



# Outreach Laboratory

311 North Aspen  
Broken Arrow, OK 74012  
(918) 251-2515  
FAX (918) 251-0008



LABORATORY  
ACCREDITATION  
BUREAU  
ACCREDITED



Certificate # L 2284 Testing



## Case Narrative

**Lab No: 20121211**

This report contains the analytical results for the 4 sample(s) received under chain of custody by Outreach Laboratory on 09/27/12 15:05:23. These samples are associated with your project.

The analytical results included in this report meet all applicable quality control procedure requirements except as noted below:

The test results in this report meet all NELAC requirements unless noted below:

This report shall not be reproduced, except in full, without the written approval of Outreach Laboratory.

All radiochemical sample results for solids are reported on a dry weight basis with the exception of tritium, carbon-14 and radon, unless wet weight was requested by the client.

### Observations / Nonconformances

Isotopic Thorium analysis was requested per email from K. Kinser dated 09/26/2012.



# Outreach Laboratory

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Broken Arrow, OK 74012  
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Client: OK Dept of Environmental Quality  
Client Project:  
Lab Number: 20121211  
Date Reported: 10/16/12  
Date Received: 9/27/12  
Page Number: 2 of 4

## Analytical Report

Method	Result	DL	Units	Qual.	Prep Date	Analysis Date	Analyst
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Lab ID: 20121211-01  
Client ID: 019112-001  
Date Sampled: 08/23/12 14:30:00  
Matrix: SCM

### Radiochemical Analyses

K-40	DOE Ga-01-R*	17.2 +/- 11.5	14.3	pCi/g		10/11/12	RLT
Tl-208	DOE Ga-01-R*	108 +/- 4.13	0.949	pCi/g		10/11/12	RLT
Bi-212	DOE Ga-01-R*	183 +/- 12.4	7.63	pCi/g		10/11/12	RLT
Pb-212	DOE Ga-01-R*	349 +/- 37.2	1.17	pCi/g		10/11/12	RLT
Bi-214 (Ra226)	DOE Ga-01-R*	0.974 +/- 1.28	1.27	pCi/g		10/11/12	RLT
Pb-214	DOE Ga-01-R*	1.86 +/- 0.641	1.64	pCi/g		10/11/12	RLT
Ac-228 (Ra228)	DOE Ga-01-R*	268 +/- 10.1	2.39	pCi/g		10/11/12	RLT
Th-234 (U238)	DOE Ga-01-R*	-94.5 +/- 5.31	12.6	pCi/g		10/11/12	RLT
U-235	DOE Ga-01-R*	0.180 +/- 0.121	0.540	pCi/g		10/11/12	RLT
Thorium-232	LANL ER 200 M*	264 +/- 18.2	0.961	pCi/g	10/11/12	10/11/12	RLT
Thorium-230	LANL ER 200 M*	56.3 +/- 9.80	11.9	pCi/g	10/11/12	10/11/12	RLT
Thorium-228	LANL ER 200 M*	269 +/- 18.4	1.92	pCi/g	10/11/12	10/11/12	RLT

Lab ID: 20121211-02  
Client ID: 019112-002  
Date Sampled: 08/23/12 15:00:00  
Matrix: SCM

### Radiochemical Analyses

K-40	DOE Ga-01-R*	30.6 +/- 7.81	9.04	pCi/g		10/11/12	RLT
Tl-208	DOE Ga-01-R*	118 +/- 4.75	1.32	pCi/g		10/11/12	RLT
Bi-212	DOE Ga-01-R*	191 +/- 10.5	5.53	pCi/g		10/11/12	RLT
Pb-212	DOE Ga-01-R*	293 +/- 24.8	0.739	pCi/g		10/11/12	RLT
Bi-214 (Ra226)	DOE Ga-01-R*	0.899 +/- 1.57	1.12	pCi/g		10/11/12	RLT
Pb-214	DOE Ga-01-R*	1.13 +/- 0.520	1.43	pCi/g		10/11/12	RLT
Ac-228 (Ra228)	DOE Ga-01-R*	294 +/- 8.76	1.70	pCi/g		10/11/12	RLT
Th-234 (U238)	DOE Ga-01-R*	80.4 +/- 9.00	6.55	pCi/g		10/11/12	RLT
U-235	DOE Ga-01-R*	-0.207 +/- 0.317	0.752	pCi/g		10/11/12	RLT
Thorium-232	LANL ER 200 M*	255 +/- 14.0	1.09	pCi/g	10/11/12	10/11/12	RLT
Thorium-230	LANL ER 200 M*	22.2 +/- 5.72	9.24	pCi/g	10/11/12	10/11/12	RLT
Thorium-228	LANL ER 200 M*	245 +/- 13.7	1.75	pCi/g	10/11/12	10/11/12	RLT

Lab ID: 20121211-03  
Client ID: 019112-003  
Date Sampled: 08/23/12 14:45:00  
Matrix: SCM



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Client: OK Dept of Environmental Quality  
Client Project:  
Lab Number: 20121211  
Date Reported: 10/16/12  
Date Received: 9/27/12  
Page Number: 3 of 4

## Analytical Report

Method	Result	DL	Units	Qual.	Prep Date	Analysis Date	Analyst
<b>Radiochemical Analyses</b>							
K-40	DOE Ga-01-R*	17.4 +/- 4.97	6.73	pCi/g		10/11/12	RLT
Tl-208	DOE Ga-01-R*	56.0 +/- 3.20	1.08	pCi/g		10/11/12	RLT
Bi-212	DOE Ga-01-R*	153 +/- 10.4	5.87	pCi/g		10/11/12	RLT
Pb-212	DOE Ga-01-R*	186 +/- 19.7	1.62	pCi/g		10/11/12	RLT
Bi-214 (Ra226)	DOE Ga-01-R*	0.974 +/- 0.741	1.29	pCi/g		10/11/12	RLT
Pb-214	DOE Ga-01-R*	2.28 +/- 0.622	1.58	pCi/g		10/11/12	RLT
Ac-228 (Ra228)	DOE Ga-01-R*	155 +/- 5.54	1.68	pCi/g		10/11/12	RLT
Th-234 (U238)	DOE Ga-01-R*	25.2 +/- 3.92	6.34	pCi/g		10/11/12	RLT
U-235	DOE Ga-01-R*	0.561 +/- 0.525	0.666	pCi/g		10/11/12	RLT
Thorium-232	LANL ER 200 M*	166 +/- 12.5	1.14	pCi/g	10/11/12	10/11/12	RLT
Thorium-230	LANL ER 200 M*	94.4 +/- 10.4	10.4	pCi/g	10/11/12	10/11/12	RLT
Thorium-228	LANL ER 200 M*	151 +/- 12.0	1.90	pCi/g	10/11/12	10/11/12	RLT

Lab ID: 20121211-04  
Client ID: 019112-004  
Date Sampled: 08/23/12 16:00:00  
Matrix: SCM

<b>Radiochemical Analyses</b>							
K-40	DOE Ga-01-R*	31.1 +/- 4.53	6.05	pCi/g		10/11/12	RLT
Tl-208	DOE Ga-01-R*	130 +/- 5.47	1.32	pCi/g		10/11/12	RLT
Bi-212	DOE Ga-01-R*	225 +/- 11.1	5.57	pCi/g		10/11/12	RLT
Pb-212	DOE Ga-01-R*	375 +/- 31.7	1.20	pCi/g		10/11/12	RLT
Bi-214 (Ra226)	DOE Ga-01-R*	2.25 +/- 0.884	1.38	pCi/g		10/11/12	RLT
Pb-214	DOE Ga-01-R*	-0.360 +/- 0.615	1.46	pCi/g		10/11/12	RLT
Ac-228 (Ra228)	DOE Ga-01-R*	287 +/- 8.21	1.67	pCi/g		10/11/12	RLT
Th-234 (U238)	DOE Ga-01-R*	130 +/- 10.2	7.95	pCi/g		10/11/12	RLT
U-235	DOE Ga-01-R*	0.467 +/- 0.330	0.783	pCi/g		10/11/12	RLT
Thorium-232	LANL ER 200 M*	324 +/- 20.8	1.02	pCi/g	10/11/12	10/11/12	RLT
Thorium-230	LANL ER 200 M*	21.4 +/- 7.38	12.1	pCi/g	10/11/12	10/11/12	RLT
Thorium-228	LANL ER 200 M*	320 +/- 20.7	2.39	pCi/g	10/11/12	10/11/12	RLT



