DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 377TH AIR BASE WING (AFMC)

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NMED
Hazardous Waste Bureau

Colonel Tom D. Miller
377 ABW/CC
2000 Wyoming Blvd SE
Kirtland AFB, New Mexico 87117-5600

Mr. Tom Blaine, Manager
Environmental Health Division Director
Environmental Health Division
New Mexico Environment Department (NMED)
1190 St. Francis Drive
Santa Fe, New Mexico 87502

Dear Mr. Blaine

Attached is the Third Quarter CY 2013 Groundwater Gas Sample Results for Solid Waste Management Units ST-106 and SS-111. This report covers groundwater gas sampling performed at Kirtland AFB in support of the Bulk Fuels Facility project.

If you have any questions or concerns about this letter or its attachment, please contact Mr. L. Wayne Bitner at (505) 853-3484 (Ludie@bitner@kirtland.af.mil) or Ms. Victoria R. Martinez at (505) 846-6362 (Victoria.martinez@kirtland.af.mil).

Sincerely

Tom D. Miller

TOM D. MILLER, Colonel USAF
Commander

Attachment: Third Quarter CY 2013 Groundwater Gas Sample Results, Bulk Fuels Facility, Solid Waste Management Units ST-106 and SS-111

cc:
NMED-HWB (Kieling, Cobrain, Moats, McDonald, Brandwein) w/attch
NMED-GWQB (Schoeppner) w/attch
NMED-PSTB (Reuter) w/attch
NMED-OGC (deSaillan) w/o attch
EPA Region 6 (King) w/o attch
AFCEC-CZRX (Oyelowo) w/o attch
Public Info Repository, AR/IR, File w/attch

40 CFR 270.11
DOCUMENT CERTIFICATION
SEPTEMBER 2013

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

TOM D. MILLER, Colonel, USAF
Commander, 377th Air Base Wing

This document has been approved for public release.

KIRTLAND AIR FORCE BASE
377th Air Base Wing Public Affairs

KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

Third Quarter CY 2013 Groundwater Gas Sample Results
Bulk Fuels Facility Spill
Solid Waste Management Units ST-106 and SS-111

September 2013

377 MSG/CEANR
2050 Wyoming Blvd. SE
Kirtland AFB, New Mexico 87117-5270

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2440 Louisiana Blvd. NE, Suite 300
Albuquerque, NM 87110
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September 16, 2013

Subject: Third Quarter CY 2013 Groundwater Gas Sample Results

This Groundwater Gas Sample Results Letter Report has been prepared by Shaw Environmental & Infrastructure, Inc. (Shaw), a CB&I company, for the U.S. Army Corps of Engineers (USACE), Albuquerque District, under Contract W912DY-10-D-0014. This letter report covers groundwater gas sampling performed at Kirtland Air Force Base (KAFB) Bulk Fuels Facility, Solid Waste Management Units ST-106 and SS-111.

Groundwater gas samples, argon gas samples, and the ambient air sample were collected in order to characterize the gas bubbles observed in some wells during quarterly groundwater sampling events, and to determine if the occurrence of these bubbles is the result of the sampling procedure. Six samples of groundwater gas, two samples of argon used to drive the down-hole pumps for groundwater sampling, and one sample of ambient air were collected from July 15, 2013 through August 7, 2013. These samples were submitted to IsoTech ® Laboratories, Inc. for analysis of major gas constituents. The New Mexico Environment Department (NMED) Hazardous Waste Bureau approved the sample procedure and well selection in the July 26, 2013 approval and request for clarification letter (Attachment A). Based on the analyses of these samples, it was determined that the dissolved gases closely match the composition of air, modified by the addition of approximately 2.5 percent carbon dioxide (CO_2), the addition of less than 0.005 percent methane, and the removal of approximately 4 percent nitrogen (N_2). There is no evidence of any significant leakage of argon drive gas in these samples, which indicates that the occurrence of gas bubbles is not the result of the sampling procedure.

Methods

Nine samples were collected and sent to IsoTech ® Laboratories, Inc. for analysis. One sample was of ambient air, two were of the argon used to drive the down-hole pumps for groundwater sampling, and six were groundwater gas samples from the following wells:

- KAFB-106205: This well is one of the most recently installed groundwater monitoring wells and had bubbles observed in the groundwater during sampling in November 2012.
- KAFB-106206: This well is one of the most recently installed groundwater monitoring wells and had bubbles observed in groundwater during sampling in November 2012.
- KAFB-106040: This is a deep well, located along the eastern edge of the plume that has had bubbles observed in six out of the past seven quarters.
- KAFB-106051: This is a deep well that serves as a sentry well along the western edge of the plume and it has had bubbles observed six out of the past seven quarters.
- KAFB-106071: This is a deep well located along the western edge of the plume and it has had bubbles observed six out of the past seven quarters.
- KAFB-106104: This is a deep well located along the eastern edge of the plume and it has had bubbles observed during the past seven quarters of sampling.

Gas bubbles were observed during the Third Quarter CY 2013 sampling events, so gas samples were collected from them as planned.

The wells, along with the gas bubble sampling procedure, were described in the June 21, 2013 letter, which was approved by the NMED Hazardous Waste Bureau in the July 26, 2013 approval and request for clarification letter (Attachment A).

On July 15, 2013 the ambient air sample, one argon sample, and groundwater gas samples from wells KAFB-106205 and KAFB-106206 were collected. The ambient air sample was collected within 25 feet of well KAFB-106206 over a period of 60 minutes, during which time the groundwater gas sample from KAFB-106206 was collected. The ambient air sample was collected upwind of any exhaust-emitting equipment, and was collected in a cali-5 bond bag, provided by IsoTech ® Laboratories, Inc., in accordance with their recommended sampling procedure provided in Attachment B. The purpose of the ambient air sample was to use as a laboratory quality control and establish background content of CO_2, argon, methane, and other gases. Photographs of the sampling and the bubbles observed in the purge water are provided in Attachment C.

The argon sample was collected in a Tedlar bag connected directly to the argon gas source. Groundwater gas samples were collected in accordance with the IsoTech ® Laboratories, Inc. recommended sampling procedure provided in Attachment B.

All samples were sent to IsoTech ® Laboratories, Inc. and analyzed for the same suite of analytes. These analytes are carbon monoxide, helium, hydrogen, argon, oxygen, nitrogen, carbon dioxide, methane, ethane, ethylene, propane, propylene, iso-butane, n-butane, iso-pentane, n-pentane, and "hexane +" (the sum of hexane [C_6H_{14}] plus heavier hydrocarbons). After the initial results from the first two wells were returned, validated, and analyzed to determine if any changes to the sampling procedure were needed, the remaining samples were collected. No changes to the sampling procedure were deemed necessary.

Between August 5 and 7, 2013 one additional argon sample and four groundwater gas samples, from wells KAFB-106040, KAFB-106051, KAFB-106071, and KAFB-106104, were collected. All samples were sent to IsoTech ® Laboratories, Inc. and analyzed for the same suite of analytes. Results are provided in Attachment D.

Results

Detectable amounts of argon (Ar), oxygen (O_2), carbon dioxide (CO_2), nitrogen (N_2), methane (CH_4), ethane (C_2H_6), and "hexane +" (the sum of hexane [C_6H_{14}] plus heavier hydrocarbons) were found in one or more of the six groundwater gas samples. Ethylene, propane, propylene, iso-butane, normal-butane, iso-pentane, and normal-pentane were analyzed for, but were nondetectable in the samples.

Analytical results are provided in Attachment D and summarized on Table 1 for the six groundwater gas samples, the ambient air sample, and the two argon drive gas samples in units of mole percent (approximately equivalent to partial pressure or volume percent). Also provided on Table 1 are calculated "enrichment factors", which are the ratios of the composition of the analytes in the groundwater gas samples divided by the compositions of the analytes in the ambient air sample. Factors greater than 1.0 indicate a higher proportion of that component relative to the ambient air sample, and factors less than 1.0 indicate a lower proportion of that component relative to the ambient air sample.

