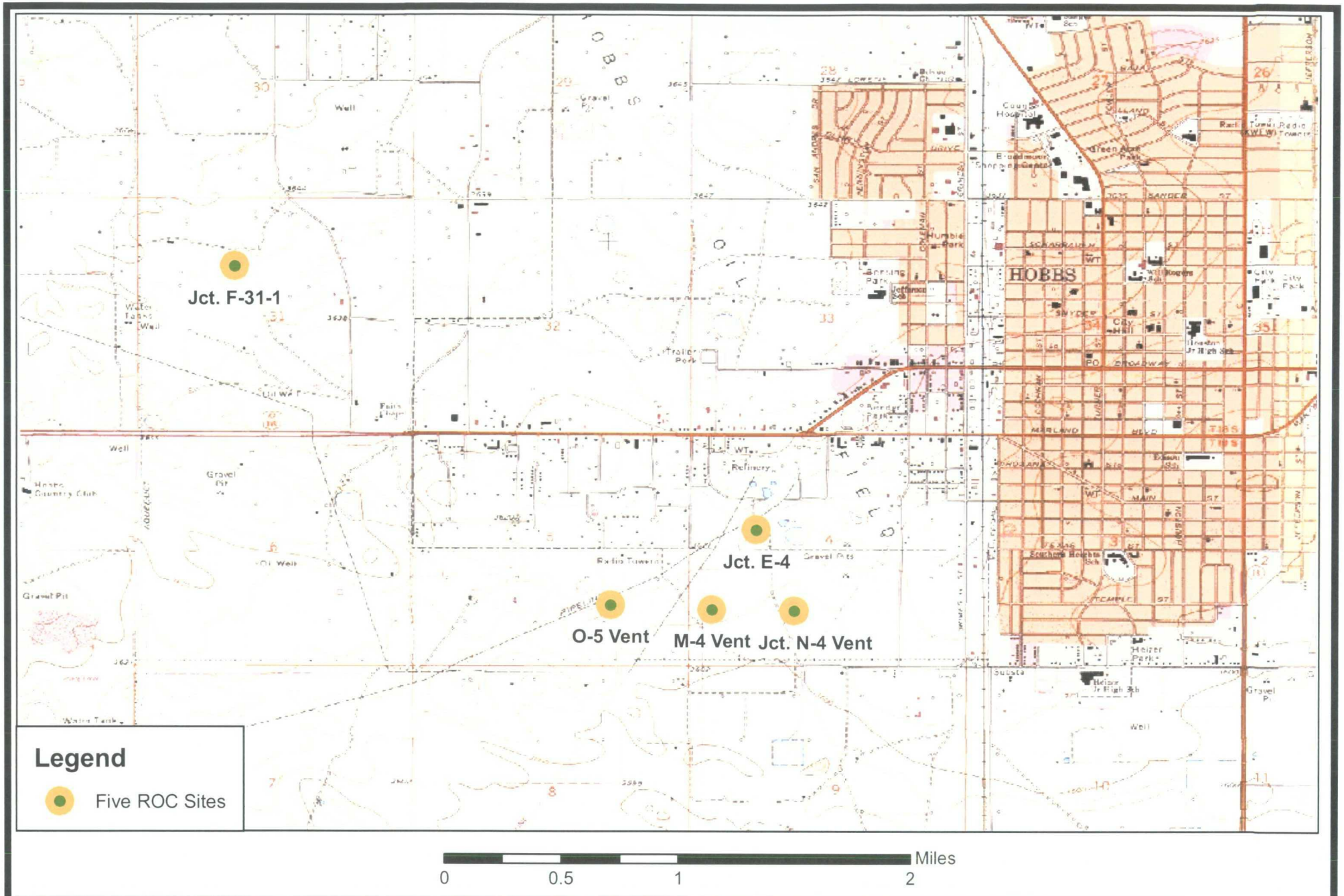
1. This Investigation and Characterization Plan (ICP), which is a proposal for data gathering, and site characterization and assessment (this submission).
2. Upon evaluation of the data and results from the ICP, a recommended remedy will be submitted in a Corrective Action Plan (CAP).
3. Finally, after implementing the remedy, a closure report with final documentation will be submitted.

If you have any questions or comments regarding this ICP, please contact Kristin Pope of Rice Operating Company as she has reviewed and approved this submission.

Sincerely,
R.T. Hicks Consultants, Ltd.

Randall T. Hicks
Principal

Copy: Rice Operating Company



R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Five New Sites Relative to Hobbs, New Mexico	Plate 1
	Rice Operating Company	April 2007

N
W E
S

Appendix A

Rice Operating Company

QUALITY PROCEDURE - 03
Sampling and Testing Protocol - Chloride Titration Using .282 Normal Silver Nitrate Solution

1.0 Purpose
This procedure is to be used to determine the concentration of chloride in soil.

2.0 Scope
This procedure is to be used as the standard field measurement for soil chloride concentrations.

3.0 Sample Collection and Preparation

3.1 Collect at least 80 grams of soil from the sample collection point. Take care to insure that the sample is representative of the general background to include visible concentrations of hydrocarbons and soil types. If necessary, prepare a composite sanlple for soils obtained at several points in the sample area. Take care to insure that no loose vegetation, rocks or liquids are included in the sample(s).

3.2 The soil sample(s) shall be immediately inserted into a one-quart or large polyethylene freezer bag. Care should be taken to insure that no cross-contamination occurs between the soil sample and the collection tools or sample processing equipment.

3.3 The sealed sample bag should be massaged to break up any clods.

4.0 Sample Preparation

4.1 Tare a clean glass vial having a minimum 40 ml capacity. Add at least 10 grams of the soil sample and record the weight.

4.2 Add at least 10 grams of reverse osmosis water to the soil sample and shake for 20 seconds.

4.3 Allow the sample to set for a period of 5 minutes or until the separation of soil and water.

4.4 Carefully pour the free liquid extract from the sample through a paper filter into a clean plastic cup if necessary.

5.0 Titration Procedure

5.1 Using a graduated pipette, remove 10 ml extract and dispense into a clean plastic cup.

5.2 Add 2-3 drops potassium chromate (K_2CrO_4) to mixture.

5.3 If the sample contains any sulfides (hydrogen or iron sulfides are common to oilfield soil samples) add 2-3 drops of hydrogen peroxide (H_2O_2) to mixture.

5.4 Using a 10 ml pipette, carefully add 0.282 normal silver nitrate (one drop at a time) to the sample while constantly agitating it. Stop adding silver nitrate when the solution begins to change from yellow to red. Be consistent with endpoint recognition.

5.5 Record the ml of silver nitrate used.

6.0 Calculation
To obtain the chloride concentration, insert measured data into the following formula:

$$\frac{0.282 \times 35{,}450 \times \text{ml } AgNO_3}{\text{ml water extract}} \times \frac{\text{grams of water in mixture}}{\text{grams of soil in mixture}}$$

Using Step 5.0, determine the chloride concentration of the RO water used to mix with the soil sample. Record this concentration and subtract it from the formula results to find the net chloride in the soil sample.

Record all results on the delineation form.

Rice Operating Company

QUALITY PROCEDURE -07
Sampling and Testing Protocol for VOC in Soil

1.0 Purpose
This procedure is to be used to determine the concentrations of Volatile Organic Compounds in soils.

2.0 Scope
This procedure is to be used as the standard field measurement for soil VOC concentrations. It is not to be used as a substitute for full spectrographic speciation of organic compounds.

3.0 Procedure

3.1 Sample Collection and Preparation

3.1.1 Collect at least 500 g. of soil from the sample collection point. Take care to insure that the sample is representative of the general background to include visible concentrations of hydrocarbons and soil types. If necessary, prepare a composite sample of soils obtained at several points in the sample area. Take care to insure that no loose vegetation, rocks or liquids are included in the sample(s).

3.1.2 The soil sample(s) shall be immediately inserted into a one-quart or larger polyethylene freezer bag and sealed. When sealed, the bag should contain a nearly equal space between the soil sample and trapped air. Record the sample name and the time that the sample was collected on the Field Analytical Report Form.

3.1.3 The sealed samples shall be allowed to set for a minimum of five minutes at a temperature of between 10-15 Celsius, (59-77° F). The sample temperatures may be adjusted by cooling the sample in ice, or by heating the sample within a generally controlled environment such as the inside of a vehicle. The samples should not be placed directly on heated surfaces or placed in direct heat sources such as lamps or heater vents.

3.1.4 The sealed sample bag should be massaged to break up any clods, and to provide the soil sample with as much exposed surface area as practically possible.

3.2 Sampling Procedure

3.2.1 The instrument to be used in conducting VOC concentration testing shall be an Environmental Instruments 13471 OVM / Datalogger or a similar pro-type instrument. (Device will be identified on VOC Field
Test Report Form.) Prior to use, the instrument shall be zeroed-out in accordance with the appropriate maintenance and calibration procedure

outlined in the instrument operation manual. The PID device will be calibrated each day it's used.

3.2.2 Carefully open one end of the collection bag and insert the probe tip into the bag taking care that the probe tip not touch the soil sample or the sidewalls of the bag.

3.2.3 Set the instrument to retain the highest result reading value. Record the reading onto the Field Test Report Form.

3.2.4 If the instrument provides a reading exceeding 100 ppm, proceed to conduct BTEX Speciation in accordance with QP-O2 and QP-O6. If the reading is 100 ppm or less, NMOCD BTEX guideline has been met and no further testing fur BTEX is necessary. File the Field Test Report Form in the project file.

