Department of Energy

Portsmouth/Paducah Project Office
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May 30, 2023

Ms. Lauren Linehan
Division of Waste Management
Kentucky Department for Environmental Protection
625 Hospital Drive
Madisonville, Kentucky 42431

PPPO-02-10024310-23B

Ms. April Webb
Hazardous Waste Branch Manager
Division of Waste Management
Kentucky Department for Environmental Protection
300 Sower Blvd., 2nd Floor
Frankfort, Kentucky 40601

Dear Ms. Linehan and Ms. Webb:

C-404 HAZARDOUS WASTE LANDFILL MAY 2023 SEMIANNUAL GROUNDWATER REPORT (OCTOBER 2022–MARCH 2023), PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY, FRNP-RPT-0297/V1, HAZARDOUS WASTE MANAGEMENT FACILITY PERMIT NO. KY8-890-008-982, AGENCY INTEREST ID NO. 3059

Enclosed is the subject report for the first reporting period, calendar year 2023. This report is required in accordance with Part II, Specific Condition II.K.6.d, of Hazardous Waste Management Facility Permit No. KY8-890-008-982 (Permit).

Results of the statistical analyses indicate that compliance well concentrations of permit-required parameters are not statistically different from those in background wells, except for arsenic, technetium, and trichloroethene (TCE) in monitoring well MW84A. Technetium-99 concentrations in compliance well MW84A showed statistically significant concentrations above concentrations observed in the background wells; however, the concentrations did not show an increasing trend, so there is no confirmed technetium-99 exceedance attributable to C-404. The trends discussed in the 2007 *C-404 Landfill Source Demonstration Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PRS-ENM-0031/R2, alternate source demonstration (ASD) showed that the C-404 Landfill was not the source of the historical, statistically significant background exceedance of TCE in MW84 (replaced by MW84A). Current concentration trends and spatial distribution data for arsenic and TCE were demonstrated to be consistent with TCE distribution and trends presented in the 2007 ASD. This demonstration precludes the need for a compliance monitoring program or a corrective action plan under Section II.K.8 of the Permit for the arsenic and TCE in MW84A.

If you have any questions or require additional information, please contact Ryan Callihan at (740) 970-0255.

Sincerely,

APRIL LADD Digitally signed by APRIL LADD Date: 2023.05.30 12:51:48 -05'00'

April Ladd
Paducah Site Lead
Portsmouth/Paducah Project Office

Enclosures:
1. Certification Page
2. *C-404 Hazardous Waste Landfill May 2023 Semiannual Groundwater Report (October 2022–March 2023), Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0297/V1

cc w/enclosures:
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CERTIFICATION

Document Identification: ***C-404 Hazardous Waste Landfill May 2023 Semiannual Groundwater Report (October 2022–March 2023), Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0297/V1, Permit No. KY8-890-008-982, Agency Interest ID No. 3059**

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

Four Rivers Nuclear Partnership, LLC

JASON CASPER (Affiliate) Digitally signed by JASON CASPER (Affiliate)
Date: 2023.05.30 09:46:34 -05'00'

Myrna E. Redfield, Program Manager
Four Rivers Nuclear Partnership, LLC

Date Signed

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

U.S. Department of Energy

APRIL LADD Digitally signed by APRIL LADD
Date: 2023.05.30 14:36:08 -05'00'

April Ladd, Acting Paducah Site Lead
Portsmouth/Paducah Project Office
U.S. Department of Energy

Date Signed

C-404 Hazardous Waste Landfill May 2023 Semiannual Groundwater Report (October 2022–March 2023), Paducah Gaseous Diffusion Plant, Paducah, Kentucky

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

This document is approved for public release per review by:

KYLE ATHERTON (Affiliate)

Digitally signed by KYLE ATHERTON (Affiliate)
Date: 2023.05.18 17:54:14 -05'00'

FRNP Classification Support | Date

C-404 Hazardous Waste Landfill May 2023 Semiannual Groundwater Report (October 2022–March 2023), Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—May 2023

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC,
managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under Contract DE-EM0004895

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CONTENTS

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TABLES

FIGURES

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ACRONYMS

AKGWA	Assembled Kentucky Groundwater
ASD	alternate source demonstration
MW	monitoring well
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 2023 Semiannual Groundwater Report (October 2022–March 2023), Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* FRNP-RPT-0297/V1, is being submitted by the U.S. Department of Energy in accordance with requirements in Kentucky Division of Waste Management Hazardous Waste Management Facility Permit, KY8-890-008-982 (Permit). The period covered by this report is October 2022 through March 2023; and the report includes analytical data from the November 2022 quarterly compliance monitoring for radionuclides as well as the January 2023 semiannual sampling for all parameters of monitoring wells located in the vicinity of the closed C-404 Hazardous Waste Landfill (C-404 Landfill).

The groundwater monitoring analytical data were subjected to statistical analyses. The statistical analyses were conducted in accordance with the Hazardous Waste Management Facility Permit. Arsenic and trichloroethene (TCE) concentrations in compliance well MW84A showed statistically significant concentrations above concentrations observed in the background wells. The statistical tests on all other parameters, except technetium-99 (Tc-99), showed no statistically significant differences above concentrations observed in background wells. Tc-99 concentrations in compliance well MW84A showed statistically significant concentrations above concentrations observed in the background wells; however, the concentrations did not show an increasing trend, so there is no confirmed Tc-99 exceedance attributable to C-404.

Arsenic and TCE concentrations in compliance well MW84A are increasing, which is similar to past TCE trends in the same well. Moreover, arsenic and TCE trends are increasing for both background and other compliance well locations, indicating that the contaminant plume discussed in the 2007 *C-404 Landfill Source Demonstration, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PRS-ENM-0031/R2, for TCE appears to have continued to migrate northeastward (PRS 2007a). Additionally, arsenic concentrations in C-404 Landfill leachate samples collected over the past 10 years have remained well below those arsenic concentrations observed in MW84A; therefore, consistent with the findings of the 2007 alternate source demonstration (ASD) for TCE, the C-404 Landfill cannot be the source of the arsenic found in the wells. This demonstration for arsenic in MW84A fulfills Section II.K.8 of the Hazardous Waste Management Facility Permit, which allows for demonstrating that the exceedance is consistent with the findings of the 2007 ASD and also allows for the demonstration to be submitted within the semiannual report.

The leachate in the C-404 Landfill leachate collection system is monitored at least monthly and, at a minimum, is removed and sampled when the level exceeds 3 ft in depth. During this reporting period of October 2022 through March 2023, the depth of the leachate on February 6, 2023, was 43 inches. Subsequently, leachate was removed from the sump and sampled. The depth of the leachate has not exceeded 3 ft during any of the other monthly monitoring events within the reporting period.

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1. INTRODUCTION

This report contains the statistical evaluation of data from groundwater sampling and analysis for the closed C-404 Hazardous Waste Landfill (C-404 Landfill) at the U.S. Department of Energy Paducah Site (Paducah Site), Paducah, Kentucky. This semiannual report is required by the Kentucky Division of Waste Management Hazardous Waste Management Facility Permit, KY8-890-008-982 (Permit), Specific Condition II.K.6.d—Recordkeeping, Reporting, and Response (KDWM 2020). The period covered by this report is October 2022 through March 2023.

Groundwater analytical results are provided in Appendix A. The statistical analyses and qualification statement are provided in Appendix B. The C-404 leachate analytical results are provided in Appendix C.

1.1 BACKGROUND

The closed C-404 Landfill is located in the west-central portion of the Paducah Site 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 uranium-contaminated solid waste. 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, as needed, into a mobile tank. The leachate then is transferred to a permitted hazardous waste storage facility on-site prior to characterization; once characterized, the leachate is transferred off-site for treatment.

In 1986, the disposal of waste at the 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 the current Hazardous Waste Management Facility Permit (KDWM 2020).

Previous groundwater monitoring documented that concentrations of trichloroethene (TCE) found in compliance wells were statistically different from those found in background wells. The *C-404 Landfill Source Demonstration, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PRS-ENM-0031/R2, demonstrated that the source of TCE in compliance wells is not from the C-404 Landfill, but rather, the source is located upgradient/crossgradient of the C-404 Landfill (PRS 2007a).

Regional Gravel Aquifer (RGA) compliance monitoring well (MW) MW90 was abandoned and replaced by MW90A in 2001. RGA compliance well MW420 was installed in 2007 to better assess groundwater quality at the C-404 Landfill (PRS 2007b).

Previous groundwater monitoring of RGA compliance well MW87 documented that concentrations in the compliance well were statistically different from background wells for lead and uranium (FRNP 2018). The *C-404 Hazardous Waste Landfill Alternate Source Demonstration—Source of Lead and Uranium in MW87 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, concluded that the statistical differences were a result of infiltration of Upper Continental Recharge System (UCRS) groundwater into the RGA well due to compromised integrity of the well (FRNP 2019). The integrity of the well had deteriorated to a point that it no longer was suitable for its intended purpose. RGA compliance wells MW84, MW87, and background well MW93 were abandoned and replaced with MW84A, MW87A, and MW93A in 2019. RGA wells MW84 and MW93 were abandoned and replaced because they were the same age (installed in 1988) as MW87. MW84A and MW87A were placed 10 ft north of MW84 and MW87, respectively, and screened at the same depth intervals. MW93A was placed 6 ft west of MW93 and screened at the same depth interval.

In the first semiannual reporting period for 2021 (October 2020–March 2021), statistical analysis of technetium-99 (Tc-99) detections in downgradient compliance well MW84A indicated a statistically significant exceedance over background concentrations. Notification of the statistically significant difference for Tc-99 in MW84A was submitted, pursuant to Part II, Specific Condition II.K.6.a, to the Kentucky Department of Waste Management.

An alternate source demonstration (ASD) investigation for Tc-99 in MW84A was performed in June 2021. The *C-404 Hazardous Waste Landfill Alternate Source Demonstration—Source of Technetium-99 in MW84A at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0206, consisted of redevelopment and over pumping of MW84A, and review of the lines of evidence relating redevelopment of MW84A and the associated Tc-99 levels (FRNP 2021). The lines of evidence concluded that the observed trend of increasing Tc-99 in MW84A is not a result of contamination introduced into the well boring during drilling and well installation, but it is indicative of dissolved Tc-99 contamination in the RGA. Quarterly compliance monitoring for Tc-99 and other radionuclides was conducted at the C-404 Landfill through the current reporting period. This current semiannual report contains results from additional quarterly compliance sampling for radiological constituents conducted in May 2022 and November 2022, in addition to the routine semiannual groundwater sampling.

In accordance with Permit Specific Condition II.K.6.j, development and submittal of an engineering feasibility plan for a corrective action program is not required when a statistically significant exceedance has been confirmed for radionuclides (i.e., Tc-99).

1.2 MONITORING PERIOD ACTIVITIES

1.2.1 Groundwater Monitoring

There are nine MWs sampled under the Permit for the C-404 Landfill: four UCRS wells and five Upper Regional Gravel Aquifer (URGA) wells. A map of the MW locations is provided in Figure 1.

Table 1 presents the well number for URGA wells located upgradient and downgradient of the C-404 Landfill. Table 1 also presents the well numbers for the UCRS wells located in proximity to the URGA wells. This table refers to the UCRS wells as being adjacent to an upgradient or downgradient URGA well location and are identified relative to URGA groundwater flow direction. The conceptual model for the C-404 Landfill indicates that groundwater in the UCRS wells flows primarily vertically downward until it reaches the URGA; therefore, UCRS wells are not considered "upgradient" or "downgradient" of other UCRS wells in the area.

Table 1. Monitoring Well Locations

UCRS	
Located south of C-404 Landfill, adjacent to upgradient URGA background well MW93A	MW94
Located north of C-404 Landfill, adjacent to downgradient URGA compliance wells	MW85, MW88, MW91A*
URGA	
Upgradient background wells	MW93A*, MW420
Downgradient compliance wells	MW84A*, MW87A*, MW90A*

*MW90 was abandoned in 2001 and replaced with MW90A. MW91 was abandoned in 2017 and replaced with MW91A. MW84, MW87, and MW93 were abandoned in 2019 and replaced with MW84A, MW87A, and MW93A.

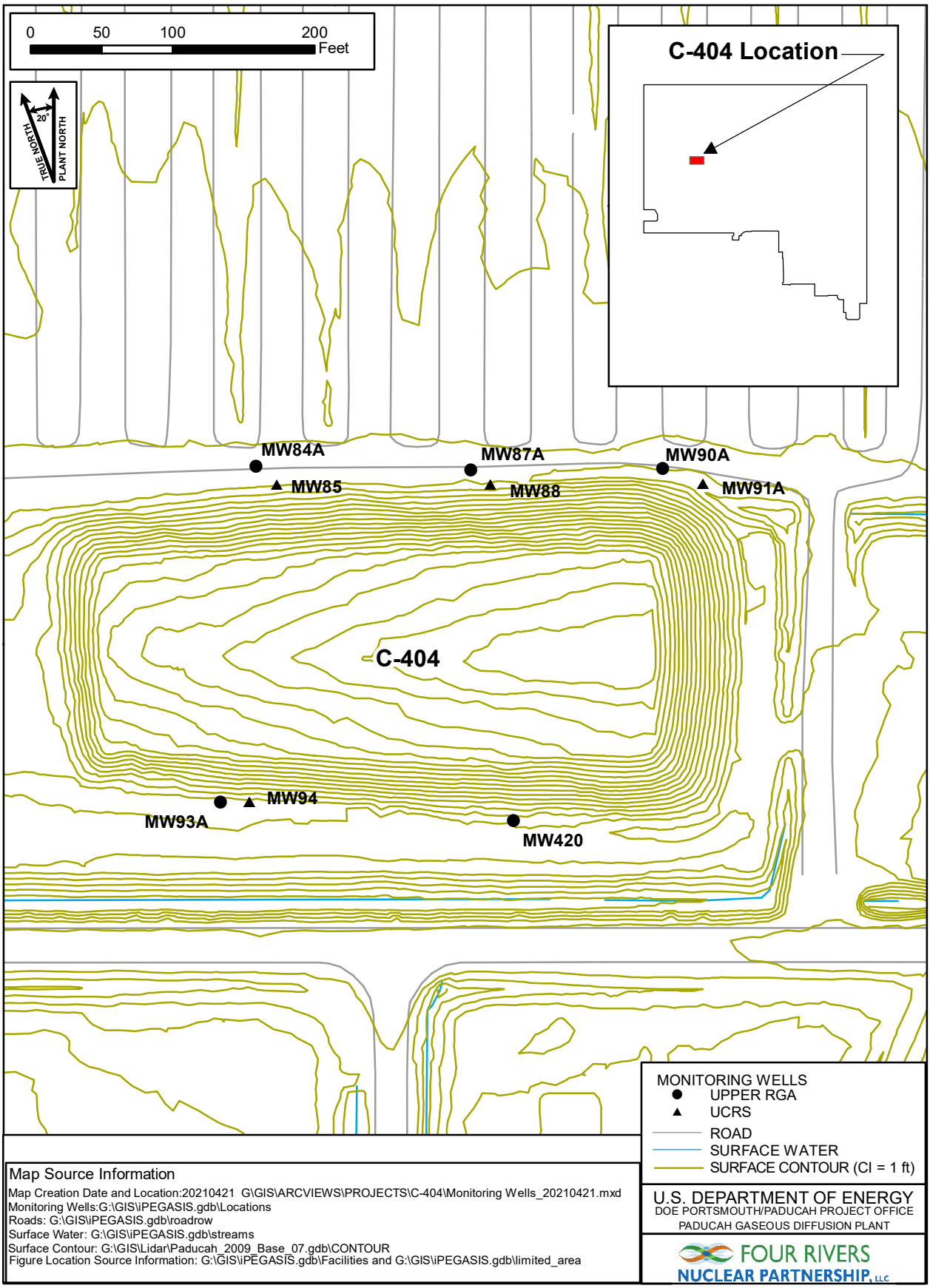

Figure 1. Monitoring Wells

Table 2 presents the Assembled Kentucky Groundwater (AKGWA) numbers for each MW.

Table 2. Assembled Kentucky Groundwater Numbers

Paducah Site Well Number	AKGWA Number
MW84A	8007-4849
MW85	8000-5234
MW87A	8007-4850
MW88	8000-5237
MW90A	8004-0357
MW91A	8007-2917
MW93A	8007-4851
MW94	8000-5103
MW420	8005-3263

All nine MWs were sampled in November 2022 and January 2023 during this reporting period. Samples collected in November 2022 were analyzed for radionuclides and the samples collected in January 2023 were analyzed for the parameters that are required by Part VIII.E of the Permit. Groundwater sampling was conducted using procedure CP4-ES-2101, *Groundwater Sampling*. The appropriate sample containers and preservatives were used. The laboratory that performed the analyses used U.S. Environmental Protection Agency-approved methods, as applicable. Appendix A of this report contains the analytical results. Appendix B of this report contains the statistical analyses.

1.2.2 Landfill Leachate

In accordance with Appendix I2, C-404 Landfill Closure Plan (Section 1.2 of the 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 3 ft in depth." Once the leachate depth reaches 3 ft, the leachate is pumped into a mobile tank. The leachate then is transferred to a permitted hazardous waste storage facility on-site prior to characterization; once characterized, the leachate is transferred off-site for treatment. During this reporting period (October 2022 through March 2023), the depth of the leachate on February 6, 2023, was 43 inches. Subsequently, 1,860 gal of leachate were removed and sampled. The depth of the leachate has not exceeded 3 ft during any of the other monthly monitoring events within the reporting period. Results of the leachate analysis of the samples collected in February 2023 have been included in Appendix C of this report.

2. STATISTICAL SYNOPSIS

The statistical analyses conducted on the data collected from the C-404 Landfill were performed in accordance with procedures in the Permit, Part VIII.E, reissued in February 2020. Appendix B of this report contains the statistical analyses performed for this reporting period. Statistical analyses utilized data from the URGA background wells, MW93A and MW420, and URGA compliance wells, MW84A, MW87A, and MW90A. Quarterly compliance monitoring groundwater sampling for radiological constituents was initiated during third quarter 2021 (July 2021) and the second quarterly monitoring event occurred during fourth quarter 2021 (November 2021). The additional quarter of groundwater data for radiological constituents alters the available data sets for the statistical analyses. For this reporting period, the data set includes nonradionuclide data from January 2021, July 2021, January 2022, July–August 2022, and January 2023. The reporting period data set for radionuclides includes January 2022, May 2022, July–August 2022, November 2022, and January 2023.

Appendix B provides a summary of the statistical analyses performed. The statistical test results on all wells and parameters showed no statistically significant exceedances above concentrations observed in the background wells with the exception of arsenic, Tc-99, and TCE in MW84A. Tc-99 concentrations in compliance well MW84A showed statistically significant concentrations above concentrations observed in the background wells; however, the concentrations did not show an increasing trend, so there is no confirmed Tc-99 exceedance attributable to C-404.

