



Department of Energy

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MAY 27 2015

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Kentucky Department for Environmental Protection
625 Hospital Drive
Madisonville, Kentucky 42431

PPPO-02-2951136-15A

Ms. April Webb
Acting Interim Federal Facility Agreement Manager
Division of Waste Management
Kentucky Department for Environmental Protection
200 Fair Oaks Lane, 2nd Floor
Frankfort, Kentucky 40601

Dear Mr. McDonough and Ms. Webb:

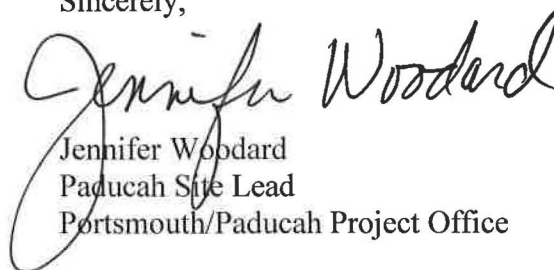
**TRANSMITTAL OF C-404 HAZARDOUS WASTE LANDFILL MAY 2015
SEMIANNUAL GROUNDWATER REPORT (OCTOBER 2014–MARCH 2015),
PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY,
PAD-ENM-0095/V1, PERMIT NUMBER KY8-890-008-982**

This report is submitted to comply with Permit Condition GSTR2 Part II, Condition T-47 of the Hazardous Waste Management Facility Permit, Permit Number KY8-890-008-982. This report provides the groundwater analytical results and statistical analysis of those results for the semiannual sampling event conducted during January 2015 at the C-404 Hazardous Waste Landfill. This report also includes groundwater flow direction as supplemental information to the permit required annual flow rate and direction.

Results of the statistical analyses indicate that compliance well concentrations of permit required parameters are not statistically different from those in background wells; therefore, there is no indication that the C-404 Landfill has adversely affected the underlying groundwater.

If you have any questions or require additional information, please contact David Dollins at (270) 441-6819.

Sincerely,



Jennifer Woodard
Paducah Site Lead
Portsmouth/Paducah Project Office

Enclosures:

1. C-404 Hazardous Waste Landfill May 2015 Semiannual Groundwater Report
2. Certification Page

e-copy w/enclosures:

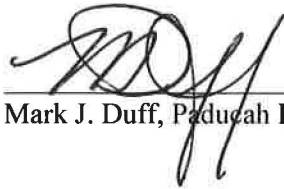
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CERTIFICATION

Document Identification: ***C-404 Hazardous Waste Landfill May 2015
Semiannual Groundwater Report (October 2014–March 2015),
Paducah Gaseous Diffusion Plant, Paducah, Kentucky,
PAD-ENM-0095/V1, Permit Number KY8-890-008-982***

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or 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 fine and imprisonment for knowing violations.

LATA Environmental Services of Kentucky, LLC



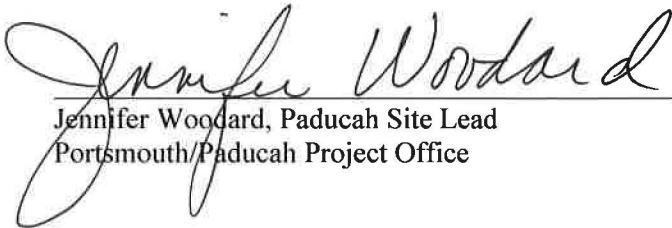
Mark J. Duff, Paducah Project Manager

5-27-15

Date Signed

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or 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 fine and imprisonment for knowing violations.

U.S. Department of Energy




Jennifer Woodard, Paducah Site Lead
Portsmouth/Paducah Project Office

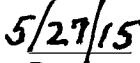
5/27/15

Date Signed

**C-404 Hazardous Waste Landfill
May 2015 Semiannual
Groundwater Report
(October 2014–March 2015),
Paducah Gaseous Diffusion Plant,
Paducah, Kentucky**

This document is approved for public release per review by:


LATA Kentucky Classification Support


Date

PAD-ENM-0095/V1

**C-404 Hazardous Waste Landfill
May 2015 Semiannual
Groundwater Report
(October 2014–March 2015),
Paducah Gaseous Diffusion Plant,
Paducah, Kentucky**

Date Issued—May 2015

Prepared for the
U.S. Department of Energy
Office of Environmental Management

Prepared by
LATA ENVIRONMENTAL SERVICES OF KENTUCKY, LLC
managing the
Environmental Remediation Activities at the
Paducah Gaseous Diffusion Plant
under contract DE-AC30-10CC40020

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ACRONYMS

AKGWA	Assembled Kentucky Groundwater Database
LOD	level of detection
MW	monitoring well
PGDP	Paducah Gaseous Diffusion Plant
RCRA	Resource Conservation and Recovery Act
RGA	Regional Gravel Aquifer
UCRS	Upper Continental Recharge System
URGA	Upper Regional Gravel Aquifer

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EXECUTIVE SUMMARY

This report, *C-404 Hazardous Waste Landfill May 2015 Semiannual Groundwater Report (October 2014–March 2015), Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PAD-ENM-0095/V1, is being submitted by the U.S. Department of Energy in accordance with requirements in the Kentucky Division of Waste Management Hazardous Waste Facility Permit, KY8-890-008-982. The reporting period covers October 2014 through March 2015 and includes analytical data from the January 2015 sampling of monitoring wells located in the vicinity of the closed C-404 Hazardous Waste Landfill (C-404 Landfill). In 1986, disposal of waste at C-404 Landfill was halted, and a portion of the disposed waste was found to be Resource Conservation and Recovery Act (RCRA) hazardous. The landfill was covered with a RCRA multilayered cap and certified closed in 1987.

The groundwater monitoring results were subjected to statistical analyses, in accordance with the Hazardous Waste Facility Permit. There is no statistical evidence of releases from the C-404 Landfill because concentrations in the compliance wells are not statistically different from the concentrations in background wells.

On March 26, 2015, the leachate level was measured at 39 inches and 2,400 gal was removed on March 30, 2015. The sample for this leachate was collected on April 8, 2015, and will be included in the next semiannual report. No issues requiring maintenance were identified during this reporting period.

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1. INTRODUCTION

This report contains the statistical evaluation of data from groundwater sampling and analysis for the C-404 Hazardous Waste Landfill (C-404 Landfill) at the Paducah Gaseous Diffusion Plant (PGDP), Paducah, Kentucky. This semiannual report is required by the Kentucky Division of Waste Management Hazardous Waste Facility Permit, KY8-890-008-982 (the permit) (KDWM 2004), GSTR2 Part II, Condition T-47—Detection Monitoring Program—Recordkeeping, Reporting, and Response. The period covered by this report is October 2014 through March 2015.

Groundwater analytical results are provided in Appendix A. The statistical analyses and qualification statement are provided in Appendix B. Landfill leachate information is provided in Appendix C. The groundwater flow direction determination is provided in Appendix D.

1.1 BACKGROUND

The C-404 Landfill is located in the west-central portion of the PGDP secured area. The 1.2-acre facility operated as a surface impoundment from approximately 1952 until early 1957. During this time, influents to the impoundment originated from the C-400 Cleaning Building. In 1957, the impoundment was converted to a solid waste disposal facility for solid uranium-contaminated wastes. When the impoundment was converted into a disposal facility, a sump was installed at the former weir to collect the leachate from the facility. Leachate is pumped from the sump and treated as needed.

In 1986, the disposal of waste at C-404 Landfill was halted, and a portion of the disposed of waste was found to be Resource Conservation and Recovery Act (RCRA)-hazardous. The landfill was covered with a RCRA multilayered cap and certified closed in 1987. It currently is regulated under RCRA as a land disposal unit and compliance is monitored under a RCRA postclosure permit issued in 1992.

Previous groundwater monitoring documented that concentrations in compliance wells were statistically different from background wells for trichloroethene (TCE). The *C-404 Landfill Source Demonstration, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (PRS 2007) documented that the source of the differences from background concentrations in compliance wells is not from the C-404 Landfill, but rather, the source is located upgradient/crossgradient of the C-404 Landfill.

1.2 MONITORING PERIOD ACTIVITIES

1.2.1 Groundwater Monitoring

Groundwater sampling was conducted in January 2015 using LATA Environmental Services of Kentucky, LLC, procedure PAD-ENM-2101, *Groundwater Sampling*. Appropriate sample containers and preservatives were used. The laboratories that performed analyses used U.S. Environmental Protection Agency-approved methods, as applicable. There are nine monitoring wells (MWs) sampled under this permit for the C-404 Landfill: four Upper Continental Recharge System (UCRS) wells and five Upper Regional Gravel Aquifer (URGA) wells. Table 1 presents the well numbers for URGA wells located upgradient and downgradient of the C-404 Landfill. Table 1 also presents the well numbers for

Table 1. Monitoring Well Locations

UCRS	
Located south of C-404, adjacent to upgradient Regional Gravel Aquifer (RGA) background well MW93	MW94
Located north of C-404, adjacent to downgradient RGA compliance wells	MW85, MW88, MW91
URGA	
Upgradient background wells	MW93, MW420
Downgradient compliance wells	MW84, MW87, MW90A*

*MW90 was abandoned in 2001 and replaced with MW90A.

the UCRS wells located in proximity to the URGA wells. This table refers to these UCRS wells as being adjacent to an “upgradient” or “downgradient” URGA well location, identified relative to the URGA groundwater flow direction (see Figure 1).

The conceptual model for the site demonstrates that groundwater in the UCRS wells flows vertically until it reaches the URGA; therefore, UCRS wells are not considered “upgradient” or “downgradient” of other wells in the area.

Table 2 presents the Assembled Kentucky Groundwater Database (AKGWA) numbers for each MW. A map of the MW locations is provided in Figure 1. All of the MWs listed in Tables 1 and 2 were sampled during this reporting period, and the samples were analyzed for the required parameters.

Appendix A of this report contains the analytical results from the wells that were sampled during the January 2015 semiannual sampling event. The parameters specified in Hazardous Waste Facility Permit, Attachment E, Groundwater Monitoring, were analyzed for all locations sampled. Appendix B of this report contains the statistical analyses. Appendix C of this report contains analytical results from leachate sampling, when collected, as well as the C-404 general inspection records, and the monthly leachate depths in the C-404 sump for this reporting period.

Per Permit Condition GSTR2, T-37, the groundwater flow rate and direction are evaluated annually and reported in the November report. For this May report, a potentiometric map has been included in Appendix D using data from sampling performed in January as supplemental information. Depth-to-water was measured on January 28, 2015, from several wells at the perimeter of the C-404 Landfill (see Table D.1). Water level measurements in 11 vicinity well locations define the potentiometric surface for the URGA (see Table D.1). Groundwater flow direction beneath the C-404 Landfill generally trends northward, but commonly varies from northeast to northwest.

1.2.2 Landfill Leachate

The C-404 General Inspection Records and the Monthly and Quarterly Landfill Inspection Results are included in Appendix C. In accordance with the Hazardous Waste Facility Permit, the quantity of liquid in the leachate collection system is monitored (at least monthly) and, at a minimum, will be “removed when the quantity exceeds three ft in depth.” The monthly leachate depths in the C-404 sump recorded for this reporting period are included in Appendix C.