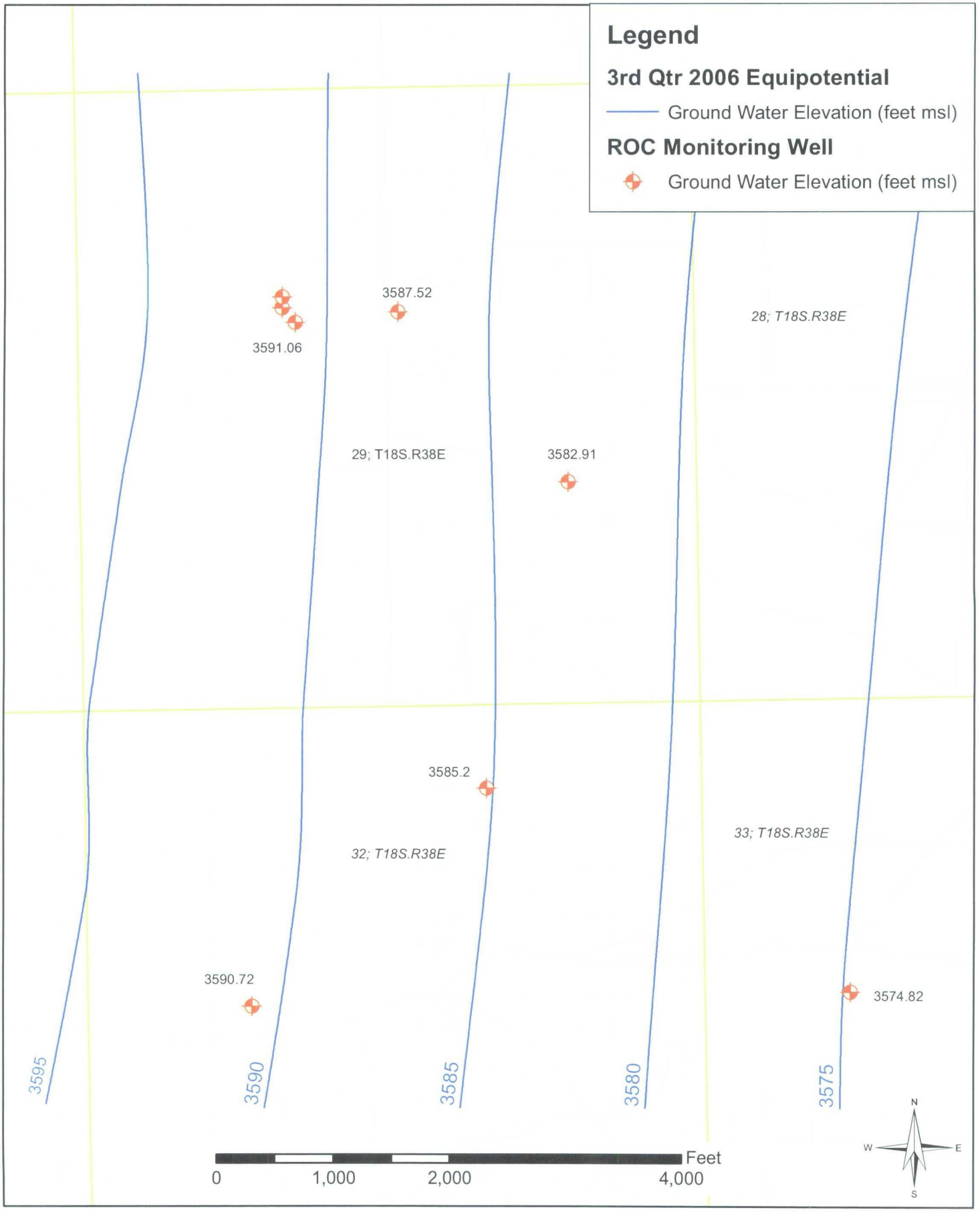
4.0 Clean-up

After testing, the soil samples shall be returned to the sampling location, and the bags collected for off-site disposal, IN NO CASE SHALL THE SAME BAG BE USED TWICE. EACH SAMPLE CONTAINER MUST BE DISCARDED AFTER EACH USE.

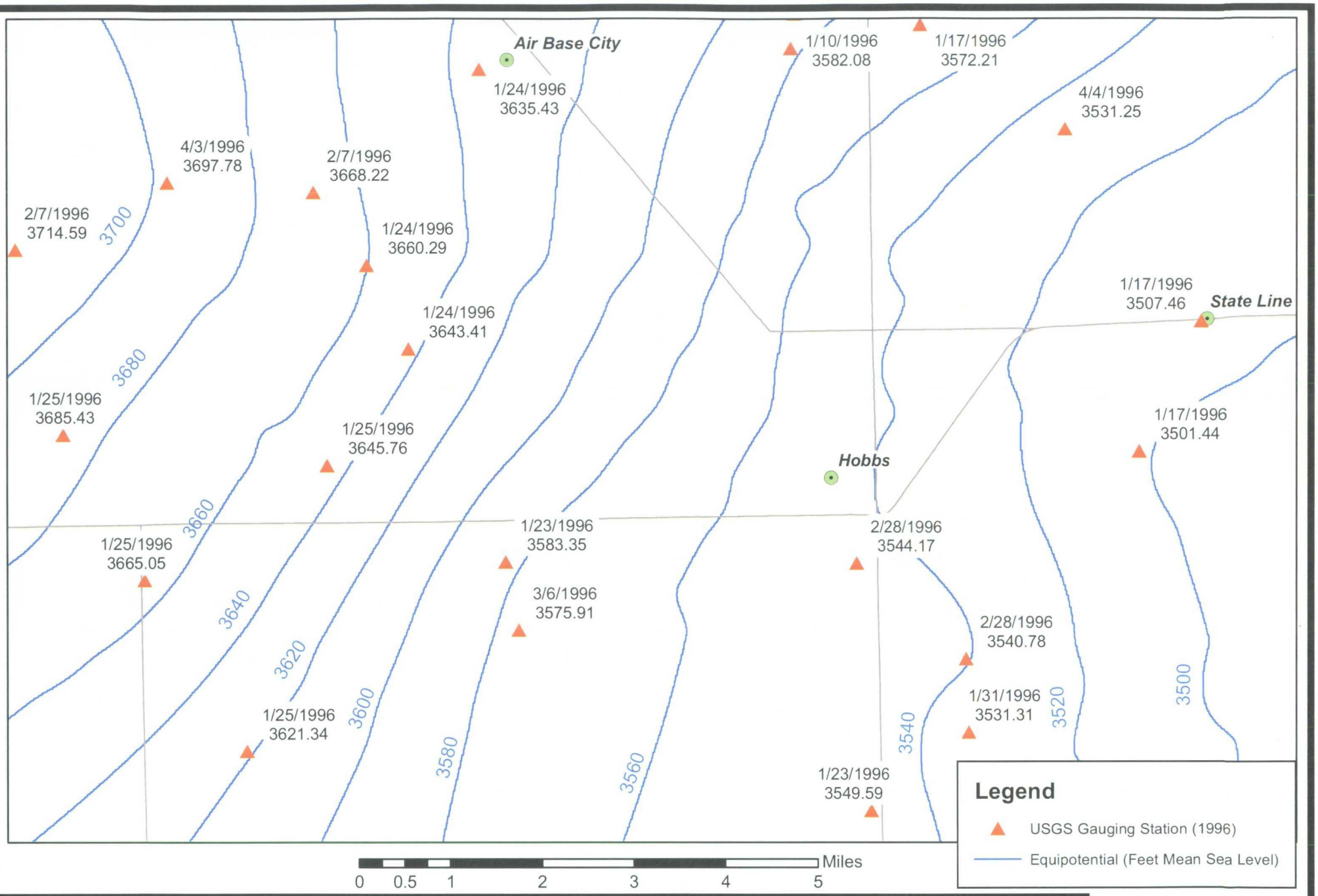
Appendix B

Regional Maps

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104



R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	3rd Qtr 2006 Potentiometric Surface	Plate A-2
	Rice Operating Company: Hobbs SWD System (Sections 29, 32 and 33 of T18S. R38E)	January 2007



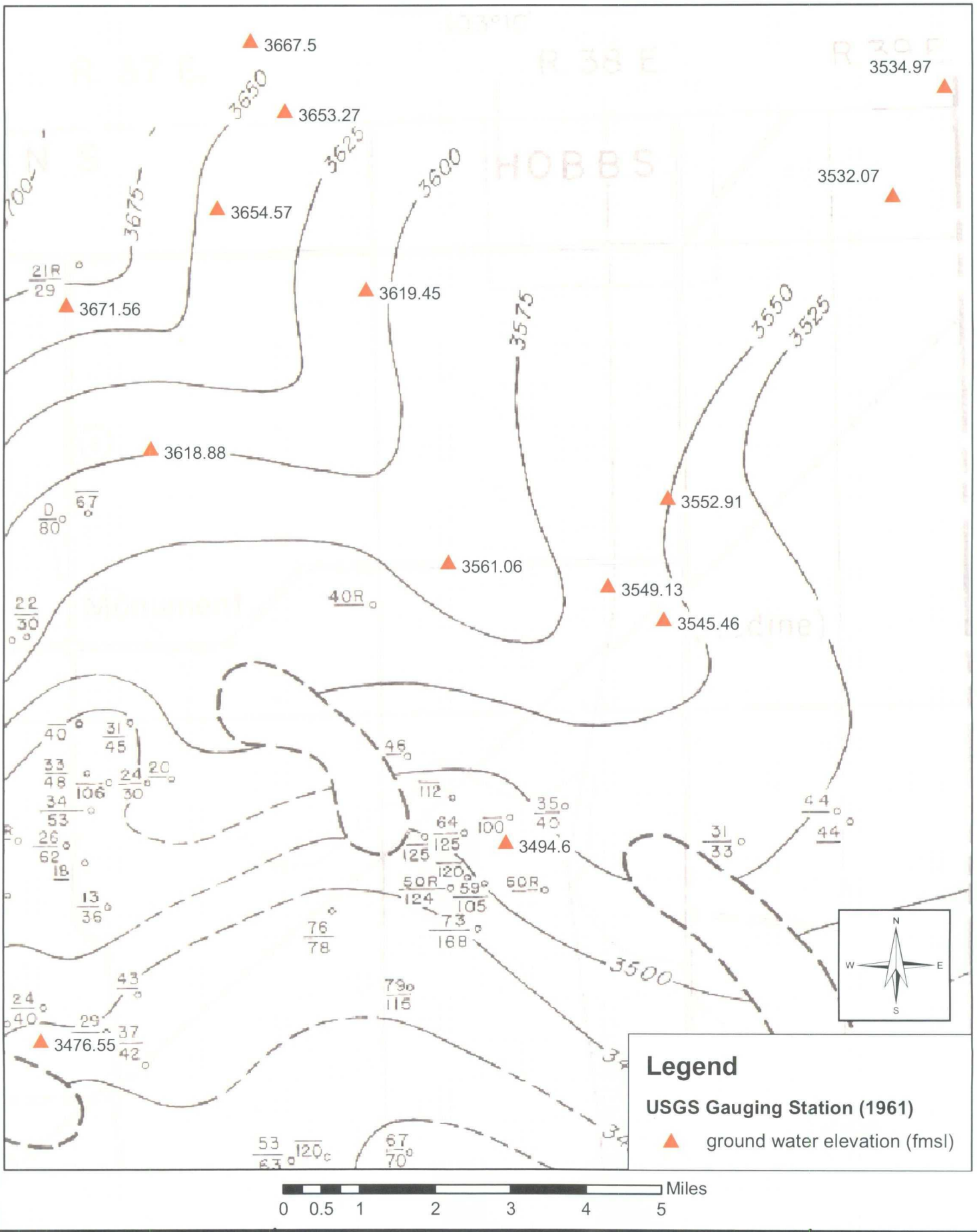
R.T. Hicks Consultants, Ltd
901 Rio Grande Blvd NW Suite F-142
Albuquerque, NM 87104
Ph: 505.266.5004