It should be kept in mind that these analytical results are compositions rather than concentrations. Compositional results differ from concentration results in that the sum of the composition analytes will always equal 100 mole percent, which is referred to as a "closed" analysis. If one starts with a standard air composition and then and adds a gas component, then the other components will have proportionally lower values. Likewise, if a component is subtracted from a composition, then the other components will have proportionally higher values due to the constraint that the sum of the components must equal 100 percent. This is quite different than analyses of trace

elements or VOCs in groundwater where a change in the concentration of one analyte does not affect the concentrations of the other analytes. It is standard practice to report gas analyses as a composition rather than a concentration in order to eliminate the effect of pressure on the results.

The results shown in Table 1 indicate that dissolved gas in the six groundwater gas samples are dominantly composed of air with three modifications. The most significant modification is the addition of an average of 2.5 mole percent CO_2. The CO_2 enrichment factors range from 43.8 to 111.2 as a result of increases from 0.042 mole % (420 ppm) in the ambient air sample to CO_2 mole percents that range from 1.84 to 4.67. This CO_2 was likely present in the groundwater as dissolved bicarbonate ions (HCO_3^-), and exolved from the groundwater as CO_2 gas when the pressure was relieved at the surface. Bicarbonate in groundwater is derived from the dissolution of naturally occurring carbonate minerals in the aquifer, and is also produced from the degradation of fuel constituents by aerobic microbes. Small amounts of methane were also detected in two of the six groundwater gas samples. This methane may be naturally occurring, or may be produced from the degradation of fuel constituents by anaerobic microbes.

Oxygen and Ar showed slight enrichment in the groundwater gas samples, while N_2 showed larger decreases relative to the air sample then can be accounted for by Ar plus CO_2 addition. A possible explanation is the differences in the solubilities of the gas components in water. The solubility of a mixture of gases in water is a function of the aqueous solubility of each pure gas at a given temperature and pressure, multiplied by the mole fraction of that gas component in the gas mixture that is in contact with the water. If we assume that the source of the dissolved gases is the use of air rotary drilling, then the relative solubilities of each gas in the groundwater can be calculated as the product of the pure solubility of each gas component and the mole fraction of each component in air.

Table 2 shows the aqueous solubilities of each pure gas compound at 25 degrees Celsius (º C) in mole fractions, the composition of air in mole fractions, and the relative aqueous solubility of each component. The pure solubilities are from International Union of Pure and Applied Chemistry "Solubility Data Series" of publications, and the mole fractions of each component in air are based on the ambient air analysis on Table 1. The last column (which is the product of the previous two columns times 100) shows that N_2 has the highest relative solubility. Some fraction of the N_2 dissolved in the groundwater may thus remain in the water if its solubility is not exceeded when the water sample is brought to the surface. This higher solubility of N_2 may explain why the N_2 composition of the groundwater samples are lower than the ambient air sample, and why Ar and O_2 compositions are slightly higher than the ambient air sample.

Conclusions and Recommendations

The analyses of the six samples show that the dissolved gases in the six groundwater samples closely match the composition of air, modified by the addition of approximately 2.5 percent CO_2, the addition of less than 0.005 percent methane, and the removal of approximately 4 percent N_2. The slight enrichment of O_2 and Ar in the groundwater samples could be explained by the higher solubility of N_2, which allows the N_2 to remain in solution when the water sample is brought to the surface.

The analyses of the six groundwater gas samples show that there is no significant leakage of argon drive gas in the samples, which demonstrates that the bubbles observed during groundwater sampling are not produced by the sampling procedure. Consequently, no changes to the sampling procedure are necessary. The bubbles closely match the composition of ambient air, which is consistent with the hypothesis that the air was introduced during air rotary drilling at the wells. If this is the case, then the bubbles will eventually no longer form in the groundwater samples as additional purging of the wells occur, although small amounts of naturally occurring CO_2 and smaller amounts of methane may continue to exolve from the samples.

It is recommended that the bubbles be sampled for the same volatile COCs as the groundwater samples to better determine and understand the impact bubbles may be having on groundwater sample results.

TABLES

Table 1. Gas Composition Results

Isotech Job No.	22253	22253	22466	22466	22491	22491	22253	22253	22466
Isotech Lab No.	367415	367416	372076	372077	372625	372626	367417	367414	372075
Sample Name	GSKAFB 106205	GSKAFB 106206	GSKAFB 106051	GSKAFB 106104	GSKAFB 106040	GSKAFB 106071	GS-002 Ambient	GS-001 Argon	GS-002 Argon
Sample Date	07/15/13	07/15/13	08/05/13	08/05/13	08/06/13	08/07/13	07/15/13	07/15/13	08/05/13
Argon %	1.24	1.24	1.26	1.18	1.13	1.04	0.934	96.67	97.64
Oxygen %	24.4	24.92	20.44	21.19	23.83	22.13	20.96	nd	nd
Carbon Dioxide %	2.81	2.08	4.67	2.08	1.84	2.05	0.042	0.006	0.015
Nitrogen %	71.54	71.76	73.63	75.55	73.2	74.78	78.06	3.32	2.35
Methane %	0.0046	0.0014	nd	nd	nd	nd	0.0003	nd	nd
Ethane %	0.0007	Nd	nd	nd	nd	nd	nd	nd	nd
Hexane + %	nd	Nd	0.0009	0.0005	nd	nd	nd	nd	nd
Specific Gravity	1.021	1.018	1.026	1.013	1.015	1.013	1	1.366	1.370
Enrichment Factors*									
Argon	1.33	1.33	1.35	1.26	1.21	1.11	1.00		
Oxygen	1.16	1.19	0.98	1.01	1.14	1.06	1.00		
Carbon Dioxide	66.9	49.5	111.2	49.5	43.8	48.8	1.00		
Nitrogen	0.92	0.92	0.94	0.97	0.94	0.96	1.00		
Methane	15.3	4.67	nd	nd	nd	nd	1.00		

Note: Compositions expressed as mole percent.

*Enrichment factors = concentration in sample / concentration in air

nd Nondetect

Table 2. Relative Effective Solubilities of Air Components in Water

Component	Pure Solubility (Mole Fraction)	Air Composition (Mole Fraction)	Effective Solubility (Mole %)
Argon	2.52E-05	0.00934	2.35E-05
Oxygen	2.29E-05	0.2096	4.81E-04
Carbon Dioxide	6.15E-04	0.00042	2.58E-05
Nitrogen	1.18E-05	0.7806	9.23E-04
Methane	2.55E-05	0.000003	7.66E-09

ATTACHMENT A

Previous Correspondence

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 377TH AIR BASE WING (AFMC)

Colonel John C. Kubinec
377 ABW/CC
2000 Wyoming Blvd SE
Kirtland AFB NM 87117-5600

JUN 21 2013

Mr. John Kieling, Manager
RCRA Permits Management Program
Hazardous Waste Bureau (HWB)
New Mexico Environment Department (NMED)
2905 Rodeo Park Road
Santa Fe New Mexico 87505

Dear Mr. Kieling

In the NMED letter dated January 17, 2013, the NMED responded to proposed actions presented in our letter: *Response to NMED Letter Dated December 7, 2012: Repeat Sampling and Gas Bubbles in Groundwater Samples, Bulk Fuels Facility Spill, Solid Waste Management Units ST-106 and SS-111,* dated January 4, 2013. NMED conveyed concerns related to the following four specific items which are addressed in this letter:

1. **NMED Comment:** NMED directed the Permittee to collect an ambient air sample for the purpose of establishing background air composition at the site. However, the Permittee did not agree to collect and analyze an ambient air sample, citing that the use of argon in place of compressed air renders understanding ambient air composition as useless. NMED disagrees; not only is ambient air composition useful for analyzing earlier data collected by compressed-air-driven pumps, but is necessary for setting the baseline atmospheric argon concentration to be used for evaluating data from samples collected with argon-powered pumps. The Permittee shall collect, analyze, and provide the results of an ambient air sample to the NMED as previously directed. Furthermore, the ambient air sample shall be collected at one of the wells and on the same day where the sampling of gas bubbles is to take place at the well.