STATISTICALLY SIGNIFICANT EXCEEDANCE OF ARSENIC BACKGROUND IN MW84A

An ASD previously was conducted for TCE in MW84. The 2007 ASD showed that the C-404 Landfill was not the source of the historical, statistically significant background exceedance of TCE in MW84. The 2007 ASD found that the statistically significant increase of TCE in compliance well MW84 appeared to be due to an upgradient source of TCE migrating through the C-404 Landfill area.

The exceedance in arsenic concentration in MW84A over background concentrations is consistent with the findings of the 2007 ASD (PRS 2007a). The trend of arsenic concentrations in MW84 and MW84A is similar to the historical TCE trends observed at MW84 and MW84A (Figure 2). Rising arsenic and TCE levels occur in adjacent compliance well MW87A as well as background wells MW93A and MW420, as demonstrated in Figures 2 and 3.

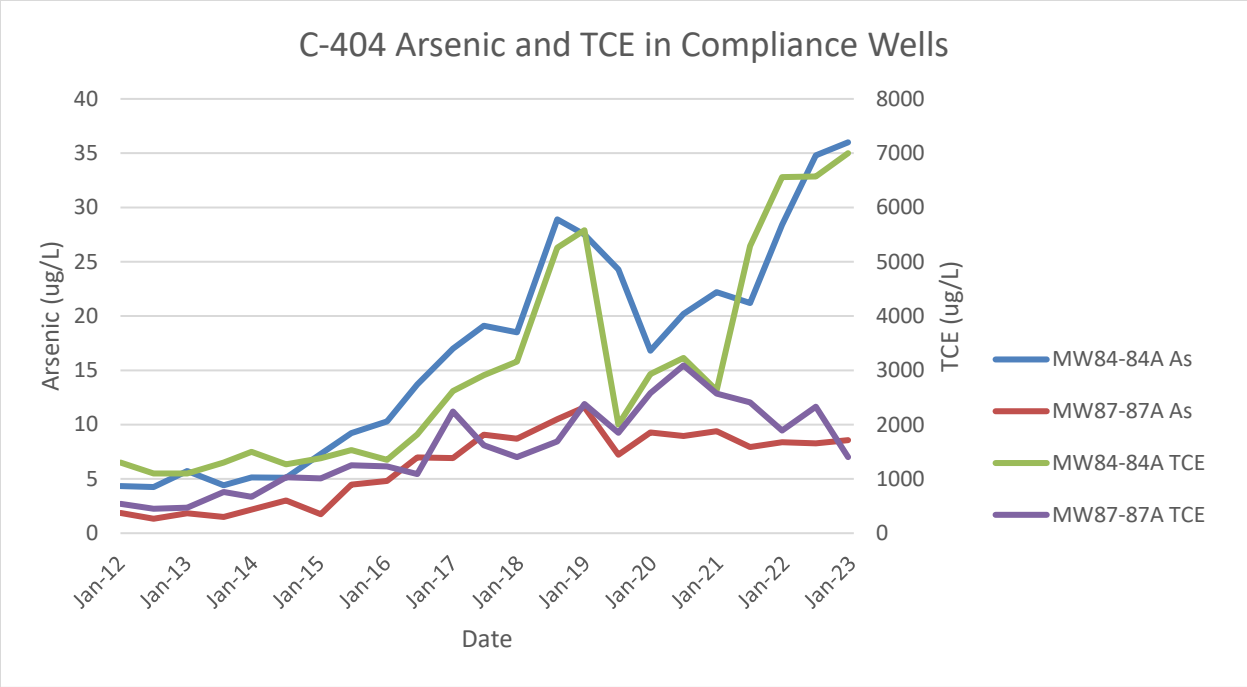

Figure 2. Arsenic and TCE Trends in C-404 Landfill Compliance Wells

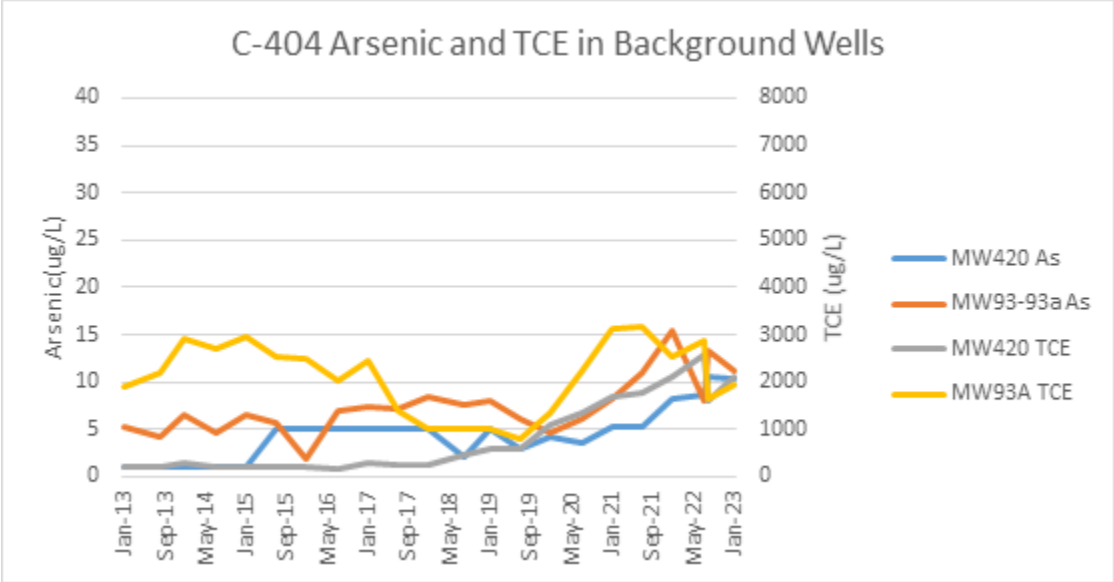

Figure 3. Arsenic and TCE Trends in C-404 Landfill Background Wells

Groundwater flow directions in January 2023 were to the northeast (see Figure 4), consistent with the flow patterns found in 2007 during the ASD source demonstration. Recent increasing arsenic and TCE concentration trends in both compliance and background wells at the C-404 Landfill further indicate that the source of the arsenic and TCE is upgradient to the C-404 Landfill.

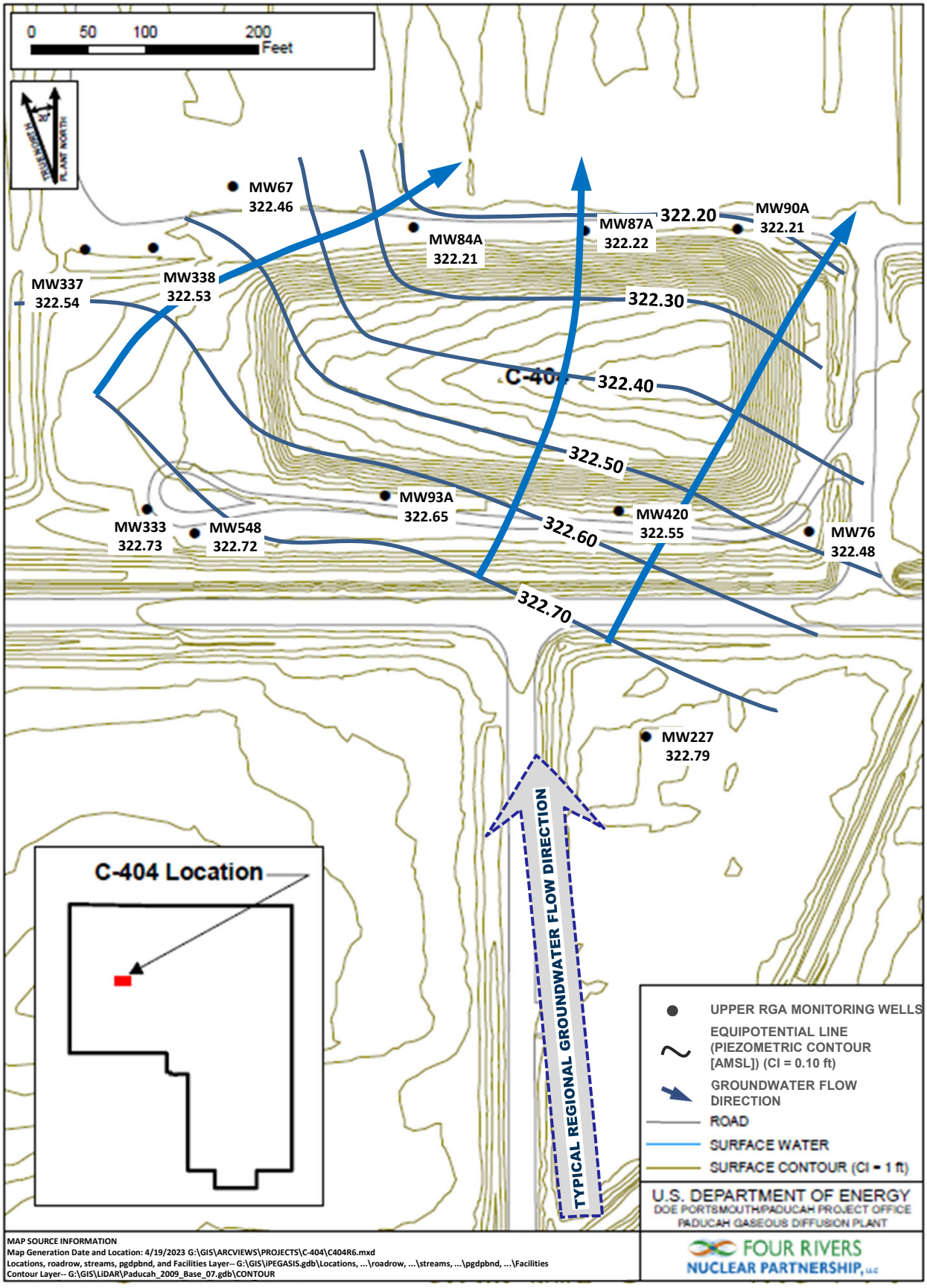

Figure 4. Potentiometric Sufface of the Upper Regional Gravel Aquifer at the C-404 Landfill, January 6, 2023

Additionally, arsenic concentrations in C-404 Landfill leachate samples collected over the past 10 years have remained well below those arsenic concentrations observed in MW84A; therefore, the C-404 Landfill cannot be the source of the arsenic found in the downgradient MWs.

This demonstration fulfills Section II.K.8 of the Hazardous Waste Management Facility Permit, which allows for demonstrating that the exceedance is consistent with the findings of the 2007 ASD and allows for the demonstration to be submitted within the semiannual report.

3. DATA VALIDATION AND QUALITY ASSURANCE/QUALITY CONTROL SUMMARY

The data and the data validation qualifiers for the November 2022 and January 2023 data sets are provided in Appendix A. All data for these data sets were considered useable as reported. Data validation was performed on the analytical data by an independent, third-party validator.

Field quality control samples are collected during each semiannual sampling event. Equipment rinseate blanks, field blanks, field duplicates, and trip blanks are obtained to ensure quality control and are reported in the analytical results in Appendix A. 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.

Samples were originally collected on January 3, 2023. Prior to shipment to the lab, the sampling crew recognized that three wells should have been split with the KDWM. Samples for those three wells along with associated field quality checks were canceled and new resample paperwork was requested. Resamples were collected and split with KDWM on January 4, 2023.

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4. PROFESSIONAL GEOLOGIST AUTHORIZATION

DOCUMENT IDENTIFICATION: *C-404 Hazardous Waste Landfill*
May 2023 Semiannual Groundwater Report
(October 2022–March 2023),
Paducah Gaseous Diffusion Plant, Paducah, Kentucky
(FRNP-RPT-0297/V1)

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

PG 113927
K Davis 5-18-2023

Kenneth R. Davis
Kenneth R. Davis

PG113927

May 18, 2023
Date

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5. REFERENCES

FRNP (Four Rivers Nuclear Partnership, LLC) 2018. *C-404 Hazardous Waste Landfill November 2018 Semiannual Groundwater Report (April 2018—September 2018), Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0026/V2, U.S. Department of Energy, Paducah, KY, November.

FRNP 2019. *C-404 Hazardous Waste Landfill Alternate Source Demonstration—Source of Lead and Uranium in MW87 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0078, Four Rivers Nuclear Partnership, LLC, Paducah, KY, February.

FRNP 2021. *C-404 Hazardous Waste Landfill Alternate Source Demonstration—Source of Technetium-99 in MW84A at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0206, Four Rivers Nuclear Partnership, LLC, Paducah, KY, August.

KDWM (Kentucky Division of Waste Management) 2020. Hazardous Waste Management Facility Permit for the U.S. Department of Energy, Paducah Gaseous Diffusion Plant, KY8-890-008-982, effective February 21.

PRS (Paducah Remediation Services, LLC) 2007a. *C-404 Landfill Source Demonstration Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PRS-ENM-0031/R2, Paducah Remediation Services, LLC, Kevil, KY, August.

PRS 2007b. *Well Plan for Addition of Wells for C-404 Monitoring Well Network, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PRS/PROJ/0028, Paducah Remediation Services, LLC, Kevil, KY, July.

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APPENDIX A

C-404 HAZARDOUS WASTE LANDFILL GROUNDWATER ANALYTICAL RESULTS

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Paducah OREIS
GROUNDWATER MONITORING REPORT

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

Sampling Point: MW84A REG Downgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8007-4849

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic		0.0337	mg/L	0.005	1/4/2023			SW846-6020B	=
Arsenic, Dissolved		0.0236	mg/L	0.005	1/4/2023			SW846-6020B	=
Barometric Pressure Reading		29.83	Inches/Hg		1/4/2023				X
Cadmium	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Chromium	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Conductivity		443	umho/cm		1/4/2023				X
Depth to Water		52.49	ft		1/4/2023				X
Dissolved Oxygen		4.5	mg/L		1/4/2023				X
Lead	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Mercury	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Oxidation Reduction Potential		287	mV		1/4/2023				X
pH		5.86	Std Unit		1/4/2023				X
Selenium	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Sulfate		7.72	mg/L	0.4	1/4/2023			SW846-9056A	=
Technetium-99		165	pCi/L	17.2	1/4/2023	14.7	23.4	HASL 300, Tc-02-RC M	=
Temperature		60.4	deg F		1/4/2023				X
Trichloroethene		7000	ug/L	100	1/4/2023			SW846-8260D	=
Turbidity		1.5	NTU		1/4/2023				X
Uranium	U	0.0002	mg/L	0.0002	1/4/2023			SW846-6020B	=
Uranium-234	U	0.659	pCi/L	1.42	1/4/2023	0.945	0.952	HASL 300, U-02-RC M	=
Uranium-235	U	0.42	pCi/L	1.14	1/4/2023	0.826	0.828	HASL 300, U-02-RC M	=
Uranium-238	U	0.386	pCi/L	0.579	1/4/2023	0.662	0.664	HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

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

Sampling Point: MW84A FR Downgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8007-4849

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic		0.0343	mg/L	0.005	1/4/2023			SW846-6020B	=
Arsenic, Dissolved		0.0232	mg/L	0.005	1/4/2023			SW846-6020B	=
Cadmium	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Chromium	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Lead	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Mercury	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Selenium	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Sulfate		8.16	mg/L	0.4	1/4/2023			SW846-9056A	=
Technetium-99		202	pCi/L	17.9	1/4/2023	16	27.4	HASL 300, Tc-02-RC M	=
Trichloroethene		6800	ug/L	100	1/4/2023			SW846-8260D	=
Uranium	U	0.0002	mg/L	0.0002	1/4/2023			SW846-6020B	=
Uranium-234	U	0.0841	pCi/L	1.66	1/4/2023	0.791	0.792	HASL 300, U-02-RC M	=
Uranium-235	U	0.416	pCi/L	1.13	1/4/2023	0.817	0.819	HASL 300, U-02-RC M	=
Uranium-238	U	-0.138	pCi/L	1.17	1/4/2023	0.415	0.416	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	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic		0.00837	mg/L	0.005	1/3/2023			SW846-6020B	=
Arsenic, Dissolved	J	0.00493	mg/L	0.005	1/3/2023			SW846-6020B	=
Barometric Pressure Reading		29.71	Inches/Hg		1/3/2023				X
Cadmium	U	0.001	mg/L	0.001	1/3/2023			SW846-6020B	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/3/2023			SW846-6020B	=
Chromium	J	0.00429	mg/L	0.01	1/3/2023			SW846-6020B	=
Chromium, Dissolved	J	0.00351	mg/L	0.01	1/3/2023			SW846-6020B	=
Conductivity		337	umho/cm		1/3/2023				X
Depth to Water		11.71	ft		1/3/2023				X
Dissolved Oxygen		2.1	mg/L		1/3/2023				X
Lead	U	0.002	mg/L	0.002	1/3/2023			SW846-6020B	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/3/2023			SW846-6020B	=
Mercury	U	0.0002	mg/L	0.0002	1/3/2023			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/3/2023			SW846-7470A	=
Oxidation Reduction Potential		236	mV		1/3/2023				X
pH		6.1	Std Unit		1/3/2023				X
Selenium	U	0.005	mg/L	0.005	1/3/2023			SW846-6020B	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/3/2023			SW846-6020B	=
Sulfate		7.75	mg/L	0.4	1/3/2023			SW846-9056A	=
Technetium-99		65.8	pCi/L	17.7	1/3/2023	12.3	14.3	HASL 300, Tc-02-RC M	=
Temperature		61.7	deg F		1/3/2023				X
Trichloroethene		70.2	ug/L	1	1/3/2023			SW846-8260D	=
Turbidity		3.27	NTU		1/3/2023				X
Uranium		0.000622	mg/L	0.0002	1/3/2023			SW846-6020B	=
Uranium-234	U	-0.0623	pCi/L	1.57	1/3/2023	0.678	0.678	HASL 300, U-02-RC M	=
Uranium-235	U	0.463	pCi/L	0.695	1/3/2023	0.794	0.797	HASL 300, U-02-RC M	=
Uranium-238	U	0.802	pCi/L	1.15	1/3/2023	0.917	0.924	HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

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

Sampling Point: MW87A REG Downgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8007-4850