1996 Regional Potentiometric Surface (USGS)

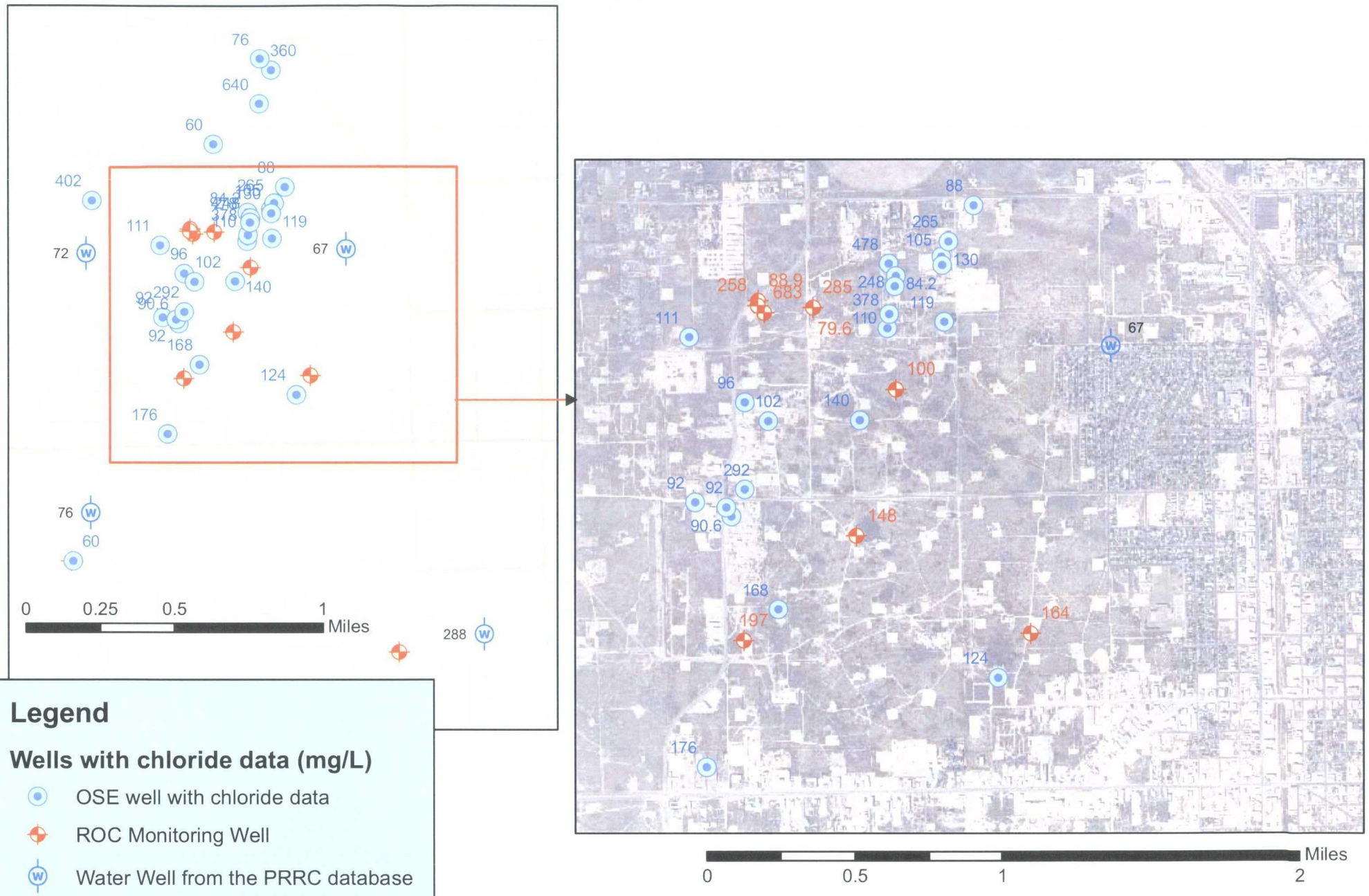
Plate A-3

Rice Operating Company: Hobbs SWD System

January 2007



R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Portion of the potentiometric surface map in the Nicholson and Clebsch (1960) report overlayed with 1961 USGS data	Plate A-4
	Rice Operating Company: Hobbs SWD System	January 2007



Legend

Wells with chloride data (mg/L)

- OSE well with chloride data
- ROC Monitoring Well
- Water Well from the PRRC database

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Chloride Concentration Map (mg/L) Rice Operating Company: Hobbs SWD System	Plate A-5 January 2007

Appendix C

Lithologic Logs

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104

LITHOLOGIC LOG (SOIL BORING)

R T Hicks Consultants Ltd

P O Box 7624
Midland, TX 79708
(432) 528-3878

MONITOR WELL NO.:	SB-1	TOTAL DEPTH:	27 Ft
SITE ID:	Hobbs SWD M-4 Vent	CLIENT:	Rice Operating Company
SURFACE ELEVATION:	3,607 (USGS Map)	COUNTY:	Lea County
CONTRACTOR:	Harrison & Cooper, Inc.	STATE:	New Mexico
DRILLING METHOD:	Air-Rotary	LOCATION:	T-19-S, R-38-E, Sec. 4 (M)
INSTALLATION DATE:	2/19/08	FIELD REP.:	Dale Littlejohn
WELL PLACEMENT:	15' West of source area	FILE NAME:	\Hobbs SWD\M-4 Lithlogs
COMMENTS:	Lat. 32° 41' 7.7" North, Long. 103° 9' 38.3" West (Hand-Held GPS)		

Lithology	TYPE	DEPTH	% REC	PID	Cl (Fld)	DEPTH	LITHOLOGIC DESCRIPTION: LITHOLOGY, COLOR, GRAIN SIZE SORTING, ROUNDING, CONSOL., DIST. DEATURES
BENTONITE							SILT Dark brown.
	spoon	5-7	10%	0.3	298	5	CALICHE Grayish brown to greenins brown, soft, hydrocarbon odor at 7 ft, becoming siltier with depth.
	spoon	10-12	5%	51.8	605	10	
							SANDSTONE (quartzite) brown, fine crystalline, well cemented, very hard drilling.
						15	
	spoon	15-17	10%	1.4	1,151		CALICHE Brown with some silt.
							Lab Data: Chloride 1,760 (mg/kg); BTEX <0.0057; Benz ND; Naphthalene ND
	spoon	20-22	100%	1.1	963	20	SAND Brown, fine grain, medium sorted, angular.
	spoon	25-27	100%	1.2	209	25	SAND Brown, medium grain, well sorted, sub-rounded to rounded.
							Lab Data: Chloride 14.3 (mg/kg); BTEX ND; Benz ND; Naphthalene ND

TD = 27 Feet

LITHOLOGIC LOG (SOIL BORING)

R T Hicks Consultants Ltd

P O Box 7624
Midland, TX 79708
(432) 528-3878

MONITOR WELL NO.:	SB-2	TOTAL DEPTH:	27 Ft
SITE ID:	Hobbs SWD M-4 Vent	CLIENT:	Rice Operating Company
SURFACE ELEVATION:	3,607 (USGS Map)	COUNTY:	Lea County
CONTRACTOR:	Harrison & Cooper, Inc.	STATE:	New Mexico
DRILLING METHOD:	Air-Rotary	LOCATION:	T-19-S, R-38-E, Sec. 4 (M)
INSTALLATION DATE:	2/21/08	FIELD REP.:	Dale Littlejohn
WELL PLACEMENT:	Center of source area	FILE NAME:	\Hobbs SWD\M-4 Lithlogs
COMMENTS:	Lat. 32° 41' 7.6" North, Long. 103° 9' 38.0" West (Hand-Held GPS)		

