environmental
properties management, LLC

January 31, 2020

Mr. Ken Kalman
U.S. Nuclear Regulatory Commission
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Rockville, MD 20852-2738

Mr. Paul Davis
Oklahoma Department of Environmental Quality
707 North Robinson
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Mr. Robert Evans
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Re: Docket No. 70-925; License No. SNM-928
Tc-99 Groundwater Assessment Report

Dear Sirs:

Solely as Trustee for the Cimarron Environmental Response Trust (CERT), Environmental Properties Management LLC (EPM) submits herein a technical memorandum discussing the assessment of technetium-99 (Tc-99) in groundwater at the Cimarron Site.

In 1996, the licensee at the time performed an investigation to identify the source of elevated beta concentrations in groundwater. Tc-99 was identified as a contaminant in groundwater as a result of that investigation, and analysis of groundwater samples (from specific locations) for Tc-99 was added to the annual environmental monitoring program.

A more expansive groundwater sampling effort, providing for analysis for Tc-99 was conducted in 2003; the results of that investigation were reported in *Draft Technitium-99 Groundwater Assessment Report*[1]. The purpose of that groundwater assessment was to identify the maximum concentration of Tc-99 in groundwater to determine whether groundwater remediation was required to reduce the concentration of Tc-99 in groundwater. As a result of that assessment, the NRC agreed that the decommissioning plan would not need to provide for the remediation of Tc-99.

Analysis of groundwater samples for Tc-99 was removed from the annual environmental monitoring program in 2009. In 2012, the NRC and EPM split groundwater samples from four locations for independent analysis for Tc-99. In a letter dated April 22, 2013, the NRC formalized its decision that "Tc-99 will not have to be addressed in the groundwater remediation

[1] Chase Environmental Group, December 2003

plan." That letter did require that analysis of groundwater samples for Tc-99 be included in the post-remediation monitoring program.

In 2019, it was determined that, regardless of whether remediation plans for groundwater need to provide for the removal of Tc-99 from groundwater, Tc-99 will nevertheless be recovered in groundwater and be discharged to surface water and/or captured by ion exchange resin or bioreactor solids. A relatively comprehensive assessment of Tc-99 concentrations in groundwater was needed to enable groundwater remediation design personnel to estimate the concentration of Tc-99 that will be in the influent to the groundwater treatment system. Therefore, data needed to be obtained for all the remediation areas from which groundwater will be recovered for treatment.

EPM retained Burns & McDonnell to evaluate Tc-99 based on the planned treatment process, employing the same methodology to estimate the concentration of Tc-99 in influent to the treatment system that was used for uranium and nitrate. The data set obtained during the 2019 sampling event is the only data set that provides sufficient quality data for wells located in all remediation areas. Consequently, instead of calculating "representative concentrations" for Tc-99 at each monitor well, the results obtained from the 2019 samples was considered the "representative concentrations".

EPM had previously notified the NRC and the DEQ that based on historic data, the initial concentration of Tc-99 in the influent to the treatment system was estimated to be 446 picoCuries per liter (pCi/L). 446 pCi/L is slightly over half of the primary drinking water standard of 900 pCi/L. Using this more robust data set, the initial concentration of Tc-99 in the influent to the treatment system is now estimated to be approximately 102 pCi/L, or approximately 11% of the primary drinking water standard.

As previously discussed with the NRC and the DEQ, even if groundwater treatment systems did not remove ***any*** Tc-99 from recovered groundwater, the concentration of Tc-99 in the influent is so low that the water could be reinjected and/or discharged with no impact to State permits. However, it is possible that the ion exchange resin will remove most if not all of the Tc-99 from the groundwater, and the biomass generated by the biodenitrification process may remove some if not all of the Tc-99 in the influent coming from the ion exchange system to the nitrate treatment system.

In addition, analytical results for some historic samples included estimated Tc-99 concentrations exceeding 200 picoCuries per liter (pCi/L) in the eastern portion (Burial Area #1) of the site, but the detection limit in the database was 300 pCi/L. Because the source of Tc-99 to groundwater

was the liquid waste streams sent to Uranium Ponds #1 and #2, Tc-99 should not be present in groundwater migrating from Burial Area #1. Therefore, additional samples were collected from monitor wells in Burial Area #1 during the 2019 sampling event to definitively determine whether Tc-99 is present in groundwater in this portion of the site.