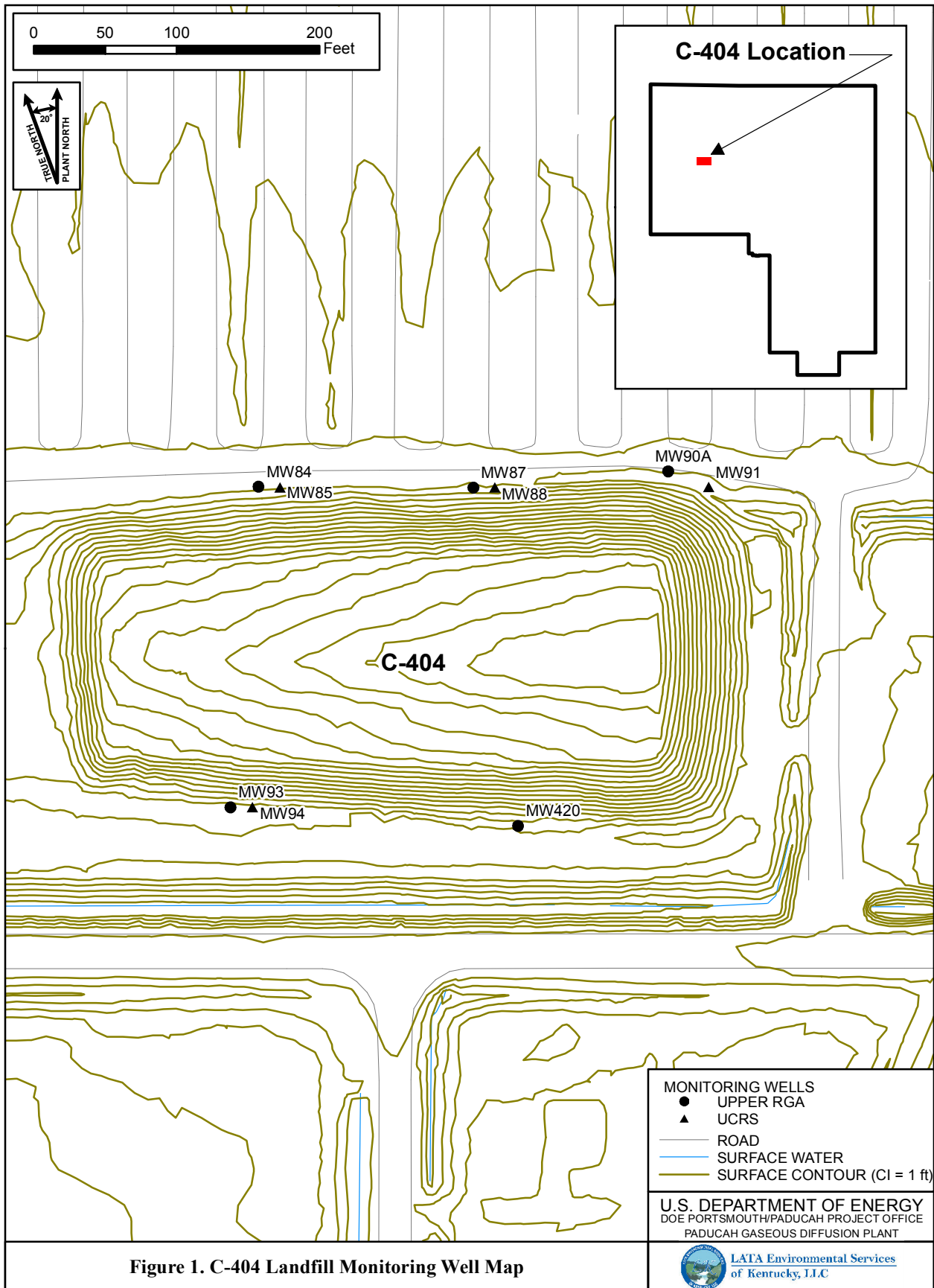


Figure 1. C-404 Landfill Monitoring Well Map

**Table 2. Assembled Kentucky
Groundwater Database Numbers**

PGDP Well Number	AKGWA Number
MW84	8000-5233
MW85	8000-5234
MW87	8000-5236
MW88	8000-5237
MW90A	8004-0357
MW91	8000-5240
MW93	8000-5102
MW94	8000-5103
MW420	8005-3263

The volume of leachate removed from the sump during this reporting period, October 2015 to March 2015, was 2,400 gal. Once the leachate depth reached 3 ft, the leachate was pumped into a mobile tank. Then, the leachate was transferred to a permitted hazardous waste storage facility on-site prior to characterization and transfer off-site for treatment. Because this leachate was removed on March 30, 2015, and sampled on April 8, 2015, the analytical data will be included in the next semiannual report.

1.2.3 Maintenance

No monitoring well maintenance was performed during this period.

2. STATISTICAL SYNOPSIS

The statistical analyses conducted on the data collected from C-404 Landfill were performed in accordance with procedures in the approved Hazardous Waste Facility Permit, Attachment Part E. Appendix B of this report contains the statistical analyses performed for this reporting period. Data utilized for statistical analyses included data from the URGA background wells, MW93 and MW420, and URGA compliance wells, MW84, MW87, and MW90A. For these statistical analyses, the reporting period data set includes data from July 2012, January 2013, August 2013, January 2014, July 2014, and January 2015.

The statistical tests on all parameters showed no statistical evidence of releases from the C-404 Landfill.

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3. DATA VALIDATION AND QA/QC SUMMARY

The data and the data validation qualifiers for the January 2015 data set are provided in Appendix A. All data for this data set were considered useable as reported.

Data validation was performed on the organic, inorganic, and radiochemical analytical data by an independent, third-party validator.

Field quality control samples are collected semiannually during each sampling event. Equipment rinseate blanks, field blanks, and trip blanks are obtained to ensure quality control and are reported in the Analytical Results in Appendix A. No contamination was detected in these samples. Laboratory quality control samples, such as matrix spikes, matrix spike duplicates, and method blanks, are performed by the laboratory and reported in the laboratory report. Both field and laboratory quality control sample results are reviewed as part of the data validation process.

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4. PROFESSIONAL GEOLOGIST AUTHORIZATION

DOCUMENT IDENTIFICATION: *C-404 Hazardous Waste Landfill
May 2015 Semiannual Groundwater Report
(October 2014–March 2015),
Paducah Gaseous Diffusion Plant, Paducah, Kentucky
(PAD-ENM-0095/V1)*

Stamped and signed pursuant to my authority as a duly registered geologist under the provisions of KRS Chapter 322A.



Kenneth R. Davis
Kenneth R. Davis

PG1194

May 26, 2015
Date

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5. REFERENCES

- KDWM (Kentucky Division of Waste Management) 2004. Hazardous Waste Facility Permit for the U.S. Department of Energy, Paducah Gaseous Diffusion Plant, KY8-890-008-982, effective April 24, 2006.
- PRS (Paducah Remediation Services, LLC) 2007. *C-404 Landfill Source Demonstration, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PRS-ENM-0031/R2, Paducah Remediation Services, LLC, Kevil, KY.

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APPENDIX A

C-404 HAZARDOUS WASTE LANDFILL ANALYTICAL RESULTS

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**Paducah OREIS
GROUNDWATER MONITORING REPORT**

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW84 REG Downgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5233

Parameter	Qualifier	Result	Units	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic		0.0073	mg/L	1/28/2015			SW846-6020	=
Arsenic, Dissolved	J	0.0025	mg/L	1/28/2015			SW846-6020	=
Barometric Pressure Reading		30.3	Inches/Hg	1/28/2015				X
Cadmium	J	0.0002	mg/L	1/28/2015			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	1/28/2015			SW846-6020	=
Chromium		0.442	mg/L	1/28/2015			SW846-6020	=
Chromium, Dissolved	J	0.0041	mg/L	1/28/2015			SW846-6020	=
Conductivity		346	umho/cm	1/28/2015				X
Depth to Water		52.6	ft	1/28/2015				X
Dissolved Oxygen		3.16	mg/L	1/28/2015				X
Lead	J	0.0019	mg/L	1/28/2015			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	1/28/2015			SW846-6020	=
Mercury	U	0.0002	mg/L	1/28/2015			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	1/28/2015			SW846-7470A	=
pH		5.9	Std Unit	1/28/2015				X
Redox		774	mV	1/28/2015				X
Selenium	U	0.005	mg/L	1/28/2015			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	1/28/2015			SW846-6020	=
Technetium-99	U	-0.685	pCi/L	1/28/2015	14	14	HASL 300, Tc-02-RC M	=
Temperature		51.1	deg F	1/28/2015				X
Trichloroethene		1380	ug/L	1/28/2015			SW846-8260B	=
Turbidity		120	NTU	1/28/2015				X
Uranium		0.0004	mg/L	1/28/2015			SW846-6020	=
Uranium-234	U	0.466	pCi/L	1/28/2015	1.28	1.28	HASL 300, U-02-RC M	=
Uranium-235	U	0.342	pCi/L	1/28/2015	1.28	1.28	HASL 300, U-02-RC M	=
Uranium-238	U	0.64	pCi/L	1/28/2015	1.26	1.26	HASL 300, U-02-RC M	=

**Paducah OREIS
GROUNDWATER MONITORING REPORT**

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW85 REG Downgradient UCRS **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5234

Parameter	Qualifier	Result	Units	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic		0.0118	mg/L	1/28/2015			SW846-6020	=
Arsenic, Dissolved		0.0082	mg/L	1/28/2015			SW846-6020	=
Barometric Pressure Reading		30.23	Inches/Hg	1/28/2015				X
Cadmium	J	0.0002	mg/L	1/28/2015			SW846-6020	=
Cadmium, Dissolved	J	0.0002	mg/L	1/28/2015			SW846-6020	=
Chromium	J	0.0075	mg/L	1/28/2015			SW846-6020	=
Chromium, Dissolved	J	0.005	mg/L	1/28/2015			SW846-6020	=
Conductivity		320	umho/cm	1/28/2015				X
Depth to Water		11.77	ft	1/28/2015				X
Dissolved Oxygen		3.24	mg/L	1/28/2015				X
Lead	U	0.002	mg/L	1/28/2015			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	1/28/2015			SW846-6020	=
Mercury	U	0.0002	mg/L	1/28/2015			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	1/28/2015			SW846-7470A	=
pH		6.11	Std Unit	1/28/2015				X
Redox		681	mV	1/28/2015				X
Selenium	U	0.005	mg/L	1/28/2015			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	1/28/2015			SW846-6020	=
Technetium-99		91	pCi/L	1/28/2015	17.4	20.1	HASL 300, Tc-02-RC M	=
Temperature		56.7	deg F	1/28/2015				X
Trichloroethene		1.57	ug/L	1/28/2015			SW846-8260B	=
Turbidity		18.4	NTU	1/28/2015				X
Uranium		0.0004	mg/L	1/28/2015			SW846-6020	=
Uranium-234	U	0.707	pCi/L	1/28/2015	1.87	1.87	HASL 300, U-02-RC M	=
Uranium-235	U	1.55	pCi/L	1/28/2015	2.23	2.24	HASL 300, U-02-RC M	=
Uranium-238	U	0.798	pCi/L	1/28/2015	1.57	1.57	HASL 300, U-02-RC M	=

**Paducah OREIS
GROUNDWATER MONITORING REPORT**

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW87 REG Downgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5236

Parameter	Qualifier	Result	Units	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic	J	0.0017	mg/L	1/22/2015			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	1/22/2015			SW846-6020	=
Barometric Pressure Reading		30.43	Inches/Hg	1/22/2015				X
Cadmium	J	0.0001	mg/L	1/22/2015			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	1/22/2015			SW846-6020	=
Chromium		0.031	mg/L	1/22/2015			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	1/22/2015			SW846-6020	=
Conductivity		308	umho/cm	1/22/2015				X
Depth to Water		52.54	ft	1/22/2015				X
Dissolved Oxygen		2.24	mg/L	1/22/2015				X
Lead	J	0.0009	mg/L	1/22/2015			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	1/22/2015			SW846-6020	=
Mercury	U	0.0002	mg/L	1/22/2015			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	1/22/2015			SW846-7470A	=
pH		6.3	Std Unit	1/22/2015				X
Redox		759	mV	1/22/2015				X
Selenium	U	0.005	mg/L	1/22/2015			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	1/22/2015			SW846-6020	=
Technetium-99	U	-0.928	pCi/L	1/22/2015	12.1	12.1	HASL 300, Tc-02-RC M	=
Temperature		58.2	deg F	1/22/2015				X
Trichloroethene		1010	ug/L	1/22/2015			SW846-8260B	=
Turbidity		13	NTU	1/22/2015				X
Uranium	J	0.0002	mg/L	1/22/2015			SW846-6020	=
Uranium-234	U	-0.47	pCi/L	1/22/2015	1.33	1.33	HASL 300, U-02-RC M	=
Uranium-235	U	0	pCi/L	1/22/2015	0.861	0.863	HASL 300, U-02-RC M	=
Uranium-238	U	-0.249	pCi/L	1/22/2015	0.751	0.753	HASL 300, U-02-RC M	=