Lithology	TYPE	DEPTH	% REC	PID	Cl (Fld)	DEPTH	LITHOLOGIC DESCRIPTION: LITHOLOGY, COLOR, GRAIN SIZE SORTING, ROUNDING, CONSOL., DIST. DEATURES
6-inch PCV; PVC casing from surface to 6 feet; BENTONITE							No Cuttings; pit contained approx. 4 feet of silty soil overlying broken to massive caliche with some silt.
	excav	4	--	45	226	5	
	excav	5	--	8	310		
	excav	6	--	17	232		SILT, Dark brown (fill material), strong hydrocarbon odor.
	excav	7	--	84	234		
	excav	8	--	1,588	243		
	excav	9	--	1,268	266	10	
	excav	10	--	1,340	286		
	excav	11	--	1,068	286		
	excav	12	--	947	284		
							CALICHE AND SILT Light brown, soft.
						15	
	spoon	15-17	50%	123	198		Lab Data: Chloride (47.4 mg/kg); BTEX (<0.197); Benz (ND); Naphthalene (0.245)
							SILTY SAND Light brown, very fine grain, well sorted, angular.
						20	
	spoon	20-22	100%	44.7	1,168		SAND Brown, medium grain, well sorted, sub-rounded, poss sandstone at 27 ft.
							Lab Data: Chloride (1,520 mg/kg); BTEX (ND); Benz (ND); Naphthalene (ND)
						25	
	spoon	25-27	100%	32	700		Lab Data: Chloride (558 mg/kg); BTEX (ND); Benz (ND); Naphthalene (0.083)

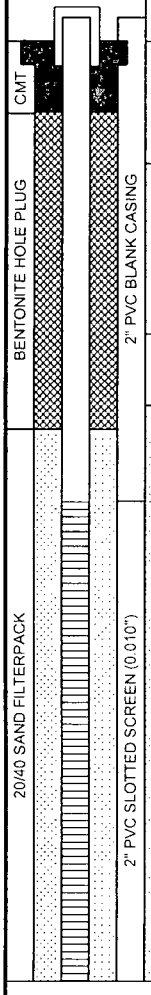
TD = 27 Feet

LITHOLOGIC LOG (MONITORING WELL)

R T Hicks Consultants Ltd

P O Box 7624
Midland, TX 79708
(432) 528-3878

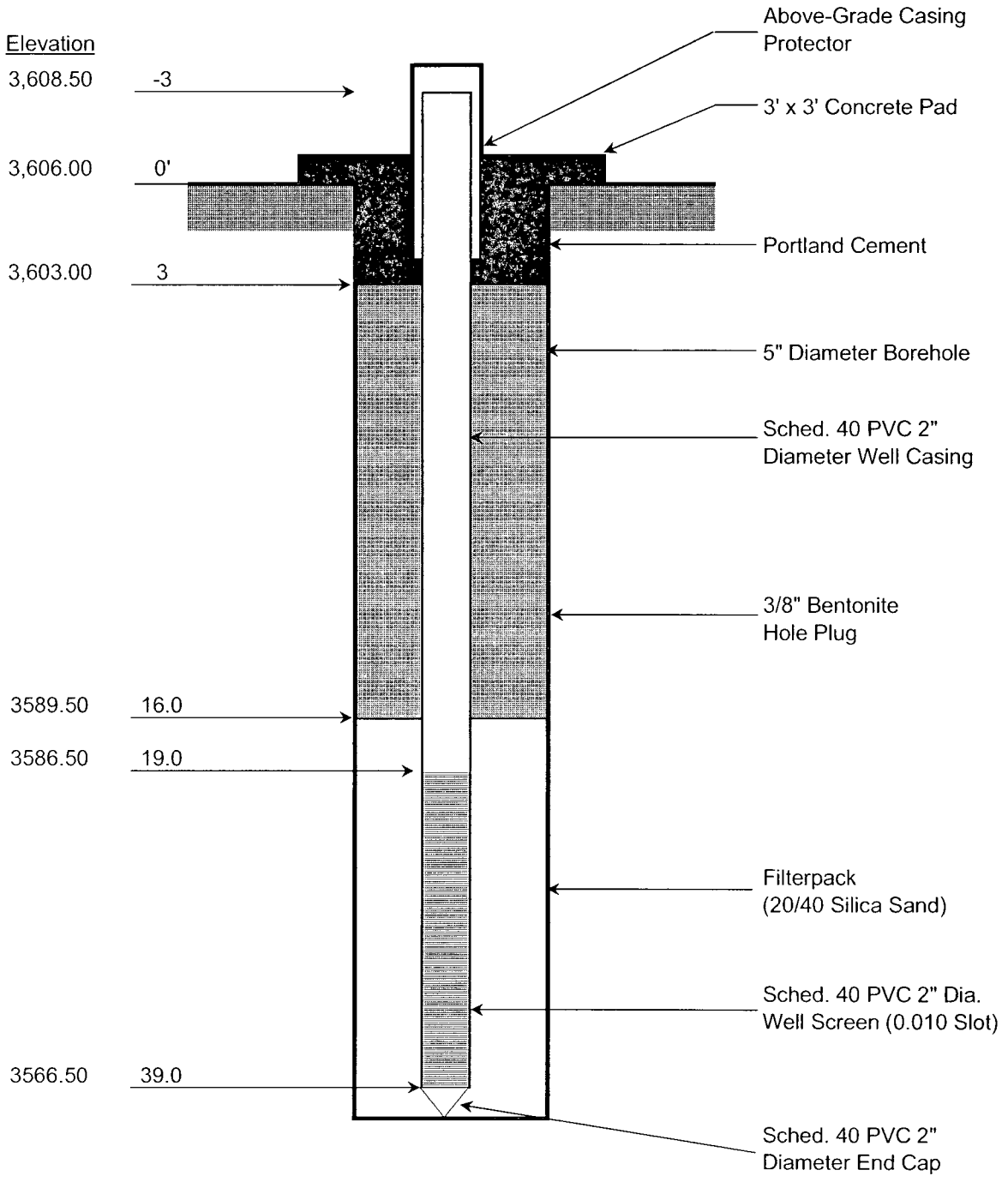
MONITOR WELL NO.:	MW-1	TOTAL DEPTH:	39 Ft
SITE ID:	Hobbs SWD M-4 Vent	CLIENT:	Rice Operating Company
SURFACE ELEVATION:	3,606 (USGS MAP)	COUNTY:	Lea County
CONTRACTOR:	Harrison & Cooper, Inc.	STATE:	New Mexico
DRILLING METHOD:	Air-Rotary	LOCATION:	T-19-S, R-38-E, Sec. 4 (M)
INSTALLATION DATE:	2/19/08	FIELD REP.:	Dale Littlejohn
WELL PLACEMENT:	Southeast of source area	FILE NAME:	\Hobbs SWD\M-4 Lithlogs
COMMENTS:	Lat. 32° 41' 7.2" North, Long. 103° 9' 37.6" West (Hand-Held GPS)		



Lithology	SAMPLE DATA (PPM)					DEPTH	LITHOLOGIC DESCRIPTION: LITHOLOGY, COLOR, GRAIN SIZE SORTING, ROUNDING, CONSOL., DIST. DEATURES
	TYPE	DEPTH	% REC	PID	Cl (Fld)		
							SILT Dark brown, asphaltic (hydrocarbon) layer at surface.
						5	
	spoon	10-11	10%	2.2	317	10	CALICHE Grayish white to grayish brown, hard drilling.
						15	CALICHE AND SILT Light reddish brown.
	spoon	15-17	60%	1.5	179	20	SAND Brown to reddish brown, medium grain, sub-rounded, well sorted.
	spoon	20-22	80%	1.3	148	25	Thin gravel zone at 21 to 23 feet
	spoon	25-27	80%	1.5	141	30	Saturated Formation
						35	

TD = 39 Feet

MONITORING WELL CONSTRUCTION DIAGRAM



R T Hicks Consultants Ltd	SITE: Hobbs SWD M-4 Vent		**Monitoring Well No. MW-1**
	DATE: 2/19/2008	REV. NO.: 1	
	AUTHOR: DTL	TECH: DTL	
	DRILLER: H & C, Inc	FILE: M-4 Lithlogs	

Analytical Report 298153

for

Rice Operating Co.

Project Manager: Kristin Pope

Hobbs SWD M-4 Vent

Hobbs SWD System

28-FEB-08

12600 West I-20 East Odessa, Texas 79765

Texas certification numbers:
Houston, TX T104704215

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 - Austin - Tampa - Miami - Latin America
Midland - Corpus Christi - Atlanta

28-FEB-08

Project Manager: **Kristin Pope**
Rice Operating Co.
122 West Taylor
Hobbs, NM 88240

Reference: XENCO Report No: **298153**
Hobbs SWD M-4 Vent
Project Address: T19S, R38E, Sec 4, Unit Letter M

Kristin Pope:

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 298153. 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. 298153 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

Sample Cross Reference 298153

Rice Operating Co., Hobbs, NM

Hobbs SWD M-4 Vent

Sample Id	Matrix	Date Collected	Sample Depth	Lab Sample Id
SB-1	S	Feb-19-08 09:14	15 - 17 ft	298153-001
SB-1	S	Feb-19-08 09:31	25 - 27 ft	298153-002
SB-2	S	Feb-21-08 11:51	15 - 17 ft	298153-003
SB-2	S	Feb-21-08 11:56	20 - 22 ft	298153-004
SB-2	S	Feb-21-08 12:05	25 - 27 ft	298153-005

Certificate of Analysis Summary 298153
Rice Operating Co., Hobbs, NM

Project Name: Hobbs SWD M-4 Vent

Project Id: Hobbs SWD System
Contact: Kristin Pope
Project Location: T19S, R38E, Sec 4, Unit Letter M

Date Received in Lab: Feb-22-08 10:20 am
Report Date: 28-FEB-08
Project Manager: Brent Barron, II