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Page Number: 4 of 4

## QC Report

Parameter	Blank	LCS	LCSD		DUP RPD	RER, NAD or DER	MS	MSD		Date
		%REC	%REC	RPD			%REC	%REC	RPD	
Ac-228 (Ra228)	-0.097				4.0	0.903				10/11/12
Am-241		106.0	109.0	3.1						10/11/12
Bi-212	-0.141				2.0	0.255				10/11/12
Bi-214 (Ra226)	-0.062				NC	0.041				10/11/12
Co-60		91.0	92.0	1.6						10/11/12
Cs-137		99.0	99.0	0.0						10/11/12
K-40	-0.284				NC	0.582				10/11/12
Pb-212	0.014				12.0	0.879				10/11/12
Pb-214	0.086				NC	1.270				10/11/12
Th-234 (U238)	0.525				24.0	1.780				10/11/12
Thorium-228	0.134	113.0			16.8	0.613	97.7	89.6	8.7	10/02/12
Thorium-230	0.164	118.0			1.7	0.064	90.8	83.9	7.9	10/02/12
Thorium-232	0.216	116.0			1.2	0.046	90.4	110.0	19.8	10/02/12
H-208	-0.015				4.0	0.643				10/11/12
H-235	0.093				NC	0.573				10/11/12

Lab Approval: \_\_\_\_\_



OKLAHOMA  
DEPARTMENT OF ENVIRONMENTAL QUALITY  
...for a clean, attractive, prosperous Oklahoma

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY  
STATE ENVIRONMENTAL LABORATORY  
707 N. Robinson; P.O. Box 1677  
Oklahoma City, OK 73102-6010

ODEQ/SEL/Quality Assurance  
Outsourcing Chain of Custody  
SEL Form #991  
Revision Date: 03/05/10  
Revision: 1

CHAIN OF CUSTODY RECORD		For Outsourcing or Returning Laboratory Samples				Page <u>1</u> of <u>1</u>
SEL ID	COLLECTION		SAMPLE INFORMATION			COMMENTS
	DATE	TIME (Military)	SAMPLE TYPE	PRESERVATION TYPE	CONTAINER TYPE	
019112-001	5-23-12	1430	soil	none	plastic	1 901.1 7
019112-002	8-23-12	1500	soil	none	plastic	1 901.1 Box 1 of 1
019112-003	8-23-12	1445	soil	none	plastic	1 901.1
019112-004	8-23-12	1600	soil	none	plastic	1 901.1
*Per email from Kelly Hunsley, the client also wishes samples to be analyzed for isotopic Thonium.						
<p>Relinquished By: <u>Candace Brown</u> Received By: <u>Indira</u> Organization: <u>PEE</u> Date/Time: <u>9/26/12 10:23 AM</u></p> <p>Method of Shipment: <input type="checkbox"/> Courier (FedEx, UPS, ETC) <input type="checkbox"/> US Mail <input type="checkbox"/> Hand Delivery Priority: <input type="checkbox"/> Overnight <input type="checkbox"/> 2-Day <input type="checkbox"/> Immediate <input type="checkbox"/> Other</p> <p>Dispatched By (Hand Delivery): _____ Date/Time: _____ Comments: _____</p> <p>Method of Shipment: <input type="checkbox"/> Courier (FedEx, UPS, ETC) <input type="checkbox"/> US Mail <input type="checkbox"/> Hand Delivery Priority: <input type="checkbox"/> Overnight <input type="checkbox"/> 2-Day <input type="checkbox"/> Immediate <input type="checkbox"/> Other</p> <p>Received By: <u>Tom M.</u> Date/Time: <u>09/27/2012</u> Organization: <u>Outreach Technology</u></p>						
DATA TRANSFER INFORMATION						
Outsourced Data Transferred By: _____ Date/Time: _____						
Method of Data Transfer: <input type="checkbox"/> E-mail <input type="checkbox"/> Fax <input type="checkbox"/> Hand Delivery <input type="checkbox"/> Hard Copy Organization: _____ Date/Time: _____						
Outsourced Data Received By: _____ Date/Time: _____						

2012/2/11

**RADIATION SURVEY RESULTS**  
**AT THE FORMER BROKEN ARROW LANDFILL SITE**  
**(W/2 of NE/4 of Section B, T8N, R15E, Tulsa County)**

**Broken Arrow, Oklahoma**

**EPA ID No. OKD074274333**

**April 16, 2012**

**Prepared for**  
**JM Assets LP**  
**1903 Excel Drive**  
**Killeen, Texas 76542**

**A&M Project No. 2028-006**

**PREPARED BY:**

**A&M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.**  
**10010 E. 16<sup>TH</sup> STREET**  
**TULSA, OKLAHOMA 74128-4813**  
**PHONE (918) 665-6575 & FAX (918) 665-6576**  
**EMAIL: aandm@aandmengineering.com**



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April 16, 2012

Ms. Rachel Franks  
Environmental Program Specialist  
Land Protection Division  
ODEQ  
P. O. Box 1677  
Oklahoma City, OK 73101-1677

Re: Radiation Survey for Former Broken Arrow Landfill, Broken Arrow,  
Oklahoma.

Dear Ms. Franks,

Enclosed is a copy of the Radiation Survey Report for the Former Broken Arrow Landfill site. The report includes recommended procedures to locate the sources in two separate areas. Upon your approval of the recommended procedure, the field work will commence.

If you have any questions or need additional information, please call me at 918-665-6575.

Sincerely yours,

Irfan Taner  
Chief Geologist

Enclosure

Cc: Mr. Ken Leonard, JM Asset LP

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### ATTACHMENTS

(LOCATED AT THE END OF THE TEXT)

#### ATTACHMENT

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ATTACHMENT 1: Radiation Survey Plan

### LIST OF FIGURES

(LOCATED AT THE END OF THE TEXT)

#### FIGURE

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FIGURE 1: Radiation Survey Map

FIGURE 2: Hot Area Map

FIGURE 3: Vertical Profile of Radiation Reading in a Boring



**RADIATION SURVEY RESULTS**  
**AT**  
**FORMER BROKEN ARROW LANDFILL SITE**  
**(W/2 OF NE/4 OF SECTION 8, T8N, R15E, TULSA COUNTY)**  
**BROKEN ARROW, OKLAHOMA**

**1. INTRODUCTION**

A&M Engineering on behalf of JM Assets LP prepared and submitted a Radiation Survey Plan for the former Broken Arrow Landfill Site located in W/2 of NE/4 of Section 8, T8N, R15E in Tulsa County, Oklahoma. The survey plan was prepared due to previous hits during radiation scanning surveys. A copy of the radiation survey plan is enclosed as Attachment 1.

The survey plan was supposed to survey 100 x 100 feet grid in the one-third northern portion, but this grid was extended to the whole property and most of the node points were surveyed in the southern two thirds of the site. Randomly selected grid areas (100 x 100 feet) were surveyed in detail.

**2. SURVEY RESULTS**

The field survey was conducted on March 22-23, 2012 following the procedures in the survey plan (Attachment 1). On March 22, 2012 ODEQ representatives were also present and conducted radiation measurements utilizing ODEQ instruments. A&M Engineering instruments were compared with ODEQ instruments and the results were similar.

Figure 1 shows the radiation readings throughout the site. In general, all the readings were less than 18 microrem per hour and similar to background readings. Background readings were taken to the north – 12-15 microrem/hr, to the east 17-19 microrem/hr, and to the west 14-17 microrem/hr, to the south 15-17 microrem/hr, and to the west 14-17 microrem/hr.

In selected random grids, more reading points were taken and these grids are shown in Figure 1.

The survey detected two areas with higher than background radiation readings (see Figure 2). The first area is adjacent to A1 node point and it measures about 50x100 feet. Two hot points were determined, one 225 microrem/hr and the other 625 microrem/hr. These two hot points were about 10x10 feet or less.

The second area with high readings is located among the C2, C3, D2 and D3 node points. In this area there was also two elongated hot areas surveyed in detail (see Figure 2). The east elongated hot area has about a 365 microrem/hr reading and the west elongated area 490 microrem/hr. Surrounding areas of these two elongated hot areas have lower readings and within 30-40 feet readings go back to background levels.

Soil samples were collected from top 6 to 10 inches in the couple hot areas (one from A1 node with a 625 microrem/hr and the other from elongated area with 490 microrem/hr reading). The soil samples were remeasured for radiation outside the hot areas and all the soil samples from hot areas were having normal background levels of radiation. Thus the soil was not the source of radiation.

Another test was conducted in the field which was to dig a hole in the westerly elongated area (the one with 490 microrem/hr) to test the radiation change in vertical profile.

Figure 3 shows the radiation readings in vertical profile of the dug hole. The radiation reading started at 450 microrem/hr and increased to 750 microrem/hr at a 12 inch depth

and dropped to 275 microrem/hr at an 18 inch depth and 125 microrem/hr at a 30 inch depth. The highest radiation reading of 750 microrem/hr was across a gravel/soil layer (see Figure 3).

During the survey on March 22, 2012, ODEQ personnel used “interference instruments” to determine the type of source for the radiation in the hot spots. According to ODEQ personnel the source could be either iodine 12 or cobalt 60 (both medical sources), or thorium. Thorium could be present in many different instruments, devices and material.