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic		0.00857	mg/L	0.005	1/4/2023			SW846-6020B	=
Arsenic, Dissolved		0.00585	mg/L	0.005	1/4/2023			SW846-6020B	=
Barometric Pressure Reading		29.83	Inches/Hg		1/4/2023				X
Cadmium	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Chromium	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Conductivity		344	umho/cm		1/4/2023				X
Depth to Water		52.55	ft		1/4/2023				X
Dissolved Oxygen		3.51	mg/L		1/4/2023				X
Lead	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Mercury	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Oxidation Reduction Potential		246	mV		1/4/2023				X
pH		5.82	Std Unit		1/4/2023				X
Selenium	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Sulfate		6.59	mg/L	0.4	1/4/2023			SW846-9056A	=
Technetium-99		24.4	pCi/L	21.2	1/4/2023	13	13.3	HASL 300, Tc-02-RC M	=
Temperature		61	deg F		1/4/2023				X
Trichloroethene		2140	ug/L	50	1/4/2023			SW846-8260D	=
Turbidity		0	NTU		1/4/2023				X
Uranium	U	0.0002	mg/L	0.0002	1/4/2023			SW846-6020B	=
Uranium-234	U	0.0747	pCi/L	1.4	1/4/2023	0.667	0.668	HASL 300, U-02-RC M	=
Uranium-235	U	0	pCi/L	0.702	1/4/2023	0.472	0.473	HASL 300, U-02-RC M	=
Uranium-238	U	-0.0454	pCi/L	0.908	1/4/2023	0.392	0.393	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	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic		0.00948	mg/L	0.005	1/3/2023			SW846-6020B	=
Arsenic, Dissolved		0.00598	mg/L	0.005	1/3/2023			SW846-6020B	=
Barometric Pressure Reading		29.74	Inches/Hg		1/3/2023				X
Cadmium	U	0.001	mg/L	0.001	1/3/2023			SW846-6020B	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/3/2023			SW846-6020B	=
Chromium	J	0.00334	mg/L	0.01	1/3/2023			SW846-6020B	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/3/2023			SW846-6020B	=
Conductivity		635	umho/cm		1/3/2023				X
Depth to Water		10.85	ft		1/3/2023				X
Dissolved Oxygen		1.19	mg/L		1/3/2023				X
Lead	J	0.000767	mg/L	0.002	1/3/2023			SW846-6020B	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/3/2023			SW846-6020B	=
Mercury	J	0.000102	mg/L	0.0002	1/3/2023			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/3/2023			SW846-7470A	=
Oxidation Reduction Potential		185	mV		1/3/2023				X
pH		5.8	Std Unit		1/3/2023				X
Selenium	U	0.005	mg/L	0.005	1/3/2023			SW846-6020B	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/3/2023			SW846-6020B	=
Sulfate		115	mg/L	4	1/3/2023			SW846-9056A	=
Technetium-99	U	21.1	pCi/L	22.1	1/3/2023	13.4	13.6	HASL 300, Tc-02-RC M	=
Temperature		61.7	deg F		1/3/2023				X
Trichloroethene		35.6	ug/L	1	1/3/2023			SW846-8260D	=
Turbidity		24.8	NTU		1/3/2023				X
Uranium	J	0.000119	mg/L	0.0002	1/3/2023			SW846-6020B	=
Uranium-234	U	0.0598	pCi/L	1.67	1/3/2023	0.779	0.78	HASL 300, U-02-RC M	=
Uranium-235	U	0.271	pCi/L	0.813	1/3/2023	0.762	0.763	HASL 300, U-02-RC M	=
Uranium-238	U	-0.105	pCi/L	1.21	1/3/2023	0.465	0.466	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	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic	J	0.00278	mg/L	0.005	1/4/2023			SW846-6020B	=
Arsenic, Dissolved	J	0.0021	mg/L	0.005	1/4/2023			SW846-6020B	=
Barometric Pressure Reading		29.85	Inches/Hg		1/4/2023				X
Cadmium	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Chromium	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Conductivity		229	umho/cm		1/4/2023				X
Depth to Water		51.7	ft		1/4/2023				X
Dissolved Oxygen		5.1	mg/L		1/4/2023				X
Lead	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Mercury	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Oxidation Reduction Potential		222	mV		1/4/2023				X
pH		5.85	Std Unit		1/4/2023				X
Selenium	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Sulfate		4.07	mg/L	0.4	1/4/2023			SW846-9056A	=
Technetium-99	U	21.6	pCi/L	23.7	1/4/2023	14.4	14.6	HASL 300, Tc-02-RC M	=
Temperature		61.2	deg F		1/4/2023				X
Trichloroethene		296	ug/L	5	1/4/2023			SW846-8260D	=
Turbidity		2.46	NTU		1/4/2023				X
Uranium	U	0.0002	mg/L	0.0002	1/4/2023			SW846-6020B	=
Uranium-234	U	-0.16	pCi/L	1.56	1/4/2023	0.602	0.602	HASL 300, U-02-RC M	=
Uranium-235	U	0.251	pCi/L	0.752	1/4/2023	0.705	0.706	HASL 300, U-02-RC M	=
Uranium-238	U	-0.0487	pCi/L	0.973	1/4/2023	0.42	0.421	HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

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

Sampling Point: MW91A REG Downgradient UCRS **Period:** Semiannual Report

AKGWA Well Tag #: 8007-2917

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic		0.00679	mg/L	0.005	1/3/2023			SW846-6020B	=
Arsenic, Dissolved	J	0.00468	mg/L	0.005	1/3/2023			SW846-6020B	=
Barometric Pressure Reading		29.75	Inches/Hg		1/3/2023				X
Cadmium	U	0.001	mg/L	0.001	1/3/2023			SW846-6020B	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/3/2023			SW846-6020B	=
Chromium	U	0.01	mg/L	0.01	1/3/2023			SW846-6020B	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/3/2023			SW846-6020B	=
Conductivity		777	umho/cm		1/3/2023				X
Depth to Water		13.38	ft		1/3/2023				X
Dissolved Oxygen		0.86	mg/L		1/3/2023				X
Lead	U	0.002	mg/L	0.002	1/3/2023			SW846-6020B	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/3/2023			SW846-6020B	=
Mercury	U	0.0002	mg/L	0.0002	1/3/2023			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/3/2023			SW846-7470A	=
Oxidation Reduction Potential		14	mV		1/3/2023				X
pH		5.99	Std Unit		1/3/2023				X
Selenium	U	0.005	mg/L	0.005	1/3/2023			SW846-6020B	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/3/2023			SW846-6020B	=
Sulfate		57.2	mg/L	2	1/3/2023			SW846-9056A	=
Technetium-99		77.1	pCi/L	16.6	1/3/2023	12	14.7	HASL 300, Tc-02-RC M	=
Temperature		62.8	deg F		1/3/2023				X
Trichloroethene		42.7	ug/L	1	1/3/2023			SW846-8260D	=
Turbidity		7.5	NTU		1/3/2023				X
Uranium	U	0.0002	mg/L	0.0002	1/3/2023			SW846-6020B	=
Uranium-234	U	0.213	pCi/L	1.1	1/3/2023	0.606	0.608	HASL 300, U-02-RC M	=
Uranium-235	U	0.329	pCi/L	0.897	1/3/2023	0.647	0.649	HASL 300, U-02-RC M	=
Uranium-238	U	-0.109	pCi/L	0.925	1/3/2023	0.329	0.33	HASL 300, U-02-RC M	=

Paducah OREIS
GROUNDWATER MONITORING REPORT

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

Sampling Point: MW93A REG Upgradient URGA **Period:** Semiannual Report

AKGWA Well Tag #: 8007-4851

Parameter	Qualifier	Result	Units	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic		0.0111	mg/L	0.005	1/4/2023			SW846-6020B	=
Arsenic, Dissolved		0.00598	mg/L	0.005	1/4/2023			SW846-6020B	=
Barometric Pressure Reading		29.86	Inches/Hg		1/4/2023				X
Cadmium	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Chromium	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Conductivity		387	umho/cm		1/4/2023				X
Depth to Water		55.49	ft		1/4/2023				X
Dissolved Oxygen		3.17	mg/L		1/4/2023				X
Lead	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Mercury	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Oxidation Reduction Potential		209	mV		1/4/2023				X
pH		5.89	Std Unit		1/4/2023				X
Selenium	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Sulfate		7.54	mg/L	0.4	1/4/2023			SW846-9056A	=
Technetium-99	U	5.6	pCi/L	18.3	1/4/2023	10.8	10.8	HASL 300, Tc-02-RC M	=
Temperature		61.7	deg F		1/4/2023				X
Trichloroethene		1960	ug/L	50	1/4/2023			SW846-8260D	=
Turbidity		1.89	NTU		1/4/2023				X
Uranium	U	0.0002	mg/L	0.0002	1/4/2023			SW846-6020B	=
Uranium-234	U	0.19	pCi/L	1.05	1/4/2023	0.568	0.57	HASL 300, U-02-RC M	=
Uranium-235	U	0.176	pCi/L	0.527	1/4/2023	0.493	0.494	HASL 300, U-02-RC M	=
Uranium-238	U	0.284	pCi/L	0.426	1/4/2023	0.487	0.488	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	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic	J	0.00238	mg/L	0.005	1/4/2023			SW846-6020B	=
Arsenic, Dissolved	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Barometric Pressure Reading		29.86	Inches/Hg		1/4/2023				X
Cadmium	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Chromium	J	0.00392	mg/L	0.01	1/4/2023			SW846-6020B	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Conductivity		750	umho/cm		1/4/2023				X
Depth to Water		15.87	ft		1/4/2023				X
Dissolved Oxygen		1.57	mg/L		1/4/2023				X
Lead	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Mercury	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Oxidation Reduction Potential		188	mV		1/4/2023				X
pH		6.31	Std Unit		1/4/2023				X
Selenium	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Sulfate		60.6	mg/L	2	1/4/2023			SW846-9056A	=
Technetium-99		1350	pCi/L	16.9	1/4/2023	32	152	HASL 300, Tc-02-RC M	=
Temperature		62.8	deg F		1/4/2023				X
Trichloroethene		38	ug/L	1	1/4/2023			SW846-8260D	=
Turbidity		17.98	NTU		1/4/2023				X
Uranium		0.00129	mg/L	0.0002	1/4/2023			SW846-6020B	=
Uranium-234	U	0.352	pCi/L	1.53	1/4/2023	0.845	0.848	HASL 300, U-02-RC M	=
Uranium-235	U	-0.0501	pCi/L	1	1/4/2023	0.432	0.433	HASL 300, U-02-RC M	=
Uranium-238	U	0.297	pCi/L	0.81	1/4/2023	0.584	0.586	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	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic		0.011	mg/L	0.005	1/4/2023			SW846-6020B	=
Arsenic, Dissolved		0.00579	mg/L	0.005	1/4/2023			SW846-6020B	=
Barometric Pressure Reading		29.85	Inches/Hg		1/4/2023				X
Cadmium	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Cadmium, Dissolved	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Chromium	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Chromium, Dissolved	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Conductivity		379	umho/cm		1/4/2023				X
Depth to Water		55.28	ft		1/4/2023				X
Dissolved Oxygen		1.84	mg/L		1/4/2023				X
Lead	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Lead, Dissolved	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Mercury	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Mercury, Dissolved	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Oxidation Reduction Potential		247	mV		1/4/2023				X
pH		5.79	Std Unit		1/4/2023				X
Selenium	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Selenium, Dissolved	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Sulfate		6.07	mg/L	0.4	1/4/2023			SW846-9056A	=
Technetium-99	U	15.7	pCi/L	17.7	1/4/2023	10.8	10.9	HASL 300, Tc-02-RC M	=
Temperature		62.4	deg F		1/4/2023				X
Trichloroethene		2110	ug/L	40	1/4/2023			SW846-8260D	=
Turbidity		3.97	NTU		1/4/2023				X
Uranium	U	0.0002	mg/L	0.0002	1/4/2023			SW846-6020B	=
Uranium-234	U	0.0442	pCi/L	1.56	1/4/2023	0.724	0.725	HASL 300, U-02-RC M	=
Uranium-235	U	0.504	pCi/L	0.756	1/4/2023	0.863	0.867	HASL 300, U-02-RC M	=
Uranium-238	U	0.155	pCi/L	0.977	1/4/2023	0.581	0.582	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	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Cadmium	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Chromium	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Lead	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Mercury	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Selenium	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Technetium-99	U	-8.7	pCi/L	20.6	1/4/2023	11.9	11.9	HASL 300, Tc-02-RC M	=
Trichloroethene	U	1	ug/L	1	1/4/2023			SW846-8260D	=
Uranium	U	0.0002	mg/L	0.0002	1/4/2023			SW846-6020B	=
Uranium-234	U	0.215	pCi/L	1.68	1/4/2023	0.878	0.88	HASL 300, U-02-RC M	=
Uranium-235	U	0.311	pCi/L	0.932	1/4/2023	0.873	0.875	HASL 300, U-02-RC M	=
Uranium-238	U	0.0704	pCi/L	1.54	1/4/2023	0.736	0.737	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	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Arsenic	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Cadmium	U	0.001	mg/L	0.001	1/4/2023			SW846-6020B	=
Chromium	U	0.01	mg/L	0.01	1/4/2023			SW846-6020B	=
Lead	U	0.002	mg/L	0.002	1/4/2023			SW846-6020B	=
Mercury	U	0.0002	mg/L	0.0002	1/4/2023			SW846-7470A	=
Selenium	U	0.005	mg/L	0.005	1/4/2023			SW846-6020B	=
Technetium-99	U	-1.33	pCi/L	17.5	1/4/2023	10	10	HASL 300, Tc-02-RC M	=
Trichloroethene	U	1	ug/L	1	1/4/2023			SW846-8260D	=
Uranium	U	0.0002	mg/L	0.0002	1/4/2023			SW846-6020B	=
Uranium-234	U	-0.0291	pCi/L	2.02	1/4/2023	0.895	0.896	HASL 300, U-02-RC M	=
Uranium-235	U	0.233	pCi/L	1.47	1/4/2023	0.872	0.874	HASL 300, U-02-RC M	=
Uranium-238	U	-0.119	pCi/L	1.37	1/4/2023	0.525	0.527	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	Reporting Limit	Date Collected	Counting Error (+/-)	TPU	Method	Validation
Trichloroethene	U	1	ug/L	1	1/3/2023			SW846-8260D	=
Trichloroethene	U	1	ug/L	1	1/4/2023			SW846-8260D	=

QUALIFIER Codes

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

SAMPLING POINT Codes

UCRS Upper Continental Recharge System
URGA Upper Regional Gravel Aquifer

SAMPLE TYPE Codes

FB Field Blank
FR Field Duplicate as defined in sampling procedure.
REG Regular
RI QC Equipment Rinseate/Decon
TB Trip Blank

VALIDATION Codes

= Validated result, no qualifier is necessary.
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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C-404 HAZARDOUS WASTE LANDFILL Finds/Unit: KY8-980-008-982/1
MAY 2023 SEMIANNUAL LAB ID: _____
Facility: US DOE—Paducah Gaseous Diffusion Plant

GROUNDWATER STATISTICAL SUMMARY

INTRODUCTION

The statistical analyses conducted on the data collected from the C-404 Hazardous Waste Landfill (C-404 Landfill) were performed in accordance with procedures provided in Appendix E of the Hazardous Waste Management Facility Permit, reissued by the Kentucky Division of Waste Management in February 2020. The percent of censored (nondetected) data points for individual parameters was calculated for the combined analytical data from the most recent five 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. Data points were used in the statistical analysis for analyte results close to the sample quantitation limit that were judged to be below that limit by the data validator.

Quarterly compliance monitoring groundwater sampling for radiological constituents was initiated in third quarter 2021 (July 2021) and has continued through November 2022. The additional quarters of groundwater data for radiological constituents alters the available data sets for the statistical analyses. For the first reporting period 2023 semiannual report, the reporting period data set includes nonradiological data from January 2021, July 2021, January 2022, July–August 2022, and January 2023. The reporting period data set for radiological constituents includes January 2022, May 2022, July–August 2022, November 2022, and January 2023.

STATISTICAL ANALYSIS PROCESS

Utilizing the current data set and four previous data sets, 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 (½ 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. Statistical Test 4 is found in Section 5.2.1 of EPA guidance document, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (April 1989).

If the statistical method above indicates no statistical difference between concentrations in downgradient wells and concentrations in background wells, then there are no indications of statistically significant impacts on the groundwater from the C-404 Landfill. If the tiered statistical method above identifies a statistically significant difference between concentrations in downgradient wells and concentrations in background wells, then the data will be evaluated further to determine if the concentrations in downgradient wells are within the statistically developed upper tolerance limit (UTL) for background concentrations or are consistent with the findings of the 2007 alternate source demonstration (ASD), as follows:

(1) Compare the most recent downgradient sample results to a 95% UTL using the five most recent sets of data for each upgradient well as described below. If downgradient concentrations are lower than the UTL for the paired upgradient concentrations, then there is no confirmed exceedance.

(2) Evaluate results using paired ANOVA of wells in the same direction relative to the landfill (e.g., compare upgradient westernmost well results to downgradient westernmost well results). If ANOVA does not identify a statistically significant difference between upgradient and downgradient wells, then the results are consistent with the historical ASD.

(3) If results show downgradient wells have statistically significant higher concentrations than upgradient wells, even when evaluated with respect to the ASD, additional intra-well evaluation of trend will be performed using the Mann-Kendall test for trend. If concentrations do not show an increasing trend, then there is no confirmed exceedance attributable to C-404.

(4) Review other Regional Gravel Aquifer (RGA) well results in vicinity to determine if they are consistent with the ASD.

If the statistical analysis identifies downgradient well concentrations that are increasing, are higher than UTL, are higher than the upgradient well concentrations even when the ASD results are taken into account, this evaluation will identify a confirmed, statistically significant exceedance (in a compliance well) over background.

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.

Table B.1. Monitoring Well Locations

URGA	
Upgradient background wells	MW93A*, MW420
Downgradient compliance wells	MW84A*, MW87A*, MW90A*

*MW90 was abandoned in 2001 and replaced with MW90A. MW84, MW87, and MW93 were abandoned in 2019 and replaced with MW84A, MW87A, and MW93A, respectively.

For this reporting period, the data set includes nonradionuclide data from January 2021, July 2021, January 2022, July–August 2022, and January 2023, and consists of five sets of data. The reporting period data set for radiological data is from January 2022 through January 2023 and also consists of five 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.

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

Parameters	Observations	Missing Observations	Censored Observations (Nondetects)	Uncensored Observations (Detects)
URGA				
Arsenic	25	0	2	23
Cadmium	25	0	24	1
Chromium	25	0	22	3
Lead	25	0	24	1
Mercury	25	0	25	0
Selenium	25	0	25	0
Technetium-99	25	0	16	9
Trichloroethene	25	0	0	25
Uranium (Metals)	25	0	19	6
Uranium-234	25	0	25	0
Uranium-235	25	0	25	0
Uranium-238	25	0	25	0

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 data and type of statistical test chosen for each of the parameters required by Part VIII.E of the Hazardous Waste Management Facility Permit.