Analysis Requested									
	Lab Id:	298153-001		298153-002		298153-003		298153-004	
	Field Id:	SB-1		SB-1		SB-2		SB-2	
	Depth:	15-17 ft		25-27 ft		15-17 ft		20-22 ft	
	Matrix:	SOIL		SOIL		SOIL		SOIL	
	Sampled:	Feb-19-08 09:14		Feb-19-08 09:31		Feb-21-08 11:51		Feb-21-08 11:56	
Anions by EPA 300/300.1	*Extracted:*								
	Analyzed:	Feb-23-08 10:52		Feb-23-08 10:52		Feb-23-08 10:52		Feb-23-08 10:52	
	Units/RL:	mg/kg	RL	mg/kg	RL	mg/kg	RL	mg/kg	RL
Chloride		1760	22.8	14.3	6.14	47.4	5.44	1520	21.6
BTEX by SW 8260B	*Extracted:*	Feb-26-08 10:25		Feb-26-08 11:35		Feb-27-08 10:30		Feb-26-08 11:39	
	Analyzed:	Feb-26-08 11:31		Feb-26-08 12:58		Feb-27-08 10:51		Feb-26-08 13:42	
	Units/RL:	mg/kg	RL	mg/kg	RL	mg/kg	RL	mg/kg	RL
Benzene		ND	0.0056	ND	0.0061	ND	0.0054	ND	0.0054
Toluene		0.0057	0.0056	ND	0.0061	0.0084	0.0054	ND	0.0054
Ethylbenzene		ND	0.0056	ND	0.0061	0.0978	0.0054	ND	0.0054
m,p-Xylenes		ND	0.0113	ND	0.0122	0.0754	0.0109	ND	0.0109
o-Xylene		ND	0.0056	ND	0.0061	0.0147	0.0054	ND	0.0054
Naphthalene		ND	0.056	ND	0.061	0.245	0.054	ND	0.055
Total BTEX		0.0057		ND		0.1963		ND	
Total Xylenes		ND		ND		0.0901		ND	
Percent Moisture	*Extracted:*								
	Analyzed:	Feb-23-08 17:00		Feb-23-08 17:00		Feb-23-08 17:00		Feb-23-08 17:00	
	Units/RL:	%	RL	%	RL	%	RL	%	RL
Percent Moisture		12.2		18.6		8.14		7.29	
TPH by SW8015 Mod	*Extracted:*					Feb-22-08 15:41			
	Analyzed:					Feb-23-08 01:05			
	Units/RL:					mg/kg	RL		
C6-C12 Gasoline Range Hydrocarbons						226	81.6		
C12-C28 Diesel Range Hydrocarbons						1320	81.6		
C28-C35 Oil Range Hydrocarbons						269	81.6		
Total TPH						1815			

Brent Barron
Odessa Laboratory Director

Certificate of Analysis Summary 298153
Rice Operating Co., Hobbs, NM

Project Name: Hobbs SWD M-4 Vent

Project Id: Hobbs SWD System
Contact: Kristin Pope
Project Location: T19S, R38E, Sec 4, Unit Letter M

Date Received in Lab: Feb-22-08 10:20 am
Report Date: 28-FEB-08
Project Manager: Brent Barron, II

Analysis Requested						
	Lab Id:	298153-005				
	Field Id:	SB-2				
	Depth:	25-27 ft				
	Matrix:	SOIL				
	Sampled:	Feb-21-08 12:05				
Anions by EPA 300/300.1	*Extracted:*					
	Analyzed:	Feb-23-08 10:52				
	Units/RL:	mg/kg	RL			
Chloride		558	10.8			
BTEX by SW 8260B	*Extracted:*	Feb-26-08 11:41				
	Analyzed:	Feb-26-08 14:03				
	Units/RL:	mg/kg	RL			
Benzene		ND	0.0053			
Toluene		ND	0.0053			
Ethylbenzene		ND	0.0053			
m,p-Xylenes		ND	0.0107			
o-Xylene		ND	0.0053			
Naphthalene		0.083	0.053			
Total BTEX		ND				
Total Xylenes		ND				
Percent Moisture	*Extracted:*					
	Analyzed:	Feb-23-08 17:00				
	Units/RL:	%	RL			
Percent Moisture		7.27				

Brent Barron
Odessa Laboratory Director

Flagging Criteria

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(PQL) and above the SQL(MDL).

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.

* Outside XENCO'S scope of NELAC Accreditation

Form 2 - Surrogate Recoveries

Project Name: Hobbs SWD M-4 Vent

Work Order #: 298153 **Project ID:** Hobbs SWD System

Lab Batch #: 715676 **Sample:** 298153-001 / SMP **Batch:** 1 **Matrix:** Soil

Units: mg/kg

BTEX by SW 8260B Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
4-Bromofluorobenzene	0.0485	0.0500	97	74-121	
Dibromofluoromethane	0.0491	0.0500	98	80-120	
1,2-Dichloroethane-D4	0.0490	0.0500	98	80-120	
Toluene-D8	0.0485	0.0500	97	81-117	

Lab Batch #: 715676 **Sample:** 298153-001 S / MS **Batch:** 1 **Matrix:** Soil

Units: mg/kg

BTEX by SW 8260B Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
4-Bromofluorobenzene	0.0569	0.0500	114	74-121	
Dibromofluoromethane	0.0526	0.0500	105	80-120	
1,2-Dichloroethane-D4	0.0485	0.0500	97	80-120	
Toluene-D8	0.0498	0.0500	100	81-117	

Lab Batch #: 715676 **Sample:** 298153-001 SD / MSD **Batch:** 1 **Matrix:** Soil

Units: mg/kg

BTEX by SW 8260B Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
4-Bromofluorobenzene	0.0502	0.0500	100	74-121	
Dibromofluoromethane	0.0504	0.0500	101	80-120	
1,2-Dichloroethane-D4	0.0494	0.0500	99	80-120	
Toluene-D8	0.0494	0.0500	99	81-117	

Lab Batch #: 715676 **Sample:** 298153-002 / SMP **Batch:** 1 **Matrix:** Soil

Units: mg/kg

BTEX by SW 8260B Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
4-Bromofluorobenzene	0.0480	0.0500	96	74-121	
Dibromofluoromethane	0.0489	0.0500	98	80-120	
1,2-Dichloroethane-D4	0.0469	0.0500	94	80-120	
Toluene-D8	0.0466	0.0500	93	81-117	

** Surrogates outside limits; data and surrogates confirmed by reanalysis

*** Poor recoveries due to dilution

Surrogate Recovery [D] = 100 * A / B

All results are based on MDL and validated for QC purposes.

Form 2 - Surrogate Recoveries

Project Name: Hobbs SWD M-4 Vent

Work Order #: 298153 **Project ID:** Hobbs SWD System

Lab Batch #: 715676 **Sample:** 298153-004 / SMP **Batch:** 1 **Matrix:** Soil

Units: mg/kg

BTEX by SW 8260B Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
4-Bromofluorobenzene	0.0514	0.0500	103	74-121	
Dibromofluoromethane	0.0520	0.0500	104	80-120	
1,2-Dichloroethane-D4	0.0526	0.0500	105	80-120	
Toluene-D8	0.0466	0.0500	93	81-117	

Lab Batch #: 715676 **Sample:** 298153-005 / SMP **Batch:** 1 **Matrix:** Soil

Units: mg/kg

BTEX by SW 8260B Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
4-Bromofluorobenzene	0.0540	0.0500	108	74-121	
Dibromofluoromethane	0.0514	0.0500	103	80-120	
1,2-Dichloroethane-D4	0.0529	0.0500	106	80-120	
Toluene-D8	0.0487	0.0500	97	81-117	

Lab Batch #: 715676 **Sample:** 505147-1-BKS / BKS **Batch:** 1 **Matrix:** Solid

Units: mg/kg

BTEX by SW 8260B Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
4-Bromofluorobenzene	0.0528	0.0500	106	74-121	
Dibromofluoromethane	0.0505	0.0500	101	80-120	
1,2-Dichloroethane-D4	0.0495	0.0500	99	80-120	
Toluene-D8	0.0485	0.0500	97	81-117	

Lab Batch #: 715676 **Sample:** 505147-1-BLK / BLK **Batch:** 1 **Matrix:** Solid

Units: mg/kg

BTEX by SW 8260B Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
4-Bromofluorobenzene	0.0507	0.0500	101	74-121	
Dibromofluoromethane	0.0498	0.0500	100	80-120	
1,2-Dichloroethane-D4	0.0461	0.0500	92	80-120	
Toluene-D8	0.0479	0.0500	96	81-117	

** Surrogates outside limits; data and surrogates confirmed by reanalysis

*** Poor recoveries due to dilution

Surrogate Recovery [D] = 100 * A / B

All results are based on MDL and validated for QC purposes.

Form 2 - Surrogate Recoveries

Project Name: Hobbs SWD M-4 Vent

Work Order #: 298153 **Project ID:** Hobbs SWD System

Lab Batch #: 715681 **Sample:** 298147-004 S / MS **Batch:** 1 **Matrix:** Soil

Units: mg/kg

BTEX by SW 8260B Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
4-Bromofluorobenzene	0.0692	0.0500	138	74-121	**
Dibromofluoromethane	0.0510	0.0500	102	80-120	
1,2-Dichloroethane-D4	0.0435	0.0500	87	80-120	
Toluene-D8	0.0688	0.0500	138	81-117	**

Lab Batch #: 715681 **Sample:** 298147-004 SD / MSD **Batch:** 1 **Matrix:** Soil

Units: mg/kg

BTEX by SW 8260B Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
4-Bromofluorobenzene	0.0604	0.0500	121	74-121	
Dibromofluoromethane	0.0498	0.0500	100	80-120	
1,2-Dichloroethane-D4	0.0492	0.0500	98	80-120	
Toluene-D8	0.0661	0.0500	132	81-117	**

Lab Batch #: 715681 **Sample:** 298153-003 / SMP **Batch:** 1 **Matrix:** Soil

Units: mg/kg

BTEX by SW 8260B Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
4-Bromofluorobenzene	0.0635	0.0500	127	74-121	**
Dibromofluoromethane	0.0541	0.0500	108	80-120	
1,2-Dichloroethane-D4	0.0507	0.0500	101	80-120	
Toluene-D8	0.0550	0.0500	110	81-117	

Lab Batch #: 715681 **Sample:** 505161-1-BKS / BKS **Batch:** 1 **Matrix:** Solid

Units: mg/kg

BTEX by SW 8260B Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
4-Bromofluorobenzene	0.0515	0.0500	103	74-121	
Dibromofluoromethane	0.0490	0.0500	98	80-120	
1,2-Dichloroethane-D4	0.0481	0.0500	96	80-120	
Toluene-D8	0.0513	0.0500	103	81-117	

** Surrogates outside limits; data and surrogates confirmed by reanalysis

*** Poor recoveries due to dilution

Surrogate Recovery [D] = 100 * A / B

All results are based on MDL and validated for QC purposes.