The radiation survey results indicate that small radiation sources are present in four hot spots in the top two feet, especially the gravel/soil mixed layer. The soil is not the source of radiation.

### **3. RECOMMENDATION**

To find the buried radiation sources, the following procedures are suggested for ODEQ approval:

1. Obtain a Ludlum 2221 with Model 44-10 probe. Will get lead collimator for the probe to help identify the hot spot.
  2. Re-survey the previously determined hot areas using Ludlum 2221 with Model 44-10 probe.
  3. Identify the radiation source areas.
  4. Dig soil gently in the identified source areas. Try to locate the source in the excavated soil.
  5. When identified, secure the source in place by marking the location.
  6. Sample the source and deliver samples to Outreach Lab in Tulsa for analysis. Outreach Laboratory is specialized in radiation analysis.
-

7. Upon receiving the analytical results, determine the disposal facility for the source.
8. Obtain approvals and shipment procedures from the disposal facility.
9. Dig the sources identified in the field and package them for shipment to the disposal facility.
10. Prepare a report and submit to ODEQ.

# **ATTACHMENT 1**



**A & M ENGINEERING & ENVIRONMENTAL SERVICES, INC.**

10010 E. 16<sup>TH</sup> STREET  
TULSA, OKLAHOMA 74128-4611

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EMAIL: [aandm@aandmengineering.com](mailto:aandm@aandmengineering.com)

March 20, 2012

Ms. Rachel Francks  
Environmental Program Specialist  
Land Protection Division- Brownfields  
P.O. Box 1677  
Oklahoma City, OK 73101-1677

Re: Radiation Survey for former Broken Arrow Landfill Site  
(W/2 of NE/4 of Section 8, T18N, R15E Tulsa County), Broken Arrow, OK  
ODEQ-LPD Case No. 09-057.

Dear Ms. Francks:

Enclosed are two copies of Radiation Survey Procedure for the former Broken Arrow Landfill site. The procedure includes your latest requests. The survey will be conducted on March 22, 2012 as agreed with you.

If you have any questions, please call me at 918-665-6575.

Sincerely yours,

Irfan Taner  
Chief Geologist  
Enclosure (2)

CC: Mr. Kenneth Leonard

**Radioactive Scanning Survey Procedure  
for  
former Broken Arrow Landfill Area  
(located within W/2 of NE/4 of Section 8, Township 18 North  
Range 15 East, Broken Arrow, OK)  
ODEQ-LPD Case No. 09-057**

**SITE LOCATION**

The subject site consists of approximately 76 acres of undeveloped land that is located approximately 2.5 miles east of downtown Broken Arrow and about 0.75 mile southwest of Creek Turnpike and Muskogee Turnpike intersection.

The site is covered partly with grassland and brush, and the denser woodland in southeast and western portions of the property.

The site currently does not have any improvements. There are earthen access roads throughout the site.

**SITE BACKGROUND**

The site historically was part of coal strip mine. The coal mining in this area was in 1920s and 1930s with some additional mining in 1960s.

The site was permitted in June 1973 to be operated as a sanitary landfill by City of Broken Arrow. The same permit was closed on September 25, 1976. The permitting records show that the site was utilized as a landfill less than 2.5 years.

During recent site investigations, a portion of the site is determined to have a buried municipal waste. The municipal waste is covered with at least three feet of soil. The buried waste thickness ranges from a few inches to 3-4 feet. The installed gas probes in the burial areas have not shown methane gas generation. The groundwater monitoring wells on the subject property has not shown any impact to groundwater.

**RADIOACTIVE SCANNING SURVEY PROCEDURE**

The site will be surveyed using Ludlum Model 3 radiation meter with the model 44-2 Sodium Iodide detector. The Ludlum Model 3 radiation meter displays its readings in units of micro Roentgens per hour ( $\mu\text{R/hr}$ ), a direct measure of gamma radiation particles in the air.

The field survey will be conducted following the steps below:

- a) The attached map shows the survey locations on the property. The survey will be conducted on a 100' x 100' grid located on the northern part of the site. Two areas are selected on-site which will be gridded 10' x 10' and surveyed. Additionally, several random sampling locations (shown on map) will be surveyed as 100' x 100' boxes with survey points at the four corners and one in the center.
- b) Prior to starting radiation measurements, the meter will be checked for correct operation.

- c) A radiation reading will be taken at each station by holding meter stationary and no more than 1 foot off ground surface.
- d) Each day before survey starts, background readings will be collected at off site to the east, west, and to the north across the 71<sup>st</sup> Street. These readings will be recorded in the field notebook.
- e) Then the survey will be performed along the established grid lines. A radiation reading will be collected at each node point and will be recorded in the field notebook.
- f) If any node point reading exceeds three times the background reading, then at least two additional readings will be collected within 5 feet of that particular node point to verify high reading.
- g) During survey source node points could be inaccessible due to heavy vegetation and brush, in such cases survey technician will try to obtain a reading as close as possible to the node point and record the actual location in the field notebook.
- h) In high reading areas (more than three times background), soil sample will be collected from the top 6-inches. The soil sample will be analyzed for radioactive constituents.

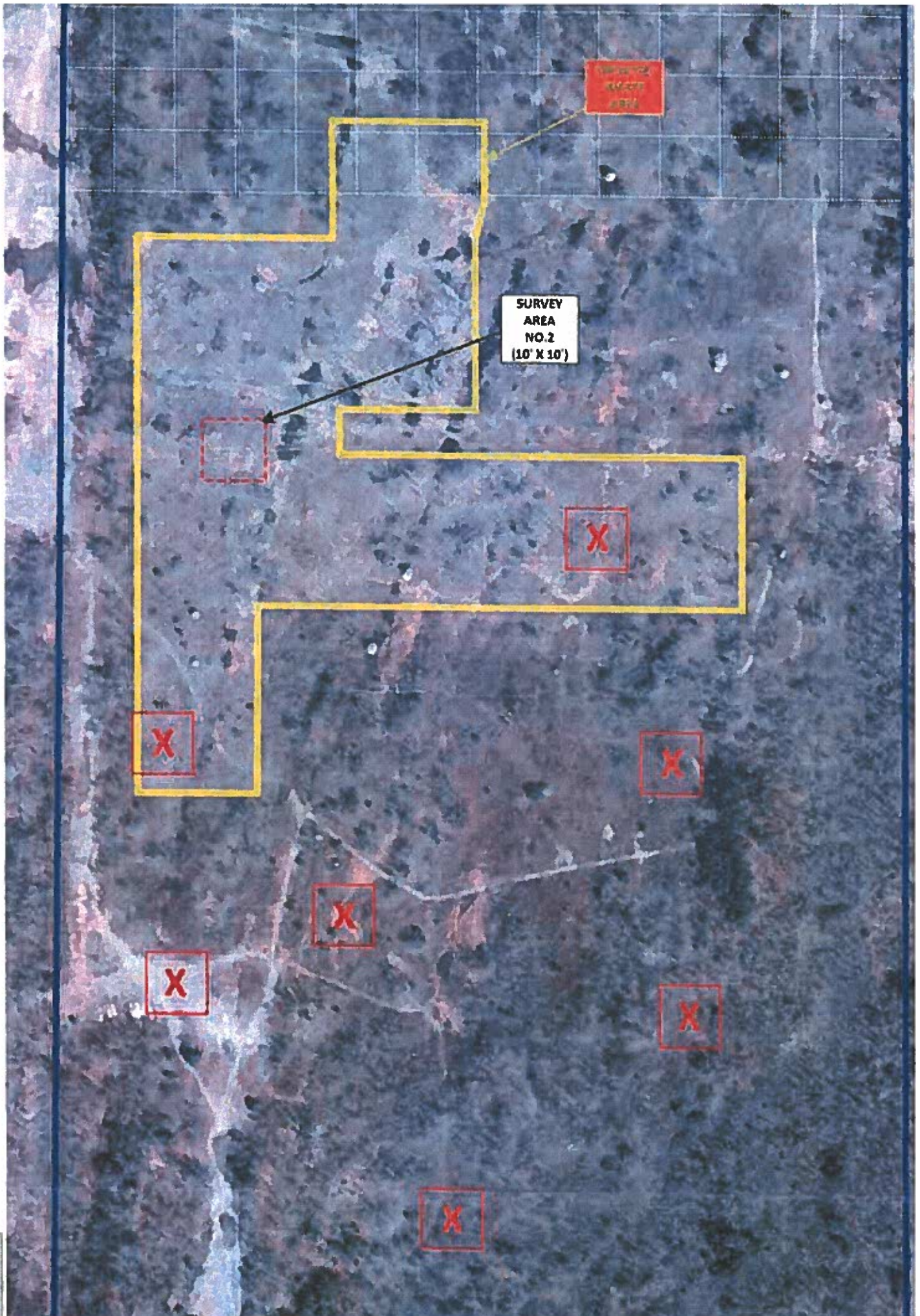
#### **COMPARISON STANDARDS**

The United States Nuclear Regulatory Commission (NRC) determines what radiation exposure level is considered safe. Occupational exposure for worker is limited to 5,000 milli REM (mREM) per year. For the general population, the exposure is 500 mREM above background radiation in any one year.