   Response: As directed by the NMED in the January 17, 2013, letter a single ambient air sample will be collected. The ambient air sample will be collected from a location within 25 feet of one of the wells where gas samples are to be obtained from groundwater and will be collected immediately prior to, at the same time as, or immediately after the gas sample is collected from the well. The ambient air sample will be collected over a duration not to exceed 60 minutes; the exact location will be determined in the field in order to prevent contamination by any exhaust emitting equipment in the immediate area; the location selected will be upwind of such equipment. The ambient air sample will be collected in a cali-5 bond bag, provided by IsoTech® Laboratories, Inc., following the methods in the attached product sheet (Attachment A). Both the ambient air and gas bubble samples will be analyzed in the same laboratory for the same suite of analyses.

The results of the ambient air sample will be used as a laboratory quality control. Additionally, the ambient air sample results will be used to establish the background content of CO_2, argon, methane, and other gases in ambient air.

2. **NMED Comment:** Isotech Laboratories, the supplier of IsoBag® sample container to be used in this effort, has specific recommendations for collecting water samples by pulsating pump for dissolved gas analysis. NMED directed the Permittee to report these procedures, if any, as they relate to collecting samples at BFF wells. The Permittee's response was that Isotech Laboratories "recommendations have been incorporated into the design of the evaluation," meaning that there are recommendations to report, which were not provided. The Permittee shall report the recommendations made by Isotech Laboratories as directed in NMED's December 7, 2012, letter.

   Response: Prior to submittal of the Kirtland AFB November 30, 2012 letter, Shaw contacted Isotech Laboratories to discuss sampling of gas bubbles; Shaw specifically discussed the Bennett™ pumps and the appropriateness of the standard protocol. Isotech Laboratories recommended no change to their sampling protocol (Attachment A) using their Isobag® sample container. As stated in the Kirtland AFB January 3, 2013 letter, the instructions in the attached laboratory-provided sheet have been incorporated into the sampling procedure outlined in the Kirtland AFB November 30, 2012 letter.

3. **NMED Comment:** The NMED directed the Permittee to provide details on sites in New Mexico where ARCH drilling technology was used to install wells where bubbles in water samples have been observed as a result of air forced into groundwater by the drilling method. The Permittee cites an opinion from an NMED staff member that ARCH may be the source for entrained air in groundwater in the case of some wells at Los Alamos National Laboratory (LANL). No information was provided by the Permittee to indicate that conditions similar to LANL exist for wells installed for the BFF project. In addition, no documentation regarding entrained air in groundwater LANL was referenced. Therefore, the NMED has no reason to believe that ARCH drilling is the source of the bubbles observed for BFF wells.

   Response: Detailed information concerning the use of ARCH drilling methodology during LANL's groundwater investigation, and subsequent reporting, has not been located. The information regarding gas bubbles as a result of ARCH drilling was anecdotal information provided by an NMED staff member in the field during the well sampling on November 6, 2012. The original intent was to remind all parties of the conversation.

4. **NMED Comment:** Collecting and analyzing gas samples from only two wells out of the more than 30 wells that have been observed with entrained gas bubbles in purge water and water samples is insufficient to support a conclusion with regard to the source of the gas bubbles. The Permittee shall propose at least six wells for gas sampling, as directed previously.

   Response: As stated in the Kirtland AFB January 3, 2013 letter, the following six wells are proposed for the sampling of gas bubbles in groundwater.

   The six wells listed below have all been approved or recommended by the NMED Hazardous Waste Bureau (HWB) in either the May 23, 2013 partial approval letter, or an email dated June 5, 2013:

   - KAFB-106205: This well is one of the most recently installed groundwater monitoring wells and had bubbles observed in groundwater during sampling in November 2012.

   - KAFB-106206: This well is one of the most recently installed groundwater monitoring wells and had bubbles observed in groundwater during sampling in November 2012.

- KAFB-106040: This is a deep well located along the eastern edge of the plume that has had bubbles observed six out of the past seven quarters.

- KAFB-106051: This is deep well that serves as a sentry well along the western edge of the plume and it has had bubbles observed six out of the past seven quarters.

- KAFB-106071: This is a deep well located along the western edge of the plume and it has had bubbles observed six out of the past seven quarters.

- KAFB-106104: This is a deep well located along the eastern edge of the plume and it has had bubbles observed during the past seven quarters of sampling.

In addition to the above listed wells, one alternate well was recommended by the NMED HWB. This well may be sampled if one of the original six proposed well does not have bubbles present at the time of sampling.

- KAFB-106092: This is an intermediate well located near the western edge of the plume and has had bubbles observed six out of the past seven quarters.

NMED will be notified no less than 10 days in advance of sampling. Initially, gas bubbles will be sampled from wells KAFB-106205 and KAFB-106206, with a 72-hour turn-around time for laboratory results. The results will be evaluated and will be used to inform the sampling of the four remaining wells. The attached schedule shows that the four wells will be sampled within approximately 10 days of receipt of the results from wells KAFB-106205 and KAFB-106206. This time period accounts for time to validate the gas analytical results from the first two samples plus the ambient sample. If there are any issues with the sample collection method or analytical data, more time may be required to have further discussions with the NMED on sample wells, approach, and/or laboratory. Sampling of gas bubbles will also be dependent on the observation of gas bubbles, since bubbles do not consistently occur in all wells from quarter to quarter (Attachment B). If no bubbles are found in groundwater at a well that is proposed for the collection of gas samples in this letter, an alternate well will be selected and proposed to NMED for approval. KAFB will request that the NMED select an alternative well within two working days of discovery that bubbles are not present in groundwater at a well.

Attachment B is an updated table illustrating the occurrences of bubbles during quarterly groundwater monitoring events. The table is current through Second Quarter 2013.

Attachment C is an updated schedule for gas bubble sampling and reporting. The first two gas bubble samples will be collected two weeks after receipt of NMED approval of this plan. A data letter report documenting the findings of the gas bubble sampling, as well as conclusions and recommendations, will be submitted to the NMED by **August 26, 2013**.

Please contact Mr. L. Wayne Bitner at 505.853.3484 or at ludie.bitner@kirtland .af.mil or Ms. Victoria R. Martinez at 505.846.6362 or at victoria.martinez@kirtland.af.mil if you have any questions.

Sincerely

JOHN C. KUBINEC, Colonel USAF
Commander

cc:
NMED-RPD (Skibitski) w/o attch
NMED-HWB (Cobrain, Moats, McDonald, Brandwein) w/attch
NMED-GWQB (J. Schoeppner) w/attch
NMED-PSTB (Reuter) w/attch
NMED-OGC w/o attch
EPA Region 6 (L. King) w/o attch
AFCEE/CMSE (Mr. Oyelowo) w/o attch
Public Info Repository (Central New Mexico) w/attch
Administrative Record/Information Repository (AR/IR) w/attch
File, w/ attch

40 CFR 270.11
DOCUMENT CERTIFICATION
JUNE 2013

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

JOHN C. KUBINEC, Colonel, USAF
Commander

This document has been approved for public release.

KIRTLAND AIR FORCE BASE
377 ABW Public Affairs

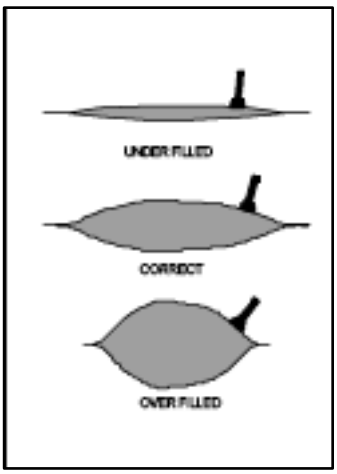
ATTACHMENT A

Collection of Gas Samples Using a Hand Pump and Gas Bags

1. Attach the inlet tubing of the hand pump provided (black end) to the monitoring probe or sampling point and pump for a sufficient length of time to purge the system of air. The purge gas may be vented to the atmosphere.

2. Remove a gas bag from its shipping container and while pumping slowly, insert the male luer fitting on the outlet of the hand pump (clear end) into the luer-fit valve on the gas bag with a slight twisting motion. Inserting the male luer fitting depresses the valve stem and opens the valve. The tapered design of this fitting allows for a leak-tight friction fit.