Tc-99 was not detected in any of the 13 samples collected from monitor wells in Burial Area #1 during the 2019 monitoring event. This conclusively demonstrates that Tc-99 is not present in groundwater in Burial Area #1.

If you have questions or comments related to this Tc-99 groundwater assessment memorandum, please contact me at 405-641-5152 or at jlux@envpm.com.

Sincerely,

Jeff Lux, P.E.
Trustee Project Manager

Attachment

cc: Michael Broderick, Oklahoma Department of Environmental Quality (electronic copy only)
NRC Public Document Room (electronic copy only)

ATTACHMENT 1

BURNS & McDONNELL ENGINEERING COMPANY

TECHNICAL MEMORANDUM BMCD-GWREMED-TM005

TECHNITIUM-99 GROUNDWATER ASSESSMENT

Memorandum

BURNS McDONNELL

Document No.: BMCD-GWREMED-TM005

Revision: A

Date: January 30, 2020

To: Jeff Lux, EPM

From: John Hesemann, Burns & McDonnell
Emily Ahlemeyer, Burns & McDonnell

Subject: Technetium-99 Groundwater Assessment

This Technetium-99 Groundwater Assessment has been developed to support remediation design activities and the potential revision of a Decommissioning Plan (D-Plan) for the Cimarron Environmental Response Trust (CERT) remediation project at the Cimarron Site located in Guthrie, Oklahoma (Site). The technetium-99 (Tc-99) groundwater concentration data required to conduct this assessment were obtained during a sampling event conducted in 2019. These data were used to assess the nature and extent of Tc-99 in groundwater at the Site, and to estimate influent Tc-99 concentrations for the Western Area (WA) groundwater treatment system planned for the Site. During the 2019 monitoring event, Tc-99 was not detected in any groundwater samples collected in Burial Area 1 (BA1) at the Site. As a result, BA1 is not discussed in the evaluation presented herein.

The methods used to evaluate the distribution of Tc-99 in WA groundwater and estimate influent Tc-99 concentrations for the WA Treatment Facility (WATF) were similar to those previously used to evaluate contaminant distribution and influent concentrations for uranium, nitrate, and fluoride, as described in the 2018 *Basis of Design for Groundwater Remediation* Technical Memorandum (2018 Basis of Design).[1] The 2019 Tc-99 groundwater analytical results are considered "representative concentrations" for the purposes of this evaluation. The historical Tc-99 groundwater dataset was not used in this evaluation due to issues related the quality, quantity, and distribution of the data.

1.0 Tc-99 Groundwater Data Review

A review of laboratory analytical results for groundwater samples collected during monitoring events conducted in 2019 was performed in accordance with the United States Environmental Protection Agency's *National Functional Guidelines for Inorganics Superfund Methods Data*

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[1] Burns & McDonnell Engineering Company, Inc. (2018). *Basis of Design for Groundwater Remediation* (BMCD-GWREMED-TM001 Rev. C). Kansas City: Hesemann.

Review.[2] The review was performed to assess the validity of the laboratory data. Tc-99 activity concentration data were rejected as a result of the analytical data review for the following WA monitor wells: T-79, 1348, 1395, 1396, 1337, and 1319B-2. Tc-99 activity concentration data were rejected for the following BA1 monitor wells: 1314, TMW-08, 02W06, 02W44, TMW-13, and TMW-24. The Tc-99 activity concentration result was also rejected for the surface water sample 1201 (Upstream). The primary cause for the rejection of Tc-99 activity concentration data was a negative activity concentration result; Tc-99 concentrations cannot be negative. All rejected data were qualified as not detected above the minimum detectable concentration (MDC). The Tc-99 activity concentration data are included as Attachment 1.0.

The Tc-99 activity concentrations were converted to mass concentrations using specific activity to maintain consistency with the tables and figures presented in the 2018 Basis of Design.[1] The specific activity of Tc-99 is 0.017 curies per gram (Ci/g), equivalent to 0.059 nanograms per picocurie (ng/pCi).[3]

2.0 Tc-99 Isopleth Map Generation

Uranium, nitrate, and fluoride isopleth groundwater concentration plots for the BA1 and WA remediation areas were previously generated using the Surfer® software application developed by Golden Software.[1] Due to limitations in the spatial distribution of Tc-99 groundwater data in the WA, Surfer® was not used to develop the Tc-99 isopleth maps.