#### **SURVEY REPORT**

After field survey all data will be evaluated and a report will be prepared and submitted to ODEQ.





SURVEY  
AREA  
NO.2  
(10' X 10')

SURVEY POINT  
AREA

X

X

X

X

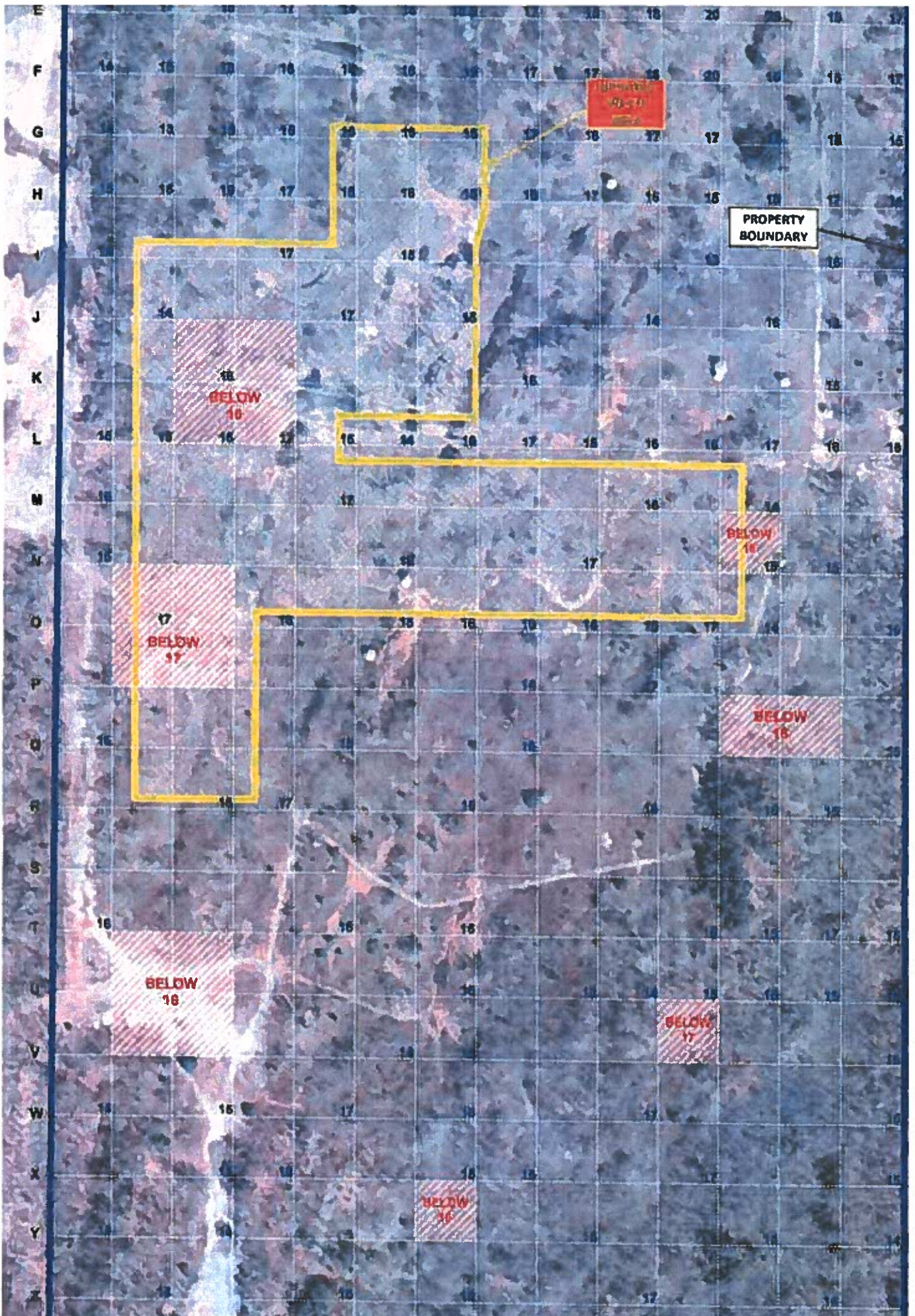
X

X

X

SURVEY POINT  
(100 FT AREA)  
RID (100 FT APART)

# FIGURES



**D**  
**KEY READING**  
**E SURVEY AREA**  
**100 FT AREA**

Fence line

Fence line

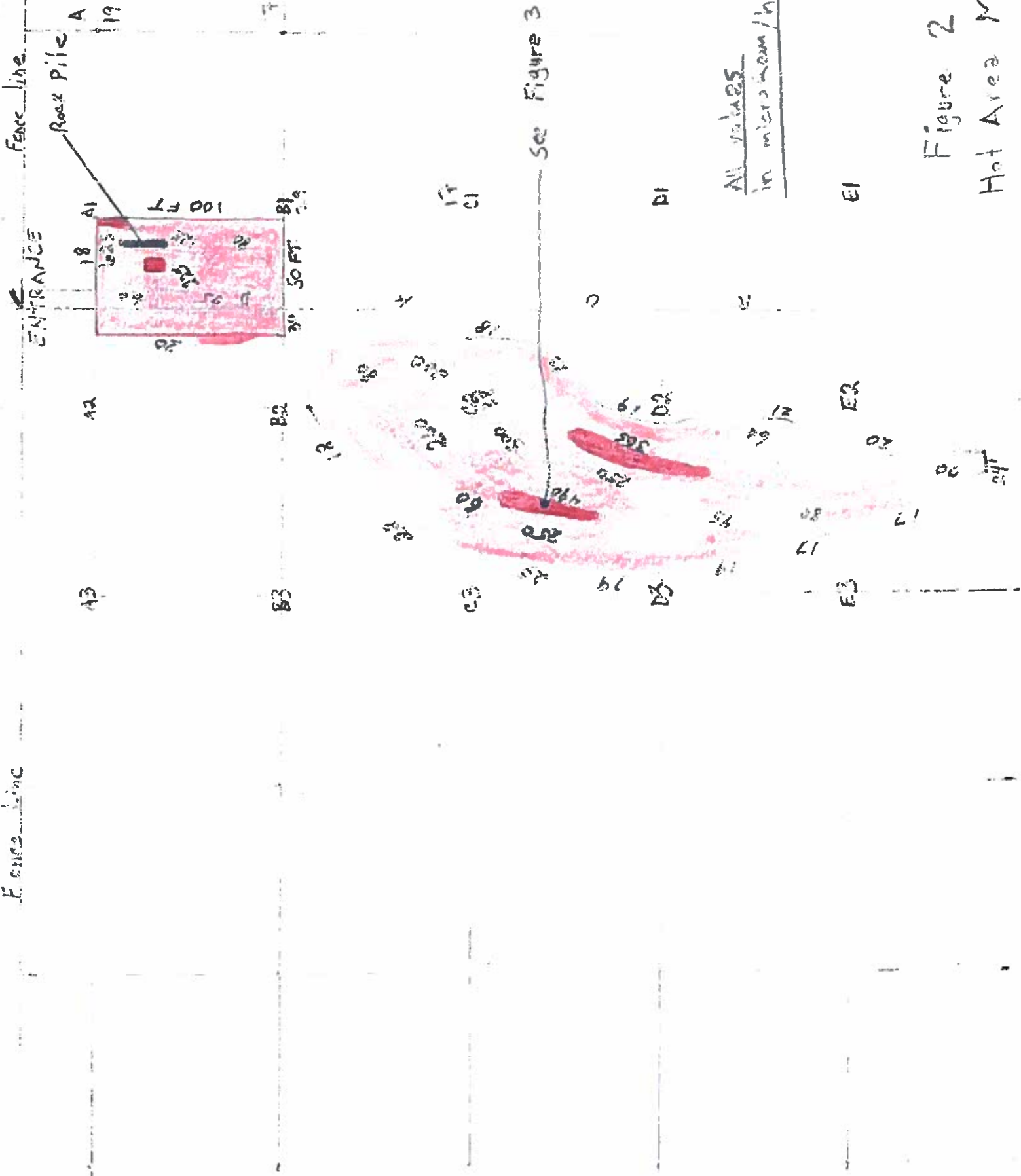
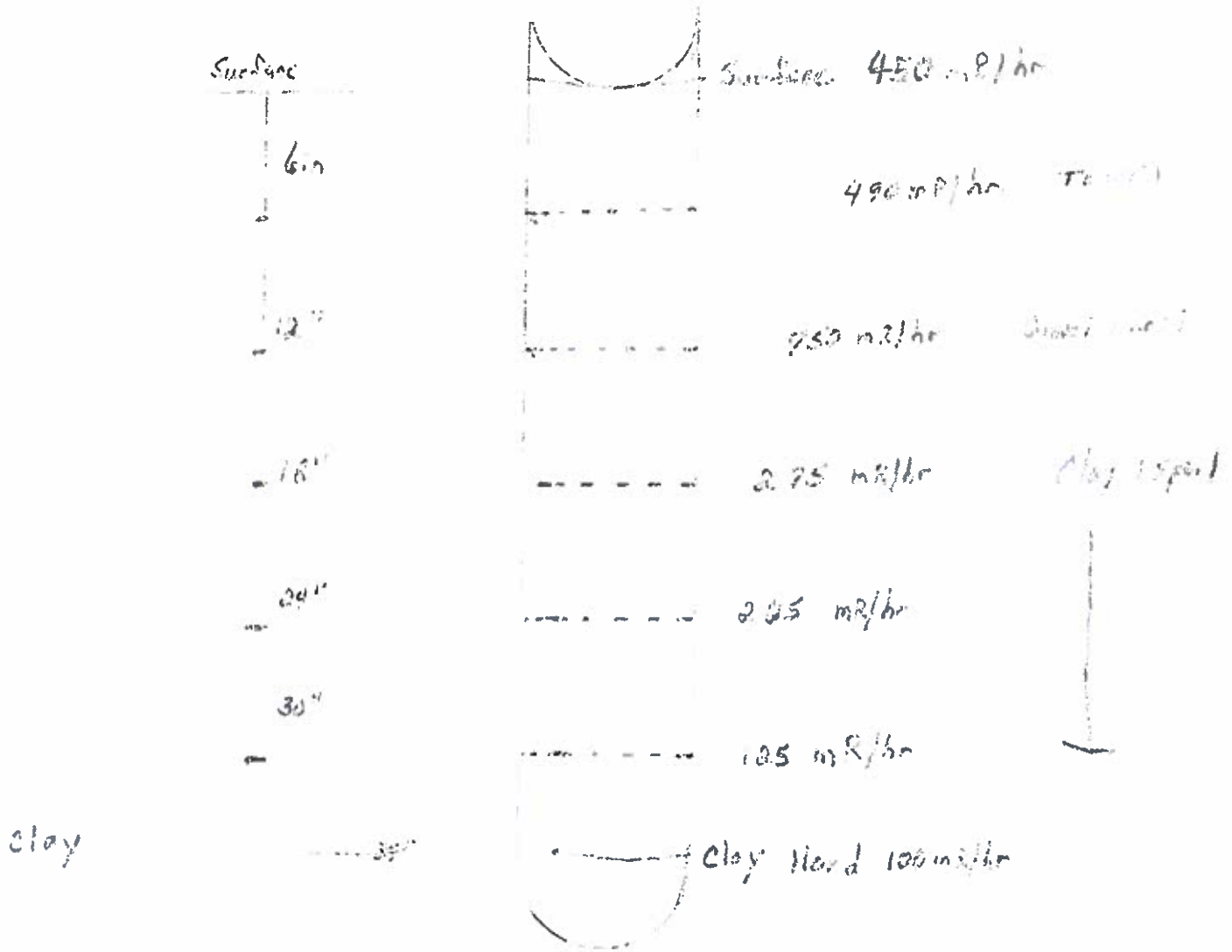