**Paducah OREIS
GROUNDWATER MONITORING REPORT**

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW88 REG Downgradient UCRS **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5237

Parameter	Qualifier	Result	Units	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic		0.0074	mg/L	1/22/2015			SW846-6020	=
Arsenic, Dissolved	J	0.0035	mg/L	1/22/2015			SW846-6020	=
Barometric Pressure Reading		30.41	Inches/Hg	1/22/2015				X
Cadmium	U	0.001	mg/L	1/22/2015			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	1/22/2015			SW846-6020	=
Chromium	J	0.0099	mg/L	1/22/2015			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	1/22/2015			SW846-6020	=
Conductivity		481	umho/cm	1/22/2015				X
Depth to Water		11.55	ft	1/22/2015				X
Dissolved Oxygen		1.36	mg/L	1/22/2015				X
Lead		0.0032	mg/L	1/22/2015			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	1/22/2015			SW846-6020	=
Mercury	J	0.0002	mg/L	1/22/2015			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	1/22/2015			SW846-7470A	=
pH		5.96	Std Unit	1/22/2015				X
Redox		742	mV	1/22/2015				X
Selenium	U	0.005	mg/L	1/22/2015			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	1/22/2015			SW846-6020	=
Technetium-99		32.7	pCi/L	1/22/2015	12.3	12.8	HASL 300, Tc-02-RC M	=
Temperature		58.9	deg F	1/22/2015				X
Trichloroethene		3.97	ug/L	1/22/2015			SW846-8260B	=
Turbidity		129	NTU	1/22/2015				X
Uranium		0.0004	mg/L	1/22/2015			SW846-6020	=
Uranium-234	U	0.878	pCi/L	1/22/2015	1.55	1.56	HASL 300, U-02-RC M	=
Uranium-235	U	1.79	pCi/L	1/22/2015	2.11	2.13	HASL 300, U-02-RC M	=
Uranium-238	U	0.97	pCi/L	1/22/2015	1.54	1.55	HASL 300, U-02-RC M	=

**Paducah OREIS
GROUNDWATER MONITORING REPORT**

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW90A REG Downgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8004-0357

Parameter	Qualifier	Result	Units	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic	U	0.005	mg/L	1/27/2015			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	1/27/2015			SW846-6020	=
Barometric Pressure Reading		30.09	Inches/Hg	1/27/2015				X
Cadmium	U	0.001	mg/L	1/27/2015			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	1/27/2015			SW846-6020	=
Chromium	U	0.01	mg/L	1/27/2015			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	1/27/2015			SW846-6020	=
Conductivity		202	umho/cm	1/27/2015				X
Depth to Water		50.81	ft	1/27/2015				X
Dissolved Oxygen		4.2	mg/L	1/27/2015				X
Lead	U	0.002	mg/L	1/27/2015			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	1/27/2015			SW846-6020	=
Mercury	U	0.0002	mg/L	1/27/2015			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	1/27/2015			SW846-7470A	=
pH		5.92	Std Unit	1/27/2015				X
Redox		567	mV	1/27/2015				X
Selenium	J	0.0018	mg/L	1/27/2015			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	1/27/2015			SW846-6020	=
Technetium-99	U	11.8	pCi/L	1/27/2015	10.5	10.6	HASL 300, Tc-02-RC M	=
Temperature		53.4	deg F	1/27/2015				X
Trichloroethene		37.3	ug/L	1/27/2015			SW846-8260B	=
Turbidity		8.7	NTU	1/27/2015				X
Uranium	U	0.0002	mg/L	1/27/2015			SW846-6020	=
Uranium-234	U	-0.029	pCi/L	1/27/2015	1.72	1.72	HASL 300, U-02-RC M	=
Uranium-235	U	-0.212	pCi/L	1/27/2015	0.939	0.942	HASL 300, U-02-RC M	=
Uranium-238	U	-0.172	pCi/L	1/27/2015	0.76	0.762	HASL 300, U-02-RC M	=

**Paducah OREIS
GROUNDWATER MONITORING REPORT**

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW91 REG Downgradient UCRS **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5240

Parameter	Qualifier	Result	Units	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic		0.0050	mg/L	1/27/2015			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	1/27/2015			SW846-6020	=
Barometric Pressure Reading		30.13	Inches/Hg	1/27/2015				X
Cadmium	U	0.001	mg/L	1/27/2015			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	1/27/2015			SW846-6020	=
Chromium		1.76	mg/L	1/27/2015			SW846-6020	=
Chromium, Dissolved		0.0206	mg/L	1/27/2015			SW846-6020	=
Conductivity		517	umho/cm	1/27/2015				X
Depth to Water		11.52	ft	1/27/2015				X
Dissolved Oxygen		4.32	mg/L	1/27/2015				X
Lead		0.0045	mg/L	1/27/2015			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	1/27/2015			SW846-6020	=
Mercury	U	0.0002	mg/L	1/27/2015			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	1/27/2015			SW846-7470A	=
pH		5.66	Std Unit	1/27/2015				X
Redox		431	mV	1/27/2015				X
Selenium	J	0.0020	mg/L	1/27/2015			SW846-6020	=
Selenium, Dissolved	J	0.0025	mg/L	1/27/2015			SW846-6020	=
Technetium-99		2460	pCi/L	1/27/2015	50.2	277	HASL 300, Tc-02-RC M	=
Temperature		58.3	deg F	1/27/2015				X
Trichloroethene		78	ug/L	1/27/2015			SW846-8260B	=
Turbidity		341	NTU	1/27/2015				X
Uranium		0.0014	mg/L	1/27/2015			SW846-6020	=
Uranium-234	U	0.855	pCi/L	1/27/2015	2.33	2.33	HASL 300, U-02-RC M	=
Uranium-235	U	-0.922	pCi/L	1/27/2015	1.81	1.81	HASL 300, U-02-RC M	=
Uranium-238	U	-1.16	pCi/L	1/27/2015	1.82	1.82	HASL 300, U-02-RC M	=

**Paducah OREIS
GROUNDWATER MONITORING REPORT**

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW93 REG Upgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5102

Parameter	Qualifier	Result	Units	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic	J	0.0019	mg/L	1/22/2015			SW846-6020	=
Arsenic, Dissolved	J	0.0035	mg/L	1/22/2015			SW846-6020	=
Barometric Pressure Reading		30.47	Inches/Hg	1/22/2015				X
Cadmium	U	0.001	mg/L	1/22/2015			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	1/22/2015			SW846-6020	=
Chromium		0.0273	mg/L	1/22/2015			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	1/22/2015			SW846-6020	=
Conductivity		430	umho/cm	1/22/2015				X
Depth to Water		54.14	ft	1/22/2015				X
Dissolved Oxygen		1.2	mg/L	1/22/2015				X
Lead		0.0024	mg/L	1/22/2015			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	1/22/2015			SW846-6020	=
Mercury	U	0.0002	mg/L	1/22/2015			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	1/22/2015			SW846-7470A	=
pH		6.22	Std Unit	1/22/2015				X
Redox		667	mV	1/22/2015				X
Selenium	U	0.005	mg/L	1/22/2015			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	1/22/2015			SW846-6020	=
Technetium-99	U	-0.016	pCi/L	1/22/2015	11.2	11.2	HASL 300, Tc-02-RC M	=
Temperature		59.9	deg F	1/22/2015				X
Trichloroethene		2970	ug/L	1/22/2015			SW846-8260B	=
Turbidity		77.4	NTU	1/22/2015				X
Uranium		0.0021	mg/L	1/22/2015			SW846-6020	=
Uranium-234	U	1.29	pCi/L	1/22/2015	1.94	1.95	HASL 300, U-02-RC M	=
Uranium-235	U	0.482	pCi/L	1/22/2015	1.36	1.36	HASL 300, U-02-RC M	=
Uranium-238	U	0.296	pCi/L	1/22/2015	1.11	1.11	HASL 300, U-02-RC M	=

**Paducah OREIS
GROUNDWATER MONITORING REPORT**

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW94 REG Upgradient UCRS **Period:** Semiannual Report

AKGWA Well Tag #: 8000-5103

Parameter	Qualifier	Result	Units	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic		0.0064	mg/L	1/22/2015			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	1/22/2015			SW846-6020	=
Barometric Pressure Reading		30.47	Inches/Hg	1/22/2015				X
Cadmium	J	0.0001	mg/L	1/22/2015			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	1/22/2015			SW846-6020	=
Chromium		0.0246	mg/L	1/22/2015			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	1/22/2015			SW846-6020	=
Conductivity		868	umho/cm	1/22/2015				X
Depth to Water		14.52	ft	1/22/2015				X
Dissolved Oxygen		1.72	mg/L	1/22/2015				X
Lead	J	0.0013	mg/L	1/22/2015			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	1/22/2015			SW846-6020	=
Mercury	U	0.0002	mg/L	1/22/2015			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	1/22/2015			SW846-7470A	=
pH		6.18	Std Unit	1/22/2015				X
Redox		688	mV	1/22/2015				X
Selenium	U	0.005	mg/L	1/22/2015			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	1/22/2015			SW846-6020	=
Technetium-99		840	pCi/L	1/22/2015	26.6	96.9	HASL 300, Tc-02-RC M	=
Temperature		59.7	deg F	1/22/2015				X
Trichloroethene		3.2	ug/L	1/22/2015			SW846-8260B	=
Turbidity		131	NTU	1/22/2015				X
Uranium	J	0.0002	mg/L	1/22/2015			SW846-6020	=
Uranium-234	U	-0.325	pCi/L	1/22/2015	1.4	1.4	HASL 300, U-02-RC M	=
Uranium-235	U	-0.328	pCi/L	1/22/2015	0.991	0.994	HASL 300, U-02-RC M	=
Uranium-238	U	0.384	pCi/L	1/22/2015	1.31	1.31	HASL 300, U-02-RC M	=

**Paducah OREIS
GROUNDWATER MONITORING REPORT**

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW420 REG Upgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8005-3263

Parameter	Qualifier	Result	Units	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic	U	0.005	mg/L	1/22/2015			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	1/22/2015			SW846-6020	=
Barometric Pressure Reading		30.45	Inches/Hg	1/22/2015				X
Cadmium	U	0.001	mg/L	1/22/2015			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	1/22/2015			SW846-6020	=
Chromium	U	0.01	mg/L	1/22/2015			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	1/22/2015			SW846-6020	=
Conductivity		297	umho/cm	1/22/2015				X
Depth to Water		54.21	ft	1/22/2015				X
Dissolved Oxygen		2.5	mg/L	1/22/2015				X
Lead	U	0.002	mg/L	1/22/2015			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	1/22/2015			SW846-6020	=
Mercury	U	0.0002	mg/L	1/22/2015			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	1/22/2015			SW846-7470A	=
pH		6.06	Std Unit	1/22/2015				X
Redox		750	mV	1/22/2015				X
Selenium	U	0.005	mg/L	1/22/2015			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	1/22/2015			SW846-6020	=
Technetium-99	U	3.82	pCi/L	1/22/2015	11.5	11.5	HASL 300, Tc-02-RC M	=
Temperature		58.4	deg F	1/22/2015				X
Trichloroethene		208	ug/L	1/22/2015			SW846-8260B	=
Turbidity		6.7	NTU	1/22/2015				X
Uranium	U	0.0002	mg/L	1/22/2015			SW846-6020	=
Uranium-234	U	0.107	pCi/L	1/22/2015	1.12	1.12	HASL 300, U-02-RC M	=
Uranium-235	U	0.36	pCi/L	1/22/2015	1.35	1.35	HASL 300, U-02-RC M	=
Uranium-238	U	0.583	pCi/L	1/22/2015	1.34	1.34	HASL 300, U-02-RC M	=