3. The bag can be filled with about twenty squeezes of the bulb. To allow space for expansion during shipment, the bag should only be filled to about 2/3 of capacity. The bag is properly filled when it is about 1 1/2 inches thick, as shown in the drawing.



4. Once the bag is filled, remove the fitting from the bag (be careful because if the fitting is pressed into the valve too tightly, the top of the valve can separate from the main valve body when attempting to remove the fitting). Although these bags are durable, they can be damaged if not handled properly. Be careful not to crease or puncture the bags.

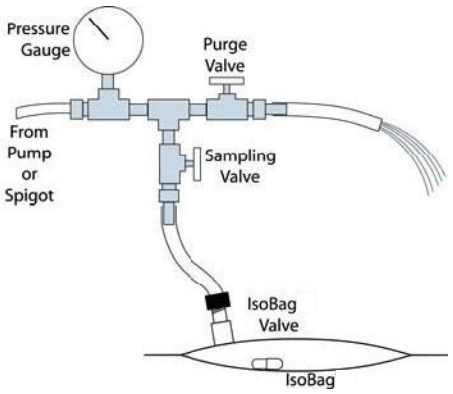
5. Record the pertinent information on the tag attached to the bag and on the chain of custody form provided and return the bag to the shipping container in which it was received. Samples should be shipped to the laboratory for analysis as soon as possible. If the samples are suspected to be flammable (>5% methane) they must be identified as hazardous and shipped according to the enclosed shipping instructions.

In preparing the sampling equipment described above we have tried to provide the user with the equipment and instructions necessary for the safe collection of gas samples under normal conditions. These have been prepared assuming that they will be used by someone who is familiar with the collection of natural gas samples and is fully aware of standard safety procedures and precautions. Isotech is not responsible for accidents resulting from improper use of this equipment or from use of unsafe practices.

Collection of Ground Water Samples from Domestic and Municipal Water Wells for Dissolved Gas Analysis

1. **Sampling source:** Water samples should either be collected from a pressurized water system or by using a suitable water pump. When sampling from a pressurized water system, it is recommended to use an outdoor spigot or other source which bypasses any water treatment systems (i.e. water softeners, etc.). When using a pump, it should be capable of maintaining a constant pressure at or above that which exists within the aquifer. This is to ensure that gases dissolved in the water within the aquifer remain dissolved until the water is transferred into an IsoBag®. If using a pulsating pump such as a bladder pump, please contact Isotech for additional recommendations.

2. **Sampling Mechanism:** *After purging the well*, a mechanism consisting of a pressure gauge in line with two valves should be attached to the spigot or pump output (see figure). The ***purge valve*** (see figure) allows water to be pumped through the system to purge both the well and the tubing. The ***sampling valve*** (which should point downward), provides a point whereby a sample split can be slowly "bled" off from that water which is being continuously purged out of the system via the ***purge valve***. Sampling in this manner allows for collection of a sample over a longer period of time, and as such should provide a sample that is more representative of the water source, in essence creating an "averaging effect" during collection.



3. **IsoBags:** The gas bags provided have been evacuated in advance. A capsule filled with bactericide has also been inserted.

4. **Collection of samples:** Slowly open the ***purge valve*** to purge any gas or air from the tubing. The flow rate should be controlled so as to allow a reasonable flow, while also maintaining a pressure close to the maximum pressure of the water system or pump. When the line has been adequately purged and a steady state situation is achieved, open the sampling valve slightly to purge the air from it. Then, with the water still running at a low rate, connect the fitting to the valve on the IsoBag and proceed to fill the bag (note: the slower the filling rate, the greater the "averaging effect"). The bag should be filled with approximately 500 cc of water (i.e. to a thickness of about 1 inch). When sufficient sample has been collected, close the sampling valve and quickly disconnect the fitting from the IsoBag. The water flow can now be turned off and the hose disconnected. Reattach the cap to the valve of the IsoBag.

5. **Submission of samples.** After recording the sample identification on the attached label, the bag should be placed in its protective box and packed **laying flat**. Complete a Chain-of-Custody/Analysis Request form and include it with the sample(s). **If possible, samples should be shipped the same day collected, via an overnight delivery service. Client MUST inform Isotech of shipment prior to arrival.** Please note Isotech's receiving hours of **Monday thru Friday** 8:00 am to 4:30 p.m.

   Ship samples to:

   Isotech Laboratories, Inc.
   1308 Parkland Court
   Champaign, IL 61821

These instructions have been provided to simplify the collection of samples for dissolved gas analysis. Although we try to foresee and avoid problems in the field, it is never possible to predict every situation. If you encounter any difficulties, or if any additions or changes in these instructions would be beneficial, please let us know.

ATTACHMENT B

Bubbles Only Data

Well ID	Shallow, Intermediate, Deep	Qt4, 2011	Qt1, 2012	Qt2, 2012	Qt3, 2012	Qt4, 2012	Qt1, 2013	Qt2, 2013
KAFB-3								
KAFB-15								
KAFB-16								
KAFB-3411	Shallow							
KAFB-1061	Shallow							
KAFB-1062	Shallow							
KAFB-1063	Shallow							
KAFB-1064	Shallow						X	X
KAFB-1065	Shallow		X					
KAFB-1066	Shallow							
KAFB-1067	Shallow							
KAFB-1068	Shallow		X					
KAFB-1069	Shallow			X				
KAFB-10610	Shallow							
KAFB-10611	Shallow							
KAFB-10612	Shallow							
KAFB-10613	Shallow						X	
KAFB-10614	Shallow							
KAFB-10615	Shallow							
KAFB-10616	Shallow							
KAFB-10617	Shallow							
KAFB-10618	Shallow							
KAFB-10619	Shallow							X
KAFB-10620	Shallow							
KAFB-10621	Shallow		X					X
KAFB-10622	Shallow							
KAFB-10623	Shallow							X
KAFB-10624	Shallow							
KAFB-10625	Shallow						X	X
KAFB-10626	Shallow			X				
KAFB-10627	Shallow							
KAFB-10628-510	Shallow							
KAFB-106029	Shallow			X			X	X
KAFB-106030	Intermediate			X		X	X	X
KAFB-106031	Deep (550 ft)				X	X	X	X
KAFB-106032	Shallow		X					
KAFB-106033	Intermediate	X			X	X	X	X
KAFB-106034	Deep (550 ft)		X		X	X	X	X
KAFB-106035	Shallow						X	
KAFB-106036	Intermediate		X			X	X	X
KAFB-106037	Shallow				X	X	X	X
KAFB-106038	Shallow						X	
KAFB-106039	Intermediate	X	X	X			X	X
KAFB-106040	Deep (550 ft)	X	X	X		X	X	X
KAFB-106041	Shallow							
KAFB-106042	Intermediate							X
KAFB-106043	Deep (590 ft)		X	X			X	X
KAFB-106044	Intermediate						X	X
KAFB-106045	Deep (550 ft)				X			
KAFB-106046	Shallow							X

Bubbles Only Data (continued)