Figure 2  
Hot Area Map

Fig. 3

Vertical Profile of Radiation Residue  
in a building



mR = microRm

# **RADIATION SURVEY PLAN**

**FORMER CITY OF BROKEN ARROW, OK LANDFILL SITE  
(W/2 OF THE NE/4 OF SECTION 8, T18N, R15E WAGONER COUNTY, OK)**

**SEPTEMBER 2013**

**PREPARED FOR:**

**JM ASSETS LP  
4203 SPINNAKER COVE  
AUSTIN, TX 78731**

**(A & M Project No. 2028-009)**

**PREPARED BY:**



**A&M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.  
10010 EAST 16<sup>TH</sup> STREET  
TULSA, OKLAHOMA 74128-4813  
PHONE: (918) 665-6575      FAX: (918) 665-6576  
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**A & M ENGINEERING & ENVIRONMENTAL SERVICES, INC.**

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September 14, 2013

Ms. Rachel Francks  
Environmental Programs Specialist  
Land Protection Division  
Brownfields Program  
Oklahoma Department of Environmental Quality  
707 North Robinson  
P.O. Box 1677  
Oklahoma City, OK 73101-1677

**RE: Radiation Survey Plan  
Former City of Broken Arrow Landfill Site  
Wagoner County, OK**

Dear Ms. Francks:

Attached for review is a Radiation Survey Plan for the above referenced site. The plan is being submitted on behalf of the current landowner, JM Assets LP, and as requested by ODEQ, has been prepared in accordance with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

JM Assets LP is prepared to begin the additional surveying activities immediately upon approval by ODEQ.

If you have any questions on this matter, or if you require any additional information, please do not hesitate to call. Expediency given to the review/approval of the plan would be greatly appreciated.

Sincerely,  
A&M Engineering and Environmental Services, Inc.

Thomas A. Trebonik, P.G.  
Senior Project Manager

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- 1**     **Results of Laboratory Analysis**
- 2**     **Survey Instrument Data Sheets**





## 1.0 Introduction

Previous investigations in support of a Brownfields Proposal for a “No Action Necessary” determination from the Oklahoma Department of Environmental Quality (ODEQ) were conducted on property which contains the former City of Broken Arrow, OK Landfill. The property (hereinafter the “Site”) is located within the W/2 of the NE/4 of Section 8, Township 18N, Range 15 East, Wagoner County, Oklahoma. From a surface soil, sediment, surface water, groundwater, and methane gas generation perspective, the previous investigations resulted in a determination that the historic site activities do not present an unreasonable risk to human health and/or the environment. However, radiation surveys conducted at the site indicated that a small portion of the property exhibited gamma activity above the natural background level of adjacent areas.

The areas within the Site previously identified with higher than background activity are primarily located in the northeastern corner of the 76 acre property and constitute an area estimated to be between one and two acres in size. The cause(s) of the elevated activity observed was initially attributed to small radiation source material (such as that used in medical equipment and testing gauges) that may have been disposed (buried) in the landfill. However, further investigation of the area of elevated activity by ODEQ personnel resulted in a determination that a layer of radioactive material exists in the shallow subsurface. The total areal extent of shallow subsurface material on the property and the entity(ies)/licensee(s) responsible for generation and placement of these materials at the site are not currently known.

As a result of ODEQ’s findings ODEQ has requested rescreening of the site on a close grid basis to allow for identification of any additional areas where these materials may have been placed. Identification of all areas exhibiting elevated activity is an important aspect in planning for removal of the existing radioactive materials and for identifying those areas posing no threat to human health. Identification of areas posing no threat to human health could then be available for planned site development.

This Radiation Survey Plan presents the procedures to be followed in conducting a radiation survey of the site to allow for identification of any additional elevated activity areas and/or for identification of areas where no activity above background levels exist. Areas where no elevated activity exists will be considered “clean” and with proper controls to protect human health and the environment from nearby impacted areas, will be considered available for immediate



development. Access to “impacted” areas will be controlled until removal and release for unrestricted use is obtained from ODEQ.

## **1.1 Purpose**

The purpose of this plan is to identify all areas of elevated activity that may require additional survey and remedial action by acquiring sound, reproducible, site specific scientific data which will allow for classification and specification of boundaries. Concurrently, implementation of this plan will allow for identification of areas which pose no threat to human health.

## **1.2 Objectives**

The primary objectives of this proposed work effort are to

- Augment the historical data collected at the site
- Identify areas for potential sampling and further characterization/remediation
- Determine non-impacted areas on the site
- Determine if data supports release of those areas from further consideration

## **2.0 Site Location**

The Site consists of approximately 76-acres of undeveloped land located within the West ½ of the Northeast ¼ of Section 8, Township 18 North, Range 15 East, Wagoner County, Oklahoma. The Site is situated in the northeast portion of the State of Oklahoma and within the west-central portion of Wagoner County. The Site is located approximately 2.5 miles east of downtown Broken Arrow, OK and 0.25 mile west of the East 71<sup>st</sup> Street/Kenosha Street and South 225<sup>th</sup> East Avenue intersection. The Creek Turnpike and Muskogee Turnpike intersection is situated approximately 0.75 mile southwest of the Site. Except for an earthen access road, the Site currently does not have any improvements (buildings, tanks, parking lots, etc.). The site is fenced and access to the site is limited. A gate provides access. When not in use, the gate is kept chained and locked. The property is posted “No Trespassing”.

## **3.0 Site History**

According to historical sources, the Site was formerly a coal strip mine that was mined in the 1920s and 1930s. Some additional mining is reported to have occurred in the 1960’s. Mining



activities occurred prior to the Surface Mining Control and Reclamation Act of 1977 and the site was left in an un-reclaimed state.