**Paducah OREIS
GROUNDWATER MONITORING REPORT**

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982

Sampling Point: MW420 FR Upgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8005-3263

Parameter	Qualifier	Result	Units	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic	U	0.005	mg/L	1/22/2015			SW846-6020	=
Arsenic, Dissolved	U	0.005	mg/L	1/22/2015			SW846-6020	=
Barometric Pressure Reading		30.45	Inches/Hg	1/22/2015				X
Cadmium	U	0.001	mg/L	1/22/2015			SW846-6020	=
Cadmium, Dissolved	U	0.001	mg/L	1/22/2015			SW846-6020	=
Chromium	U	0.01	mg/L	1/22/2015			SW846-6020	=
Chromium, Dissolved	U	0.01	mg/L	1/22/2015			SW846-6020	=
Conductivity		297	umho/cm	1/22/2015				X
Depth to Water		54.21	ft	1/22/2015				X
Dissolved Oxygen		2.5	mg/L	1/22/2015				X
Lead	U	0.002	mg/L	1/22/2015			SW846-6020	=
Lead, Dissolved	U	0.002	mg/L	1/22/2015			SW846-6020	=
Mercury	U	0.0002	mg/L	1/22/2015			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	1/22/2015			SW846-7470A	=
pH		6.06	Std Unit	1/22/2015				X
Redox		750	mV	1/22/2015				X
Selenium	U	0.005	mg/L	1/22/2015			SW846-6020	=
Selenium, Dissolved	U	0.005	mg/L	1/22/2015			SW846-6020	=
Technetium-99	U	7.05	pCi/L	1/22/2015	11.5	11.6	HASL 300, Tc-02-RC M	=
Temperature		58.4	deg F	1/22/2015				X
Trichloroethene		187	ug/L	1/22/2015			SW846-8260B	=
Turbidity		6.7	NTU	1/22/2015				X
Uranium	U	0.0002	mg/L	1/22/2015			SW846-6020	=
Uranium-234	U	-0.83	pCi/L	1/22/2015	1.29	1.29	HASL 300, U-02-RC M	=
Uranium-235	U	-0.794	pCi/L	1/22/2015	1.56	1.56	HASL 300, U-02-RC M	=
Uranium-238	U	-1.39	pCi/L	1/22/2015	1.36	1.36	HASL 300, U-02-RC M	=

**Paducah OREIS
GROUNDWATER MONITORING REPORT**

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982
Type of Sample: FB **Period:** Semiannual Report QC Samples
AKGWA Well Tag #: 0000-0000

Parameter	Qualifier	Result	Units	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic	U	0.005	mg/L	1/27/2015			SW846-6020	=
Cadmium	U	0.001	mg/L	1/27/2015			SW846-6020	=
Chromium	U	0.01	mg/L	1/27/2015			SW846-6020	=
Lead	U	0.002	mg/L	1/27/2015			SW846-6020	=
Mercury	U	0.0002	mg/L	1/27/2015			SW846-7470A	=
Selenium	U	0.005	mg/L	1/27/2015			SW846-6020	=
Technetium-99	U	6.7	pCi/L	1/27/2015	10.7	10.7	HASL 300, Tc-02-RC M	=
Trichloroethene	U	1	ug/L	1/27/2015			SW846-8260B	=
Uranium	U	0.0002	mg/L	1/27/2015			SW846-6020	=
Uranium-234	U	-0.397	pCi/L	1/27/2015	0.92	0.922	HASL 300, U-02-RC M	=
Uranium-235	U	-0.245	pCi/L	1/27/2015	1.08	1.09	HASL 300, U-02-RC M	=
Uranium-238	U	1.04	pCi/L	1/27/2015	1.66	1.66	HASL 300, U-02-RC M	=

**Paducah OREIS
GROUNDWATER MONITORING REPORT**

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982
Type of Sample: RI **Period:** Semiannual Report QC Samples
AKGWA Well Tag #: 0000-0000

Parameter	Qualifier	Result	Units	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic	U	0.005	mg/L	1/27/2015			SW846-6020	=
Cadmium	U	0.001	mg/L	1/27/2015			SW846-6020	=
Chromium	U	0.01	mg/L	1/27/2015			SW846-6020	=
Lead	U	0.002	mg/L	1/27/2015			SW846-6020	=
Mercury	U	0.0002	mg/L	1/27/2015			SW846-7470A	=
Selenium	U	0.005	mg/L	1/27/2015			SW846-6020	=
Technetium-99	U	-0.038	pCi/L	1/27/2015	10.1	10.1	HASL 300, Tc-02-RC M	=
Trichloroethene	U	1	ug/L	1/27/2015			SW846-8260B	=
Uranium	U	0.0002	mg/L	1/27/2015			SW846-6020	=
Uranium-234	U	-0.277	pCi/L	1/27/2015	1.25	1.25	HASL 300, U-02-RC M	=
Uranium-235	U	0.887	pCi/L	1/27/2015	1.74	1.75	HASL 300, U-02-RC M	=
Uranium-238	U	0.717	pCi/L	1/27/2015	1.41	1.41	HASL 300, U-02-RC M	=

**Paducah OREIS
GROUNDWATER MONITORING REPORT**

Facility: C-404 Landfill **County:** McCracken **Permit #:** KY8-890-008-982
Type of Sample: TB **Period:** Semiannual Report QC Samples
AKGWA Well Tag #: 0000-0000

Parameter	Qualifier	Result	Units	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Trichloroethene	U	1	ug/L	1/28/2015			SW846-8260B	=
	U	1	ug/L	1/22/2015			SW846-8260B	=
	U	1	ug/L	1/27/2015			SW846-8260B	=
	U	1	ug/L	1/27/2015			SW846-8260B	=

MEDIA Codes

WG Groundwater

QUALIFIER Codes

U Analyte analyzed for, but not detected at or below the lowest concentration reported.

J Estimated quantitation.

SAMPLE METHOD Codes

GR Grab

SAMPLING POINT Codes

UCRS Upper Continental Recharge System

URGA Upper Regional Gravel Aquifer

SAMPLE TYPE Codes

FB Field Blank

FR Field Replicate (Code used for Field Duplicate)

REG Regular

RI QC Equipment Rinseate/Decon

TB Trip Blank

VALIDATION Code

= Validated result, which is detected and unqualified.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

X Not validated.

APPENDIX B

C-404 HAZARDOUS WASTE LANDFILL STATISTICAL ANALYSES

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GROUNDWATER STATISTICAL SUMMARY

Introduction

The statistical analyses conducted on the data collected from C-404 Hazardous Waste Landfill (C-404 Landfill) were performed in accordance with procedures provided in Appendix E of the C-404 Hazardous Waste Management Permit and previously approved by the Kentucky Division of Waste Management (KDWM). The percent of censored (nondetected) data points for individual parameters was calculated for the combined analytical data from the most recent six sampling events. The percent of censored data was used to select the types of statistical analyses to determine whether compliance well concentrations differed from background well concentrations. For this report, the reporting period data set includes data from July 2012, January 2013, August 2013, January 2014, July 2014, and January 2015.

Statistical Analysis Process

The type of statistical test conducted for each chemical data set is a function of the number of samples and proportion of censored data (nondetects) to uncensored data (detects) in each group. The percent of censored (nondetected) data points for individual parameters was calculated for the combined analytical data. The statistical procedures applied to the data are summarized below.

- Determine the percentage of the censored data using the reporting period data set.
- Group by percentage of censored data where the following apply:
 - If censored data are greater than or equal to 90%, determine the limit of detection (LOD) and half of the LOD (1/2 LOD). This is Statistical Test 1.
 - If censored data are between 50% and 90%, perform a Test of Proportions. If the analysis indicates a significant proportional difference in compliance wells, further analyze through nonparametric Analysis of Variance (ANOVA) Test. This is Statistical Test 2.
 - If censored data are between 15% and 50%, perform nonparametric ANOVA Test. If results exceed the critical value, compute the critical difference used to identify individual well concentrations, which are significantly elevated compared with background. This is Statistical Test 3.
 - If censored data are less than 15%, actual data values are analyzed using parametric ANOVA procedures. If the wells exhibit equal variances, then the data are used as presented. If the wells do not exhibit equal variances, then the log of the data is taken and then used in the calculations. Where statistical testing indicates elevated compliance well concentrations, Bonferroni's Test of Contrasts is performed. This is Statistical Test 4. If variances are found to be unequal even for log-transformed concentrations, Statistical Test 4 is abandoned and Statistical Test 3 is used to compare compliance wells with background wells.

Data Analysis

Data from the upgradient background wells in the Upper Regional Gravel Aquifer (URGA) are included for comparison with three downgradient URGA wells. Figure 1 of this C-404 Landfill Groundwater Report provides a map of the well locations associated with the C-404 Landfill. Upper Continental Recharge System (UCRS) wells in Figure 1 are provided for reference only. Data from wells that are in the UCRS are not included in the statistical analyses.

Table B.1 presents the C-404 Landfill upgradient or background wells and downgradient or compliance wells from the URGA. Data from the URGA compliance wells were compared with data from the URGA background wells.

For this report, the reporting period data set from July 2012 through January 2015 consists of six sets of data.

Table B.2 lists the number of analyses (observations), nondetects (censored observations), detects (uncensored observations), and missing observations by parameter. When field duplicate data are available from a well, the higher of the two readings was retained for further evaluation.

Censoring Percentage and Statistical Analysis

The type of statistical test set applied to the data is a function of the number of nondetects (censored) versus detects (uncensored) in each of the parameter groups and among the wells. Table B.3 presents the percentage of censored and uncensored data and type of statistical test chosen for each of the parameters.

Table B.1. Monitoring Well Locations

UCRS	
Located South of C-404; adjacent to upgradient Regional Gravel Aquifer (RGA) background well MW93	MW94
Located North of C-404, adjacent to downgradient RGA compliance wells	MW85, MW88, MW91
URGA	
Upgradient background wells	MW93, MW420
Downgradient compliance wells	MW84, MW87, MW90A*

*MW90 was abandoned in 2001 and replaced with MW90A.

Table B.2. Summary of Missing, Censored, and Uncensored Data Collected

Parameters	Observations	Missing Observations*	Censored Observations	Uncensored Observations
URGA				
Arsenic	30	0	11	19
Arsenic, Dissolved	30	0	16	14
Cadmium	30	0	27	3
Cadmium, Dissolved	30	0	30	0
Chromium	30	0	16	14
Chromium, Dissolved	30	0	29	1
Lead	30	0	23	7
Lead, Dissolved	30	0	30	0
Mercury	30	0	30	0
Mercury, Dissolved	30	0	30	0
Selenium	30	0	26	4
Selenium, Dissolved	30	0	30	0
Technetium-99	30	0	25	5
Trichloroethene	30	0	0	30
Uranium (Metals)	30	0	26	4
Uranium, Dissolved	30	0	29	1
Uranium-234	30	0	30	0
Uranium-235	30	0	30	0
Uranium-238	30	0	29	1

*Missing parameters that were dissolved metals were not analyzed when the parent total metals were not detected in prior sampling events.