Well ID	Shallow, Intermediate, Deep	Qt4, 2011	Qt1, 2012	Qt2, 2012	Qt3, 2012	Qt4, 2012	Qt1, 2013	Qt2, 2013
KAFB-106047	Intermediate		X			X	X	X
KAFB-106048	Deep (550 ft)					X	X	X
KAFB-106049	Shallow						X	
KAFB-106050	Intermediate				X	X	X	X
KAFB-106051	Deep (550 ft)		X	X	X	X	X	X
KAFB-106052	Shallow							X
KAFB-106053	Intermediate	X	X					X
KAFB-106054	Deep (550 ft)	X	X					
KAFB-106055	Shallow							X
KAFB-106057	Intermediate	X	X		X		X	X
KAFB-106058	Deep (550 ft)		X			X	X	X
KAFB-106059	Shallow				X			
KAFB-106060	Intermediate		X	X	X		X	X
KAFB-106061	Deep (590 ft)							
KAFB-106062	Deep (590 ft)							
KAFB-106063	Intermediate		X				X	X
KAFB-106064	Shallow						X	
KAFB-106065	Intermediate		X		X	X	X	X
KAFB-106066	Deep (550 ft)		X			X	X	X
KAFB-106067	Shallow						X	
KAFB-106068	Deep (590 ft)		X	X	X		X	X
KAFB-106069	Intermediate							
KAFB-106070	Shallow							X
KAFB-106071	Deep (590 ft)	X	X	X		X	X	X
KAFB-106072	Intermediate		X	X		X		X
KAFB-106073	Intermediate		X		X	X	X	X
KAFB-106074	Deep (590 ft)		X		X			
KAFB-106075	Shallow				X		X	X
KAFB-106076	Shallow							
KAFB-106077	Intermediate					X	X	X
KAFB-106078	Deep (590 ft)			X				
KAFB-106079	Shallow		X	X	X		X	
KAFB-106080	Intermediate							
KAFB-106081	Deep (590 ft)							
KAFB-106082	Shallow				X		X	X
KAFB-106083	Intermediate		X	X	X		X	X
KAFB-106084	Deep (590 ft)		X	X	X		X	X
KAFB-106085	Shallow						X	X
KAFB-106086	Intermediate			X	X	X	X	X
KAFB-106087	Deep (590 ft)			X	X	X	X	X
KAFB-106088	Shallow							
KAFB-106089	Intermediate		X	X	X	X	X	X
KAFB-106090	Deep (590 ft)	X	X	X	X	X	X	X
KAFB-106091	Shallow							X
KAFB-106092	Intermediate	X	X	X		X	X	X
KAFB-106093	Deep (590 ft)		X	X	X		X	X
KAFB-106094	Shallow	X	X				X	
KAFB-106095	Intermediate			X		X	X	X
KAFB-106096	Deep (590 ft)	X	X			X		
KAFB-106097	Intermediate		X	X	X		X	X
KAFB-106098	Deep (550 ft)		X	X			X	X

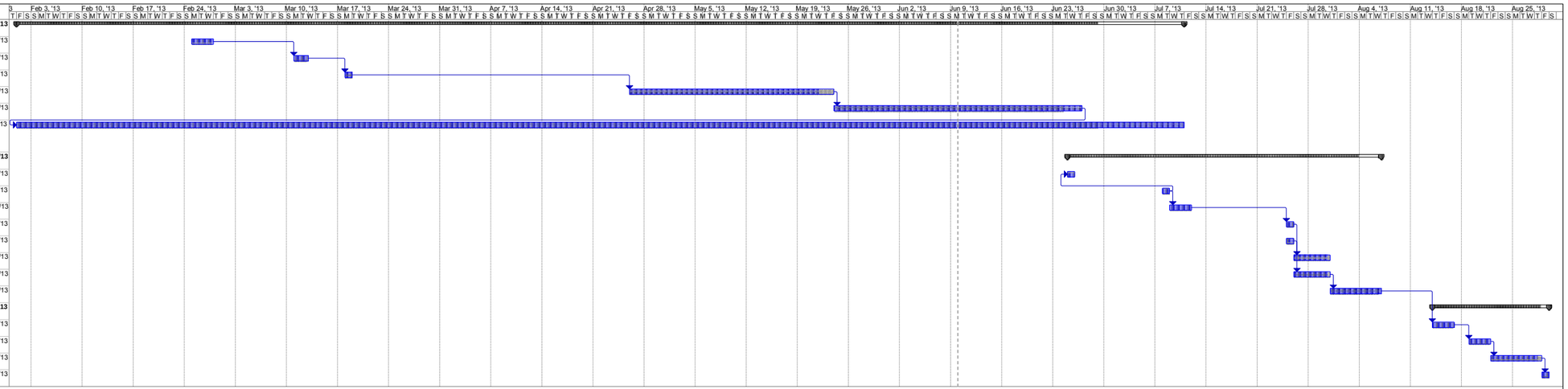
Bubbles Only Data (concluded)

Well ID	Shallow, Intermediate, Deep	Qt4, 2011	Qt1, 2012	Qt2, 2012	Qt3, 2012	Qt4, 2012	Qt1, 2013	Qt2, 2013
KAFB-106099	Intermediate	X	X			X		X
KAFB-106100	Deep (550 ft)		X				X	X
KAFB-106101	Intermediate			X			X	
KAFB-106102	Deep (550 ft)							
KAFB-106103	Intermediate	X						
KAFB-106104	Deep (550 ft)	X	X	X	X	X	X	X
KAFB-106105	Intermediate		X				X	X
KAFB-106106	Shallow		X					
KAFB-106107	Deep (550 ft)		X	X	X	X	X	X
KAFB-106160								
KAFB-106161							X	
KAFB-106201	Shallow						X	
KAFB-106202	Intermediate					X	X	
KAFB-106203	Deep					X	X	X
KAFB-106204	Shallow							
KAFB-106205	Intermediate					X		X
KAFB-106205R	Intermediate					X		
KAFB-106206	Intermediate					X	X	X
KAFB-106206R	Intermediate					X		
KAFB-106207	Shallow							X
KAFB-106208	Intermediate						X	X
KAFB-106209	Deep					X	X	X
KAFB-106209R	Deep					X		
KAFB-106007-R								
KAFB-2819-R-CRT								
KAFB-VA2								
KAFB-ST106-VA2								

ft Foot/feet
ID Identification

ATTACHMENT C

ID	Task Name	Duration	Start	Finish
1	**Kirtland AFB Letter Response w/ Sample Method**	**114 days**	**Fri 2/1/13**	**Wed 7/10/13**
2	USACE and KAFB Review	3 days	Mon 2/25/13	Wed 2/27/13
3	Staffing for Commander Signature	2 days	Mon 3/11/13	Tue 3/12/13
4	Submit to NMED	1 day	Mon 3/18/13	Mon 3/18/13
5	NMED Review	20 days	Fri 4/26/13	Thu 5/23/13
6	Revised Letter Response w/Sample Method	24 days	Fri 5/24/13	Wed 6/26/13
7	NMED Review of Revised Letter Response w/Sample Method	114 days	Fri 2/1/13	Wed 7/10/13
8	**Gas Bubble Sampling**	**31 days**	**Tue 6/25/13**	**Tue 8/6/13**
9	NMED Notification	1 day	Tue 6/25/13	Tue 6/25/13
10	Sample at KAFB-106205 and KAFB-106206	1 day	Mon 7/8/13	Mon 7/8/13
11	Lab Analsis of KAFB-106205 and KAFB-106206 Sample	3 days	Tue 7/9/13	Thu 7/11/13
12	Sample at KAFB-106040 and KAFB-106051	1 day	Thu 7/25/13	Thu 7/25/13
13	Sample at KAFB-106071 and KAFB-106104	1 day	Thu 7/25/13	Thu 7/25/13
14	Lab Analysis of KAFB-106040 and KAFB-106051 Samples	3 days	Fri 7/26/13	Tue 7/30/13
15	Lab Analysis of KAFB-106071 and KAFB-106104 Samples	3 days	Fri 7/26/13	Tue 7/30/13
16	Data Validation	5 days	Wed 7/31/13	Tue 8/6/13
17	**Data Table Letter**	**12 days**	**Wed 8/14/13**	**Thu 8/29/13**
18	Prepare Data Table and Cover letter	3 days	Wed 8/14/13	Fri 8/16/13
19	USACE and KAFB Review	3 days	Mon 8/19/13	Wed 8/21/13
20	Staffing for Commander Signature	5 days	Thu 8/22/13	Wed 8/28/13
21	Submit to NMED	1 day	Thu 8/29/13	Thu 8/29/13



Project: Gas_Bubble_Sampling_Sched
Date: Mon 6/10/13

Task	Milestone	Project Summary	External Milestone	Inactive Milestone	Manual Task	Manual Summary Rollup	Start-only	Progress
Split	Summary	External Tasks	Inactive Task	Inactive Summary	Duration-only	Manual Summary	Finish-only	Deadline