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

Parameter	Total Samples (Nonmissing)	Uncensored (Detects)	Censored (Nondetects)	Percent Censored	Statistical Test Set*
URGA					
Arsenic	25	23	2	8	4
Cadmium	25	1	24	96	1
Chromium	25	3	22	88	2
Lead	25	1	24	96	1
Mercury	25	0	25	100	1
Selenium	25	0	25	100	1
Technetium-99	25	9	16	64	2
Trichloroethene	25	25	0	0	4
Uranium (Metals)	25	6	19	76	2
Uranium-234	25	0	25	100	1
Uranium-235	25	0	25	100	1
Uranium-238	25	0	25	100	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.

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 C-404 Landfill statistical analyses for the first reporting period 2023, 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 B1 through B5. The statistician qualification statement is presented in Attachment B6.

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

Parameter	LOD Values	½ LOD Values
URGA		
Cadmium (mg/L)	0.001	0.0005
Lead (mg/L)	0.002	0.001
Mercury (mg/L)	0.0002	0.0001
Selenium (mg/L)	0.005	0.0025
Uranium-234 (pCi/L)	1.56	0.78
Uranium-235 (pCi/L)	1.14	0.57
Uranium-238 (pCi/L)	0.977	0.489

Table B.5. Summary of Conclusions from the C-404 Hazardous Waste Landfill Statistical Analyses for the First Reporting Period 2023

Attachment	RGA Well Type	Parameter	Applied Statistical Test	Results
B1	URGA	Arsenic	Statistical Test 4, parametric ANOVA, with 95% UTL, paired (parametric) ANOVA (MW84A vs. MW93A), and Mann-Kendall.	Because parametric ANOVA indicated a statistically significant difference between concentrations in background wells and compliance well MW84A, a comparison to the 95% UTL was performed. The 95% UTL indicated a statistically significant difference between concentrations in compliance well MW84A and concentrations in background wells; therefore, a paired (parametric) ANOVA (MW84A vs. MW93A) was performed. The paired (parametric) ANOVA identified a significant difference between upgradient (MW93A) and downgradient (MW84A) wells. The Mann-Kendall trend analysis identified a statistically significant increasing trend for arsenic in MW84A.
B2	URGA	Chromium	Statistical Test 2, Test of Proportions, nonparametric ANOVA.	Because the Test of Proportions indicated statistically significant evidence that the proportion of detects in one group of data exceeds the proportion of detects in the other group, nonparametric ANOVA was performed. Nonparametric ANOVA indicated no statistically significant difference between concentrations in downgradient wells and the concentrations in background wells.
B3	URGA	Technetium-99	Statistical Test 2, Test of Proportions, nonparametric ANOVA, 95% UTL, paired (parametric) ANOVA, paired (nonparametric) ANOVA, and Mann-Kendall.	Because the Test of Proportions indicated statistically significant evidence that the proportion of detects in one group of data exceeds the proportion of detects in the other group, nonparametric ANOVA was performed. Nonparametric ANOVA indicated a statistically significant difference between concentrations in downgradient wells and the concentrations in background wells for compliance well MW84A. A comparison to the 95% UTL identified a statistically significant difference between compliance well MW84A and background wells. A paired (parametric) ANOVA (MW84A vs. MW93A) was performed; however, equality of variance could not be confirmed and the test was abandoned. Paired (nonparametric) ANOVA identified a significant difference between upgradient (MW93A) and downgradient (MW84A) wells. The Mann-Kendall trend analysis identified a statistically significant decreasing trend for technetium-99 in MW84A.

Table B.5. Summary of Conclusions from the C-404 Hazardous Waste Landfill Statistical Analyses for the First Reporting Period 2023 (Continued)

Attachment	RGA Well Type	Parameter	Applied Statistical Test	Results
B4	URGA	Trichloroethene (TCE)	Statistical Test 4, parametric ANOVA, with 95% UTL, paired (parametric) ANOVA (MW84A vs. MW93A), and Mann-Kendall trend analysis.	Because parametric ANOVA indicated a statistically significant difference between concentrations in background wells and compliance well MW84A, a comparison to the 95% UTL was performed. The 95% UTL indicated a statistically significant difference between concentrations in compliance well MW84A and concentrations in background wells; therefore, a paired ANOVA (MW84A vs. MW93A) was performed that indicated a statistically significant difference between the wells. The Mann-Kendall trend analysis identified a statistically significant increasing trend for TCE in MW84A.
B5	URGA	Uranium	Statistical Test 2, Test of Proportions	No statistically significant difference between concentrations in downgradient wells and concentrations in background wells.

In summary, Statistical Test 2, Test of Proportions, for chromium in the URGA identified a statistically significant difference between background and downgradient wells; however, detectable concentrations of chromium were not observed in any of the downgradient wells. As a result, an evaluation by nonparametric ANOVA was performed and did not indicate a statistically significant exceedance in downgradient wells as compared to background wells.

Statistical Test 2, Test of Proportions, for technetium-99 in the URGA identified a statistically significant difference between background and downgradient wells. As a result, an evaluation by nonparametric ANOVA was performed and identified a statistically significant exceedance in downgradient well MW84A as compared to background wells. The MW84A technetium-99 concentration exceeded the 95% UTL. Because equality of variance could not be confirmed by paired (parametric) ANOVA, the test was abandoned. Paired (nonparametric) ANOVA identified a significant difference between upgradient (MW93A) and downgradient (MW84A) wells. Mann-Kendall trend analysis was performed and showed a decreasing trend.

Statistical Test 2, Test of Proportions, for uranium in the URGA indicated no statistically significant difference between concentrations in downgradient wells and concentrations in background wells.

Statistical Test 4, parametric ANOVA, for arsenic identified a statistically significant difference between concentrations in downgradient well MW84A and concentrations in background wells; therefore, the data were evaluated further by comparing results to the UTL. The 95% UTL indicated a statistically significant difference between concentrations in downgradient well MW84A and concentrations in background wells. Based on these results, the data were evaluated using paired (parametric) ANOVA of wells in the same direction relative to the landfill [e.g., performed a comparison of downgradient well (MW84A) results to upgradient westernmost well (MW93A) results]. Results of the paired (parametric) ANOVA identified a statistically significant difference between upgradient and downgradient wells. A Mann-Kendall test was performed to evaluate the data further, and a statistically significant increasing trend was identified for arsenic in MW84A.

Statistical Test 4, parametric ANOVA, for TCE in the URGA indicated a statistically significant difference between concentrations in downgradient well MW84A and concentrations in background wells; therefore, the data were evaluated further by comparing results to the UTL. The 95% UTL indicated a statistically significant difference between concentrations in downgradient well MW84A and concentrations in background wells; therefore, paired (parametric) ANOVA was performed on upgradient well MW93A and downgradient well MW84A. Paired (parametric) ANOVA identified a statistically significant difference between the upgradient and downgradient wells. A Mann-Kendall test was performed to evaluate the data further, and identified a statistically significant increasing trend for TCE in MW84A.

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ATTACHMENT B1

ARSENIC
STATISTICAL TEST 4

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Attachment B1: Arsenic URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Arsenic (As, mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-21	**0.0154**	**0.00832**	**0.0212**	**0.00939**	**0.00211**
Jul-21	**0.00806**	**0.00859**	**0.0284**	**0.00793**	0.0025
Jan-22	**0.0134**	**0.0106**	**0.0348**	**0.00838**	**0.00213**
Jul-22	**0.0111**	**0.0103**	**0.036**	**0.00827**	0.0025
Jan-23	**0.0111**	**0.011**	**0.0343**	**0.00857**	**0.00278**
n_i	10		5	5	5
Sum	1.08E-01		1.55E-01	4.25E-02	1.20E-02
(x_i)avg	1.08E-02		3.09E-02	8.51E-03	2.40E-03

mg/L = miligrams per liter

Bolded values indicate a detected result.

Overall mean x.. =	0.01	
N =	25	N = the total number of samples
p =	4	p = the number of n_i groups
x.. =	0.32	x.. = the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test

Table of Residuals

Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-21	4.61E-03	-2.47E-03	-9.74E-03	8.82E-04	-2.94E-04
Jul-21	-2.73E-03	-2.20E-03	-2.54E-03	-5.78E-04	9.60E-05
Jan-22	2.61E-03	-1.87E-04	3.86E-03	-1.28E-04	-2.74E-04
Jul-22	3.13E-04	-4.87E-04	5.06E-03	-2.38E-04	9.60E-05
Jan-23	3.13E-04	2.13E-04	3.36E-03	6.20E-05	3.76E-04

X: Mean Value =	-5.38E-19	
S: Standard Deviation =	2.898E-03	
K* Factor =	2.292	(for n = 25)
CV = S/X =	-5.39E+15	< 1, data are normally distributed

Data are normally distributed (i.e.,<1)

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

If the coefficient of variation is < 1, the data are normally distributed.
If the coefficient of variation is > or = 1, data are not normally distributed.

Attachment B1: Arsenic URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Determine Equality of Variance of Dataset

p = number of well groups
n_i = number of data points per well
N = total sample size
S^2 = the square of the standard deviation
$\ln(S_i^2)$ = natural logarithm of each variance
f = total sample size minus the number of wells (groups)
$f_i = n_i - 1$
x.. = the sum of the total number of samples
$(x_{avg})_{..} =$ the mean of the total number of samples

$x_{..} =$ 3.17E-01
$(x_{avg})_{..} =$ 1.27E-02

p = 4
N = 25

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$	n_i	$f_iS_i^2$	$f_i\ln(S_i^2)$
2.284E-03	5.219E-06	-1.22E+01	10	4.70E-05	-1.09E+02
6.187E-03	3.828E-05	-1.02E+01	5	1.53E-04	-4.07E+01
5.452E-04	2.972E-07	-1.50E+01	5	1.19E-06	-6.01E+01
2.834E-04	8.033E-08	-1.63E+01	5	3.21E-07	-6.53E+01

$\sum(S_i^2) =$ 4.39E-05 $\sum f_i\ln(S_i^2) =$ -2.76E+02

Equality of Variance: Bartlett's Test

f = 21
$Sp^2 =$ 9.60E-06
$\ln Sp^2 =$ -1.16E+01
$c^2 =$ 3.30E+01 (If $c^2 \le c^2_{crit}$, then variances are equal at the given significance level).
c^2_{crit} * = 7.81E+00 at a 5% significance level with 3 degrees of freedom

NOTE: The variances are NOT equal. **(i.e., $c^2 > c^2_{crit}$)**

Variances are not equal, transform the original data to lognormal (i.e., since $c^2 > c^2_{crit}$).

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

Attachment B1: Arsenic URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Lognormal Data for Arsenic

ln[As (mg/L)]					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-21	-4.17	-4.79	-3.85	-4.67	-6.16
Jul-21	-4.82	-4.76	-3.56	-4.84	-5.99
Jan-22	-4.31	-4.55	-3.36	-4.78	-6.15
Jul-22	-4.50	-4.58	-3.32	-4.80	-5.99
Jan-23	-4.50	-4.51	-3.37	-4.76	-5.89
Mean x_i	-4.46	-4.64	-3.49	-4.77	-6.04
Background Mean	-4.55		NA	NA	NA
Grand Mean	-4.68				
x_i^2	1.74E+01	2.29E+01	1.49E+01	2.18E+01	3.80E+01
	2.32E+01	2.26E+01	1.27E+01	2.34E+01	3.59E+01
These values needed for ANOVA	1.86E+01	2.07E+01	1.13E+01	2.29E+01	3.78E+01
	2.03E+01	2.09E+01	1.11E+01	2.30E+01	3.59E+01
	2.03E+01	2.03E+01	1.14E+01	2.27E+01	3.46E+01
Sum x_i^2	564				

mg/L = milligrams per liter

Determine Normality of Dataset

Coefficient of Variability Test

Table of ln[As (mg/L)] Data

Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-21	-4.17	-4.79	-3.85	-4.67	-6.16
Jul-21	-4.82	-4.76	-3.56	-4.84	-5.99
Jan-22	-4.31	-4.55	-3.36	-4.78	-6.15
Jul-22	-4.50	-4.58	-3.32	-4.80	-5.99
Jan-23	-4.50	-4.51	-3.37	-4.76	-5.89

X: Mean Value = -4.68E+00
S: Standard Deviation = 8.44E-01
K* Factor = 2.292 (for n = 25)
CV = S/X = -1.80E-01 <1, data are normally distributed

Data are normally distributed (i.e.,<1)

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

Attachment B1: Arsenic URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Determine Equality of Variance of Dataset for Lognormal Data

p = number of wells (background wells considered as one group)
n_i = number of data points per well
N = total sample size
S^2 = the square of the standard deviation
$\ln(S_i^2)$ = natural logarithm of each variance
f = total sample size minus the number of wells (groups)
$f_i = n_i - 1$
x.. = the sum of the total lognormal dataset
$(x_{avg})_{..}$ = the mean of the lognormal dataset

$x_{..} =$ -1.17E+02
$(x_{avg})_{..} =$ -4.68E+00
$n_i =$ 5
p = 4
N = 25

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$	ni	$f_iS_i^2$	$f_i\ln(S_i^2)$
2.05E-01	4.21E-02	-3.17E+00	10	3.79E-01	-2.85E+01
2.21E-01	4.90E-02	-3.02E+00	5	1.96E-01	-1.21E+01
6.28E-02	3.94E-03	-5.54E+00	5	1.58E-02	-2.21E+01
1.18E-01	1.39E-02	-4.27E+00	5	5.57E-02	-1.71E+01

$\sum(S_i^2) =$ 1.09E-01 $\sum f_i\ln(S_i^2) =$ -7.98E+01

Equality of Variance: Bartlett's Test

f =	21			
Sp^2 =	3.08E-02			
ln Sp^2 =	-3.48E+00			
c^2 =	6.72E+00	(If $c^2 \le c^2_{crit}$, then variances are equal at the given significance level).		
c^2_{crit} * =	7.81E+00	at a 5% significance level with	3	degrees of freedom

NOTE: The variances are equal. **(i.e., $c^2 \le c^2_{crit}$)**

Because variances are equal, the Parametric ANOVA for the lognormal dataset will proceed.

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

**Section 5.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989)].

Attachment B1: Arsenic URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Parametric ANOVA

Between Well Sum of Squares[1]

Source of Variation	Sums of Squares	df	Mean Squares	$F_{calculated}$
Between Wells (SS wells)	1.64E+01	3	5.48E+00	1.78E+02
Error within wells (SS error)	6.46E-01	21	3.08E-02	
Total (SS total)	1.71E+01	24		

If $F_{calculated} > F_{tabulated}$, then reject the hypothesis of equal well means. If $F_{calculated}$ is less than or equal to $F_{tabulated}$, it can be concluded that there is no significant difference between concentrations, therefore, there is no evidence of well contamination.

$F_{tabulated} = 3.07$**

CONCLUSION: $F_{calculated} > F_{tabulated}$; therefore, evidence of well contamination. Additional comparisons must be made.

NOTE: ** Table 2, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* , USEPA, 1989. $F_{tabulated}$ taken at the 5% significance level.

Comparison of Compliance Wells to Background Wells (Bonferroni Test)

n_b =	10	N-p =	21	α =	0.05
$(x_b)_{avg}$ =	-4.55E+00	m =	3	1-α/m =	9.83E-01

n_b = total sample size of all background wells

$(x_b)_{avg}$ = average concentration from all background wells

Well No.	Well Mean	Differences of Avg.	Standard Error	Bonferroni's t[2]	D_i	Conclusion
	$(x_b)_{avg}$	$(x_i)_{avg}-(x_b)_{avg}$	SE_i	$t_{(N-p),(\alpha/m)}$		
MW93A						
MW420						
MW84A	-3.49E+00	1.05E+00	0.10	2.277	0.22	evidence of contamination
MW87A	-4.77E+00	-2.20E-01	0.10	2.277	0.22	not contaminated
MW90A	-6.04E+00	-1.49E+00	0.10	2.277	0.22	not contaminated

CONCLUSION: If the "Differences of Averages" is greater than D_i, then the well is contaminated. After performing Bonferroni's t calculation, the following can be concluded: MW84A shows statistically significantly levels of contamination as compared background wells. MW90A and MW87A do not show statistically significant levels of contamination.

[1]Section 5.2.1, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* , (EPA, 1989).

[2]Table 3 (EPA, 1989)

A 95% UTL comparison is performed.

Attachment B1: Arsenic URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

95% Upper Tolerance Limit (UTL)

Compare the most recent downgradient sample results to a calculated 95% UTL using the five most recent sets of data for each upgradient well, as described below. If downgradient concentration is less than the UTL for the paired upgradient concentrations, then there is no confirmed exceedance.

January 2023 Data, First Reporting Period
Arsenic Observations (mg/L)

Well No.						
MW93A	**0.01540**	**0.00806**	**0.01340**	**0.01110**	**0.01110**	**Upgradient Well[!]**
MW420	**0.00832**	**0.00859**	**0.01060**	**0.01030**	**0.01100**	**Upgradient Well[!]**
						Current Data
MW84A						**0.0343**
	X: Mean Value =		0.0108			
	S: Standard Deviation =		0.0023			
	K* factor =		2.911	(for n = 10)		
	CV = S/X		0.2118	<1, assume normal distribution		
	Upper Tolerance Interval: TL = X +(KxS) =		**1.74E-02**	(mg/L)		

! = Data from previous 5 sampling events.
CV = coefficient of variation
* = Table 5, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

Result: **MW84A exceeded the UTL, which is statistically significant evidence that this compliance well has elevated concentration with respect to background data.**

Because the 95% UTL indicated a statistically significant difference between compliance test wells and background wells at the C-404 Landfill in compliance well MW84A, the paired ANOVA was performed.

Paired (Parametric) ANOVA - MW93A and MW84A

Evaluate results using paired ANOVA of wells in the same direction relative to the landfill [e.g., compare upgradient westernmost well results to downgradient westernmost well results]. If ANOVA does not identify a statistically significant difference between upgradient and downgradient wells, then the results are consistent with the historical ASD.

Arsenic (As, mg/L)				
Date	Background	Compliance		
	MW93A	MW84A	n_i^2	
Jan-21	**0.01540**	**0.02120**	2.37E-04	4.49E-04
Jul-21	**0.00806**	**0.02840**	6.50E-05	8.07E-04
Jan-22	**0.01340**	**0.03480**	1.80E-04	1.21E-03
Jul-22	**0.01110**	**0.03600**	1.23E-04	1.30E-03
Jan-23	**0.01110**	**0.03430**	1.23E-04	1.18E-03
Sum (x_i)	5.91E-02	1.55E-01	2.14E-01	Total Sum (x..)
n_i	5	5		
$(x_i)_{avg}$	1.18E-02	3.09E-02		
$(x_i)^2$	3.49E-03	2.39E-02		

mg/L = milligrams per liter
Bolded values indicate a detected result.