Table B.3. Percent Censored Report and Statistical Test Set Selected

Parameter	Total Samples (Nonmissing)	Uncensored	Censored	Percent Censored	Statistical Test Set
URGA					
Arsenic	30	19	11	37%	3
Arsenic, Dissolved	30	14	16	53%	2
Cadmium	30	3	27	90%	1
Chromium	30	14	16	53%	2
Chromium, Dissolved	30	1	29	97%	1
Lead	30	7	23	77%	2
Mercury	30	0	30	100%	1
Selenium	30	4	26	87%	2
Technetium-99	30	5	25	83%	2
Trichloroethene	30	30	0	0%	4/3*
Uranium	30	6	24	80%	2
Uranium, Dissolved	30	1	29	97%	1
Uranium-234	30	0	30	100%	1
Uranium-235	30	0	30	100%	1
Uranium-238	30	1	29	97%	1

A list of the constituents with greater than or equal to 90% censored data is included in Table B.4, which summarizes the results of Statistical Test 1.

*Because equality of variance could not be confirmed, Statistical Test 4 was abandoned and Statistical Test 3, Non-parametric ANOVA, was performed.

SUMMARY OF CONCLUSIONS

The results for Statistical Test 1, LOD, are summarized in Table B.4. Table B.5 provides the summary of conclusions for the statistical analyses for the C-404 Landfill, including the statistical tests performed, the attachment number, well type, parameter, and results of each statistical test. Results of Statistical Test 2, Statistical Test 3, and Statistical Test 4 are presented in Attachments 1 through 7.

In summary, Statistical Test 2, Test of Proportions, for dissolved arsenic, chromium, lead, selenium, technetium-99, and uranium, as well as Statistical Test 3, Nonparametric ANOVA, for total arsenic in the URGA indicated no statistical evidence of releases of these contaminants from the C-404 Landfill.

Statistical Test 4, Parametric ANOVA, could not be used for trichloroethene in the URGA because there was no evidence of equality of variance. Thus, Statistical Test 4 was abandoned and Statistical Test 3, Non-parametric ANOVA, was performed. Statistical Test 3 showed there was no statistical evidence of releases of trichloroethene from the C-404 Landfill.

Table B.4. Statistical Test 1: Limit of Detection

Parameter	LOD Values	½ LOD Values
URGA		
Cadmium (mg/L)	0.001	0.0005
Chromium, Dissolved (mg/L)	0.01	0.005
Mercury (mg/L)	0.0002	0.0001
Uranium, Dissolved (mg/L)	0.0002	0.0001
Uranium-234 (pCi/L)	4.31	2.155
Uranium-235 (pCi/L)	5.04	2.52
Uranium-238 (pCi/L)	4.93	2.465

Table B.5. Summary of Conclusions from the Statistical Analyses for the C-404 Hazardous Waste Landfill for the January 2015 Data Set

Attachment	RGA Well Type	Parameter	Applied Statistical Test	Results
B1	URGA	Arsenic	Statistical Test 3, Nonparametric ANOVA	No statistical evidence of releases from the C-404 Landfill in compliance wells.
B2	URGA	Arsenic, Dissolved	Statistical Test 2, Test of Proportions	No statistical evidence of releases from the C-404 Landfill in compliance wells.
B3	URGA	Chromium	Statistical Test 2, Test of Proportions	No statistical evidence of releases from the C-404 Landfill in compliance wells.
B4	URGA	Lead	Statistical Test 2, Test of Proportions	No statistical evidence of releases from the C-404 Landfill in compliance wells.
B5	URGA	Selenium	Statistical Test 2, Test of Proportions	No statistical evidence of releases from the C-404 Landfill in compliance wells.
B6	URGA	Technetium-99	Statistical Test 2 Test of Proportions	No statistical evidence of releases from the C-404 Landfill in compliance wells.
B7	URGA	Trichloroethene	Statistical Test 4 Parametric ANOVA	Because equality of variance could not be confirmed, Statistical Test 4 was abandoned and Statistical Test 3, Non-parametric ANOVA, was performed. No statistical evidence of releases from the C-404 Landfill in compliance wells.
B8	URGA	Uranium	Statistical Test 2 Test of Proportions	No statistical evidence of releases from the C-404 Landfill in compliance wells.

ATTACHMENT B1

ARSENIC (TOTAL)
STATISTICAL TEST 3

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Attachment B1: Statistical Test 3, Nonparametric ANOVA, January 2015 Arsenic (Total) URGA

Arsenic (Total) (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	0.00412	0.0005	0.00425	0.00133	0.0005
Jan-13	0.00652	0.0005	0.00572	0.00183	0.0005
Aug-13	0.00472	0.0005	0.00441	0.0015	0.0005
Jan-14	0.00656	0.0011	0.00514	0.00218	0.0005
Jul-14	0.0058	0.0025	0.00511	0.00302	0.0025
Jan-15	0.00185	0.0025	0.0073	0.00174	0.0025
Sum	0.0371		0.03193	0.01160	0.0070
n _i	12		6	6	6
(x _i) _{avg}	0.00309		0.00532	0.00193	0.0012

mg/L = milligrams per liter

BG=background

DL=detection limit

All data sets represent 1/2DL values for nondetects.

Bolded values indicate a detected result.

Overall mean $\bar{x} = 0.00292$

N = 30

p = 4

$\bar{x} = 0.09$

Attachment B1: Statistical Test 3, Nonparametric ANOVA, January 2015 Arsenic (Total) URG

Statistical Test 3, Non-parametric ANOVA

Ranking of Observations

Sequence	Arsenic (mg/L)	Adjusted Rank	Tie Number
1	0.0005	4	Tie 1
2	0.0005	4	
3	0.0005	4	
4	0.0005	4	
5	0.0005	4	
6	0.0005	4	
7	0.0005	4	
8	0.0011	8	
9	0.00133	9	
10	0.0015	10	
11	0.00174	11	
12	0.00183	12	
13	0.00185	13	
14	0.00218	14	
15	0.0025	16.5	Tie 2
16	0.0025	16.5	
17	0.0025	16.5	
18	0.0025	16.5	
19	0.00302	19	
20	0.00412	20	
21	0.00425	21	
22	0.00441	22	
23	0.00472	23	
24	0.00511	24	
25	0.00514	25	
26	0.00572	26	
27	0.0058	27	
28	0.00652	28	
29	0.00656	29	
30	0.0073	30	

mg/L = milligrams per liter

BG=background

DL=detection limit

All data sets represent 1/2DL values for nondetects.

Bolded values indicate a detected result.

n_{tie} Adjustment for Ties: $(n_{tie}^3 - n_{tie})$

7 Tie 1 = 336

4 Tie 2= 60

$\sum T_i =$ 396

Attachment B1: Statistical Test 3, Nonparametric ANOVA, January 2015 Arsenic (Total) URGA

Sums of Ranks and Averages

Arsenic (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	0.00412	0.0005	0.00425	0.00133	0.0005
Jan-13	0.00652	0.0005	0.00572	0.00183	0.0005
Aug-13	0.00472	0.0005	0.00441	0.0015	0.0005
Jan-14	0.00656	0.0011	0.00514	0.00218	0.0005
Jul-14	0.0058	0.0025	0.00511	0.00302	0.0025
Jan-15	0.00185	0.0025	0.0073	0.00174	0.0025

Observation Ranks for Arsenic					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	20	4	21	9	4
Jan-13	28	4	26	12	4
Aug-13	23	4	22	10	4
Jan-14	29	8	25	14	4
Jul-14	27	16.5	24	19	16.5
Jan-15	13	16.5	30	11	16.5
R _i	193		148	75	49
(R _i) _{avg}	16.1		24.7	12.5	8.2
R _i ² /n _i	3104.1		3650.7	937.5	400.2

$\Sigma R_i^2/n_i = 8092.4$

mg/L = milligrams per liter

BG=background

DL=detection limit

All data sets represent 1/2DL values for nondetects.

Bolded values indicate a detected result.

K= 4

N= 30

Calculation of Kruskal-Wallis Statistic

H = 11.418 Kruskal-Wallis Statistic $H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$

H' = 11.588 Corrected Kruskal-Wallis $H' = H/[1-(\Sigma T_i/N^3-N)]$

$\chi^2_{crit} = 7.815$ 3 degrees of freedom at the 5% significance level

NOTE: $H' > \chi^2_{crit}$

If $H' \leq \chi^2_{crit}$, the data from each well come from the same continuous distribution and hence have the same median concentrations of a specific constituent.

If $H' > \chi^2_{crit}$, reject the null hypothesis and calculate the critical difference for well comparisons to the background.

K-1= 3

$\alpha/(K-1) = 0.01667$

$Z(\alpha/(K-1))^{**} = 2.1280$

$\alpha = 0.05$

$1-(\alpha/(K-1)) = 0.983$

NOTE * Table 1, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance*, USEPA, 1989.

**Table 4, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance*, USEPA, 1989.

Attachment B1: Statistical Test 3, Nonparametric ANOVA, January 2015 Arsenic (Total) URGA

Calculate Critical Values

Average Background Ranking = 16.083

	Well No.	C_i	$(R_i)_{avg} - (R_b)_{avg}$	Conclusion
BG Well	MW93			
BG Well	MW420			
	MW84	9.367	8.58	not contaminated
	MW87	9.367	-3.58	not contaminated
	MW90A	9.367	-7.92	not contaminated

mg/L = milligrams per liter

BG=background

DL=detection limit

All data sets represent 1/2DL values for nondetects.

Bolded values indicate a detected result.

If $(R_i)_{avg} - (R_b)_{avg} > C_i$, then there is evidence that the compliance well is contaminated.

CONCLUSION: Since $(R_i)_{avg} - (R_b)_{avg} < C_i$ for all MW84, MW87 and MW90A, there is no statistical evidence of releases from C-404 in these downgradient compliance test wells.

Section 5.2.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance*, USEPA, 1989

ATTACHMENT B2

**ARSENIC (DISSOLVED)
STATISTICAL TEST 2**

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Attachment B2: Statistical Test 2, Test of Proportions, January 2015 Arsenic, Dissolved URGA

Arsenic, Dissolved (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	0.00377	0.0005	0.00411	0.00128	0.0005
Jan-13	0.004	0.0005	0.00374	0.00132	0.0005
Aug-13	0.00422	0.0005	0.00391	0.0016	0.0005
Jan-14	0.00536	0.0005	0.00412	0.00181	0.0005
Jul-14	0.0025	0.0025	0.0025	0.0025	0.0025
Jan-15	0.0035	0.0025	0.00245	0.0025	0.0025

mg/L = milligrams per liter

BG=background

DL=detection limit

All data sets represent 1/2DL values for nondetects.

Bolded values indicate a detected result.

Test of Proportions

Calculate the number of detections in background wells vs. compliance wells.

X= 5 X=number of samples above DL in background wells
 Y= 9 Y=number of samples above DL in compliance wells
 n_b= 12 n_b=count of background well results/samples analyzed
 n_c= 18 n_c=count of compliance well results/samples analyzed
 n= 30 n=total number of samples

P = 0.467 P=(x+y)/n
 nP = 14 n=n_b+n_c
 n(1-P) = 16

NOTE: If nP and n(1-P) are both >= 5, then the normal approximation may be used.

P_b = 0.417 P_b =proportion of detects in background wells
 P_c = 0.500 P_c =proportion of detects in compliance wells
 S_D = 0.186 S_D=standard error of difference in proportions
 Z = -0.448 Z = (P_b-P_c)/S_D
 absolute value of Z = 0.448

If the absolute value of Z exceeds the 97.5th percentile value of 1.96 from the standard normal distribution, this provides statistically significant evidence at the 5% significance level that the proportion of detects in one group of data exceeds the proportion of detects in the other group.

CONCLUSION: Because the absolute value of Z is less than 1.96, there is no statistical evidence that the proportion of samples with detected results differs between the background well and compliance well samples.