NEW MEXICO
ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau

2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6303
Phone (505) 476-6000 Fax (505) 476-6030
www.nmenv.state.nm.us

SUSANA MARTINEZ
Governor

JOHN A. SANCHEZ
Lieutenant Governor

RYAN FLYNN
Cabinet Secretary-Designate

BUTCH TONGATE
Deputy Secretary

TOM BLAINE, P.E.
Director
Environmental Health Division

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

July 26, 2013

Colonel Tom D. Miller
Base Commander
377 ABW/CC
2000Wyoming Blvd. SE
Kirtland AFB, NM 87117-5606

John Pike
Director, Environmental Management Services
377 MSG
2050 Wyoming Blvd. SE, Suite 116
Kirtland AFB, NM 87117-5270

RE: APPROVAL AND REQUEST FOR CLARIFICATION
JUNE 21, 2013, LETTER REGARDING SAMPLING OF GAS BUBBLES IN GROUNDWATER, BULK FUELS FACILITY SPILL, SOLID WASTE MANAGEMENT UNITS ST-106 AND SS-111
KIRTLAND AIR FORCE BASE
EPA ID# NM9570024423, HWB-KAFB-13-MISC

Dear Colonel Miller and Mr. Pike:

The New Mexico Environment Department (NMED) has reviewed the U.S. Air Force's (Permittee) letter of June 21, 2013, which states that it is a response to NMED's letter of January 17, 2013, concerning the plan to sample gas bubbles present in groundwater at and near the Bulk Fuels Facility Spill, Solid Waste Management Units ST-106 and SS-111, Kirtland Air Force Base.

The subject letter did not refer to NMED's latest letter dated May 23, 2013, on this topic. However, the revised plan discussed within the June 2013 letter adequately addresses the concerns raised in NMED's May 2013 letter. Therefore, NMED hereby approves the revised plan (and schedule) included within your June 21, 2013, submittal.

NMED notes that one of the items discussed in NMED's May 23, 2103 letter concerned groundwater monitoring well KAFB-106206, which was listed as an intermediate-depth well in

the earlier version of the plan. In the current submittal, KAFB-106206 is still listed as an intermediate-depth well. NMED understands that the well was completed as a deep well. To maintain the accuracy of NMED's administrative record, provide replacement page(s) for the plan, as necessary, with the corrected depth listing for well 106206 by August 26, 2013.

Should you have any questions, please contact Mr. Will Moats of my staff at (505) 222-9551.

Sincerely,

Tom Blaine

For John E. Kieling
Chief
Hazardous Waste Bureau

cc: T. Blaine, NMED EHD
D. Cobrain, NMED HWB
W. Moats, NMED HWB
W. McDonald, NMED HWB
S. Brandwein, NMED HWB
S. Reuter, NMED PSTB
B. Gallegos, AEHD
F. Shean, ABCWUA
L. King, EPA-Region 6 (6PD-N)
File: KAFB 2013 Bulk Fuels Facility Spill and Reading

ATTACHMENT B

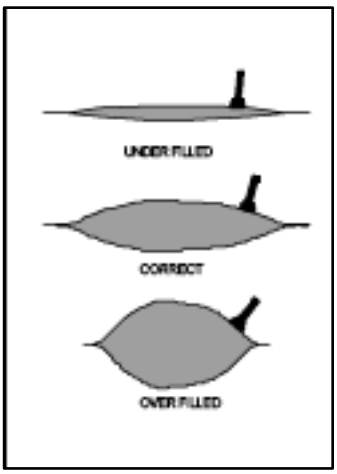
IsoTech ® Laboratories, Inc. Recommended Sampling Procedures

Collection of Gas Samples Using a Hand Pump and Gas Bags

1. Attach the inlet tubing of the hand pump provided (black end) to the monitoring probe or sampling point and pump for a sufficient length of time to purge the system of air. The purge gas may be vented to the atmosphere.

2. Remove a gas bag from its shipping container and while pumping slowly, insert the male luer fitting on the outlet of the hand pump (clear end) into the luer-fit valve on the gas bag with a slight twisting motion. Inserting the male luer fitting depresses the valve stem and opens the valve. The tapered design of this fitting allows for a leak-tight friction fit.

3. The bag can be filled with about twenty squeezes of the bulb. To allow space for expansion during shipment, the bag should only be filled to about 2/3 of capacity. The bag is properly filled when it is about 1 1/2 inches thick, as shown in the drawing.



4. Once the bag is filled, remove the fitting from the bag (be careful because if the fitting is pressed into the valve too tightly, the top of the valve can separate from the main valve body when attempting to remove the fitting). Although these bags are durable, they can be damaged if not handled properly. Be careful not to crease or puncture the bags.

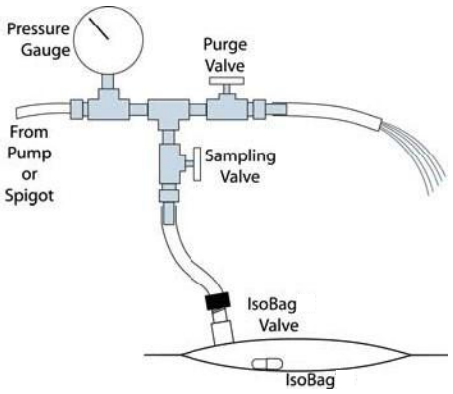
5. Record the pertinent information on the tag attached to the bag and on the chain of custody form provided and return the bag to the shipping container in which it was received. Samples should be shipped to the laboratory for analysis as soon as possible. If the samples are suspected to be flammable (>5% methane) they must be identified as hazardous and shipped according to the enclosed shipping instructions.

In preparing the sampling equipment described above we have tried to provide the user with the equipment and instructions necessary for the safe collection of gas samples under normal conditions. These have been prepared assuming that they will be used by someone who is familiar with the collection of natural gas samples and is fully aware of standard safety procedures and precautions. Isotech is not responsible for accidents resulting from improper use of this equipment or from use of unsafe practices.

Collection of Ground Water Samples from Domestic and Municipal Water Wells for Dissolved Gas Analysis

1. **Sampling source:** Water samples should either be collected from a pressurized water system or by using a suitable water pump. When sampling from a pressurized water system, it is recommended to use an outdoor spigot or other source which bypasses any water treatment systems (i.e. water softeners, etc.). When using a pump, it should be capable of maintaining a constant pressure at or above that which exists within the aquifer. This is to ensure that gases dissolved in the water within the aquifer remain dissolved until the water is transferred into an IsoBag®. If using a pulsating pump such as a bladder pump, please contact Isotech for additional recommendations.

2. **Sampling Mechanism:** *After purging the well*, a mechanism consisting of a pressure gauge in line with two valves should be attached to the spigot or pump output (see figure). The ***purge valve*** (see figure) allows water to be pumped through the system to purge both the well and the tubing. The ***sampling valve*** (which should point downward), provides a point whereby a sample split can be slowly "bled" off from that water which is being continuously purged out of the system via the ***purge valve***. Sampling in this manner allows for collection of a sample over a longer period of time, and as such should provide a sample that is more representative of the water source, in essence creating an "averaging effect" during collection.



3. **IsoBags:** The gas bags provided have been evacuated in advance. A capsule filled with bactericide has also been inserted.

4. **Collection of samples:** Slowly open the ***purge valve*** to purge any gas or air from the tubing. The flow rate should be controlled so as to allow a reasonable flow, while also maintaining a pressure close to the maximum pressure of the water system or pump. When the line has been adequately purged and a steady state situation is achieved, open the sampling valve slightly to purge the air from it. Then, with the water still running at a low rate, connect the fitting to the valve on the IsoBag and proceed to fill the bag (note: the slower the filling rate, the greater the "averaging effect"). The bag should be filled with approximately 500 cc of water (i.e. to a thickness of about 1 inch). When sufficient sample has been collected, close the sampling valve and quickly disconnect the fitting from the IsoBag. The water flow can now be turned off and the hose disconnected. Reattach the cap to the valve of the IsoBag.