Form 2 - Surrogate Recoveries

Project Name: Hobbs SWD M-4 Vent

Work Order #: 298153 **Project ID:** Hobbs SWD System

Lab Batch #: 715681 **Sample:** 505161-1-BLK / BLK **Batch:** 1 **Matrix:** Solid

Units: mg/kg

BTEX by SW 8260B Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
4-Bromofluorobenzene	0.0487	0.0500	97	74-121	
Dibromofluoromethane	0.0505	0.0500	101	80-120	
1,2-Dichloroethane-D4	0.0488	0.0500	98	80-120	
Toluene-D8	0.0519	0.0500	104	81-117	

Lab Batch #: 715557 **Sample:** 298153-003 / SMP **Batch:** 1 **Matrix:** Soil

Units: mg/kg

TPH by SW8015 Mod Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
1-Chlorooctane	97.0	100	97	70-135	
o-Terphenyl	53.2	50.0	106	70-135	

Lab Batch #: 715557 **Sample:** 298159-001 S / MS **Batch:** 1 **Matrix:** Soil

Units: mg/kg

TPH by SW8015 Mod Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
1-Chlorooctane	107	100	107	70-135	
o-Terphenyl	49.3	50.0	99	70-135	

Lab Batch #: 715557 **Sample:** 298159-001 SD / MSD **Batch:** 1 **Matrix:** Soil

Units: mg/kg

TPH by SW8015 Mod Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
1-Chlorooctane	112	100	112	70-135	
o-Terphenyl	51.0	50.0	102	70-135	

** Surrogates outside limits; data and surrogates confirmed by reanalysis

*** Poor recoveries due to dilution

Surrogate Recovery [D] = 100 * A / B

All results are based on MDL and validated for QC purposes.

Form 2 - Surrogate Recoveries

Project Name: Hobbs SWD M-4 Vent

Work Order #: 298153 **Project ID:** Hobbs SWD System

Lab Batch #: 715557 **Sample:** 505061-1-BKS / BKS **Batch:** 1 **Matrix:** Solid

Units: mg/kg

TPH by SW8015 Mod Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
1-Chlorooctane	107	100	107	70-135	
o-Terphenyl	49.3	50.0	99	70-135	

Lab Batch #: 715557 **Sample:** 505061-1-BLK / BLK **Batch:** 1 **Matrix:** Solid

Units: mg/kg

TPH by SW8015 Mod Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
1-Chlorooctane	96.1	100	96	70-135	
o-Terphenyl	52.0	50.0	104	70-135	

Lab Batch #: 715557 **Sample:** 505061-1-BSD / BSD **Batch:** 1 **Matrix:** Solid

Units: mg/kg

TPH by SW8015 Mod Analytes	SURROGATE RECOVERY STUDY Amount Found [A]	True Amount [B]	Recovery %R [D]	Control Limits %R	Flags
1-Chlorooctane	107	100	107	70-135	
o-Terphenyl	48.5	50.0	97	70-135	

** Surrogates outside limits; data and surrogates confirmed by reanalysis

*** Poor recoveries due to dilution

Surrogate Recovery [D] = 100 * A / B

All results are based on MDL and validated for QC purposes.

Blank Spike Recovery

Project Name: Hobbs SWD M-4 Vent

Work Order #: 298153 **Project ID:** Hobbs SWD System

Lab Batch #: 715676 **Sample:** 505147-1-BKS **Matrix:** Solid
Date Analyzed: 02/26/2008 **Date Prepared:** 02/26/2008 **Analyst:** KHM
Reporting Units: mg/kg **Batch #:** 1

BTEX by SW 8260B Analytes	Blank Result [A]	BLANK /BLANK SPIKE RECOVERY STUDY Spike Added [B]	Blank Spike Result [C]	Blank Spike %R [D]	Control Limits %R	Flags
Benzene	ND	0.0500	0.0486	97	66-142	
Toluene	ND	0.0500	0.0504	101	59-139	
Ethylbenzene	ND	0.0500	0.0462	92	75-125	
m,p-Xylenes	ND	0.1000	0.0957	96	75-125	
o-Xylene	ND	0.0500	0.0476	95	75-125	

Lab Batch #: 715681 **Sample:** 505161-1-BKS **Matrix:** Solid
Date Analyzed: 02/27/2008 **Date Prepared:** 02/27/2008 **Analyst:** WEW
Reporting Units: mg/kg **Batch #:** 1

BTEX by SW 8260B Analytes	Blank Result [A]	BLANK /BLANK SPIKE RECOVERY STUDY Spike Added [B]	Blank Spike Result [C]	Blank Spike %R [D]	Control Limits %R	Flags
Benzene	ND	0.0500	0.0477	95	66-142	
Toluene	0.0012	0.0500	0.0507	101	59-139	
Ethylbenzene	ND	0.0500	0.0478	96	75-125	
m,p-Xylenes	ND	0.1000	0.0970	97	75-125	
o-Xylene	ND	0.0500	0.0420	84	75-125	

Lab Batch #: 715578 **Sample:** 715578-1-BKS **Matrix:** Solid
Date Analyzed: 02/23/2008 **Date Prepared:** 02/23/2008 **Analyst:** IRO
Reporting Units: mg/kg **Batch #:** 1

Anions by EPA 300/300.1 Analytes	Blank Result [A]	BLANK /BLANK SPIKE RECOVERY STUDY Spike Added [B]	Blank Spike Result [C]	Blank Spike %R [D]	Control Limits %R	Flags
Chloride	ND	10.0	9.95	100	75-125	

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

BS / BSD Recoveries

Project Name: Hobbs SWD M-4 Vent

Work Order #: 298153
Analyst: SHE
Lab Batch ID: 715557
Sample: 505061-1-BKS
Units: mg/kg

Date Prepared: 02/22/2008
Batch #: 1

Project ID: Hobbs SWD System
Date Analyzed: 02/22/2008
Matrix: Solid

BLANK /BLANK SPIKE / BLANK SPIKE DUPLICATE RECOVERY STUDY

TPH by SW8015 Mod Analytes	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	Control Limits %RPD	Flag
C6-C12 Gasoline Range Hydrocarbons	ND	1000	887	89	1000	892	89	1	70-135	35	
C12-C28 Diesel Range Hydrocarbons	ND	1000	824	82	1000	829	83	1	70-135	35	

Relative Percent Difference RPD = 200*|(D-F)/(D+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

Form 3 - MS Recoveries

Project Name: Hobbs SWD M-4 Vent

Work Order #: 298153
Lab Batch #: 715578
Date Analyzed: 02/23/2008
QC- Sample ID: 298134-001 S
Reporting Units: mg/kg

Date Prepared: 02/23/2008
Batch #: 1

Project ID: Hobbs SWD System
Analyst: IRO
Matrix: Soil

Inorganic Anions by EPA 300	MATRIX / MATRIX SPIKE RECOVERY STUDY					
Analytes	Parent Sample Result [A]	Spike Added [B]	Spiked Sample Result [C]	%R [D]	Control Limits %R	Flag
Chloride	987	210	1120	63	75-125	X

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

Form 3 - MS / MSD Recoveries

Project Name: Hobbs SWD M-4 Vent

Work Order # : 298153 **Project ID:** Hobbs SWD System

Lab Batch ID: 715676 **QC- Sample ID:** 298153-001 S **Batch #:** 1 **Matrix:** Soil

Date Analyzed: 02/26/2008 **Date Prepared:** 02/26/2008 **Analyst:** KHM

Reporting Units: mg/kg

BTEX by SW 8260B Analytes	MATRIX SPIKE / MATRIX SPIKE DUPLICATE RECOVERY STUDY										
	Parent Sample Result [A]	Spike Added [B]	Spiked Sample Result [C]	Spiked Sample %R [D]	Spike Added [E]	Duplicate Spiked Sample Result [F]	Spiked Dup. %R [G]	RPD %	Control Limits %R	Control Limits %RPD	Flag
Benzene	ND	0.2904	0.2849	98	0.2846	0.2811	99	1	66-142	25	
Toluene	0.0057	0.2904	0.2904	98	0.2846	0.2847	98	0	59-139	25	
Ethylbenzene	ND	0.2904	0.2846	98	0.2846	0.2783	98	0	75-125	25	
m,p-Xylenes	ND	0.5808	0.5793	100	0.5692	0.5433	95	5	75-125	25	
o-Xylene	ND	0.2904	0.2833	98	0.2846	0.2709	95	3	75-125	25	

Lab Batch ID: 715681 **QC- Sample ID:** 298147-004 S **Batch #:** 1 **Matrix:** Soil

Date Analyzed: 02/27/2008 **Date Prepared:** 02/27/2008 **Analyst:** WEW

Reporting Units: mg/kg

BTEX by SW 8260B Analytes	MATRIX SPIKE / MATRIX SPIKE DUPLICATE RECOVERY STUDY										
	Parent Sample Result [A]	Spike Added [B]	Spiked Sample Result [C]	Spiked Sample %R [D]	Spike Added [E]	Duplicate Spiked Sample Result [F]	Spiked Dup. %R [G]	RPD %	Control Limits %R	Control Limits %RPD	Flag
Benzene	0.0066	0.2897	0.2909	98	0.2897	0.3072	104	6	66-142	25	
Toluene	0.9707	0.2897	1.513	187	0.2897	1.104	46	121	59-139	25	XF
Ethylbenzene	2.324	0.2897	2.981	227	0.2897	2.273	0	200	75-125	25	XF
m,p-Xylenes	5.129	0.5794	6.316	205	0.5794	4.928	0	200	75-125	25	XF
o-Xylene	1.703	0.2897	2.135	149	0.2897	1.688	0	200	75-125	25	XF