¹ Section 8.1.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (EPA, 1989)

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ATTACHMENT B3

CHROMIUM
STATISTICAL TEST 2

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Attachment B3: Statistical Test 2, Test of Proportions, January 2015 Chromium URGA

Chromium (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	0.005	0.005	0.005	0.0218	0.005
Jan-13	0.224	0.005	0.0604	0.177	0.005
Aug-13	0.0288	0.005	0.0639	0.0691	0.005
Jan-14	0.005	0.005	0.0921	0.005	0.005
Jul-14	0.011	0.005	0.331	0.00903	0.00227
Jan-15	0.0273	0.005	0.442	0.031	0.005

mg/L = milligrams per liter

BG=background

DL=detection limit

All data sets represent 1/2DL values for nondetects.

Bolded values indicate a detected result.

¹Test of Proportions

Calculate the number of detections in background wells vs. compliance wells.

X= 4 X=number of samples above DL in background wells
 Y= 11 Y=number of samples above DL in compliance wells
 n_b= 12 n_b=count of background well results/samples analyzed
 n_c= 18 n_c=count of compliance well results/samples analyzed
 n= 30 n=total number of samples

P = 0.500 P=(x+y)/n
 nP = 15 n=n_b+n_c
 n(1-P) = 15

NOTE: If nP and n(1-P) are both >= 5, then the normal approximation may be used.

P_b = 0.333 P_b =proportion of detects in background wells
 P_c = 0.611 P_c =proportion of detects in compliance wells
 S_D = 0.186 S_D=standard error of difference in proportions
 Z = -1.491 Z = (P_b-P_c)/S_D
 absolute value of Z = 1.491

If the absolute value of Z exceeds the 97.5th percentile value of 1.96 from the standard normal distribution, this provides statistically significant evidence at the 5% significance level that the proportion of detects in one group of data exceeds the proportion of detects in the other group.

CONCLUSION: Because the absolute value of Z is less than 1.96, there is no statistical evidence that the proportion of samples with detected results differs between the background well and compliance well samples.

¹ Section 8.1.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (EPA, 1989)

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ATTACHMENT B4

LEAD
STATISTICAL TEST 2

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Attachment B4: Statistical Test 2, Test of Proportions, January 2015 Lead URGA

Lead (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	0.00065	0.00065	0.00065	0.00065	0.00065
Jan-13	0.00256	0.00065	0.00164	0.0117	0.00065
Aug-13	0.00065	0.00065	0.00065	0.00065	0.00065
Jan-14	0.00065	0.00065	0.00065	0.00065	0.00065
Jul-14	0.00066	0.001	0.001	0.001	0.001
Jan-15	0.0024	0.001	0.00189	0.0009	0.001

mg/L = milligrams per liter

BG=background

DL=detection limit

Nondetect values are 1/2DL.

Bolded values indicate a detected result.

Test of Proportions

Calculate the number of detections in background wells vs. compliance wells.

X= 3 X=number of samples above DL in background wells
 Y= 4 Y=number of samples above DL in compliance wells
 n_b= 12 n_b=count of background well results/samples analyzed
 n_c= 18 n_c=count of compliance well results/samples analyzed
 n= 30 n=total number of samples

P = 0.233 P=(x+y)/n
 nP = 7 n=n_b+n_c
 n(1-P) = 23

NOTE: If nP and n(1-P) are both >= 5, then the normal approximation may be used.

P_b = 0.250 P_b =proportion of detects in background wells
 P_c = 0.222 P_c =proportion of detects in compliance wells
 S_D = 0.158 S_D=standard error of difference in proportions
 Z = 0.176 Z = (P_b-P_c)/S_D
 absolute value of Z = 0.176

If the absolute value of Z exceeds the 97.5th percentile value of 1.96 from the standard normal distribution, this provides statistically significant evidence at the 5% significance level that the proportion of detects in one group of data exceeds the proportion of detects in the other group.

CONCLUSION: Because the absolute value of Z is less than 1.96, there is no statistical evidence that the proportion of samples with detected results differs between the background well and compliance well samples.

¹ Section 8.1.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (EPA, 1989)

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ATTACHMENT B5

SELENIUM
STATISTICAL TEST 2

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Attachment B5: Statistical Test 2, Test of Proportions, January 2015 Selenium URGA

Selenium (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	0.0025	0.0025	0.0025	0.0025	0.0025
Jan-13	0.0025	0.0025	0.0025	0.0025	0.0025
Aug-13	0.0025	0.0025	0.0025	0.0025	0.0025
Jan-14	0.00596	0.0025	0.00652	0.0025	0.0025
Jul-14	0.0025	0.0025	0.0025	0.0025	0.00166
Jan-15	0.0025	0.0025	0.0025	0.0025	0.00182

mg/L = milligrams per liter

BG=background

DL=detection limit

Nondetect values are 1/2DL.

Bolded values indicate a detected result.

Test of Proportions

Calculate the number of detections in background wells vs. compliance wells.

X= 1 X=number of samples above DL in background wells
 Y= 3 Y=number of samples above DL in compliance wells
 n_b= 12 n_b=count of background well results/samples analyzed
 n_c= 18 n_c=count of compliance well results/samples analyzed
 n= 30 n=total number of samples

P = 0.133 P=(x+y)/n
 nP = 4 n=n_b+n_c
 n(1-P) = 26

NOTE: If nP and n(1-P) are both >= 5, then the normal approximation may be used.

P_b = 0.083 P_b =proportion of detects in background wells
 P_c = 0.167 P_c =proportion of detects in compliance wells
 S_D = 0.127 S_D=standard error of difference in proportions
 Z = -0.658 Z = (P_b-P_c)/S_D
 absolute value of Z = 0.658

If the absolute value of Z exceeds the 97.5th percentile value of 1.96 from the standard normal distribution, this provides statistically significant evidence at the 5% significance level that the proportion of detects in one group of data exceeds the proportion of detects in the other group.

CONCLUSION: Because the absolute value of Z is less than 1.96, there is no statistical evidence that the proportion of samples with detected results differs between the background well and compliance well samples.

¹ Section 8.1.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (EPA, 1989)

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ATTACHMENT B6

TECHNETIUM-99
STATISTICAL TEST 2

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Attachment B6: Statistical Test 2, Test of Proportions, January 2015 Technetium-99 URGA

Technetium-99 (pCi/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	9.25	9.25	22.3	9.25	9.25
Jan-13	7.4	49.1	7.4	7.4	7.4
Aug-13	3.165	17.9	18.8	4.88	7.25
Jan-14	8.1	16.8	8.1	8.1	8.1
Jul-14	8.4	7.85	8.05	8.4	8.05
Jan-15	9.7	9.75	12.2	10.5	8.75

pCi/L = picocuries per liter

BG=background

DL=detection limit

Data represent 1/2DL values for nondetects.

Bolded values indicate a detected result.

Test of Proportions

Calculate the number of detections in background wells vs. compliance wells.

X= 3 X=number of samples above DL in background wells
 Y= 2 Y=number of samples above DL in compliance wells
 n_b = 12 n_b =count of background well results/samples analyzed
 n_c = 18 n_c =count of compliance well results/samples analyzed
 n= 30 n=total number of samples

P = 0.167 $P=(x+y)/n$
 nP = 5 $n=n_b+n_c$
 $n(1-P)$ = 25

NOTE: If nP and $n(1-P)$ are both ≥ 5 , then the normal approximation may be used.

P_b = 0.250 P_b =proportion of detects in background wells
 P_c = 0.111 P_c =proportion of detects in compliance wells
 S_D = 0.139 S_D =standard error of difference in proportions
 Z = 1.000 $Z = (P_b-P_c)/S_D$
 absolute value of Z = 1.000

If the absolute value of Z exceeds the 97.5th percentile value of 1.96 from the standard normal distribution, this provides statistically significant evidence at the 5% significance level that the proportion of detects in one group of data exceeds the proportion of detects in the other group.

CONCLUSION: Because the absolute value of Z is less than 1.96, there is no statistical evidence that the proportion of samples with detected results differs between the background well and compliance well samples.

¹ Section 8.1.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (EPA, 1989)

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ATTACHMENT B7

**TRICHLOROETHENE
STATISTICAL TESTS 4/3**

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**Attachment B7: Statistical Test 4, Parametric ANOVA,
January 2015 Trichloroethene URG**

Trichloroethene (TCE, µg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	1500	210	1100	450	14
Jan-13	1900	190	1100	470	17
Aug-13	2200	230	1300	760	35
Jan-14	2900	290	1500	670	25
Jul-14	2710	203	1270	1030	46.2
Jan-15	2970	208	1380	1010	37.3
ni	12		6	6	6
Sum	15511		7650	4390	174.50
(x _i)avg	1292.58		1275.00	731.67	29.08

µg/L = micrograms per liter

Bolded values indicate a detected result.

Overall mean \bar{x} . = 924.18
 N = 30
 p = 4
 \bar{x} . = 27725.50

Determine Normality of Dataset

Coefficient of Variability Test

Table of Residuals

Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	207.42	-1082.58	-175.00	-281.67	-15.08
Jan-13	607.42	-1102.58	-175.00	-261.67	-12.08
Aug-13	907.42	-1062.58	25.00	28.33	5.92
Jan-14	1607.42	-1002.58	225.00	-61.67	-4.08
Jul-14	1417.42	-1089.58	-5.00	298.33	17.12
Jan-15	1677.42	-1084.58	105.00	278.33	8.22

X: Mean Value = 4.06E-14 924.1833333
 S: Standard Deviation = 742.1 897.6461311
 K* Factor = 2.22 (for n = 30)
 CV = S/X = 1.83E+16 > or = 1, residuals are not normal 0.97

*K factor [from Table 5, Appendix B of *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989)].

Because the coefficient of variation is < 1, the residuals appear to be normally distributed.

**Attachment B7: Statistical Test 4, Parametric ANOVA,
January 2015 Trichloroethene URGA**

Determine Equality of Variance of Dataset

p = number of wells x̄ = 27725.50
 n_i = number of data points per well (x̄_{avg}) = 924.18
 N = total sample size p = 4
 S² = the square of the standard deviation N = 30
 ln(S_i²) = natural logarithm of each variance
 f = total sample size minus the number of wells (groups)
 f_i = n_i - 1

Calculations for Equality of Variance: Bartlett's Test

S _i	S _i ²	ln(S _i ²)	n _i	f _i S _i ²	f _i ln(S _i ²)
1188.101	1411582.99	14.160	12	15527412.9	155.8
157.194	24710.000	10.115	6	123550.000	50.6
252.540	63776.667	11.063	6	318883.333	55.3
12.535	157.138	5.057	6	785.688	25.3

$\sum(S_i^2) = 1500226.80$ $\sum f_i \ln(S_i^2) = 286.9$

Equality of Variance: Bartlett's Test

f = 26
 Sp² = 614255.075
 ln Sp² = 13.328
 $\chi^2 = 59.594$ (If calculated $\chi^2 \leq \chi^2_{crit}$, then variances are equal at the given significance level).
 $\chi^2_{crit} * = 7.815$ at a 5% significance level with 3 degrees of freedom

Variances are not equal, transform the original data to lognormal.

*Table 1, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities*, Interim Guidance (EPA 1989).