Overall mean x.. =	2.14E-02	
N =	10	N = the total number of samples
p =	2	p = the number of n_i groups
$x_{..}$ =	2.14E-01	x.. = the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test

Table of Residuals ($x_i - x_{iavg}$)

Date	Background	Compliance
	MW93A	MW84A
Jan-21	3.59E-03	-9.74E-03
Jul-21	-3.75E-03	-2.54E-03
Jan-22	1.59E-03	3.86E-03
Jul-22	-7.12E-04	5.06E-03
Jan-23	-7.12E-04	3.36E-03

X: Mean Value =	-1.39E-18	
S: Standard Deviation =	4.52E-03	
K* Factor =	2.911	(for n = 10)
CV = S/X =	–3.25E+15	<1, data are normally distributed

Data are normally distributed (i.e., < 1)

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

If the coefficient of variation is < 1, the data are normally distributed.
If the coefficient of variation is > or = 1, data are not normally distributed.

Attachment B1: Arsenic URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Determine Equality of Variance of Dataset

p = number of wells	$x_{..} =$ 2.14E-01
n_i = number of data points per well	$(x_{avg})_{..} =$ 2.14E-02
N = total sample size	$n_i =$ 5
S^2 = the square of the standard deviation	p = 2
$\ln(S_i^2)$ = natural logarithm of each variance	N = 10
f = total sample size minus the number of wells (groups)	$f_i =$ 4
$f_i = n_i - 1$	

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$†	n_i	$f_i S_i^2$	$f_i \ln(S_i^2)$†
2.76E-03	7.62E-06	-1.18E+01	5	3.05E-05	-4.71E+01
6.19E-03	3.83E-05	-1.02E+01	5	1.53E-04	-4.07E+01

$\sum(S_i^2) =$ 4.59E-05 $\sum f_i \ln(S_i^2) =$ -8.78E+01

Equality of Variance: Bartlett's Test

f =	8.00E+00	
$Sp^2 =$	2.29E-05	
ln $Sp^2 =$	-1.07E+01	
$\chi^2 =$	2.36E+00	(If calculated $\chi^2 \leq$ tabulated χ^2_{crit}, then variances are equal at the given significance level).
χ^2_{crit} * =	3.84E+00	at a 5% significance level with 1 degrees of freedom (p-1)

NOTE: The variances are equal. (i.e., calculated $\chi^2 \leq \chi^2_{crit}$)

Since calculated $\chi^2 \leq \chi^2_{crit}$, then the analysis can proceed as normal.

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

Attachment B1: Arsenic URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Between Well Sum of Squares

Source of Variation	Sums of Squares		Degrees of Freedom	Mean Squares	Calculated F	F Statistic**
Between Wells	SS_{wells} =	9.15E-04	1	9.15E-04	3.99E+01	5.32
Error	SS_{Error} =	1.84E-04	8	2.29E-05		
Total	SS_{Total} =	1.10E-03	9			

If calculated F > F statistic, then reject the hypothesis of equal well means. If calculated F is less than or equal to F statistic, it can be concluded that there is no significant difference between concentrations; therefore, there is no evidence of well contamination.

CONCLUSION: **Calculated F > F statistic; therefore, ANOVA has identified a significant difference between upgradient and downgradient wells.**

Mann-Kendall trend analysis was performed.

**Table 2, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989). F statistic taken at the 5% significance level.

Attachment B1: Arsenic URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Mann-Kendall Trend Test Analysis
MW84A Arsenic January 2023

Date/Time of Computation	ProUCL 5.13/29/2023 3:33:03 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Input Data

MW84A_As_2023-1

Date Collected	Result (µg/L)
Jul-19	**16.8**
Jan-20	**20.2**
Jul-20	**22.2**
Jan-21	**21.2**
Jul-21	**28.4**
Jan-22	**34.8**
Jul-22	**36.0**
Jan-23	**34.3**

Bolded values indicate detected result.

General Statistics

Number or Reported Events Not Used	0
Number of Generated Events	8
Number Values Reported (n)	8
Minimum	16.8
Maximum	36
Mean	26.74
Geometric Mean	25.78
Median	25.3
Standard Deviation	7.592
Coefficient of Variation	0.284

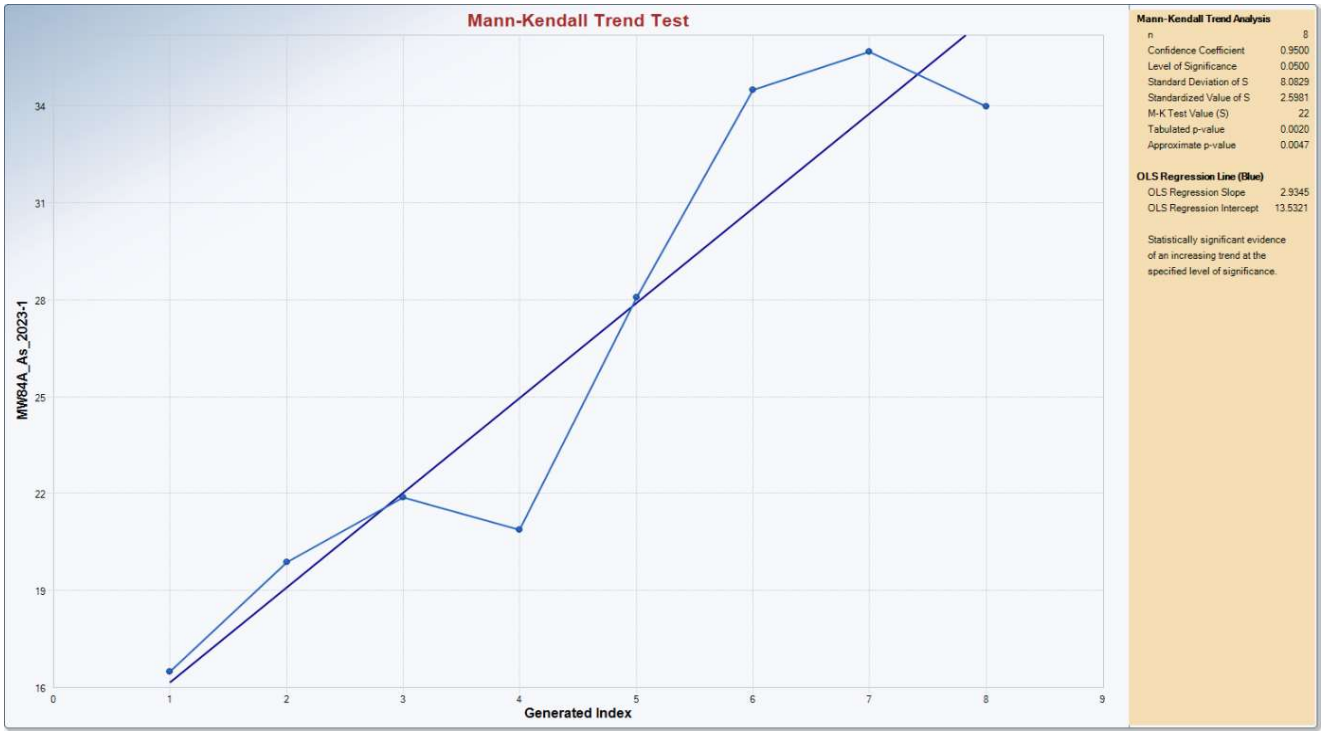
Mann-Kendall Test

M-K Test Value (S)	22
Tabulated p-value	0.002
Standard Deviation of S	8.083
Standardized Value of S	2.598
Approximate p-value	0.00469

Statistically significant evidence of an increasing trend at the specified level of significance.

Attachment B1: Arsenic URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Mann-Kendall Trend Test Analysis
MW84A Arsenic January 2023



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ATTACHMENT B2

CHROMIUM
STATISTICAL TEST 2

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Attachment B2: Chromium URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Chromium (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-21	**0.00338**	0.005	0.005	0.005	0.005
Jul-21	0.005	0.005	0.005	0.005	0.005
Jan-22	**0.00777**	0.005	0.005	0.005	0.005
Jul-22	**0.00527**	0.005	0.005	0.005	0.005
Jan-23	0.005	0.005	0.005	0.005	0.005

mg/L = milligrams per liter
BG = background
DL = detection limit
All data sets represent 1/2 DL 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 =	0	Y = number of samples above DL in compliance wells
n_b =	10	n_b = count of background well results/samples analyzed
n_c =	15	n_c = count of compliance well results/samples analyzed
n =	25	n = total number of samples

P =	0	P = (x+y)/n
nP =	3	$n = n_b+n_c$
n(1-P) =	22	

NOTE: If nP and n(1-P) are both >= 5, then the normal approximation may be used; however, because nP < 5 and/or n(1-P) < 5, the test was continued to determine if the conclusion, along with a simple evaluation of the data would be similar.

P_b =	3.00E-01	P_b = proportion of detects in background wells
P_c =	0.00E+00	P_c = proportion of detects in compliance wells
S_D =	1.33E-01	S_D = standard error of difference in proportions
Z =	2.261	$Z = (P_b-P_c)/S_D$
absolute value of Z =	2.261	

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 greater than 1.96, there is statistical evidence that the proportion of samples with detected results differs between the background well and compliance well samples. Non-parametric ANOVA was performed.**

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

Attachment B2: Chromium URGA, Statistical Test Statistical Test 2, Test of Proportions
First Reporting Period 2023

Chromium (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-21	**0.00338**	0.005	0.005	0.005	0.005
Jul-21	0.005	0.005	0.005	0.005	0.005
Jan-22	**0.00777**	0.005	0.005	0.005	0.005
Jul-22	**0.00527**	0.005	0.005	0.005	0.005
Jan-23	0.005	0.005	0.005	0.005	0.005
Sum	5.14E-02		2.50E-02	2.50E-02	2.50E-02
n_i	10		5	5	5
$(x_i)_{avg}$	5.14E-03		5.00E-03	5.00E-03	5.00E-03

mg/L = milligrams per liter
BG = background
DL = detection limit
All data sets represent 1/2 DL values for nondetects.
Bolded values indicate a detected result.

Overall mean x.. = 5.06E-03

N =	25	N = the total number of samples
p =	4	p = the number of n_i groups
x.. =	0.13	x.. = the sum of the total number of samples

Attachment B2: Chromium URGA, Statistical Test Statistical Test 2, Test of Proportions
First Reporting Period 2023

Nonparametric ANOVA

Ranking of Observations

Sequence	Chromium (mg/L)	Adjusted Rank	Tie Number
1	0	11.5	Tie
2	0	11.5	
3	0	11.5	
4	0	11.5	
5	0	11.5	
6	0	11.5	
7	0	11.5	
8	0	11.5	
9	0	11.5	
10	0	11.5	
11	0	11.5	
12	0	11.5	
13	0	11.5	
14	0	11.5	
15	0	11.5	
16	0	11.5	
17	0	11.5	
18	0	11.5	
19	0	11.5	
20	0	11.5	
21	0	11.5	
22	0	11.5	
23	**0.00338**	23	
24	**0.00527**	24	
25	**0.00777**	25	

mg/L = milligrams per liter
BG = background
DL = detection limit
Bolded values indicate a detected result.
NOTE: For this method, observations below the detection limit that are considered nondetects (i.e., U qualified data) are reported as a concentration of 0.

n_{tie}
22 Tie 1 = 1.06E+04

$\sum T_i$ = 1.06E+04

Attachment B2: Chromium URGA, Statistical Test Statistical Test 2, Test of Proportions
First Reporting Period 2023

Sums of Ranks and Averages

Chromium (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-21	**0.00338**	0	0	0	0
Jul-21	0	0	0	0	0
Jan-22	**0.00777**	0	0	0	0
Jul-22	**0.00527**	0	0	0	0
Jan-23	0	0	0	0	0

Observation Ranks for Chromium					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-21	23	11.5	11.5	11.5	11.5
Jul-21	11.5	11.5	11.5	11.5	11.5
Jan-22	25	11.5	11.5	11.5	11.5
Jul-22	24	11.5	11.5	11.5	11.5
Jan-23	11.5	11.5	11.5	11.5	11.5
R_i	1.53E+02		5.75E+01	5.75E+01	5.75E+01
$(R_i)_{avg}$	1.53E+01		1.15E+01	1.15E+01	1.15E+01
R_i^2/n_i	2.33E+03		6.61E+02	6.61E+02	6.61E+02

$\Sigma R_i^2/n_i$ = 4.31E+03

mg/L = milligrams per liter

K = the number of n_i groups
N = the total number of samples

K = 4
N = 25

Bolded values indicate a detected result.
NOTE: For this method, observations below the detection limit that are considered nondetects (i.e., U qualified data) are reported as a concentration of 0.

Calculation of Kruskal-Wallis Statistic

H =	1.56E+00	Kruskal-Wallis Statistic	$H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$
H' =	4.89E+00	Corrected Kruskal-Wallis	$H' = H/[1-(\sum T_i/N^3-N)]$
χ^2_{crit}* =	7.81E+00	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	α/(K-1) =	1.67E-02	Z(α/(K-1))** =	2.13E+00
α =	0.05	1-(α/K-1) =	9.83E-01		

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 B2: Chromium URGA, Statistical Test Statistical Test 2, Test of Proportions
First Reporting Period 2023

Calculate Critical Values

Average Background Ranking = 15.3

	Well No.	C_i	$(R_i)_{avg} - (R_b)_{avg}$	Conclusion
BG Well	MW93A			
BG Well	MW420			
	MW84A	8.58E+00	-3.75E+00	not contaminated
	MW87A	8.58E+00	-3.75E+00	not contaminated
	MW90A	8.58E+00	-3.75E+00	not contaminated

mg/L = milligrams per liter
BG = background
DL = detection limit

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

If $(R_i)_{avg} - (R_b)_{avg} < C_i$ for wells, there is no evidence of a statistically significant difference between concentrations in downgradient compliance test wells and background wells.

Since $(R_i)_{avg} - (R_b)_{avg} < C_i$ for MW84A, MW87A, and MW90A, there is no statistically significant difference between background wells and these downgradient compliance test wells; 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).

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ATTACHMENT B3

TECHNETIUM-99
STATISTICAL TEST 2

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Attachment B3: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Technetium-99 (pCi/L)					
Date	**Background**	**Background**	**Compliance**	**Compliance**	**Compliance**
	MW93A	**MW420**	**MW84A**	**MW87A**	**MW90A**
Jan-22	10.45	9.65	**225**	10	9.55
May-22	7.95	7.95	**47.9**	6	**34.4**
Jul-Aug-22	7.85	7.25	**47.2**	6.7	**25.7**
Nov-22	8.65	8.3	**64**	8.4	**22.3**
Jan-23	9.15	8.85	**202**	**24.4**	11.85

pCi/L = picocuries per liter
BG = background
DL = detection limit
Nondetect values are 1/2 DL.
Bolded values indicate a detected result.

[!] **Test of Proportions**

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

X =	0	X = number of samples above DL in background wells
Y =	9	Y = number of samples above DL in compliance wells
n_b =	10	n_b = count of background well results/samples analyzed
n_c =	15	n_c = count of compliance well results/samples analyzed
n =	25	n = total number of samples

P =	0.360	P = (x+y)/n
nP =	9	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 =	0.00E+00	P_b = proportion of detects in background wells
P_c =	6.00E-01	P_c = proportion of detects in compliance wells
S_D =	1.96E-01	S_D = standard error of difference in proportions
Z =	-3.062	Z = (P_b-P_c)/S_D
absolute value of Z =	3.062	

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 greater than 1.96, Nonparametric ANOVA was performed.

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

Attachment B3: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Nonparametric ANOVA

Technetium-99 (pCi/L)					
Date	**Background**	**Background**	**Compliance**	**Compliance**	**Compliance**
	MW93A	**MW420**	**MW84A**	**MW87A**	**MW90A**
Jan-22	10.45	9.65	**225**	10	9.55
May-22	7.95	7.95	**47.9**	6	**34.4**
Jul-Aug-22	7.85	7.25	**47.2**	6.7	**25.7**
Nov-22	8.65	8.3	**64**	8.4	**22.3**
Jan-23	9.15	8.85	**202**	**24.4**	11.85
Sum	8.61E+01		5.86E+02	5.55E+01	1.04E+02
n_i	10		5	5	5
$(x_i)_{avg}$	8.61E+00		1.17E+02	1.11E+01	2.08E+01

pCi/L = picocuries per liter
BG = background
DL = detection limit
All data sets represent 1/2 DL values for nondetects.
Bolded values indicate a detected result.

Overall mean x.. = 3.33E+01

N =	25	N = the total number of samples
p =	4	p = the number of n_i groups
x.. =	8.31E+02	x.. = the sum of the total number of samples

Attachment B3: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Nonparametric ANOVA

Ranking of Observations

Sequence	Technetium-99 (pCi/L)	Adjusted Rank	Tie Number
1	0	8.5	Tie 1
2	0	8.5	
3	0	8.5	
4	0	8.5	
5	0	8.5	
6	0	8.5	
7	0	8.5	
8	0	8.5	
9	0	8.5	
10	0	8.5	
11	0	8.5	
12	0	8.5	
13	0	8.5	
14	0	8.5	
15	0	8.5	
16	0	8.5	
17	**22.3**	17	
18	**24.4**	18	
19	**25.7**	19	
20	**34.4**	20	
21	**47.2**	21	
22	**47.9**	22	
23	**64**	23	
24	**202**	24	
25	**225**	25	

pCi/L = picocuries per liter
BG = background
DL = detection limit
Bolded values indicate a detected result.
NOTE: For this method, observations below the detection limit that are considered nondetects (i.e., U qualified data) are reported as a concentration of 0.

n_{tie}

16 Tie 1 = 4.08E+03

$\sum T_i$ = 4.08E+03

Attachment B3: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Nonparametric ANOVA

Sums of Ranks and Averages

Technetium-99 (pCi/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-22	0	0	**225**	0	0
May-22	0	0	**47.9**	0	**34.4**
Jul-Aug-22	0	0	**47.2**	0	**25.7**
Nov-22	0	0	**64**	0	**22.3**
Jan-23	0	0	**202**	**24.4**	0

Observation Ranks for Technetium-99					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-22	8.5	8.5	25	8.5	8.5
May-22	8.5	8.5	22	8.5	20
Jul-Aug-22	8.5	8.5	21	8.5	19
Nov-22	8.5	8.5	23	8.5	17
Jan-23	8.5	8.5	24	18	8.5
R_i	8.50E+01		1.15E+02	5.20E+01	7.30E+01
$(R_i)_{avg}$	8.50E+00		2.30E+01	1.04E+01	1.46E+01
R_i^2/n_i	7.23E+02		2.65E+03	5.41E+02	1.07E+03

$\Sigma R_i^2/n_i$ = 4.97E+03

K = 4

N = 25

pCi/L = picocuries per liter

BG = background

DL = detection limit

K = the number of n_i groups

N = the total number of samples

Bolded values indicate a detected result.