Matrix Spike Percent Recovery [D] = 100*(C-A)/B
Relative Percent Difference RPD = 200*(D-G)/(D+G)

Matrix Spike Duplicate Percent Recovery [G] = 100*(F-A)/E

ND = Not Detected, J = Present Below Reporting Limit, B = Present in Blank, NR = Not Requested, I = Interference, NA = Not ApplicableN = See Narrative, EQL = Estimated Quantitation Limit

Form 3 - MS / MSD Recoveries

Project Name: Hobbs SWD M-4 Vent

Work Order # : 298153 **Project ID:** Hobbs SWD System

Lab Batch ID: 715557 **QC- Sample ID:** 298159-001 S **Batch #:** 1 **Matrix:** Soil

Date Analyzed: 02/23/2008 **Date Prepared:** 02/22/2008 **Analyst:** SHE

Reporting Units: mg/kg

	MATRIX SPIKE / MATRIX SPIKE DUPLICATE RECOVERY STUDY										
TPH by SW8015 Mod **Analytes**	**Parent Sample Result [A]**	**Spike Added [B]**	**Spiked Sample Result [C]**	**Spiked Sample %R [D]**	**Spike Added [E]**	**Duplicate Spiked Sample Result [F]**	**Spiked Dup. %R [G]**	**RPD %**	**Control Limits %R**	**Control Limits %RPD**	**Flag**
C6-C12 Gasoline Range Hydrocarbons	ND	1140	1020	89	1140	1040	91	2	70-135	35	
C12-C28 Diesel Range Hydrocarbons	110	1140	983	77	1140	1000	78	1	70-135	35	

Matrix Spike Percent Recovery [D] = 100*(C-A)/B
Relative Percent Difference RPD = 200*(D-G)/(D+G)

Matrix Spike Duplicate Percent Recovery [G] = 100*(F-A)/E

ND = Not Detected, J = Present Below Reporting Limit, B = Present in Blank, NR = Not Requested, I = Interference, NA = Not ApplicableN = See Narrative, EQL = Estimated Quantitation Limit

Sample Duplicate Recovery

Project Name: Hobbs SWD M-4 Vent

Work Order #: 298153

Lab Batch #: 715578 **Project ID:** Hobbs SWD System

Date Analyzed: 02/23/2008 **Date Prepared:** 02/23/2008 **Analyst:** IRO

QC- Sample ID: 298134-001 D **Batch #:** 1 **Matrix:** Soil

Reporting Units: mg/kg

Anions by EPA 300/300.1	SAMPLE / SAMPLE DUPLICATE RECOVERY				
Analyte	Parent Sample Result [A]	Sample Duplicate Result [B]	RPD	Control Limits %RPD	Flag
Chloride	987	991	0	20	

Lab Batch #: 715411

Date Analyzed: 02/23/2008 **Date Prepared:** 02/23/2008 **Analyst:** WRU

QC- Sample ID: 298133-001 D **Batch #:** 1 **Matrix:** Sludge

Reporting Units: %

Percent Moisture	SAMPLE / SAMPLE DUPLICATE RECOVERY				
Analyte	Parent Sample Result [A]	Sample Duplicate Result [B]	RPD	Control Limits %RPD	Flag
Percent Moisture	45.6	45.7	0	20	

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

Environmental Lab of Texas

12600 West I-20 East
Odessa, Texas 79765
Phone: 432-563-1800
Fax: 432-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Kristin Farris
Company Name: Rice Operating Company
Company Address: 122 West Taylor
City/State/Zip: Hobbs, New Mexico 88240
Telephone No: 505-393-9174 Fax No: 505-397-1471
Email results to: dale@rthicksconsult.com, Lweinheimer@riceswd.com,and kpope@riceswd.com
Sampler Signature: Dale Littlejohn

Project Name: Hobbs SWD M-4 Vent
Project #: Hobbs SWD System
Project Location: T19S, R38E, Sec 4, Unit Letter M
ROC Billing Code

LAB # (lab use only)	GIS CODE	FIELD CODE	Sample Depth (soils only) Begin (ft)	End (ft)	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify)	Analyze For: TCLP: / TOTAL: GRO/DRO (EPA 8015M)	Cations (Ca, Mg, Na, K)	Anions (Cl, SO4, CO3, HCO3)	SAR / ESP / CEC	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX-N (EPA 8260)	RCI	N.O.R.M.	Total Dissolved Solids	Chloride	Moisture Percent		RUSH TAT (Pre-Schedule)	Standard TAT
298153			Begin (ft)	End (ft)																													
-01		SB-1	15.0	17.0	2/19/08	0914	1	X									X								X			X				X
-02		SB-1	25.0	27.0	2/19/08	0931	1	X									X								X			X				X
-03		SB-2	15.0	17.0	2/21/08	1151	1	X									X		X						X			X				X
-04		SB-2	20.0	22.0	2/21/08	1156	1	X									X								X			X				X
-05		SB-2	25.0	27.0	2/21/08	1205	1	X									X								X			X				X

Special Instructior

Sample Containers Intact? Y N
Temperature Upon Receipt: -2.0
Laboratory Comments:

Relinquished by:	Date	Time	Received by:	Date	Time
Dale Littlejohn	2/22/08	10:20			
Relinquished by:	Date	Time	Received by ELOT:	Date	Time
			Andrea Law	2.22.08	10:20

4 oz glass w/seal on cooler

Environmental Lab of Texas

Variance/ Corrective Action Report- Sample Log-In

Client: Rice

Date/ Time: 2.22.08 10:20

Lab ID # : 298153

Initials: AL

Sample Receipt Checklist

					Client Initials
#1	Temperature of container/ cooler?	Yes	No	-2.0 °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?	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?	Yes	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

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

Appendix D

HYDRUS-1D Model

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104

R. T. HICKS CONSULTANTS, LTD.
901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

Appendix D- HYDRUS-1D Model for M-4 Vent Site

To simulate the effects of the release at the M-4 Vent site, the gravity-driven vertical water flow through the vadose zone is simulated using HYDRUS-1D. The resultant chloride flux to ground water is used as input to a simple ground water mixing model. The output of the mixing model is a predicted chloride concentration in ground water at the down gradient edge of the affected area as would be observed in a monitoring well at this location.

HYDRUS-1D numerically solves the Richard's equation for water flow and the Fickian-based advection-dispersion equation for heat and solute transportation. The HYDRUS-1D flow equation includes a sink term (a term used to specify water leaving the system) to account for transpiration by plants. The solute transport equation can consider advective, dispersive transport in the liquid phase, diffusion in the gaseous phase, nonlinear and non-equilibrium sorption, linear equilibrium reactions between the liquid and gaseous phases, zero-order production, and first-order degradation. Because chloride is a conservative tracer (i.e. this ion neither mineralizes, volatilizes nor degrades over time), only advective and dispersive transport are considered in this simulation.

The ground water mixing model uses the chloride flux from the vadose zone to ground water provided by HYDRUS-1D and instantaneously mixes this chloride and water with the ground water flux of chloride plus water that enters the mixing cell beneath the subject site. We refer the reader to API Publication 4734, Modeling Study of Produced Water Release Scenarios (Hendrickx and others, 2005) for a general description of the techniques employed for this simulation experiment.

A description of the model input parameters are listed below.

HYDRUS 1-D INPUTS

Soil Profile - The HYDRUS 1-D soil profile was chosen to be conservative of ground water quality by choice of materials having hydraulic conductivities greater than or equal to those observed during the boring of SB-1, SB-2 and MW-1 at the site. A vadose zone depth of 27 feet was used from the boring log of MW-1.

Dispersion lengths - Standard practice calls for employing a dispersion length that is 10% of the model length and was used in this simulation.

Climate – Weather data used in calculation of the initial condition and the predictive modeling was from the Pearl, New Mexico weather station, about 15 miles west of the site. This station is the closest station to the proposed study area for which the necessary HYDRUS-1D input file exists. Climate on the eastern plains of New Mexico is similar enough that this was considered an acceptable choice. The weather data spans the 46. 5 year period from July, 1946 to December, 1992.

HYDRUS-1D can also employ a uniform yearly infiltration rate that will obviously smooth the temporal variations. Because the atmospheric data are of high quality, we have elected to allow HYDRUS-1D to predict the deep percolation rate and the resultant variable flux to ground water. This choice results in higher predicted peak chloride concentrations in ground

water due to temporally variable high fluxes from the vadose zone than would be predicted by an averaged infiltration rate. As such, this choice is conservative of ground water quality.

Soil Moisture - Because soils are relatively dry in this climate and vadose zone hydraulic conductivity varies with moisture content, it is important that simulations are started with representative soil moisture content. Commonly, the calculation of soil moisture content begins with using professional judgment as an initial input and then running sufficient years of weather data through the model to establish a "steady state" moisture content. For this simulation, only minimal changes in the HYDRUS-1D soil moisture content profile occurred after year 20 of the initial condition calculation. Therefore, 46.5 years (1 cycle of the weather data) was considered sufficient to establish an initial moisture condition.

No vegetation was assumed to exist at the site for this initial condition calculation. This choice is conservative of ground water quality as it results in a "wetter" soil profile with consequently higher hydraulic conductivities in the vadose zone.