**Attachment B7: Statistical Test 4, Parametric ANOVA,
January 2015 Trichloroethene URGA**

Lognormal Data for TCE

Date	ln[TCE (µg/L)]				
	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	7.31	5.35	7.00	6.11	2.64
Jan-13	7.55	5.25	7.00	6.15	2.83
Aug-13	7.70	5.44	7.17	6.63	3.56
Jan-14	7.97	5.67	7.31	6.51	3.22
Jul-14	7.90	5.31	7.15	6.94	3.83
Jan-15	8.00	5.34	7.23	6.92	3.62
\bar{x}_i	78.79		42.87	39.26	19.70
(\bar{x})avg	6.57		7.14	6.54	3.28

µg/L = micrograms per liter

Determine Normality of Dataset

Coefficient of Variability Test

Table of residuals

Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jan-12	0.75	-1.22	-0.14	-0.43	-0.64
Jul-12	0.98	-1.32	-0.14	-0.39	-0.45
Jan-13	1.13	-1.13	0.03	0.09	0.27
Aug-13	1.41	-0.90	0.17	-0.04	-0.06
Jan-14	1.34	-1.25	0.00	0.39	0.55
Jan-15	1.43	-1.23	0.09	0.37	0.34

X: Mean Value = 0.00
 S: Standard Deviation = 0.8
 K* Factor = 2.22 (for n = 30)
 CV = S/X = 2.87E+15 > or = 1, log-transformed data are not normally distributed

*K factor [from Table 5, Appendix B of *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989)].

**Attachment B7: Statistical Test 4, Parametric ANOVA,
January 2015 Trichloroethene URGA**

Determine Equality of Variance of Dataset

p = number of wells (background wells considered as one group) x = 180.61
 ni = number of data points per well (x_{avg}) = 6.02
 N = total sample size
 S² = the square of the standard deviation p = 4
 ln(Si²) = natural logarithm of each variance N = 30
 f = total sample size minus the number of wells (groups)
 fi = ni - 1

Calculations for Equality of Variance: Bartlett's Test

Si	Si ²	ln(Si ²)	ni	fiSi ²	fi ln(Si ²)
1.243	1.545	0.435	12	16.999	4.8
0.124	0.015	-4.181	6	0.076	-20.9
0.359	0.129	-2.047	6	0.646	-10.2
0.471	0.222	-1.505	6	1.111	-7.5

$\sum(S_i^2) = 1.91$ $\sum fi \ln(S_i^2) = -33.9$

Equality of Variance: Bartlett's Test

f = 26
 Sp² = 0.724
 ln Sp² = -0.323
 $\chi^2 = 25.487$ (If calculated $\chi^2 \leq$ tabulated χ^2 , then variances are equal at the given significance level).
 tabulated $\chi^2 * = 7.815$ at a 5% significance level with 3 degrees of freedom

Variances are not equal.

*Table 1, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989)].

Because variances are not equal, Statistical Test 3 - Nonparameteric ANOVA is performed.

**Attachment B7: Statistical Test 3, Nonparametric ANOVA,
January 2015 Trichloroethene URGA**

Statistical Test 3, Nonparametric ANOVA

TCE (µg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	1500	210	1100	450	14
Jan-13	1900	190	1100	470	17
Aug-13	2200	230	1300	760	35
Jan-14	2900	290	1500	670	25
Jul-14	2710	203	1270	1030	46.2
Jan-15	2970	208	1380	1010	37.3
n _i	12		6	6	6
x _i	15511		7650	4390	174.50
(x _i)avg	1292.58		1275.00	731.67	29.08

Overall mean x. = 924.18

N = 30

p = 4

x. = 27725.50

µg/L = micrograms per liter

**Attachment B7: Statistical Test 3, Nonparametric ANOVA,
January 2015 Trichloroethene URGA**

Non-Parametric ANOVA

Ranking of Observations

Sequence	TCE (µg/L)	Adjusted Rank	Tie Number
1	14	1	
2	17	2	
3	25	3	
4	35	4	
5	37.3	5	
6	46.2	6	
7	190	7	
8	203	8	
9	208	9	
10	210	10	
11	230	11	
12	290	12	
13	450	13	
14	470	14	
15	670	15	
16	760	16	
17	1010	17	
18	1030	18	
19	1100	19.5	Tie 1
20	1100	19.5	
21	1270	21	
22	1300	22	
23	1380	23	
24	1500	24.5	Tie 2
25	1500	24.5	
26	1900	26	
27	2200	27	
28	2710	28	
29	2900	29	
30	2970	30	

	<u>Adjustment for Ties:</u>	$n_{tie}^3 - n_{tie}$
n_{tie}	Tie 1	2 6
	Tie 2	2 6

$$\sum T_i = 12$$

**Attachment B7: Statistical Test 3, Nonparametric ANOVA,
January 2015 Trichloroethene URGA**

Sums of Ranks and Averages

TCE (µg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	1500	210	1100	450	14
Jan-13	1900	190	1100	470	17
Aug-13	2200	230	1300	760	35
Jan-14	2900	290	1500	670	25
Jul-14	2710	203	1270	1030	46.2
Jan-15	2970	208	1380	1010	37.3

Observation Ranks for TCE					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-11	24.5	10	19.5	13	1
Jan-12	26	7	19.5	14	2
Jul-12	27	11	22	16	4
Jan-13	29	12	24.5	15	3
Aug-13	28	8	21	18	6
Jan-14	30	9	23	17	5
R _i	221.5		129.5	93	21
(R _i) _{avg}	18.5		21.6	15.5	3.5
R _i ² /n _i	4088.5		2795.0	1441.5	73.5

$$\sum R_i^2/n_i = 8398.6$$

$$K = 4$$

$$N = 30$$

Calculation of Kruskal-Wallis Statistic

$$H = 15.369 \quad \text{Kruskal-Wallis Statistic} \quad H = [12/N(N+1) * \sum R_i^2/n_i] - 3(N+1)$$

$$H' = 15.375 \quad \text{Corrected Kruskal-Wallis} \quad H' = H/[1 - (\sum T_i/N^3 - N)]$$

$$\chi^2_{crit*} = 7.815 \quad 3 \quad \text{degrees of freedom at the 5\% significance level}$$

NOTE: $H' > \chi^2_{crit}$

If $H' \leq \chi^2_{crit}$, the data from each well come from the same continuous distribution and hence have the same median concentrations of a specific constituent.

If $H' > \chi^2_{crit}$, reject the null hypothesis and calculate the critical difference for well comparisons to the background.

$$K-1 = 3 \quad \alpha/(K-1) = 0.01667 \quad Z(\alpha/(K-1))^{**} = 2.128$$

$$\alpha = 0.05 \quad 1-(\alpha/(K-1)) = 0.983$$

NOTE *Table 1, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).
 **Table 4, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

**Attachment B7: Statistical Test 3, Nonparametric ANOVA,
January 2015 Trichloroethene URGA**

Calculate Critical Values

Average Background Ranking = 18.5

	Well No.	C_i	$(R_i)_{avg} - (R_b)_{avg}$	Conclusion
BG Well	MW93			
BG Well	MW420			
	MW84	9.367	3.13	not contaminated
	MW87	9.367	-2.96	not contaminated
	MW90A	9.367	-14.96	not contaminated

If $(R_i)_{avg} - (R_b)_{avg} > C_i$, then there is evidence that the compliance well is contaminated.

CONCLUSION: Since $(R_i)_{avg} - (R_b)_{avg} < C_i$, there is no statistically significant evidence that downgradient compliance test wells are contaminated; however, the negative value indicates that background wells have elevated concentrations.

Section 5.2.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

ATTACHMENT B8

URANIUM
STATISTICAL TEST 2

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Attachment B8: Statistical Test 2, Test of Proportions, January 2015 Uranium URGA

Uranium (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93	MW420	MW84	MW87	MW90A
Jul-12	0.0005	0.0005	0.0005	0.0005	0.0005
Jan-13	0.0005	0.0005	0.0005	0.0005	0.0005
Aug-13	0.0005	0.0005	0.0005	0.0005	0.0005
Jan-14	0.0005	0.0005	0.0005	0.0005	0.0005
Jul-14	0.00009	0.0001	0.00011	0.00009	0.0001
Jan-15	0.00214	0.0001	0.00043	0.00019	0.0001

mg/L = milligrams per liter

BG=background

DL=detection limit

Nondetect values are 1/2DL.

Bolded values indicate a detected result.

Test of Proportions

Calculate the number of detections in background wells vs. compliance wells.

X= 2 X=number of samples above DL in background wells
 Y= 4 Y=number of samples above DL in compliance wells
 n_b= 12 n_b=count of background well results/samples analyzed
 n_c= 18 n_c=count of compliance well results/samples analyzed
 n= 30 n=total number of samples

P = 0.200 P=(x+y)/n
 nP = 6 n=n_b+n_c
 n(1-P) = 24

NOTE: If nP and n(1-P) are both >= 5, then the normal approximation may be used.

P_b = 0.167 P_b =proportion of detects in background wells
 P_c = 0.222 P_c =proportion of detects in compliance wells
 S_D = 0.149 S_D=standard error of difference in proportions
 Z = -0.373 Z = (P_b-P_c)/S_D
 absolute value of Z = 0.373

If the absolute value of Z exceeds the 97.5th percentile value of 1.96 from the standard normal distribution, this provides statistically significant evidence at the 5% significance level that the proportion of detects in one group of data exceeds the proportion of detects in the other group.

CONCLUSION: Because the absolute value of Z is less than 1.96, there is no statistical evidence that the proportion of samples with detected results differs between the background well and compliance well samples.

¹ Section 8.1.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (EPA, 1989)

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ATTACHMENT B9
STATISTICIAN STATEMENT

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May 14, 2015
LKYBA10836-14-0011

Ms. Jennifer Johnson
LATA Sharp Remediation Services
P.O. Box 280,
Kevil, KY 42053

Subject: Statistical analysis of groundwater data for C-404 landfill

Dear Ms. Johnson:

I am submitting this statement as a supplementary document to the completed statistical analysis I performed on the groundwater data for the C-404 Landfill at the Paducah Gaseous Diffusion Plant.

As a Senior Environmental Engineer, with a doctorate in Civil Engineering and Professional Engineer license with the States of Tennessee and Georgia, I have twenty-two years of experience in the analysis and interpretation of environmental data.


For this project, the statistical analyses on groundwater data from July 2012 through January 2015 were performed in accordance with the C-404 Hazardous Waste Landfill Permit, Appendix C using Microsoft Excel 2010. The Excel files were saved in a format compatible with Microsoft Excel 1997-2003. The spreadsheets include the results for the following statistical tests:

- Test of Proportions
- Parametric Analysis of Variance (ANOVA)
- Nonparametric ANOVA

The statistical analyses procedures were based on the U.S. Environmental Protection Agency (USEPA) *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Interim Final Guidance* (1989).

Please feel free to contact me via email (westor@geoconsultantsllc.com) or phone (865-242-7732) if you have any questions.

Sincerely,



Olivia R. West, Ph.D., P.E.

OW:km

cc: GEO Kevil DMC

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APPENDIX C

**C-404 HAZARDOUS WASTE LANDFILL
LEACHATE INFORMATION**

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**PADUCAH GASEOUS DIFFUSION PLANT
C-404 HAZARDOUS WASTE LANDFILL
PERMIT NUMBER KY8-890-008-982**

LEACHATE INFORMATION

This appendix includes the C-404 Landfill monthly and quarterly inspection checklist, and volumes of leachate removed during this reporting period. The analytical results of the leachate sampling will be included in the next semiannual report.

C-404 Monthly Inspection Summary^{1, 2, 3, 4}

Period of Inspection: OCTOBER 2014

Leachate Level	Date (M/D/YY)	Level (inches deep)*	Inspector(s)
First monthly leachate level determination	10-14-14	17.9	Sam Martin Jeff Boulton
Second monthly leachate level determination	 	 	
Third monthly leachate level determination	 	 	

* If the leachate level in the sump is at 3 feet (36 inches), then contact the appropriate personnel to initial removal and sampling of leachate AND when leachate is removed, complete the "C-404 Inspection Checklist for Leachate Removal."

NOTES:

1. If any item is found to be unacceptable and cannot be explained in the space available, the inspector must identify the specific observation and nature of the problem on the "C-404 Inspection Addendum" Form.
2. Third quarter of calendar year inspection includes the annual leachate collection system inspection.
3. The original forms shall be kept on file in the facility operating record.
4. Upon completing the monthly inspections, e-mail Environmental Compliance the leachate level and whether or not the leachate needs to be sampled or removed.