5. **Submission of samples.** After recording the sample identification on the attached label, the bag should be placed in its protective box and packed **laying flat**. Complete a Chain-of-Custody/Analysis Request form and include it with the sample(s). **If possible, samples should be shipped the same day collected, via an overnight delivery service. Client MUST inform Isotech of shipment prior to arrival.** Please note Isotech's receiving hours of **Monday thru Friday** 8:00 am to 4:30 p.m.

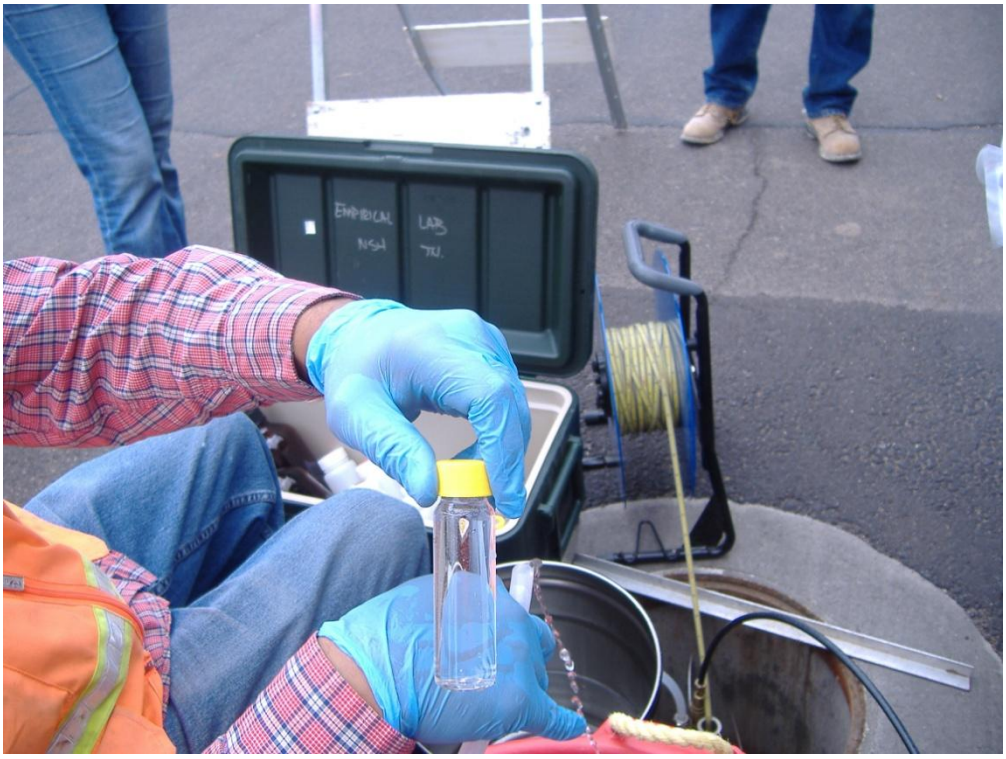
   Ship samples to:

   Isotech Laboratories, Inc.
   1308 Parkland Court
   Champaign, IL 61821

These instructions have been provided to simplify the collection of samples for dissolved gas analysis. Although we try to foresee and avoid problems in the field, it is never possible to predict every situation. If you encounter any difficulties, or if any additions or changes in these instructions would be beneficial, please let us know.

ATTACHMENT C

Photographs of Sampling and the Bubbles Observed in the Purge Water



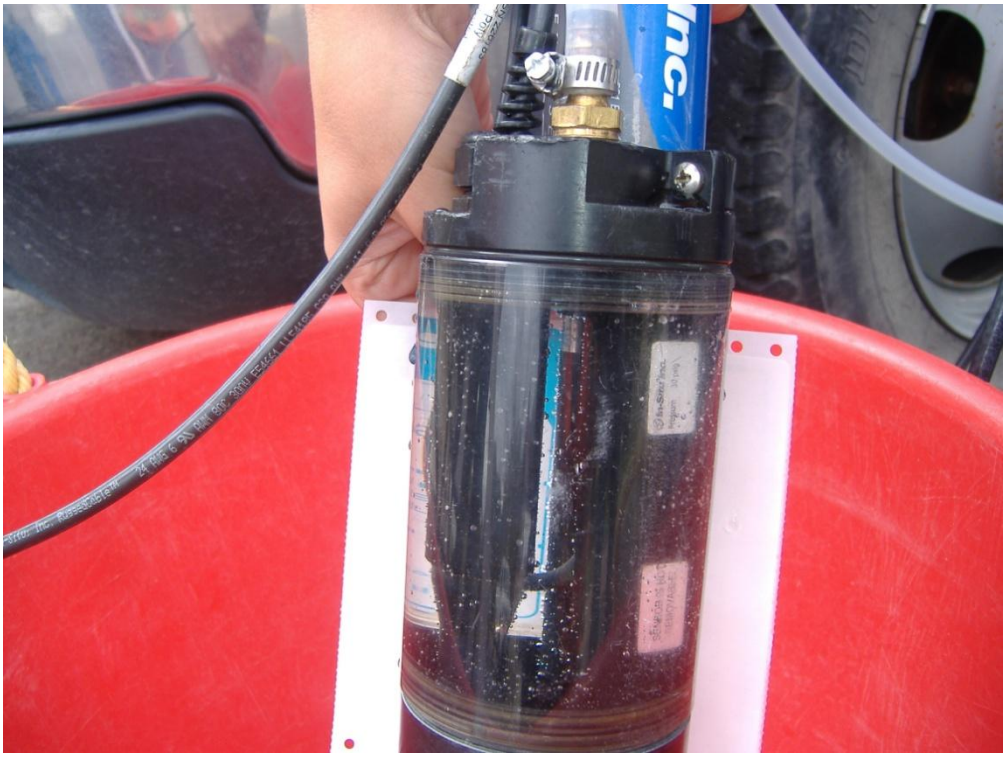
VOA Bubbles

Ambient Air Sample

Argon Sample

Groundwater Gas Sample

Groundwater Gas Sample Collected



Bubbles in Purge Water

ATTACHMENT D

Sample Analytical Results

ISOTECH
ISOTECH LABORATORIES INC

ANALYSIS REPORT

Lab #: 367414 Job #: 22253 IS-65948 Co. Job#:
Sample Name: GS-001 Argon Co. Lab#:
Company: CB & I
Date Sampled: 7/15/2013
Container: Tedlar Bag
Field/Site Name: KAFB-BFF/140705
Location: Albuquerque, NM
Formation/Depth:
Sampling Point:
Date Received: 7/16/2013 Date Reported: 7/18/2013

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	$\delta^{15}N$ ‰
Carbon Monoxide	nd			
Helium	nd			
Hydrogen	nd			
Argon	96.67			
Oxygen	nd			
Nitrogen	3.32			
Carbon Dioxide	0.006			
Methane	nd			
Ethane	nd			
Ethylene	nd			
Propane	nd			
Propylene	nd			
Iso-butane	nd			
N-butane	nd			
Iso-pentane	nd			
N-pentane	nd			
Hexanes +	nd			

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 0
Specific gravity, calculated: 1.366

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
ISOTECH LABORATORIES INC

ANALYSIS REPORT

Lab #:	367415	Job #:	22253	IS-65948
Sample Name/Number:	GSKAFB-106205			
Company:	CB & I			
Date Sampled:	7/15/2013			
Container:	IsoBag			
Field/Site Name:	KAFB-BFF/140705			
Location:	Albuquerque, NM			
Formation/Depth:				
Sampling Point:				
Date Received:	7/16/2013	Date Reported:	7/18/2013	

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	$\delta^{18}O$ ‰
Carbon Monoxide	nd			
Helium	na			
Hydrogen	nd			
Argon	1.24			
Oxygen	24.40			
Nitrogen	71.54			
Carbon Dioxide	2.81			
Methane	0.0046			
Ethane	0.0007			
Ethylene	nd			
Propane	nd			
Propylene	nd			
Iso-butane	nd			
N-butane	nd			
Iso-pentane	nd			
N-pentane	nd			
Hexanes +	nd			

Remarks:
Analysis is of gas extracted from water by headspace equilibration. Analysis has been corrected for helium added to create headspace. Helium dilution factor = 0.85
*Addition of helium negates the ability to detect native helium and may negate the ability to detect hydrogen.