NOTE: For this method, observations below the detection limit that are considered nondetects (i.e., U qualified data) are reported as a concentration of 0.

Calculation of Kruskal-Wallis Statistic

H = 1.38E+01 Kruskal-Wallis Statistic $H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$

H' = 1.87E+01 Corrected Kruskal-Wallis $H' = H/[1-(\sum T_i/N^3-N)]$

χ^2_{crit}* = 7.81E+00 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 $\alpha/(K-1)$ = 1.67E-02 $Z(\alpha/(K-1))$** = 2.13E+00

α = 0.05 $1-(\alpha/K-1)$ = 9.83E-01

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 B3: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Nonparametric ANOVA

Calculate Critical Values

Average Background Ranking = 8.5

	Well No.	C_i	$(R_i)_{avg} - (R_b)_{avg}$	Conclusion
BG Well	MW93A			
BG Well	MW420			
	MW84A	8.58E+00	1.45E+01	**evidence of contamination**
	MW87A	8.58E+00	1.90E+00	not contaminated
	MW90A	8.58E+00	6.10E+00	not contaminated

pCi/L = picocuries per liter
BG = background
DL = detection limit

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

If $(R_i)_{avg} - (R_b)_{avg} < C_i$ for wells, there is no evidence of a statistically significant difference between concentrations in downgradient compliance test wells and background wells.

Since $(R_i)_{avg} - (R_b)_{avg} > C_i$ for MW84A, there is a statistically significant difference between downgradient compliance test wells and background wells in MW84A from the C-404 Landfill.

Because nonparametric ANOVA indicated a statistically significant difference between compliance test wells and background wells at the C-404 Landfill in compliance well MW84A, the 95% UTL was performed.

Since $(R_i)_{avg} - (R_b)_{avg} < C_i$ for MW87A and MW90A, there is no statistically significant difference between background wells and these downgradient compliance test wells.

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

Attachment B3: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

95% Upper Tolerance Limit (UTL)

Compare the most recent downgradient sample results to a calculated 95% UTL using the five most recent sets of data for each upgradient well, as described below. If downgradient concentration is less than the UTL for the paired upgradient concentrations, then there is no confirmed exceedance.

January 2023 Data, First Reporting Period
Technetium-99 Observations (pCi/L)

Well No.						
MW93A	**10.45**	**7.95**	**7.85**	**8.65**	**9.15**	**Upgradient Well!**
MW420	**9.65**	**7.95**	**7.25**	**8.3**	**8.85**	**Upgradient Well!**
						Current Data
MW84A						**202**
		X: Mean Value =	9			
		S: Standard Deviation =	1			
		K* factor =	2.911	(for n = 10)		
		CV = S/X	1.11E-01	<1, assume normal distribution		
		Upper Tolerance Interval: TL = X +(KxS) =	**1.14E+01**	(pCi/L)		

! = Data from previous 5 sampling events.
Nondetect values are 1/2 DL.
CV = coefficient of variation
* = Table 5, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

Result: **MW84A exceeded the UTL, which is statistically significant evidence that this compliance well has elevated concentration with respect to background data.**

Because the 95% UTL indicated a statistically significant difference between compliance test wells and background wells at the C-404 Landfill in compliance wells MW84A, the paired (parametric) ANOVA was performed.

Attachment B3: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Paired (Parametric) ANOVA - MW93A and MW84A

Evaluate results using paired ANOVA of wells in the same direction relative to the landfill [e.g., compare upgradient westernmost well results to downgradient westernmost well results]. If ANOVA does not identify a statistically significant difference between upgradient and downgradient wells, then the results are consistent with the historical ASD.

Technetium-99 (pCi/L)				
Date	Background	Compliance		
	MW93A	MW84A	n_i^2	
Jan-22	10.45	**225**	1.09E+02	5.06E+04
May-22	7.95	**47.9**	6.32E+01	2.29E+03
Jul-Aug-22	7.85	**47.2**	6.16E+01	2.23E+03
Nov-22	8.65	**64**	7.48E+01	4.10E+03
Jan-23	9.15	**202**	8.37E+01	4.08E+04
Sum (x_i)	4.41E+01	5.86E+02	6.30E+02	Total Sum (x..)
n_i	5	5		
$(x_i)_{avg}$	8.81E+00	1.17E+02		
$(x_i)^2$	1.94E+03	3.44E+05		

pCi/L = picocuries per liter
Nondetect values are 1/2 DL.
Bolded values indicate a detected result.

Overall mean x.. =	6.30E+01	
N =	10	N = the total number of samples
p =	2	p = the number of n_i groups
$x_{..}$ =	6.30E+02	x.. = the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test

Table of Residuals ($x_i - x_{iavg}$)

Date	Background	Compliance
	MW93A	MW84A
Jan-22	1.64E+00	1.08E+02
May-22	-8.60E-01	-6.93E+01
Jul-Aug-22	-9.60E-01	-7.00E+01
Nov-22	-1.60E-01	-5.32E+01
Jan-23	3.40E-01	8.48E+01

X: Mean Value =	0.00E+00	
S: Standard Deviation =	59	
K* Factor =	2.911	(for n = 10)
CV = S/X =	#ΔIç/0!	#DIV/0!

†The Coefficient of Variability Test was not performed due to mean = 0 (i.e., division by 0 not possible).

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

If the coefficient of variation is < 1, the data are normally distributed.
If the coefficient of variation is > or = 1, data are not normally distributed.

Attachment B3: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Determine Equality of Variance of Dataset

p = number of wells	$x_{..} =$ 6.30E+02
n_i = number of data points per well	$(x_{avg})_{..} =$ 6.30E+01
N = total sample size	$n_i =$ 5
S^2 = the square of the standard deviation	p = 2
$\ln(S_i^2)$ = natural logarithm of each variance	N = 10
f = total sample size minus the number of wells (groups)	f_i = 4
$f_i = n_i - 1$	

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$†	n_i	$f_i S_i^2$	$f_i \ln(S_i^2)$†
1.06E+00	1.12E+00	1.16E-01	5	4.49E+00	4.64E-01
8.85E+01	7.84E+03	8.97E+00	5	3.13E+04	3.59E+01

$\sum(S_i^2) =$ 7.84E+03 $\sum f_i \ln(S_i^2) =$ 3.63E+01

Equality of Variance: Bartlett's Test

f =	8	
$Sp^2 =$	3.92E+03	
ln $Sp^2 =$	8.27E+00	
$\chi^2 =$	2.99E+01	(If calculated $\chi^2 \leq$ tabulated χ^2_{crit}, then variances are equal at the given significance level).
χ^2_{crit} * =	3.84E+00	at a 5% significance level witl 1 degrees of freedom (p-1)

NOTE: The variances are NOT equal. (i.e., calculated $\chi^2 > \chi^2_{crit}$)

Variances are not equal, transform the original data to lognormal (i.e., since calculated $\chi^2 > \chi^2_{crit}$).

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

Attachment B3: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Paired (Parametric) ANOVA—Lognormal Data

ln[Technetium-99 (pCi/L)]				
Date	Background	Compliance		
	MW93A	MW84A	n_i^2	
Jan-22	2.35	**5.42**	5.51E+00	2.93E+01
May-22	2.07	**3.87**	4.30E+00	1.50E+01
Jul-Aug-22	2.06	**3.85**	4.25E+00	1.49E+01
Nov-22	2.16	**4.16**	4.66E+00	1.73E+01
Jan-23	2.21	**5.31**	4.90E+00	2.82E+01
Sum (x_i)	1.09E+01	2.26E+01	3.35E+01	Total Sum (x..)
n_i	5	5		
$(x_i)_{avg}$	2.17E+00	4.52E+00		
$(x_i)^2$	1.18E+02	5.11E+02		

pCi/L = picocuries per liter **Bolded values indicate a detected result.**

Overall mean x.. =	3.35E+00	
N =	10	N = the total number of samples
p =	2	p = the number of n_i groups
$x_{..}$ =	3.35E+01	x.. = the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test—Lognormal Data

Table of Residuals (x_i-$x_i$avg) for Lognormal Data

Date	Background	Compliance
	MW93A	MW84A
Jan-22	1.76E-01	8.95E-01
May-22	-9.71E-02	-6.52E-01
Jul-Aug-22	-1.10E-01	-6.67E-01
Nov-22	-1.28E-02	-3.62E-01
Jan-23	4.34E-02	7.87E-01

X: Mean Value =	-4.44E-16	
S: Standard Deviation =	5.25E-01	
K* Factor =	2.911	(for n = 10)
CV = S/X =	–1.18E+15	<1, data are normally distributed

Data are normally distributed (i.e., < or =1)

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

If the coefficient of variation is < 1, the residuals are normally distributed.
If the coefficient of variation is > or = 1, the residuals are not normally distributed.

Attachment B3: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Determine Equality of Variance—Lognormal Data

p = number of wells	$x_{..} =$ 3.35E+01
n_i = number of data points per well	$(x_{avg})_{..} =$ 3.35E+00
N = total sample size	$n_{i} =$ 5
S^2 = the square of the standard deviation	p = 2
$\ln(S_i^2)$ = natural logarithm of each variance	N = 10
f = total sample size minus the number of wells (groups)	f_i = 4
$f_i = n_i - 1$	

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$	n_i	$f_iS_i^2$	$f_i\ln(S_i^2)$
1.17E-01	1.37E-02	-4.29E+00	5	5.46E-02	-1.72E+01
7.78E-01	6.05E-01	-5.02E-01	5	2.42E+00	-2.01E+00

$\sum(S_i^2) =$ 6.19E-01 $\sum f_i\ln(S_i^2) =$ -1.92E+01

Equality of Variance: Bartlett's Test

f =	8	
Sp^2 =	3.10E-01	
ln Sp^2 =	-1.17E+00	
χ^2 =	9.80E+00	(If calculated $\chi^2 \leq$ tabulated χ^2_{crit}, then variances are equal at the given significance level).
χ^2_{crit} * =	3.84E+00	at a 5% significance level witl 1 degrees of freedom (p-1)

NOTE: The variances are NOT equal. (i.e., calculated $\chi^2 \leq \chi^2_{crit}$)

Since the variances are not equal, paired (nonparametric) ANOVA is performed.

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

**Section 5.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989)].

Paired Nonparametric ANOVA

Technetium-99 (pCi/L)		
Date	Background	Compliance
	MW93A	MW84A
Jan-22	10.45	**225**
May-22	7.95	**47.9**
Jul-Aug-22	7.85	**47.2**
Nov-22	8.65	**64**
Jan-23	9.15	**202**
Sum	4.41E+01	5.86E+02
n_i	5	5
$(x_i)_{avg}$	8.81E+00	1.17E+02

pCi/L = picocuries per liter
DL = detection limit
All data sets represent 1/2 DL values for nondetects.
Bolded values indicate a detected result.

Overall mean x.. = 6.30E+01
N = 10
p = 2
x.. = 6.30E+02

Ranking of Observations

Sequence	Technetium-99	Adjusted	Tie Number
1	0	3	
2	0	3	
3	0	3	Tie 1
4	0	3	
5	0	3	
6	**47.2**	6	
7	**47.9**	7	
8	**64**	8	
9	**202**	9	
10	**225**	10	

pCi/L = picocuries per liter
Bolded values indicate a detected result.

n_{tie}	Adjustment for Ties: $(n_{tie}^3 - n_{tie})$	
5	Tie 1 =	1.20E+02
	$\sum T_i$ =	1.20E+02

Note: for this method, observations below the detection that are considered non-detects (i.e., U qualified data) are reported as a concentration 0.

Sums of Ranks and Averages

Observation Ranks for Tc-99		
Date	Background	Compliance
	MW93A	MW84A
Jan-22	3	10
May-22	3	7
Jul-Aug-22	3	6
Nov-22	3	8
Jan-23	3	9
R_i	15	40
$(R_i)_{avg}$	3.0	8
R_i^2/n_i	45.0	320.0

$\Sigma R_i^2/n_i$ = 365
K = 2
N = 10

K = the number of n_i groups
N = the total number of samples

Attachment B3: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Calculation of Kruskal-Wallis Statistic

H =	6.82E+00	Kruskal-Wallis Statistic	$H = [12/N(N+1)*\Sigma R_i^2/n_i] - 3(N+1)$
H' =	7.76E+00	Corrected Kruskal-Wallis	$H' = H/[1-(\sum T_i/N^3-N)]$
χ^2_{crit} * =	3.84E+00	1	degrees of freedom at the 5% significance level

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

If $H' \leq \chi^2_{crit}$, the data from each well comes 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 =	1	α/(K-1) =	5.00E-02	Z(α/(K-1))** =	1.64E+00
α =	0.05	1-(α/K-1) =	9.50E-01		

*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).

Calculate Critical Values

Average Background Ranking = 3.000

	Well No.	C_i	$(R_i)_{avg} - (R_b)_{avg}$	Conclusion
BG Well	MW93A			
	MW84A	3.15E+00	5.00E+00	**evidence of contamination**

pCi/L = picocuries per liter
BG = background

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

If $(R_i)_{avg} - (R_b)_{avg} < C_i$ for wells, there is no evidence of a statistically significant difference between concentrations in downgradient compliance test wells and background wells.

Since (Ri)avg - (Rb)avg > Ci for MW84A, there is a statistically significant difference in this downgradient compliance test well.

Because the nonparametric ANOVA for the two wells indicated a statistically significant difference between compliance test wells and background wells at the C-404 Landfill in compliance well MW84A, a Mann Kendall statistical analysis was performed.

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

Attachment B3: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Mann-Kendall Trend Analysis for Technetium-99 in MW84A

Input Data

Date Collected	Result (pCi/L)
Apr-21	**294**
Jul-21	**229**
Nov-21	**258**
Jan-22	**225**
May-22	**47.9**
Jul-22	**47.2**
Nov-22	**64**
Jan-23	**202**

Bolded values indicate a detected result.

Mann-Kendall Trend Test Analysis

User Selected Options	
Date/Time of Computation	ProUCL 5.14/10/2023 1:35:57 PM
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

MW84A_Tc-99 Jan 2023

General Statistics

Number or Reported Events Not Used	0
Number of Generated Events	8
Number Values Reported (n)	8
Minimum	47.2
Maximum	294
Mean	170.9
Geometric Mean	135.6
Median	213.5
Standard Deviation	101.3
Coefficient of Variation	0.593

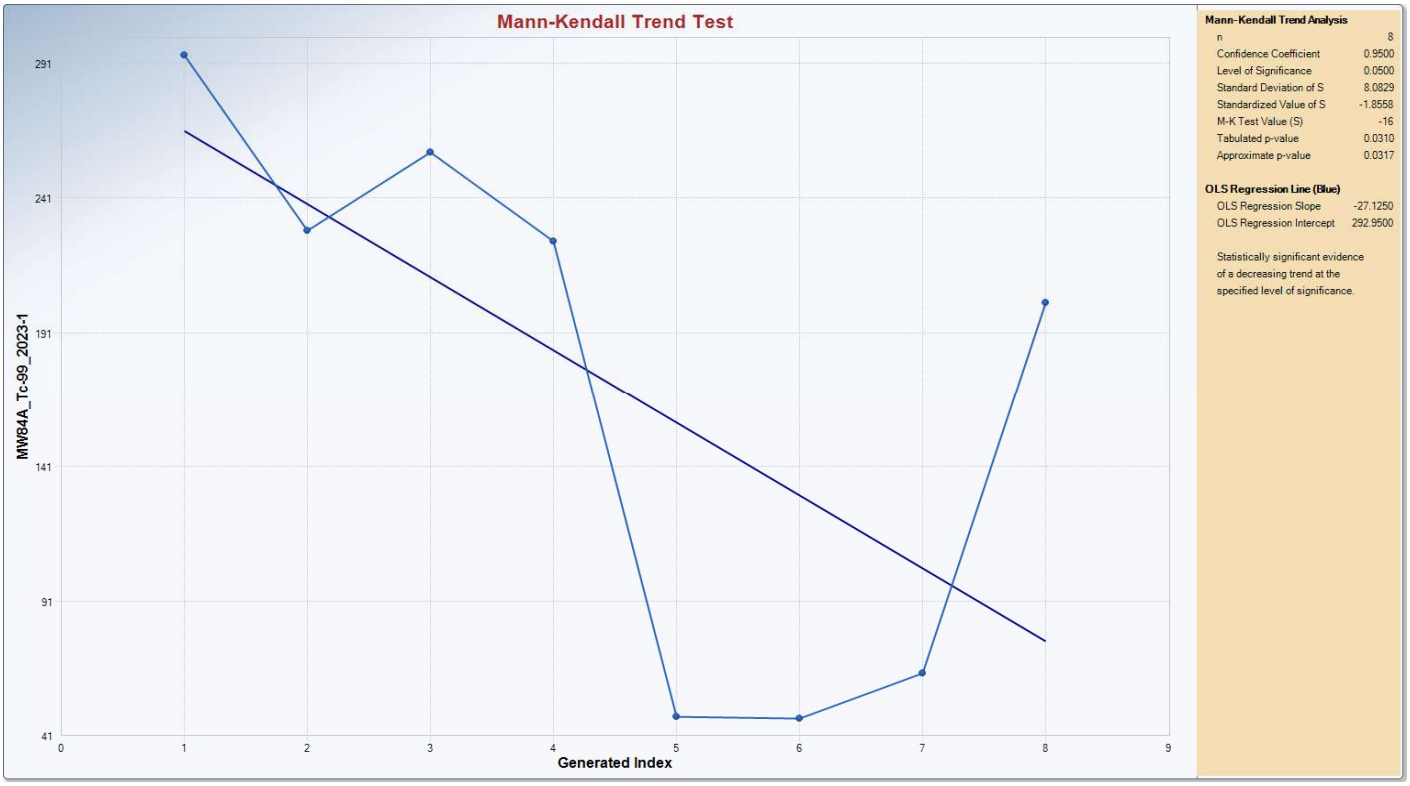
Mann-Kendall Test

M-K Test Value (S)	-16
Tabulated p-value	0.031
Standard Deviation of S	8.083
Standardized Value of S	-1.856
Approximate p-value	0.0317

Statistically significant evidence of a decreasing trend at the specified level of significance.

Attachment B3: Technetium-99 URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Mann-Kendall Trend Analysis for Technetium-99 in MW84A



ATTACHMENT B4

TRICHLOROETHENE
STATISTICAL TEST 4

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Attachment B4: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Trichloroethene (TCE, µg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-21	**3120**	**1690**	**2630**	**2570**	**99.6**
Jul-21	**3170**	**1790**	**5290**	**2410**	**148**
Jan-22	**2550**	**2100**	**6560**	**1890**	**146**
Jul-22	**1630**	**1620**	**6570**	**1400**	**222**
Jan-23	**1960**	**2110**	**7000**	**2140**	**296**
n_i	10		5	5	5
Sum	2.17E+04		2.81E+04	1.04E+04	9.12E+02
(x_i)avg	2.17E+03		5.61E+03	2.08E+03	1.82E+02

µg/L = micrograms per liter
Bolded values indicate a detected result.