Initial Chloride Profile – For simulation of the remedy, the vadose zone chloride concentration profiles from SB-1, SB-2, and the excavation of the M-4 vent site were averaged to produce a vadose zone chloride profile representative of conditions below the site. Laboratory chloride measurements were used in place of field chloride measurements when both existed for the same location. This chloride concentration profile was used in the Hydrus 1-D prediction of vadose zone chloride migration into ground water

MIXING MODEL INPUTS

As described in API Publication 4734, the ground water mixing model takes the background chloride concentration in ground water multiplied by the ground water flux to calculate the total mass of ground water chloride entering the ground water mixing cell, which lies below the area of interest. The chloride and water flux from HYDRUS-1D is added to the ground water chloride mass and flux to create a final chloride concentration in ground water at an imaginary monitoring well located at the down gradient edge of the mixing cell (the edge of the release site).

Influence Distance - The influence distance is defined as the maximal length of the release parallel to groundwater flow direction. As the exact direction of ground water flow is not known, this dimension was taken as 30 feet for the M-4 vent site.

Background Chloride Concentration – A 0.0 mg/L chloride concentration was used as the concentration of chloride in ground water at this location to allow the model to show only the chloride impact to ground water of this site.

Hydraulic Conductivity - Site-specific values for hydraulic conductivity of the Ogallala Formation range between 0.5 ft/day to 100 ft/day based on published information (Nicholson and Clebsch, 1961; Ash, 1963; McAda and Hart, 1985; Secor, 1995; and Musharrafieh and Chudnoff, 1999). Most recently, Musharrafieh and Chudnoff used values of 80 ft/day to 100 ft/day for the Ogallala Aquifer for the M-4 site area. To be conservative of ground water quality, we used a value of 75 ft/day for the portion of the saturated zone most likely impacted by the release.

Groundwater Gradient - A potentiometric surface map created using 2006 ROC monitoring wells about one-mile north of the area shows ground water flowing in an east-southeast direction with a hydraulic gradient of approximately 0.0028 ft/ft. Local

topography around the M-4 vent site has a gradient of 0.0045 ft/ft. To be conservative of ground water quality, the lower value of 0.0028 ft/ft was used. The resulting ground water flux is about 0.21 feet/day (6.4 cm/day).

Aquifer Thickness - An aquifer thickness 20 feet was employed in the mixing model to simulate a well at the down gradient edge of the site.

For all variables for which field data did not exist, assumptions conservative of ground water quality were made. A summary of the input parameters and a description of the source information used in the HYDRUS-1D model for this application are provided in Table 1 below.

Table 1: Input Data for Simulation

Input Parameter	Source
Vadose Zone Thickness - 27 feet	From MW-1 at the site
Vadose Zone Texture	SB-1, SB-2, and MW-1 Well Log with conservative assumptions
Dispersion Length - 10% of model length	Standard Modeling Practice
Climate	Pearl Weather Station Data, 46 years
Soil Moisture	HYDRUS-1D initial condition simulation
Initial soil chloride concentration profile	Field and Laboratory Measurements from the Excavation, SB-1, and SB-2
Length of release parallel to ground water flow 30 feet	Maximum Diameter of the effected site
Background Chloride in Ground Water - 0 ppm	Shows solely the chloride impact to ground water of the M-4 site
Ground Water Flux - 0.02 feet/day	Calculated from published data and nearby wells
Aquifer Thickness - 20-feet	Conservative Assumption

RESULTS OF REMEDY MODELING

The selected vadose zone remedy is:

A. Grading the site to create a 3-5% slope
B. Creation of a ponding area where precipitation shed from the sloped surface can accumulate over an area that is not impacted by past leakage from the vent
C. Importation of clean silty-loam topsoil to place over the prepared surface
D. Re-vegetation with a seed mixture acceptable to the landowner

To simulate this remedy:

- The vadose zone profile for the site was first constructed and an initial condition was calculated. This moisture content profile was installed in the model's soil profile.

- To simulate the installation of the cap, the upper two-feet of the vadose zone were removed and replaced with a silt-loam given a volumetric moisture content of 0.15 (volume of water/total volume of soil). This moisture content is higher than average

moisture contents soils in southeastern New Mexico and is therefore a conservative assumption.

  - Vegetation was allowed to root within this soil layer after 5 years. This time was chosen to be conservative of ground water quality.
  - Surface ponding was not allowed to simulate the sloped cap.

- The averaged chloride profile was installed in the model's soil profile.

Figure 1 shows the water flux from the vadose zone to ground water with the ET cap installed as discussed above. Flux is initially about .15 mm/day. With establishment of the vegetative on the sloped cap, flux declines below 0.05 mm/day. Moist years representing El Nino events result in a flux above 0.05 mm/day for a period of about 3 years with a peak flux of 0.3 mm/day.

Figure 1: Vadose Zone Water Flux into the Aquifer

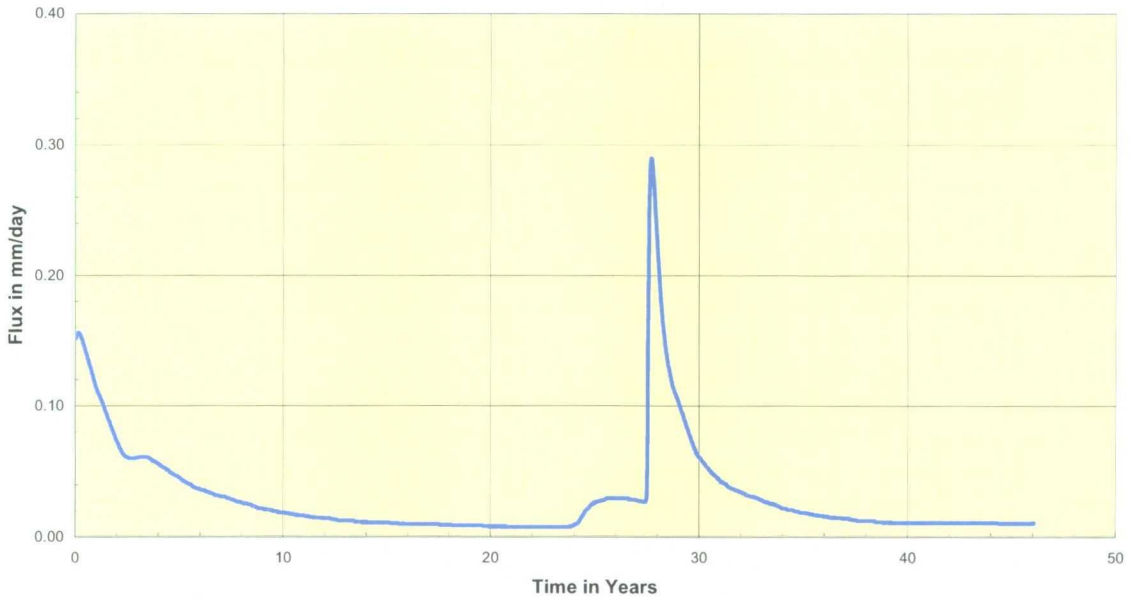
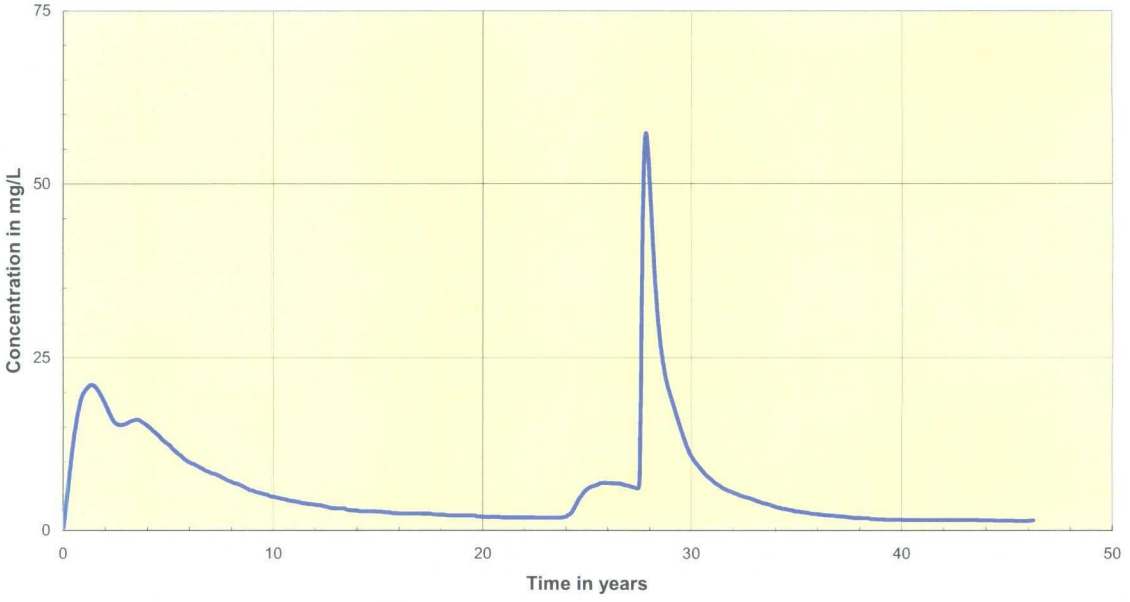


Figure 2 shows chloride concentration in a 20-foot thick aquifer immediately down gradient of the site with an assumed background chloride concentration of 0.0 mg/L. This choice shows solely the predicted effect on ground water of the site with the installed remedy. As can be seen, chloride in the lower vadose zone enters ground water raising chloride concentration less than 25 mg/L as vegetation is being established. Infiltration is consequently reduced. With "drying" out of the vadose zone soil materials, hydraulic conductivities are reduced. The resultant vadose zone chloride flux to ground water is lowered such that ground water chloride concentration does not rise above 10 mg/L except during an El Nino event within the climate record. This event (apparent in years 27 and 28) results in a chloride concentration above 25 mg/L for about a year.

Figure 2: Predicted Chloride Concentration in the Aquifer, M-4 Site with an ET Cap



By construction, the model is conservative of ground water quality.