In the early 1970's, consideration was made for using the site for land filling purposes. The Site was permitted through the Oklahoma State Department of Health (OSDH) for hazardous waste disposal by the manufacturer of acetylene on February 15, 1973. OSDH stamped this first permit "invalid" with a remark of "Sold to Broken Arrow of S.L." (Sanitary Landfill). Hazardous waste generated from the manufacture of acetylene was not disposed at the site.

OSDH then reissued Permit No. 3573002 on June 15, 1973 to the City of Broken Arrow, OK for a sanitary landfill at the site. The same permit was closed on September 25, 1976. This permitting record indicates that the Site was utilized only for a maximum of 2.5 years by the City of Broken Arrow for disposing municipal waste. It is not currently known if the City of Broken Arrow accepted any radiological waste/materials at the site.

As part of a change in ownership, a Phase I Environmental Site Assessment (ESA) was originally conducted in February 2008 and was later updated in December 2008 and January 2009. Records indicate that historically, the Site had been strip mined and later permitted as a municipal landfill for the City of Broken Arrow, OK. The current owner of the property, JM Assets LP, later purchased the site for development. JM Assts LP has never conducted any disposal activities or industrial activities at the site and the site remains undeveloped.

As a result of the change in ownership, and in consideration of future development of the site, JM Assets LP, entered into Memorandum of Agreement and Consent Order (MACO) with the Oklahoma Department of Environmental Quality (ODEQ). The MACO acknowledges the entering of the property into the Brownfields Program administered by ODEQ. Investigation and Site Characterization activities in support of a Brownfields Proposal for obtaining a Certificate of No Further Action have been conducted. However, to date, a Certificate of No Further Action has not been granted by ODEQ and is pending resolution of the elevated gamma activity and radioactive material found at the site.

#### **4.0 Radionuclides of Concern**

Sampling and radiochemical analysis of the identified shallow subsurface materials at the site indicate the presence of uranium, thorium, and associated daughter isotopes as well as the metals



magnesium, chromium, manganese, molybdenum, and aluminum. Results of analysis conducted on the shallow subsurface materials are presented in **Attachment 1**.

At the activity and concentrations detected, these materials are not generally associated with the natural geologic strata of the area and are believed to have been brought to the site and disposed/dumped. The exact timing of placement of these materials is not currently known.

## **5.0 Proposed Radiation Survey**

Procedures to be followed in conducting the radiation survey at the Site will be in accordance with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). The MARSSIM is a multi-agency (Dept. of Defense, Dept. of Energy, Environmental Protection Agency, and the Nuclear Regulatory Commission) consensus document that provides information and guidance on planning, conducting, evaluating, and documenting, radiological surveys on building surfaces and surface soil for demonstrating compliance with dose or risk-based regulations or standards. It is anticipated that the entire site will be surveyed using direct measurement equipment and a reference coordinate system for documentation purposes. Soil sampling is not anticipated to be conducted during performance of the radiation survey.

### **5.1 Survey Grid Establishment**

It is proposed that a reference coordinate system based on intersecting perpendicular lines be used at the Site. For MARSSIM defined Class 1 land areas, defined as areas that have, or had prior to remediation, a potential for radioactive contamination (based on site operating history) or known contamination (based on previous radiation surveys), a grid pattern of 10 to 20 meters is believed to be sufficient to identify survey locations with a reasonable level of effort, while not being overly cost prohibitive (MARSSIM Page 4-27).

A base map containing the reference coordinate system with nodes will be prepared for use in the field and will be based on differential global positioning system (GPS) data overlain on a site aerial photograph. A Trimble R8 GNSS Model 2 GPS system, with a horizontal precision of approximately  $\pm 1/2$  inch ( $\pm 1.3$  centimeters) will be used to establish the grid. The procedure will involve establishing four site control points which surround the Site and recording the coordinates and elevations of the points using a Trimble GPS receiver to record the static positional data. The recorded data for each point will then be uploaded to the Online Positioning



User Service-Rapid Static (OPUS-RS) web-site operated by the National Geodetic Survey. The OPUS-RS web-site processes the uploaded data and determines a highly accurate position of each point with respect to at least three Continuously Operating Reference Stations (CORS). The average longitude, latitude and elevation residuals of the control points based on the North American Vertical Datum of 1988 (NAVD1988) will be generated and converted to the local state plane coordinate system. The state plane coordinates will be used to create the grid and each node of the grid will be assigned its own unique coordinate for survey purposes. Using the GPS assigned node coordinate method allows for accurately locating a node point in the future should it become necessary. For map reference and presentation purposes, each node will also be assigned a unique alphanumeric identifier. **Figure 1** presents a typical alphanumeric grid layout.

Based on the historical information of the site and previously gathered survey data, it is proposed that a grid pattern of 50 feet by 50 feet (~15 meters x 15 meters) be utilized in the radiation survey. In areas where survey node points are inaccessible (due to heavy vegetation and/or trees), it may be necessary to off-set the established survey point. In such cases, radiation survey data gathered will be obtained as close as possible to the node point and a record of the actual location of the point surveyed will be made. Clearing open land areas of brush and weeds will be considered prior to conducting the radiation survey.

## **5.2 Instrumentation**

It is proposed to utilize a Ludlum Model 3 Survey Meter (or equivalent) equipped with either a Ludlum 44-2 or 44-10 Sodium Iodide detector. The detector used will be based on equipment availability at the time the survey is conducted. The difference between the two detectors is primarily in the Sodium Iodide crystal size (1"x 1" vs 2"x 2" diameter by length) and detector sensitivity. Based on historical information of the Site, either detector is suitable for use at the Site. At a minimum, the survey meter chosen will be configured to allow for direct measurement of gamma radiation in the air in microRoentgens per hour ( $\mu\text{R/hr}$ ). **Attachment 2** presents manufacturer data sheets for the Ludlum Model 3 Survey Meter and the Ludlum 44-2 and 44-10 detectors.

Prior to use, the survey meter will be checked for proper operation by conducting an operational check (including a battery test and instrument test) in accordance with Manufacturers recommendations. In the event the operational check indicates problems, the batteries will be



replaced, any cause for instrument non-performance will be evaluated and corrected, and/or the meter recalibrated to ensure proper operation.

### **5.3 Survey Technique**

Each day, prior to conducting Site radiation surveying activities, background radiation levels will be determined for comparison purposes. The background reference areas will be chosen from adjacent properties to the north, south, east, and west of the Site and will be based on ease of access. Background reference areas from these locations have similar physical, chemical, geological, radiological, and biological characteristics and should adequately define the radiological conditions of the surrounding area. Background readings will be collected from the same locations each day and the background readings recorded to document and assess potential variations which may occur. GPS coordinates for the chosen background reference areas will be collected and recorded for future use.

Two measurement readings will be collected at each background reference area: one at ground surface and one approximately 3 feet (1 meter) above the ground surface. Measurement readings will be collected by holding the survey meter stationary.

After collection of the background readings, survey activities at the Site will be initiated or continued along the established grid. Measurement readings will be collected at the survey nodes located by the GPS equipment and recorded. Two measurement readings will be collected at each survey node: one at ground surface and one approximately 3 feet (1 meter) above the ground surface. Measurement readings will be collected by holding the survey meter stationary. After recording the reading, the surveyor(s) will move along the grid line to the next survey node location.

In the event measurement readings at a survey node exceed three times the minimum recorded background level, additional readings at ground level and 1 meter above the ground level will be collected at each of four points approximately 3 meters from the survey node. The points will be determined by walking approximately 3 meters along a line diagonal to the grid system (i.e., NE, SE, SW, and NW) to a point and recording the measurement readings. **Figure 2** present a typical schematic of the locations of additional readings which may be taken.

Once the additional readings have been recorded, surveying along the established grid will then continue. This procedure will continue until the entire Site has been surveyed. As previously mentioned however, in areas where survey node points are inaccessible (due to heavy vegetation



and/or trees), it may be necessary to off-set an established survey node location. In such cases, radiation survey data gathered will be obtained as close as possible to the node point and a record of the actual location of the point surveyed will be made.

## **6.0 Evaluation of Survey Results**

Data gathered will initially be compared against background levels of radiation to determine if any additional areas of elevated activity exist at the property. Since the survey grid proposed for the Site is smaller than the historic survey grid used (100' x 100'), the known areas of elevated activity will be re-evaluated on the closer grid basis and their locations clearly identified with GPS coordinates.