Overall mean x.. =	2.44E+03	
N =	25	N = the total number of samples
p =	4	p = the number of n_i groups
x.. =	6.11E+04	x.. = the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test

Table of Residuals

Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-21	9.46E+02	-4.84E+02	-2.98E+03	4.88E+02	-8.27E+01
Jul-21	9.96E+02	-3.84E+02	-3.20E+02	3.28E+02	-3.43E+01
Jan-22	3.76E+02	-7.40E+01	9.50E+02	-1.92E+02	-3.63E+01
Jul-22	-5.44E+02	-5.54E+02	9.60E+02	-6.82E+02	3.97E+01
Jan-23	-2.14E+02	-6.40E+01	1.39E+03	5.80E+01	1.14E+02

X: Mean Value =	1.59E-14	
S: Standard Deviation =	8.34E+02	
K* Factor =	2.292	(for n = 25)
CV = S/X =	5.24E+16	

Conclusion: Since the coefficient of variability is greater than 1, the 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)].

If the coefficient of variation is < 1, the data are normally distributed.
If the coefficient of variation is > or = 1, data are not normally distributed.

Attachment B4: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Determine Equality of Variance of Dataset

p = number of well groups
n_i = number of data points per well
N = total sample size
S^2 = the square of the standard deviation
$\ln(S_i^2)$ = natural logarithm of each variance
f = total sample size minus the number of wells (groups)
$f_i = n_i - 1$
x.. = the sum of the total number of samples
$(x_{avg})_{..}$ = the mean of the total number of samples

$x_{..} =$ 6.11E+04
$(x_{avg})_{..} =$ 2.44E+03

p = 4
N = 25

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$	n_i	$f_iS_i^2$	$f_i\ln(S_i^2)$
5.84E+02	3.41E+05	1.27E+01	10	3.07E+06	1.15E+02
1.78E+03	3.18E+06	1.50E+01	5	1.27E+07	5.99E+01
4.61E+02	2.13E+05	1.23E+01	5	8.51E+05	4.91E+01
7.72E+01	5.96E+03	8.69E+00	5	2.38E+04	3.48E+01

$\sum(S_i^2) =$ 3.74E+06 $\sum f_i\ln(S_i^2) =$ 2.58E+02

Equality of Variance: Bartlett's Test

f = 21
$Sp^2 =$ 7.94E+05
$\ln Sp^2 =$ 1.36E+01
$c^2 =$ 2.69E+01 (If $c^2 \le c^2_{crit}$, then variances are equal at the given significance level).
c^2_{crit} * = 7.81E+00 at a 5% significance level with 3 degrees of freedom

NOTE: The variances are NOT equal. (i.e., $c^2 > c^2_{crit}$)

Variances are not equal, transform the original data to lognormal (i.e., since $c^2 > c^2_{crit}$).

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

Attachment B4: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Lognormal Data for TCE

ln[TCE (µg/L)]					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-21	8.05	7.43	7.87	7.85	4.60
Jul-21	8.06	7.49	8.57	7.79	5.00
Jan-22	7.84	7.65	8.79	7.54	4.98
Jul-22	7.40	7.39	8.79	7.24	5.40
Jan-23	7.58	7.65	8.85	7.67	5.69
Mean x_i	7.79	7.52	8.58	7.62	5.14
Background Mean	7.65		NA	NA	NA
Grand Mean	7.33E+00				
x_i^2	6.47E+01	5.52E+01	6.20E+01	6.16E+01	2.12E+01
	6.50E+01	5.61E+01	7.35E+01	6.06E+01	2.50E+01
These values needed for ANOVA	6.15E+01	5.85E+01	7.72E+01	5.69E+01	2.48E+01
	5.47E+01	5.46E+01	7.73E+01	5.25E+01	2.92E+01
	5.75E+01	5.86E+01	7.84E+01	5.88E+01	3.24E+01
Sum x_i^2	1.38E+03				

µg/L = micrograms per liter

Determine Normality of Dataset

Coefficient of Variability Test

Table of ln[TCE (µg/L)] Data

Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-21	8.05	7.43	7.87	7.85	4.60
Jul-21	8.06	7.49	8.57	7.79	5.00
Jan-22	7.84	7.65	8.79	7.54	4.98
Jul-22	7.40	7.39	8.79	7.24	5.40
Jan-23	7.58	7.65	8.85	7.67	5.69

X: Mean Value =	7.33E+00	
S: Standard Deviation =	1.22E+00	
K* Factor =	2.292	(for n = 25)
CV = S/X =	1.66E-01	<1, data are normally distributed

Data are normally distributed (i.e.,<1)

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

Attachment B4: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Determine Equality of Variance of Dataset for Lognormal Data

p = number of wells (background wells considered as one group)
n_i = number of data points per well
N = total sample size
S^2 = the square of the standard deviation
$\ln(S_i^2)$ = natural logarithm of each variance
f = total sample size minus the number of wells (groups)
$f_i = n_i - 1$
x.. = the sum of the total lognormal dataset
$(x_{avg})_{..}$ = the mean of the lognormal dataset

$x_{..} =$ 1.83E+02
$(x_{avg})_{..} =$ 7.33E+00
$n_i =$ 5
p = 4
N = 25

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$	ni	$f_iS_i^2$	$f_i\ln(S_i^2)$
2.52E-01	6.36E-02	-2.75E+00	10	5.73E-01	-2.48E+01
4.06E-01	1.65E-01	-1.80E+00	5	6.60E-01	-7.21E+00
2.40E-01	5.77E-02	-2.85E+00	5	2.31E-01	-1.14E+01
4.20E-01	1.77E-01	-1.73E+00	5	7.07E-01	-6.93E+00

$\sum(S_i^2) =$ 4.63E-01 $\sum f_i\ln(S_i^2) =$ -5.03E+01

Equality of Variance: Bartlett's Test

f = 21
$Sp^2 =$ 1.03E-01
$\ln Sp^2 =$ -2.27E+00
$c^2 =$ 2.68E+00 (If $c^2 \le c^2_{crit}$, then variances are equal at the given significance level).
c^2_{crit} * = 7.81E+00 at a 5% significance level with 3 degrees of freedom

NOTE: The variances are equal. (i.e., $c^2 \le c^2_{crit}$)

Because variances are equal, the Parametric ANOVA for the lognormal dataset will proceed.

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

**Section 5.2, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989)].

Attachment B4: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Parametric ANOVA

Between Well Sum of Squares[1]

Source of Variation	Sums of Squares	df	Mean Squares	$F_{calculated}$
Between Wells (SS wells)	3.33E+01	3	1.11E+01	1.07E+02
Error within wells (SS error)	2.17E+00	21	1.03E-01	
Total (SS total)	3.55E+01	24		

If $F_{calculated} > F_{tabulated}$, then reject the hypothesis of equal well means. If $F_{calculated}$ is less than or equal to $F_{tabulated}$, it can be concluded that there is no significant difference between concentrations, therefore, there is no evidence of well contamination.

$F_{tabulated}$ = 3.07**

CONCLUSION: $F_{calculated} > F_{tabulated}$; therefore, evidence of well contamination. Additional comparisons must be made.

NOTE: ** Table 2, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* , USEPA, 1989. $F_{tabulated}$ taken at the 5% significance level.

Comparison of Compliance Wells to Background Wells (Bonferroni Test)

n_b =	10	N-p =	21	α =	0.05
$(x_b)_{avg}$ =	7.65E+00	m =	3	1-α/m =	9.83E-01

n_b = total sample size of all background wells

$(x_b)_{avg}$ = average concentration from all background wells

Well No.	Well Mean	Differences of Avg.	Standard Error	Bonferroni's t[2]	D_i	Conclusion
	$(x_b)_{avg}$	$(x_i)_{avg}-(x_b)_{avg}$	SE_i	$t_{(N-p),(\alpha/m)}$		
MW93A						
MW420						
MW84A	8.58E+00	9.22E-01	1.76E-01	2.27	0.40	**evidence of contamination**
MW87A	7.62E+00	-3.52E-02	1.76E-01	2.27	0.40	not contaminated
MW90A	5.14E+00	-2.52E+00	1.76E-01	2.27	0.40	not contaminated

CONCLUSION: **If the "Differences of Averages" is greater than D_i, then the well is contaminated. After performing Bonferroni's t calculation, the following can be concluded: MW84A shows statistically significantly levels of contamination as compared background wells. MW87A and MW90A do not show statistically significant levels of contamination.**

[1]Section 5.2.1, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* , (EPA, 1989).

[2]Appendix B, Table 3 (EPA, 1989).

A 95% UTL comparison is performed.

Attachment B4: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

95% Upper Tolerance Limit (UTL)

Compare the most recent downgradient sample results to a calculated 95% UTL using the five most recent sets of data for each upgradient well, as described below. If downgradient concentration is less than the UTL for the paired upgradient concentrations, then there is no confirmed exceedance.

January 2023 Data, First Reporting Period
TCE Observations (µg/L)

Well No.						
MW93A	3120	3170	2550	1630	1960	Upgradient Well!
MW420	1690	1790	2100	1620	2110	Upgradient Well!
						Current Data
MW84A						7000
	X: Mean Value =		2174			
	S: Standard Deviation =		584			
	K* factor =		2.911	(for n = 10)		
	CV = S/X		0.2686	<1, assume normal distribution		
	Upper Tolerance Interval: TL = X +(KxS) =		**3.87E+03**	(µg/L)		

! = Data from previous 5 sampling events.
CV = coefficient of variation
* = Table 5, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989).

Result: **MW84A exceeded the 95% UTL, which is statistically significant evidence that this compliance well has elevated TCE concentrations with respect to background data.**

Because the 95% UTL indicated a statistically significant difference between compliance test wells and background wells at the C-404 Landfill in compliance well MW84A, the paired ANOVA was performed.

Paired (Parametric) ANOVA - MW93A and MW84A

Evaluate results using paired ANOVA of wells in the same direction relative to the landfill [e.g., compare upgradient westernmost well results to downgradient westernmost well results]. If ANOVA does not identify a statistically significant difference between upgradient and downgradient wells, then the results are consistent with the historical ASD.

TCE (µg/L)				
Date	Background	Compliance		
	MW93A	MW84A	n_i^2	
Jan-21	**3120**	**2630**	9.73E+06	6.92E+06
Jul-21	**3170**	**5290**	1.00E+07	2.80E+07
Jan-22	**2550**	**6560**	6.50E+06	4.30E+07
Jul-22	**1630**	**6570**	2.66E+06	4.32E+07
Jan-23	**1960**	**7000**	3.84E+06	4.90E+07
Sum (x_i)	1.24E+04	2.81E+04	4.05E+04	Total Sum (x..)
n_i	5	5		
$(x_i)_{avg}$	2.49E+03	5.61E+03		
$(x_i)^2$	1.55E+08	7.87E+08		

µg/L = micrograms per liter
Bolded values indicate a detected result.

Overall mean x.. =	4.05E+03	
N =	10	N = the total number of samples
p =	2	p = the number of n_i groups
$x_{..}$ =	4.05E+04	x.. = the sum of the total number of samples

Determine Normality of Dataset

Coefficient of Variability Test

Table of Residuals ($x_i - x_{iavg}$)

Date	Background	Compliance
	MW93A	MW84A
Jan-21	6.34E+02	-2.98E+03
Jul-21	6.84E+02	-3.20E+02
Jan-22	6.40E+01	9.50E+02
Jul-22	-8.56E+02	9.60E+02
Jan-23	-5.26E+02	1.39E+03

X: Mean Value =	0.00E+00	
S: Standard Deviation =	1.27E+03	
K* Factor =	2.911	(for n = 10)
CV = S/X =	#ΔIç/0!	#DIV/0!

†The Coefficient of Variability Test was not performed due to mean = 0 (i.e., division by 0 not possible).

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

If the coefficient of variation is < 1, the data are normally distributed.
If the coefficient of variation is > or = 1, data are not normally distributed.

Attachment B4: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Determine Equality of Variance of Dataset

p = number of wells	$x_{..} =$ 4.05E+04
n_i = number of data points per well	$(x_{avg})_{..} =$ 4.05E+03
N = total sample size	$n_{i} =$ 5
S^2 = the square of the standard deviation	p = 2
$\ln(S_i^2)$ = natural logarithm of each variance	N = 10
f = total sample size minus the number of wells (groups)	f_i = 4
$f_i = n_i - 1$	

Calculations for Equality of Variance: Bartlett's Test

S_i	S_i^2	$\ln(S_i^2)$†	n_i	$f_iS_i^2$	$f_i\ln(S_i^2)$†
6.86E+02	4.71E+05	1.31E+01	5	1.88E+06	5.22E+01
1.78E+03	3.18E+06	1.50E+01	5	1.27E+07	5.99E+01

$\sum(S_i^2) =$ 3.66E+06 $\sum f_i\ln(S_i^2) =$ 1.12E+02

Equality of Variance: Bartlett's Test

f =	8	
Sp^2 =	1.83E+06	
ln Sp^2 =	1.44E+01	
χ^2 =	3.20E+00	(If calculated $\chi^2 \leq$ tabulated χ^2_{crit}, then variances are equal at the given significance level).
χ^2_{crit} * =	3.84E+00	at a 5% significance level with 1 degrees of freedom (p-1)

NOTE: The variances are equal. (i.e., calculated $\chi^2 \leq \chi^2_{crit}$)

Since calculated $\chi^2 \leq \chi^2_{crit}$, then the analysis can proceed as normal.

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

Attachment B4: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Between Well Sum of Squares

Source of Variation	Sums of Squares		Degrees of Freedom	Mean Squares	Calculated F	F Statistic**
Between Wells	SS_{wells} =	2.44E+07	1	2.44E+07	1.33E+01	5.32E+00
Error	SS_{Error} =	1.46E+07	8	1.83E+06		
Total	SS_{Total} =	3.90E+07	9			

If calculated F > F statistic, then reject the hypothesis of equal well means. If calculated F is less than or equal to F statistic, it can be concluded that there is no significant difference between concentrations; therefore, there is no evidence of well contamination.

CONCLUSION: **Calculated F > F statistic; therefore, ANOVA has identified a significant difference between upgradient and downgradient wells.**

Mann-Kendall trend analysis was performed.

**Table 2, Appendix B, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance* (EPA 1989). F statistic taken at the 5% significance level.

Attachment B4: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Mann-Kendall Trend Test Analysis
MW84A Trichloroethene January 2023

Mann-Kendall Trend Test Analysis

User Selected Options	
Date/Time of Computation	ProUCL 5.13/29/2023 4:09:40 PM
From File	WorkSheet_b.xls
Full Precision	OFF
Confidence Coefficient	0.95
Level of Significance	0.05

Input Data	
Date Collected	Result (µg/L)
Jul-19	**2000**
Jan-20	**2930**
Jul-20	**3230**
Jan-21	**2630**
Jul-21	**5290**
Jan-22	**6560**
Jul-22	**6570**
Jan-23	**7000**

Bolded values indicate a detected result.

MW84A_TCE_2023-1

General Statistics

Number or Reported Events Not Used	0
Number of Generated Events	8
Number Values Reported (n)	8
Minimum	2000
Maximum	7000
Mean	4526
Geometric Mean	4097
Median	4260
Standard Deviation	2043
Coefficient of Variation	0.451

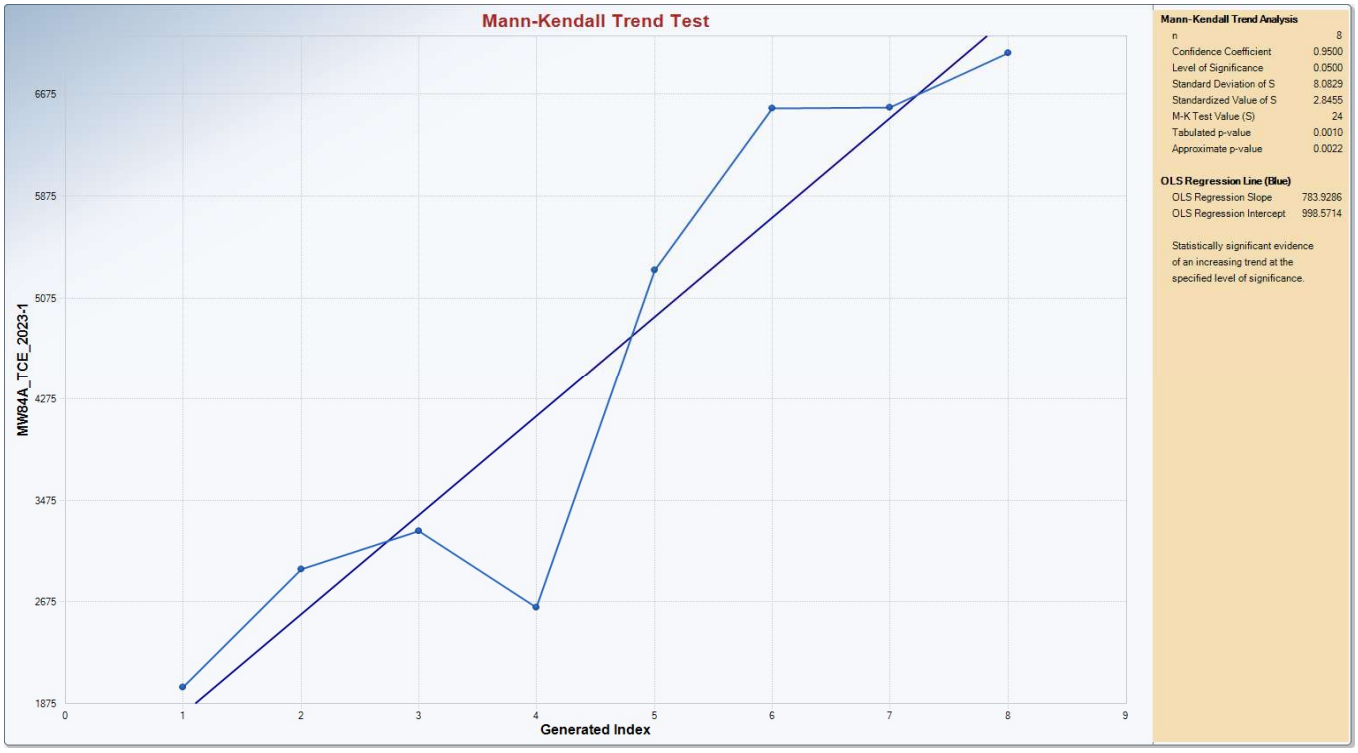
Mann-Kendall Test

M-K Test Value (S)	24
Tabulated p-value	0.001
Standard Deviation of S	8.083
Standardized Value of S	2.846
Approximate p-value	0.00222

Statistically significant evidence of an increasing trend at the specified level of significance.