C-404 Monthly Inspection Summary^{1, 2, 3, 4}

Period of Inspection: November 2014

Leachate Level	Date (M/D/YY)	Level (inches deep)*	Inspector(s)
First monthly leachate level determination		17.3	11-17-14
Second monthly leachate level determination	11-17-14	17.9	Jeff Boutton
Third monthly leachate level determination			

* If the leachate level in the sump is at 3 feet (36 inches), then contact the appropriate personnel to initial removal and sampling of leachate AND when leachate is removed, complete the "C-404 Inspection Checklist for Leachate Removal."

NOTES:

1. If any item is found to be unacceptable and cannot be explained in the space available, the inspector must identify the specific observation and nature of the problem on the "C-404 Inspection Addendum" Form.
2. Third quarter of calendar year inspection includes the annual leachate collection system inspection.
3. The original forms shall be kept on file in the facility operating record.
4. Upon completing the monthly inspections, e-mail Environmental Compliance the leachate level and whether or not the leachate needs to be sampled or removed.

ENM-F-0001 (8/17/10)
PAD-ENM-0022

C-404 Monthly Inspection Summary^{1, 2, 3, 4}

Period of Inspection: December 2014

Leachate Level	Date (M/D/YY)	Level (inches deep)*	Inspector(s)
First monthly leachate level determination			
Second monthly leachate level determination		97.3	
Third monthly leachate level determination	12-16-14	21.2	Sam Martin Chad Holzer Jeff Boulton

* If the leachate level in the sump is at 3 feet (36 inches), then contact the appropriate personnel to initial removal and sampling of leachate AND when leachate is removed, complete the "C-404 Inspection Checklist for Leachate Removal."

NOTES:

1. If any item is found to be unacceptable and cannot be explained in the space available, the inspector must identify the specific observation and nature of the problem on the "C-404 Inspection Addendum" Form.
2. Third quarter of calendar year inspection includes the annual leachate collection system inspection.
3. The original forms shall be kept on file in the facility operating record.
4. Upon completing the monthly inspections, e-mail Environmental Compliance the leachate level and whether or not the leachate needs to be sampled or removed.

ENM-F-0001 (8/17/10)
PAD-ENM-0022

C-404 Quarterly Inspection Checklist^{1,5}

Item No.	Inspection Item	Item Description	Inspection Results		Comments/Observations
			A	U	
A	Warning Signs	Four signs around landfill	✓		
B	Vegetative Cover ²	Gully erosion depth > 6 inches	✓		
		Vegetative die-off	✓		
		Varmint intrusion/burrowing from animals	✓		
		Overgrowth	✓		
		Depressions	✓		
C	Ditches ³	Debris in ditches	✓		
		Excessive sediment	✓		
		Drainage	✓		
		Erosion	✓		
D	Anchor Trench ⁴	Washouts or depressions	✓		
		Lack of discharge	✓		
		Unusual volume or color	✓		
		Drainage (4 drains from landfill)	✓		
E	Leachate System	Level	✓		21.2 inches
		Cracks or damage	✓		
Inspector: <u>Jeff Boulton</u> (Printed Name) <u>Sam Martin</u> <u>Chad Holzer</u>			Signature: <u>Jeff Boulton</u> Date: <u>12-16-14</u> Time: <u>1443</u>		

A=Acceptable
U=Unacceptable

NOTES:

1. If any item is found to be unacceptable, the inspector must identify the specific observation and nature of the problem on the "C-404 Inspection Addendum" Form.
2. For Item No. B, the vegetative cover shall be mowed regularly during the active growing season to discourage the growth of weeds, competitive species, or deep-rooted vegetation. Mowing shall be conducted using a sickle-type mower to prevent airborne contaminants. A radiation work permit will be required. Any erosion damage greater than 6 inches will be repaired by restoring to its original grade and reseeding. Differential settlement will be repaired by restoring site to its original grade and reseeding.
3. For Item No. C, blockage of or damage to the system shall be repaired by removing debris and accumulated sediment and restoring the ditch to its original grade. Ditches shall be reseeded and additional gravel shall be installed as needed.
4. For Item No. D, drainage pipe failures shall be repaired by removing the failed pipe, installing a new section, and replacing the fill material as necessary.
5. The original forms shall be kept on file in the facility operating record.

C-404 Monthly Inspection Summary^{1, 2, 3, 4}

Period of Inspection: January, February, March 2015

Leachate Level	Date (M/D/YY)	Level (inches deep)*	Inspector(s)
First monthly leachate level determination	1-14-15	22"	Jeff Shidal
Second monthly leachate level determination	2-26-15	31"	Jeff Shidal Cody Boulton
Third monthly leachate level determination	3-26-15	39	Jeff Boulton Chad Holzer Sam Martin

* If the leachate level in the sump is at 3 feet (36 inches), then contact the appropriate personnel to initial removal and sampling of leachate AND when leachate is removed, complete the "C-404 Inspection Checklist for Leachate Removal."

NOTES:

1. If any item is found to be unacceptable and cannot be explained in the space available, the inspector must identify the specific observation and nature of the problem on the "C-404 Inspection Addendum" Form.
2. Third quarter of calendar year inspection includes the annual leachate collection system inspection.
3. The original forms shall be kept on file in the facility operating record.
4. Upon completing the monthly inspections, e-mail Environmental Compliance the leachate level and whether or not the leachate needs to be sampled or removed.

ENM-F-0001 (8/17/10)
PAD-ENM-0022

C-404 Inspection Checklist for Leachate Removal^{1, 2, 3}

Leachate Removal Inspection		YES	NO	N/A	Date (M/D/YY)	Volume (gallons)
Was any removal necessary during the quarter?		✓			3-30-15	2-1200 Poly Tanks
Has any leachate removed during the quarter been sampled?			✓		Sampled ON 4-8-15	
Date of superficial inspection upon removal of leachate.		✓			3-30-15	
Date of sampling of leachate after removal.		✓			4-8-15	
IT will be on next Quarter's Report Jeff Boulton 4-8-15						
Item No.	Inspection Item	Item Description	Inspection Results		Comments	
			A	U		
A	Leachate Pit	Interior malformations	✓			
		Exterior malformations	✓			
Inspector: <u>Jeff Boulton</u> (Printed Name)			Signature: <u>Jeff Boulton</u> Date: <u>3-30-15</u> Time: <u>1546</u>			

A=Acceptable
U=Unacceptable

NOTES:

- This form is completed if the leachate level in the sump is at 3 feet (36 inches) and is being removed. Ensure the appropriate personnel have been contacted and complete the information above.
- If any item is found to be unacceptable, the inspector must identify the specific observation and nature of the problem on the "C-404 Inspection Addendum" Form.
- The original forms shall be kept on file in the facility operating record.

C-404 Quarterly Inspection Checklist^{1,5}

Item No.	Inspection Item	Item Description	Inspection Results		Comments/Observations
			A	U	
A	Warning Signs	Four signs around landfill	✓		
B	Vegetative Cover ²	Gully erosion depth > 6 inches	✓		
		Vegetative die-off	✓		
		Varmint intrusion/burrowing from animals	✓		
		Overgrowth	✓		
		Depressions	✓		
C	Ditches ³	Debris in ditches	✓		
		Excessive sediment	✓		
		Drainage	✓		
		Erosion	✓		
D	Anchor Trench ⁴	Washouts or depressions	✓		
		Lack of discharge	✓		
		Unusual volume or color	✓		
		Drainage (4 drains from landfill)	✓		
E	Leachate System	Level	✓		
		Cracks or damage	✓		
Inspector: <u>Jeff Boulton</u> (Printed Name)			Signature: <u>Jeff Boulton</u> Date: <u>1-15-15</u> Time: <u>0835</u>		

A=Acceptable
U=Unacceptable

Inspector That Help.
Sam Martin
Jason Boulton 1-15-15

NOTES:

1. If any item is found to be unacceptable, the inspector must identify the specific observation and nature of the problem on the "C-404 Inspection Addendum" Form.
2. For Item No. B, the vegetative cover shall be mowed regularly during the active growing season to discourage the growth of weeds, competitive species, or deep-rooted vegetation. Mowing shall be conducted using a sickle-type mower to prevent airborne contaminants. A radiation work permit will be required. Any erosion damage greater than 6 inches will be repaired by restoring to its original grade and reseeded. Differential settlement will be repaired by restoring site to its original grade and reseeding.
3. For Item No. C, blockage of or damage to the system shall be repaired by removing debris and accumulated sediment and restoring the ditch to its original grade. Ditches shall be reseeded and additional gravel shall be installed as needed.
4. For Item No. D, drainage pipe failures shall be repaired by removing the failed pipe, installing a new section, and replacing the fill material as necessary.
5. The original forms shall be kept on file in the facility operating record.

APPENDIX D

**C-404 HAZARDOUS WASTE LANDFILL
GROUNDWATER FLOW RATE AND DIRECTION**

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C-404 LANDFILL FLOW DIRECTION

The C-404 Hazardous Waste Landfill (C-404 Landfill) Permit requires annual determination of average hydraulic flow rate and direction of flow in the uppermost aquifer. The uppermost aquifer below C-404 Landfill is the Regional Gravel Aquifer (RGA). Water level measurements currently are taken from several wells at the perimeter of the C-404 Landfill on a semiannual basis. The flow direction information included in this report is supplemental to the permit-required annual flow rate and direction.

The water levels used for this analysis (taken on January 28, 2015) were measured as closely as possible and within a 24-hour period to ensure the comparability of the data. These measurements were used to plot the potentiometric surface of the upper RGA for the January 2015 sampling event. As indicated in previous reports, flow direction beneath the C-404 Landfill generally trends northward, but commonly varies from northeast to northwest.

Contours for the potentiometric surface were drawn after water-level data were corrected for barometric efficiency. The potentiometric contours depict the directions of hydraulic flow during each sampling event.

The January potentiometric surface data of the upper RGA are presented in Table D.1, and a potentiometric surface map is presented in Figure D.1.

Table D.1. Barometric Pressure Corrections

C-404 Landfill (January 2015) Water Levels									
Date	Time	Well	Datum Elev (ft amsl)	BP (in Hg)	Delta BP (ft H ₂ O)	Raw Data		Corrected Data*	
						DTW (ft)	Elev (ft amsl)	DTW (ft)	Elev (ft amsl)
1/28/2015	8:04	MW67	374.95	30.30	0.00	51.64	323.31	51.64	323.31
1/28/2015	9:28	MW76	376.77	30.30	0.00	53.15	323.62	53.15	323.62
1/28/2015	9:10	MW84	376.01	30.30	0.00	52.60	323.41	52.60	323.41
1/28/2015	8:02	MW87	375.79	30.30	0.00	52.51	323.28	52.51	323.28
1/28/2015	7:58	MW90A	374.20	30.30	0.00	51.02	323.18	51.02	323.18
1/28/2015	7:49	MW93	377.67	30.30	0.00	54.00	323.67	54.00	323.67
1/28/2015	7:40	MW227	378.81	30.30	0.00	55.03	323.78	55.03	323.78
1/28/2015	7:53	MW333	377.35	30.30	0.00	53.53	323.82	53.53	323.82
1/28/2015	9:18	MW337	374.67	30.30	0.00	51.03	323.64	51.03	323.64
1/28/2015	9:16	MW338	374.86	30.30	0.00	51.30	323.56	51.30	323.56
1/28/2015	7:46	MW420	377.70	30.30	0.00	54.10	323.60	54.10	323.60
Initial Barometric Pressure			30.30						
Elev = elevation									
amsl = above mean sea level									
BP = barometric pressure									
DTW = depth to water in feet below datum									
*Assumes a barometric efficiency of 1.0									