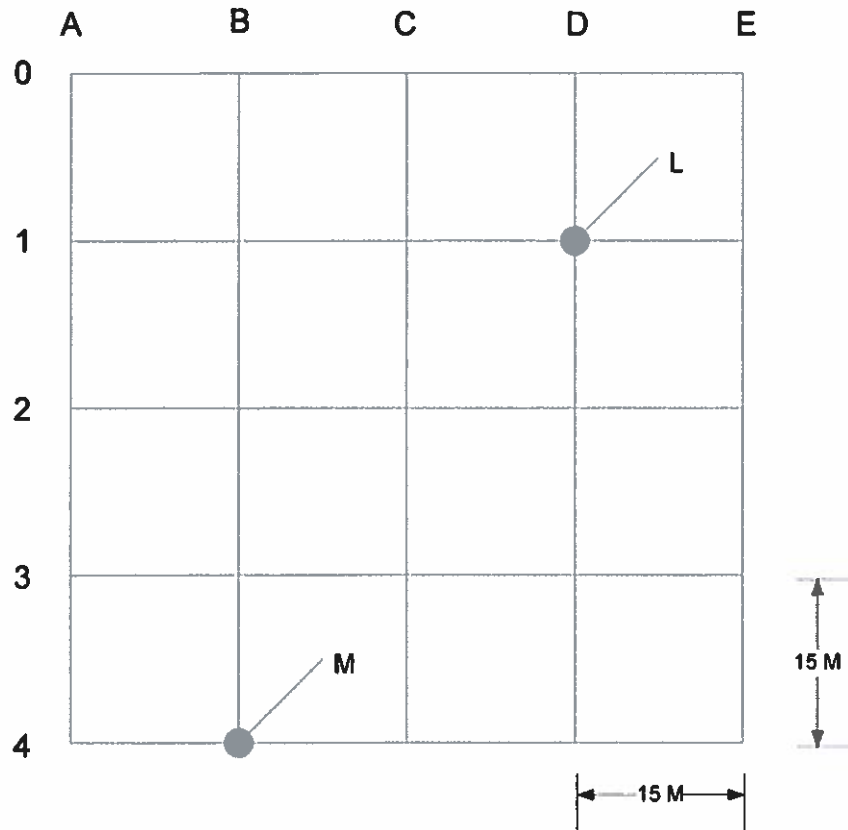
At the conclusion of the survey, a Report of Findings will be prepared for submittal to ODEQ. The Report of Findings will include documentation of all activities conducted at the Site, all data gathered during the survey activities, and a map delineating all areas of elevated activity which will require additional characterization and remediation. The map will also delineate those areas which pose no threat to human health or the environment.



## FIGURES







POINT L: ALPHANUMERIC COORDINATE – D1

POINT M: ALPHANUMERIC COORDINATE – B4

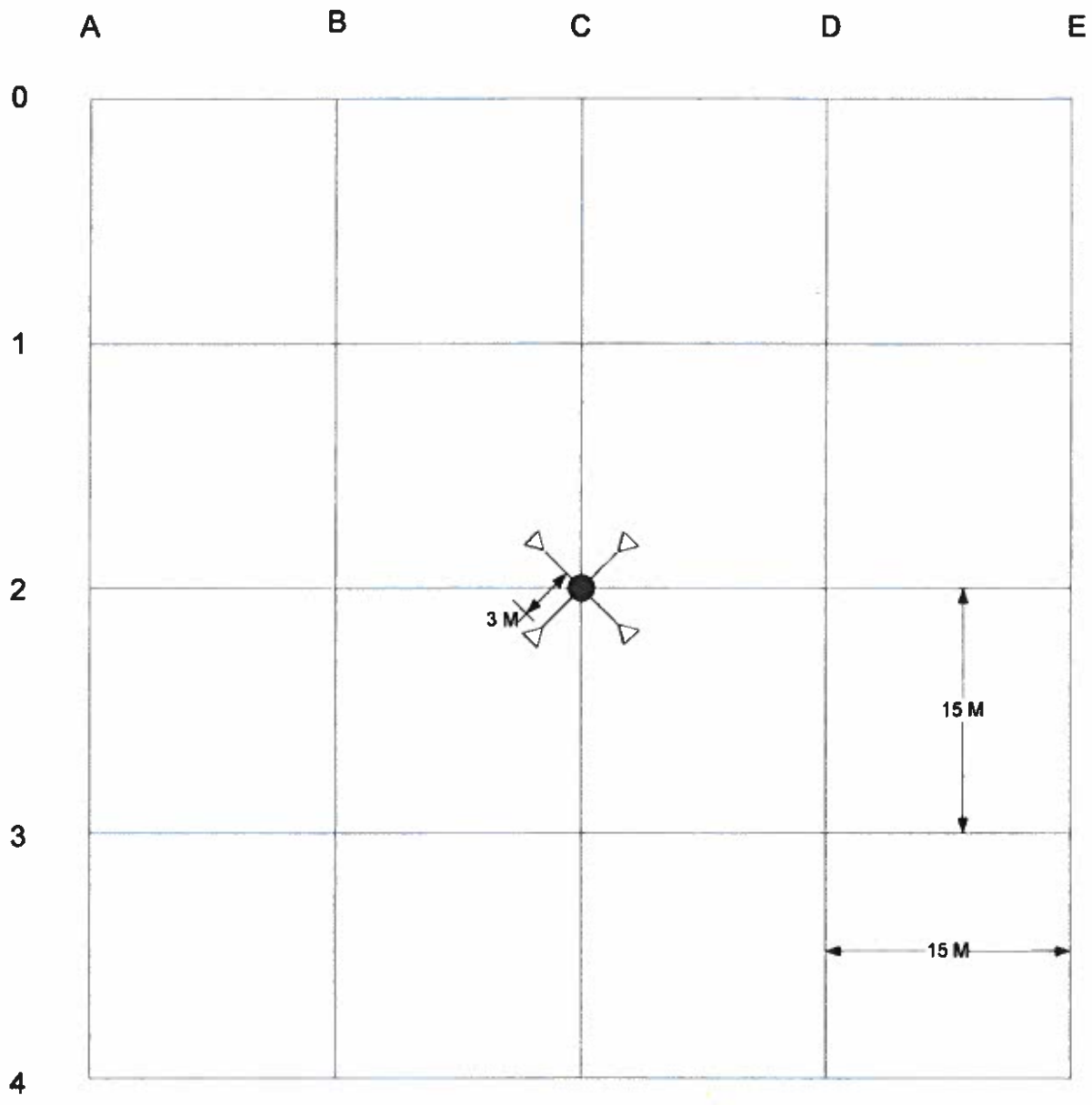


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**FIGURE 1**  
TYPICAL ALPHANUMERIC SURVEY GRID  
FORMER BROKEN ARROW LANDFILL SITE  
BROKEN ARROW, WAGONER COUNTY, OKLAHOMA

SCALE: NOT TO SCALE	DATE: 9-9-13	FIGURE NO Figure 1
APPROVED BY: TAT	DRAWN BY: BOC	PROJECT NO 2048-009



- GRID NODE SURVEY LOCATION (15 METER GRID)
- ▽ OFF-GRID SURVEY LOCATION (3 METER OFFSET)



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**FIGURE 2**  
**SCHEMATIC OF OFF-GRID SURVEY LOCATIONS**  
**FORMER BROKEN ARROW LANDFILL SITE**  
**BROKEN ARROW, WAGONER COUNTY, OKLAHOMA**

SCALE: NOT TO SCALE	DATE: 9-9-13	FIGURE NO: Figure 2
APPROVED BY: TAT	DRAWN BY: BOC	PROJECT NO: 2048-009

**ATTACHMENT 1**

**RESULTS OF LABORATORY ANALYSIS**





## Outreach Laboratory

311 North Aspen  
Broken Arrow, OK 74012  
(918) 251-2515  
FAX (918) 251-0008



LABORATORY  
ACCREDITATION  
BUREAU  
ACCREDITED



Certificate # L 2284 Testing



### Case Narrative

**Lab No: 20121211**

This report contains the analytical results for the 4 sample(s) received under chain of custody by Outreach Laboratory on 09/27/12 15:05:23. These samples are associated with your project.

The analytical results included in this report meet all applicable quality control procedure requirements except as noted below:

The test results in this report meet all NELAC requirements unless noted below:

This report shall not be reproduced, except in full, without the written approval of Outreach Laboratory.

All radiochemical sample results for solids are reported on a dry weight basis with the exception of tritium, carbon-14 and radon, unless wet weight was requested by the client.

#### Observations / Nonconformances

Isotopic Thorium analysis was requested per email from K. Kinser dated 09/26/2012.