Attachment B4: Trichloroethene URGA, Statistical Test 4, Parametric ANOVA, First Reporting Period 2023

Mann-Kendall Trend Test Analysis
MW84A Trichloroethene January 2023



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ATTACHMENT B5

URANIUM
STATISTICAL TEST 2

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Attachment B5: Uranium URGA, Statistical Test 2, Test of Proportions, First Reporting Period 2023

Uranium (mg/L)					
Date	Background	Background	Compliance	Compliance	Compliance
	MW93A	MW420	MW84A	MW87A	MW90A
Jan-21	**0.0001**	0.0001	**0.000156**	0.0001	0.0001
Jul-21	**0.000079**	0.0001	0.0001	0.0001	0.0001
Jan-22	**0.000126**	0.0001	0.0001	0.0001	0.0001
Jul-22	**0.000076**	0.0001	**0.000068**	0.0001	0.0001
Jan-23	0.0001	0.0001	0.0001	0.0001	0.0001

mg/L = milligrams per liter
BG = background
DL = detection limit
Nondetect values are 1/2 DL.
Bolded values indicate a detected result.

[!] **Test 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 =	2	Y = number of samples above DL in compliance wells
n_b =	10	n_b = count of background well results/samples analyzed
n_c =	15	n_c = count of compliance well results/samples analyzed
n =	25	n = total number of samples

P =	0.240	P=(x+y)/n
nP =	6	$n=n_b+n_c$
n(1-P) =	19	

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

P_b =	4.00E-01	P_b = proportion of detects in background wells
P_c =	1.33E-01	P_c = proportion of detects in compliance wells
S_D =	1.74E-01	S_D = standard error of difference in proportions
Z =	1.529	$Z = (P_b-P_c)/S_D$
absolute value of Z =	1.529	

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.**

[!] 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

STATISTICIAN STATEMENT

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FOUR RIVERS
NUCLEAR PARTNERSHIP, LLC

Four Rivers Nuclear Partnership, LLC
5511 Hobbs Road
Kevil, KY 42053
www.fourriversnuclearpartnership.com

April 17, 2023

Mr. Dennis Greene
Four Rivers Nuclear Partnership, LLC
5511 Hobbs Road
Kevil, KY 42053

Dear Mr. Greene:

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

As an Environmental Scientist, with a bachelor's degree in Earth Sciences/Geology, I have over 30 years of experience in reviewing and assessing laboratory analytical results associated with environmental sampling and investigation activities.

For this project, the statistical analyses on groundwater data from January 2021 through January 2023 were performed in accordance with the Hazardous Waste Management Facility Permit, Appendix E using Microsoft Excel 2016 and U.S. Environmental Protection Agency's (EPA's) ProUCL 5.1. The spreadsheets include the results for the following statistical tests:

- Test of Proportions
- Parametric Analysis of Variance (ANOVA)
- Nonparametric ANOVA
- 95% Upper Tolerance Limit
- Paired (parametric) ANOVA
- Paired (nonparametric) ANOVA
- Mann-Kendall

The statistical analyses procedures were based on EPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Interim Final Guidance* (1989).

Sincerely,

Bryan Smith

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APPENDIX C

C-404 HAZARDOUS WASTE LANDFILL LEACHATE ANALYTICAL RESULTS

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Paducah OREIS Report for 404L23-01

L1404L1-23 from: C404L on 2/9/2023 Media: WW SmpMethod: GR

Comments: Water is 4.18' from ground surface. CB 2-9-23

Analysis	Results	Units	Result Qual	Foot Note	Reporting Limit	Counting Error	TPU**	Method	LabCode	V/V/A*
ANION										
Fluoride	6.9	mg/L			4			SW846-9056	GEL	I / X /
FS										
Conductivity	0.549	umho/cm						FS	FS	/ /
Dissolved Oxygen	10.23	mg/L						FS	FS	/ /
Oxidation Reduction Potential	-173.1	mV						FS	FS	/ /
pH	8.09	Std Unit						FS	FS	/ /
Temperature	54.6	deg F						FS	FS	/ /
METAL										
Arsenic	0.00236	mg/L	J		0.005			SW846-6020B	GEL	/ X /
Barium	0.0808	mg/L			0.004			SW846-6020B	GEL	/ X /
Cadmium	0.001	mg/L	U		0.001			SW846-6020B	GEL	/ X /
Chromium	0.01	mg/L	U		0.01			SW846-6020B	GEL	/ X /
Copper	0.00808	mg/L			0.002			SW846-6020B	GEL	/ X /
Iron	0.0603	mg/L	J		0.1			SW846-6020B	GEL	/ X /
Lead	0.002	mg/L	U		0.002			SW846-6020B	GEL	/ X /
Mercury	0.0002	mg/L	U		0.0002			SW846-7470A	GEL	/ X /
Nickel	0.00383	mg/L			0.002			SW846-6020B	GEL	/ X /
Selenium	0.005	mg/L	U		0.005			SW846-6020B	GEL	/ X /
Silver	0.001	mg/L	U		0.001			SW846-6020B	GEL	/ X /
Uranium	57.8	mg/L			0.2			SW846-6020B	GEL	I / X /
Zinc	0.02	mg/L	U		0.02			SW846-6020B	GEL	/ X /
PPCB										
PCB-1016	0.1	ug/L	U		0.1			SW846-8082A	GEL	/ X /
PCB-1221	0.1	ug/L	U		0.1			SW846-8082A	GEL	/ X /
PCB-1232	0.1	ug/L	U		0.1			SW846-8082A	GEL	/ X /
PCB-1242	0.1	ug/L	U		0.1			SW846-8082A	GEL	/ X /
PCB-1248	1.01	ug/L			0.1			SW846-8082A	GEL	/ X /
PCB-1254	0.403	ug/L			0.1			SW846-8082A	GEL	/ X /
PCB-1260	0.0752	ug/L	J		0.1			SW846-8082A	GEL	/ X /
Polychlorinated biphenyl	1.49	ug/L			0.1			SW846-8082A	GEL	I / X /
RADS										
Cesium-137	0.381	pCi/L	U		11	5.91	5.91	EPA-901.1	GEL	/ X /
Neptunium-237	2.85	pCi/L			1.86	2.09	2.14	ASTM-1475-00M	GEL	/ X /
Plutonium-239/240	0.35	pCi/L	U		1.13	0.696	0.697	HASL 300, Pu-11-RC M	GEL	/ X /
Technetium-99	284	pCi/L			18.8	17.1	36.2	HASL 300, Tc-02-RC M	GEL	/ X /
Thorium-230	0.859	pCi/L	U		1.67	1.13	1.14	HASL 300, Th-01-RC M	GEL	/ X /
Uranium-234	1890	pCi/L			61.5	196	308	HASL 300, U-02-RC M	GEL	/ X /
Uranium-235	294	pCi/L			19.2	86.9	94.4	HASL 300, U-02-RC M	GEL	/ X /
Uranium-238	20100	pCi/L			15.5	633	2590	HASL 300, U-02-RC M	GEL	/ X /
VOA										
Trichloroethene	1	ug/L	U		1			SW846-8260D	GEL	/ X /
WETCHEM										
Ammonia as Nitrogen	0.127	mg/L	B		0.05			EPA-350.1	GEL	/ X / J, FDUP-OU

*Verification/Validation/Assessment ** TPUs reported at 1.96 sigma

Paducah OREIS Report for 404L23-01

L1404LD1-23 from: C404L on 2/9/2023 Media: WW SmpMethod: GR

Comments: Water is 4.18' from ground surface. CB 2-9-23

Analysis	Results	Units	Result Qual	Foot Note	Reporting Limit	Counting Error	TPU**	Method	LabCode	V/V/A*
ANION										
Fluoride	7.03	mg/L			4			SW846-9056	GEL	I / X /
METAL										
Arsenic	0.00243	mg/L	J		0.005			SW846-6020B	GEL	/ X /
Barium	0.0808	mg/L			0.004			SW846-6020B	GEL	/ X /
Cadmium	0.001	mg/L	U		0.001			SW846-6020B	GEL	/ X /
Chromium	0.01	mg/L	U		0.01			SW846-6020B	GEL	/ X /
Copper	0.00851	mg/L			0.002			SW846-6020B	GEL	/ X /
Iron	0.0634	mg/L	J		0.1			SW846-6020B	GEL	/ X /
Lead	0.002	mg/L	U		0.002			SW846-6020B	GEL	/ X /
Mercury	0.0002	mg/L	U		0.0002			SW846-7470A	GEL	/ X /
Nickel	0.00367	mg/L			0.002			SW846-6020B	GEL	/ X /
Selenium	0.005	mg/L	U		0.005			SW846-6020B	GEL	/ X /
Silver	0.001	mg/L	U		0.001			SW846-6020B	GEL	/ X /
Uranium	58.8	mg/L			0.2			SW846-6020B	GEL	I / X /
Zinc	0.02	mg/L	U		0.02			SW846-6020B	GEL	/ X /
PPCB										
PCB-1016	0.102	ug/L	U		0.102			SW846-8082A	GEL	/ X /
PCB-1221	0.102	ug/L	U		0.102			SW846-8082A	GEL	/ X /
PCB-1232	0.102	ug/L	U		0.102			SW846-8082A	GEL	/ X /
PCB-1242	0.102	ug/L	U		0.102			SW846-8082A	GEL	/ X /
PCB-1248	0.943	ug/L			0.102			SW846-8082A	GEL	/ X /
PCB-1254	0.345	ug/L			0.102			SW846-8082A	GEL	/ X /
PCB-1260	0.0526	ug/L	J		0.102			SW846-8082A	GEL	/ X /
Polychlorinated biphenyl	1.34	ug/L			0.102			SW846-8082A	GEL	I / X /
RADS										
Cesium-137	-1.15	pCi/L	U		10.3	6.06	6.08	EPA-901.1	GEL	/ X /
Neptunium-237	1.37	pCi/L	U		2.38	1.63	1.64	ASTM-1475-00M	GEL	/ X /
Plutonium-239/240	0.134	pCi/L	U		0.849	0.458	0.458	HASL 300, Pu-11-RC M	GEL	/ X /
Technetium-99	289	pCi/L			17.6	16.4	36.4	HASL 300, Tc-02-RC M	GEL	/ X /
Thorium-230	1.5	pCi/L	U		1.58	1.25	1.27	HASL 300, Th-01-RC M	GEL	/ X /
Uranium-234	1650	pCi/L			63.5	155	241	HASL 300, U-02-RC M	GEL	/ X /
Uranium-235	240	pCi/L			13.4	65.3	70.6	HASL 300, U-02-RC M	GEL	/ X /
Uranium-238	19400	pCi/L			10.8	519	2230	HASL 300, U-02-RC M	GEL	/ X /
VOA										
Trichloroethene	1	ug/L	U		1			SW846-8260D	GEL	/ X /
WETCHEM										
Ammonia as Nitrogen	0.048	mg/L	BJ		0.05			EPA-350.1	GEL	S / X / J, FDUP-OU

*Verification/Validation/Assessment ** TPUs reported at 1.96 sigma

Paducah OREIS Report for 404L23-01

FB404L1-23 from: QC on 2/9/2023 Media: WQ SmpMethod:

Comments:

Analysis	Results	Units	Result Qual	Foot Note	Reporting Limit	Counting Error	TPU**	Method	LabCode	V/V/A*
ANION										
Fluoride	0.526	mg/L	J		4			SW846-9056	GEL	/X/
METAL										
Arsenic	0.005	mg/L	U		0.005			SW846-6020B	GEL	/X/
Barium	0.004	mg/L	U		0.004			SW846-6020B	GEL	/X/
Cadmium	0.001	mg/L	U		0.001			SW846-6020B	GEL	/X/
Chromium	0.01	mg/L	U		0.01			SW846-6020B	GEL	/X/
Copper	0.002	mg/L	U		0.002			SW846-6020B	GEL	/X/
Iron	0.1	mg/L	U		0.1			SW846-6020B	GEL	/X/
Lead	0.002	mg/L	U		0.002			SW846-6020B	GEL	/X/
Mercury	0.0002	mg/L	U		0.0002			SW846-7470A	GEL	/X/
Nickel	0.002	mg/L	U		0.002			SW846-6020B	GEL	/X/
Selenium	0.005	mg/L	U		0.005			SW846-6020B	GEL	/X/
Silver	0.001	mg/L	U		0.001			SW846-6020B	GEL	/X/
Uranium	0.000104	mg/L	J		0.0002			SW846-6020B	GEL	/X/
Zinc	0.02	mg/L	U		0.02			SW846-6020B	GEL	/X/
PPCB										
PCB-1016	0.107	ug/L	U		0.107			SW846-8082A	GEL	/X/
PCB-1221	0.107	ug/L	U		0.107			SW846-8082A	GEL	/X/
PCB-1232	0.107	ug/L	U		0.107			SW846-8082A	GEL	/X/
PCB-1242	0.107	ug/L	U		0.107			SW846-8082A	GEL	/X/
PCB-1248	0.107	ug/L	U		0.107			SW846-8082A	GEL	/X/
PCB-1254	0.107	ug/L	U		0.107			SW846-8082A	GEL	/X/
PCB-1260	0.107	ug/L	U		0.107			SW846-8082A	GEL	/X/
Polychlorinated biphenyl	0.107	ug/L	U		0.107			SW846-8082A	GEL	/X/
RADS										
Cesium-137	-1.17	pCi/L	U		6.68	3.69	3.73	EPA-901.1	GEL	/X/
Neptunium-237	-0.481	pCi/L	U		2.27	0.663	0.664	ASTM-1475-00M	GEL	/X/
Plutonium-239/240	0.136	pCi/L	U		0.407	0.381	0.382	HASL 300, Pu-11-RC M	GEL	/X/
Technetium-99	-0.304	pCi/L	U		18.3	10.6	10.6	HASL 300, Tc-02-RC M	GEL	/X/
Thorium-230	0.148	pCi/L	U		1.69	0.836	0.839	HASL 300, Th-01-RC M	GEL	/X/
Uranium-234	1.01	pCi/L	U		2.3	1.46	1.48	HASL 300, U-02-RC M	GEL	/X/
Uranium-235	0.257	pCi/L	U		1.62	0.963	0.964	HASL 300, U-02-RC M	GEL	/X/
Uranium-238	0.415	pCi/L	U		1.51	0.954	0.956	HASL 300, U-02-RC M	GEL	/X/
VOA										
Trichloroethene	1	ug/L	U		1			SW846-8260D	GEL	/X/
WETCHEM										
Ammonia as Nitrogen	0.025	mg/L	BJ		0.05			EPA-350.1	GEL	/X/

*Verification/Validation/Assessment ** TPUs reported at 1.96 sigma

Paducah OREIS Report for 404L23-01

RI404L1-23 from: QC on 2/9/2023 Media: WQ SmpMethod:

Comments:

Analysis	Results	Units	Result Qual	Foot Note	Reporting Limit	Counting Error	TPU**	Method	LabCode	V/V/A*
ANION										
Fluoride	4	mg/L	U		4			SW846-9056	GEL	/X/
METAL										
Arsenic	0.005	mg/L	U		0.005			SW846-6020B	GEL	/X/
Barium	0.004	mg/L	U		0.004			SW846-6020B	GEL	/X/
Cadmium	0.001	mg/L	U		0.001			SW846-6020B	GEL	/X/
Chromium	0.01	mg/L	U		0.01			SW846-6020B	GEL	/X/
Copper	0.002	mg/L	U		0.002			SW846-6020B	GEL	/X/
Iron	0.1	mg/L	U		0.1			SW846-6020B	GEL	/X/
Lead	0.002	mg/L	U		0.002			SW846-6020B	GEL	/X/
Mercury	0.0002	mg/L	U		0.0002			SW846-7470A	GEL	/X/
Nickel	0.002	mg/L	U		0.002			SW846-6020B	GEL	/X/
Selenium	0.005	mg/L	U		0.005			SW846-6020B	GEL	/X/
Silver	0.001	mg/L	U		0.001			SW846-6020B	GEL	/X/
Uranium	0.0002	mg/L	U		0.0002			SW846-6020B	GEL	/X/
Zinc	0.02	mg/L	U		0.02			SW846-6020B	GEL	/X/
PPCB										
PCB-1016	0.1	ug/L	U		0.1			SW846-8082A	GEL	/X/
PCB-1221	0.1	ug/L	U		0.1			SW846-8082A	GEL	/X/
PCB-1232	0.1	ug/L	U		0.1			SW846-8082A	GEL	/X/
PCB-1242	0.1	ug/L	U		0.1			SW846-8082A	GEL	/X/
PCB-1248	0.1	ug/L	U		0.1			SW846-8082A	GEL	/X/
PCB-1254	0.1	ug/L	U		0.1			SW846-8082A	GEL	/X/
PCB-1260	0.1	ug/L	U		0.1			SW846-8082A	GEL	/X/
Polychlorinated biphenyl	0.1	ug/L	U		0.1			SW846-8082A	GEL	/X/
RADS										
Cesium-137	-6.17	pCi/L	U		7.87	5.16	5.89	EPA-901.1	GEL	/X/
Neptunium-237	-0.0851	pCi/L	U		1.86	0.769	0.769	ASTM-1475-00M	GEL	/X/
Plutonium-239/240	0.131	pCi/L	U		0.828	0.492	0.493	HASL 300, Pu-11-RC M	GEL	/X/
Technetium-99	-6.24	pCi/L	U		18.4	10.5	10.5	HASL 300, Tc-02-RC M	GEL	/X/
Thorium-230	-0.202	pCi/L	U		1.97	0.795	0.796	HASL 300, Th-01-RC M	GEL	/X/
Uranium-234	-0.55	pCi/L	U		1.43	0.662	0.662	HASL 300, U-02-RC M	GEL	/X/
Uranium-235	0.395	pCi/L	U		0.756	0.513	0.515	HASL 300, U-02-RC M	GEL	/X/
Uranium-238	0	pCi/L	U		0.856	0.434	0.434	HASL 300, U-02-RC M	GEL	/X/
VOA										
Trichloroethene	1	ug/L	U		1			SW846-8260D	GEL	/X/
WETCHEM										
Ammonia as Nitrogen	0.0292	mg/L	BJ		0.05			EPA-350.1	GEL	/X/

TB404L1-23 from: QC on 2/9/2023 Media: WQ SmpMethod:

Comments:

Analysis	Results	Units	Result Qual	Foot Note	Reporting Limit	Counting Error	TPU**	Method	LabCode	V/V/A*
VOA										
Trichloroethene	1	ug/L	U		1			SW846-8260D	GEL	/X/

*Verification/Validation/Assessment ** TPUs reported at 1.96 sigma