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Isotopic composition of oxygen is relative to VSMOW, except for carbon dioxide which is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
ISOTECH LABORATORIES INC

ANALYSIS REPORT

Lab #:	367416	Job #:	22253	IS-65948
Sample Name/Number:	GSKAFB-106206			
Company:	CB & I			
Date Sampled:	7/15/2013			
Container:	IsoBag			
Field/Site Name:	KAFB-BFF/140705			
Location:	Albuquerque, NM			
Formation/Depth:				
Sampling Point:				
Date Received:	7/16/2013	Date Reported:	7/18/2013	

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	$\delta^{18}O$ ‰
Carbon Monoxide	nd			
Helium	na			
Hydrogen	nd			
Argon	1.24			
Oxygen	24.92			
Nitrogen	71.76			
Carbon Dioxide	2.08			
Methane	0.0014			
Ethane	nd			
Ethylene	nd			
Propane	nd			
Propylene	nd			
Iso-butane	nd			
N-butane	nd			
Iso-pentane	nd			
N-pentane	nd			
Hexanes +	nd			

Remarks:
Analysis is of gas extracted from water by headspace equilibration. Analysis has been corrected for helium added to create headspace. Helium dilution factor = 0.79
*Addition of helium negates the ability to detect native helium and may negate the ability to detect hydrogen.

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Isotopic composition of oxygen is relative to VSMOW, except for carbon dioxide which is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
ISOTECH LABORATORIES INC

ANALYSIS REPORT

Lab #:	367417	Job #:	22253	IS-65948
Sample Name/Number:	GS002 Ambient			
Company:	CB & I			
Date Sampled:	7/15/2013			
Container:	Cali-5-Bond Bag			
Field/Site Name:	KAFB-BFF/140705			
Location:	Albuquerque, NM			
Formation/Depth:				
Sampling Point:				
Date Received:	7/16/2013	Date Reported:	7/18/2013	

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	$\delta^{18}O$ ‰
Carbon Monoxide	nd			
Helium	nd			
Hydrogen	nd			
Argon	0.934			
Oxygen	20.96			
Nitrogen	78.06			
Carbon Dioxide	0.042			
Methane	0.0003			
Ethane	nd			
Ethylene	nd			
Propane	nd			
Propylene	nd			
Iso-butane	nd			
N-butane	nd			
Iso-pentane	nd			
N-pentane	nd			
Hexanes +	nd			

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Isotopic composition of oxygen is relative to VSMOW, except for carbon dioxide which is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
ISOTECH LABORATORIES INC

ANALYSIS REPORT

Lab #: 372075 Job #: 22466 IS-65948 Co. Job#:
Sample Name: GS002 Argon Co. Lab#:
Company: CB & I
Date Sampled: 8/05/2013
Container: Tedlar Bag
Field/Site Name: KAFB-BFF/140705
Location:
Formation/Depth:
Sampling Point:
Date Received: 8/06/2013 Date Reported: 8/07/2013

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	$\delta^{15}N$ ‰
Carbon Monoxide	nd			
Helium	nd			
Hydrogen	nd			
Argon	97.64			
Oxygen	nd			
Nitrogen	2.35			
Carbon Dioxide	0.015			
Methane	nd			
Ethane	nd			
Ethylene	nd			
Propane	nd			
Propylene	nd			
Iso-butane	nd			
N-butane	nd			
Iso-pentane	nd			
N-pentane	nd			
Hexanes +	nd			

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 0
Specific gravity, calculated: 1.370

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
ISOTECH LABORATORIES INC

ANALYSIS REPORT

Lab #: 372076 Job #: 22466 IS-65948 Co. Job#:
Sample Name: GSKAFB-106051 Co. Lab#:
Company: CB & I
Date Sampled: 8/05/2013
Container: IsoBag
Field/Site Name: KAFB-BFF/140705
Location:
Formation/Depth:
Sampling Point:
Date Received: 8/06/2013 Date Reported: 8/07/2013

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	$\delta^{15}N$ ‰
Carbon Monoxide	nd			
Helium	na			
Hydrogen	nd			
Argon	1.26			
Oxygen	20.44			
Nitrogen	73.63			
Carbon Dioxide	4.67			
Methane	nd			
Ethane	nd			
Ethylene	nd			
Propane	nd			
Propylene	nd			
Iso-butane	nd			
N-butane	nd			
Iso-pentane	nd			
N-pentane	nd			
Hexanes +	0.0009			

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 0
Specific gravity, calculated: 1.026

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
ISOTECH LABORATORIES INC

ANALYSIS REPORT

Lab #: 372077 Job #: 22466 IS-65948 Co. Job#:
Sample Name: GSKAFB-106104 Co. Lab#:
Company: CB & I
Date Sampled: 8/05/2013
Container: IsoBag
Field/Site Name: KAFB-BFF/140705
Location:
Formation/Depth:
Sampling Point:
Date Received: 8/06/2013 Date Reported: 8/07/2013

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	$\delta^{15}N$ ‰
Carbon Monoxide	nd			
Helium	na			
Hydrogen	nd			
Argon	1.18			
Oxygen	21.19			
Nitrogen	75.55			
Carbon Dioxide	2.08			
Methane	nd			
Ethane	nd			
Ethylene	nd			
Propane	nd			
Propylene	nd			
Iso-butane	nd			
N-butane	nd			
Iso-pentane	nd			
N-pentane	nd			
Hexanes +	0.0005			

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 0
Specific gravity, calculated: 1.013

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
ISOTECH LABORATORIES INC

ANALYSIS REPORT

Lab #:	372625	Job #:	22491	IS-65948
Sample Name/Number:	GSKAFB-106040			
Company:	CB & I			
Date Sampled:	8/06/2013			
Container:	IsoBag			
Field/Site Name:	140705/KAFB-BFF			
Location:				
Formation/Depth:				
Sampling Point:				
Date Received:	8/08/2013	Date Reported:	8/13/2013	

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	$\delta^{18}O$ ‰
Carbon Monoxide	nd			
Helium	na			
Hydrogen	nd			
Argon	1.13			
Oxygen	23.83			
Nitrogen	73.20			
Carbon Dioxide	1.84			
Methane	nd			
Ethane	nd			
Ethylene	nd			
Propane	nd			
Propylene	nd			
Iso-butane	nd			
N-butane	nd			
Iso-pentane	nd			
N-pentane	nd			
Hexanes +	nd			

Remarks:
Analysis is of gas extracted from water by headspace equilibration. Analysis has been corrected for helium added to create headspace. Helium dilution factor = 0.84
*Addition of helium negates the ability to detect native helium and may negate the ability to detect hydrogen.

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Isotopic composition of oxygen is relative to VSMOW, except for carbon dioxide which is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
ISOTECH LABORATORIES INC

ANALYSIS REPORT

Lab #:	372626	Job #:	22491	IS-65948
Sample Name/Number:	GSKAFB-106071			
Company:	CB & I			
Date Sampled:	8/07/2013			
Container:	IsoBag			
Field/Site Name:	140705/KAFB-BFF			
Location:				
Formation/Depth:				
Sampling Point:				
Date Received:	8/08/2013	Date Reported:	8/13/2013	

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	$\delta^{18}O$ ‰
Carbon Monoxide	nd			
Helium	na			
Hydrogen	nd			
Argon	1.04			
Oxygen	22.13			
Nitrogen	74.78			
Carbon Dioxide	2.05			
Methane	nd			
Ethane	nd			
Ethylene	nd			
Propane	nd			
Propylene	nd			
Iso-butane	nd			
N-butane	nd			
Iso-pentane	nd			
N-pentane	nd			
Hexanes +	nd			

Remarks:
Analysis is of gas extracted from water by headspace equilibration. Analysis has been corrected for helium added to create headspace. Helium dilution factor = 0.84
*Addition of helium negates the ability to detect native helium and may negate the ability to detect hydrogen.

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Isotopic composition of oxygen is relative to VSMOW, except for carbon dioxide which is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.