# Outreach Laboratory

311 North Aspen  
Broken Arrow, OK 74012  
(918) 251-2515  
FAX (918) 251-0008

Client: OK Dept of Environmental Quality  
Client Project:  
Lab Number: 20121211  
Date Reported: 10/16/12  
Date Received: 9/27/12  
Page Number: 2 of 4

## Analytical Report

Method	Result	DL	Units	Qual.	Prep Date	Analysis Date	Analyst
--------	--------	----	-------	-------	-----------	---------------	---------

Lab ID: 20121211-01  
Client ID: 019112-001  
Date Sampled: 08/23/12 14:30:00  
Matrix: SCM

### Radiochemical Analyses

K-40	DOE Ga-01-R*	17.2 +/- 11.5	14.3	pCi/g		10/11/12	RLT
Tl-208	DOE Ga-01-R*	108 +/- 4.13	0.949	pCi/g		10/11/12	RLT
Bi-212	DOE Ga-01-R*	183 +/- 12.4	7.63	pCi/g		10/11/12	RLT
Pb-212	DOE Ga-01-R*	349 +/- 37.2	1.17	pCi/g		10/11/12	RLT
Bi-214 (Ra226)	DOE Ga-01-R*	0.974 +/- 1.28	1.27	pCi/g		10/11/12	RLT
Pb-214	DOE Ga-01-R*	1.86 +/- 0.641	1.64	pCi/g		10/11/12	RLT
Ac-228 (Ra228)	DOE Ga-01-R*	268 +/- 10.1	2.39	pCi/g		10/11/12	RLT
Th-234 (U238)	DOE Ga-01-R*	-94.5 +/- 5.31	12.6	pCi/g		10/11/12	RLT
U-235	DOE Ga-01-R*	0.180 +/- 0.121	0.540	pCi/g		10/11/12	RLT
Thorium-232	LANL ER 200 M*	264 +/- 18.2	0.961	pCi/g	10/11/12	10/11/12	RLT
Thorium-230	LANL ER 200 M*	56.3 +/- 9.80	11.9	pCi/g	10/11/12	10/11/12	RLT
Thorium-228	LANL ER 200 M*	269 +/- 18.4	1.92	pCi/g	10/11/12	10/11/12	RLT

Lab ID: 20121211-02  
Client ID: 019112-002  
Date Sampled: 08/23/12 15:00:00  
Matrix: SCM

### Radiochemical Analyses

K-40	DOE Ga-01-R*	30.6 +/- 7.81	9.04	pCi/g		10/11/12	RLT
Tl-208	DOE Ga-01-R*	118 +/- 4.75	1.32	pCi/g		10/11/12	RLT
Bi-212	DOE Ga-01-R*	191 +/- 10.5	5.53	pCi/g		10/11/12	RLT
Pb-212	DOE Ga-01-R*	293 +/- 24.8	0.739	pCi/g		10/11/12	RLT
Bi-214 (Ra226)	DOE Ga-01-R*	0.899 +/- 1.57	1.12	pCi/g		10/11/12	RLT
Pb-214	DOE Ga-01-R*	1.13 +/- 0.520	1.43	pCi/g		10/11/12	RLT
Ac-228 (Ra228)	DOE Ga-01-R*	294 +/- 8.76	1.70	pCi/g		10/11/12	RLT
Th-234 (U238)	DOE Ga-01-R*	80.4 +/- 9.00	6.55	pCi/g		10/11/12	RLT
U-235	DOE Ga-01-R*	-0.207 +/- 0.317	0.752	pCi/g		10/11/12	RLT
Thorium-232	LANL ER 200 M*	255 +/- 14.0	1.09	pCi/g	10/11/12	10/11/12	RLT
Thorium-230	LANL ER 200 M*	22.2 +/- 5.72	9.24	pCi/g	10/11/12	10/11/12	RLT
Thorium-228	LANL ER 200 M*	245 +/- 13.7	1.75	pCi/g	10/11/12	10/11/12	RLT

Lab ID: 20121211-03  
Client ID: 019112-003  
Date Sampled: 08/23/12 14:45:00  
Matrix: SCM



**Outreach  
Laboratory**

311 North Aspen  
Broken Arrow, OK 74012  
(918) 251-2515  
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Client: OK Dept of Environmental Quality  
Client Project:  
Lab Number: 20121211  
Date Reported: 10/16/12  
Date Received: 9/27/12  
Page Number: 3 of 4

**Analytical Report**

Method	Result	DL	Units	Qual.	Prep Date	Analysis Date	Analyst
<b>Radiochemical Analyses</b>							
K-40	DOE Ga-01-R*	17.4 +/- 4.97	6.73	pCi/g		10/11/12	RLT
Tl-208	DOE Ga-01-R*	56.0 +/- 3.20	1.08	pCi/g		10/11/12	RLT
Bi-212	DOE Ga-01-R*	153 +/- 10.4	5.87	pCi/g		10/11/12	RLT
Pb-212	DOE Ga-01-R*	186 +/- 19.7	1.62	pCi/g		10/11/12	RLT
Bi-214 (Ra226)	DOE Ga-01-R*	0.974 +/- 0.741	1.29	pCi/g		10/11/12	RLT
Pb-214	DOE Ga-01-R*	2.28 +/- 0.622	1.58	pCi/g		10/11/12	RLT
Ac-228 (Ra228)	DOE Ga-01-R*	155 +/- 5.54	1.68	pCi/g		10/11/12	RLT
Th-234 (U238)	DOE Ga-01-R*	25.2 +/- 3.92	6.34	pCi/g		10/11/12	RLT
U-235	DOE Ga-01-R*	0.561 +/- 0.525	0.666	pCi/g		10/11/12	RLT
Thorium-232	LANL ER 200 M*	166 +/- 12.5	1.14	pCi/g	10/11/12	10/11/12	RLT
Thorium-230	LANL ER 200 M*	94.4 +/- 10.4	10.4	pCi/g	10/11/12	10/11/12	RLT
Thorium-228	LANL ER 200 M*	151 +/- 12.0	1.90	pCi/g	10/11/12	10/11/12	RLT

Lab ID: 20121211-04  
Client ID: 019112-004  
Date Sampled: 08/23/12 16:00:00  
Matrix: SCM

<b>Radiochemical Analyses</b>							
K-40	DOE Ga-01-R*	31.1 +/- 4.53	6.05	pCi/g		10/11/12	RLT
Tl-208	DOE Ga-01-R*	130 +/- 5.47	1.32	pCi/g		10/11/12	RLT
Bi-212	DOE Ga-01-R*	225 +/- 11.1	5.57	pCi/g		10/11/12	RLT
Pb-212	DOE Ga-01-R*	375 +/- 31.7	1.20	pCi/g		10/11/12	RLT
Bi-214 (Ra226)	DOE Ga-01-R*	2.25 +/- 0.884	1.38	pCi/g		10/11/12	RLT
Pb-214	DOE Ga-01-R*	-0.360 +/- 0.615	1.46	pCi/g		10/11/12	RLT
Ac-228 (Ra228)	DOE Ga-01-R*	287 +/- 8.21	1.67	pCi/g		10/11/12	RLT
Th-234 (U238)	DOE Ga-01-R*	130 +/- 10.2	7.95	pCi/g		10/11/12	RLT
U-235	DOE Ga-01-R*	0.467 +/- 0.330	0.783	pCi/g		10/11/12	RLT
Thorium-232	LANL ER 200 M*	324 +/- 20.8	1.02	pCi/g	10/11/12	10/11/12	RLT
Thorium-230	LANL ER 200 M*	21.4 +/- 7.38	12.1	pCi/g	10/11/12	10/11/12	RLT
Thorium-228	LANL ER 200 M*	320 +/- 20.7	2.39	pCi/g	10/11/12	10/11/12	RLT



# Outreach Laboratory

311 North Aspen  
Broken Arrow, OK 74012  
(918) 251-2515  
FAX (918) 251-0008

Client: OK Dept of Environmental Quality  
Client Project:  
Lab Number: 20121211  
Date Reported: 10/16/12  
Date Received: 9/27/12  
Page Number: 4 of 4

## QC Report

Parameter	Blank	LCS	LCSD		DUP RPD	RER, NAD or DER	MS	MSD		Date
		%REC	%REC	RPD			%REC	%REC	RPD	
Ac-228 (Ra228)	-0.097				4.0	0.903				10/11/12
Am-241		106.0	109.0	3.1						10/11/12
Bi-212	-0.141				2.0	0.255				10/11/12
Bi-214 (Ra226)	-0.062				NC	0.041				10/11/12
Co-60		91.0	92.0	1.6						10/11/12
Cs-137		99.0	99.0	0.0						10/11/12
K-40	-0.284				NC	0.582				10/11/12
Pb-212	0.014				12.0	0.879				10/11/12
Pb-214	0.086				NC	1.270				10/11/12
Th-234 (U238)	0.525				24.0	1.780				10/11/12
Thorium-228	0.134	113.0			16.8	0.613	97.7	89.6	8.7	10/02/12
Thorium-230	0.164	118.0			1.7	0.064	90.8	83.9	7.9	10/02/12
Thorium-232	0.216	116.0			1.2	0.046	90.4	110.0	19.8	10/02/12
Po-210	-0.015				4.0	0.643				10/11/12
Po-214	0.093				NC	0.573				10/11/12

Lab Approval: \_\_\_\_\_