The Tc-99 isopleths were manually created using concentration data obtained from WA groundwater sample results, knowledge of historical site features (i.e., storage ponds, drainage channels, topography, etc.), and observed groundwater flow direction. Tc-99 groundwater concentrations for wells screened within Sandstone A (SSA) were used to develop a formation-specific isopleth map. Groundwater concentrations for wells screened within Sandstone B (SSB), transition zone, and alluvial formations were used to develop a separate Tc-99 isopleth map for the hydrostratigraphic unit comprised of these three aquifer formations. Copies of the WA isopleth maps are included as Attachment 2.0.

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[2] United States Environmental Protection Agency. (2017). *National Functional Guidelines for Inorganics Superfund Methods Data Review* (EPA-540-R-201 7-001). Office of Superfund Remediation and Technology Innovation. Washington, DC.

[3] 49 C.F.R. §173.435 Table of A1 and A2 Values for Radionuclides.

3.0 Remediation Area and Pore Volume Estimates

The WA consists of 11 individual remediation areas: WAA-BLUFF, WAA-EAST, WAA-WEST, WAA U>DCGL, 1206-NORTH, WU-1348, WU-PBA, WU-BA3, WU-UP1, WU-UP2-SSA, and WU-UP2-SSB (see figures provided in Attachment 3.0). Remediation areas were established based on uranium, nitrate, and fluoride concentrations and zones of hydraulic influence associated with groundwater extraction or treated water injection. Zones of hydraulic influence for remediation extraction and injection components were established by particle tracking analyses conducted using the 2018 groundwater flow model, as discussed in the 2018 Basis of Design.[1]

Pore volume, calculated by multiplying the aquifer volume targeted for remediation by effective porosity, is one of the input parameters required for estimating Tc-99 influent concentrations over the course of WATF operation. As described in the 2018 Basis of Design, the targeted aquifer volume was calculated, for most remediation areas, by multiplying the lateral extent of each remediation area by saturated thickness. Three-dimensional visualization (3DV) modeling was used to calculate the aquifer volume for remediation areas with variable saturated thicknesses, as discussed in the 2018 Basis of Design.[1]

Depending on the location, the remediation areas were developed based on:

- The extent of the extraction component(s) approximate hydraulic capture zone within which uranium concentrations are at or above 30 µg/L and – for WA areas only – nitrate concentrations are at or above 10 mg/L; and/or
- The approximate hydraulic zone of influence associated with injection component(s).

Tc-99 concentrations were not considered in remediation area development because Tc-99 is not being targeted for remediation at the Site. In addition, the Tc-99 remediation impacts delineated by the 10 nanogram per liter (ng/L) isopleths presented on the maps included in Attachment 2.0 are contained within the original remediation areas. Consequently, the remediation areas described in the 2018 Basis of Design, and the corresponding calculated pore volumes, were not altered for the purposes of estimating Tc-99 influent concentrations over the course of WATF operation.

4.0 Area-Weighted Influent Tc-99 Concentration Estimates

Figures included in Attachment 3.0 illustrate the remediation areas described in Section 3.0, the remediation component locations, and the extent of Tc-99 groundwater impacts. As shown in Attachment 3.0A, Tc-99 groundwater impacts in SSA are limited to a portion of the WU-UP1

remediation area and a portion of the WU-UP2-SSA remediation area. As shown in Attachment 3.0B, Tc-99 groundwater impacts within the hydrostratigraphic unit comprised of SSB, transition zone, and alluvium formations are limited to the WU-UP2-SSB remediation area, portions of the WAA-BLUFF and WAA U>DCGL remediation areas, and portions of the SSB formation underlying the WU-UP1 and WU-UP2-SSA remediation area.

Tc-99 concentrations in groundwater recovered by some groundwater extraction components are expected to increase after remediation begins in the WA, as groundwater with higher Tc-99 concentrations is drawn toward extraction components. Tc-99 concentrations are expected to increase above the initial concentration for the following components:

- GE-WAA-03 – this alluvial extraction well is currently located outside the extent of Tc-99 impacts; however, this well is expected to capture a portion of the SSB-transition zone-alluvium Tc-99 plume (see Attachment 3.0B). For influent concentration modeling purposes, the Tc-99 concentration at this well is assumed to increase from 0 to 11 ng/L, based on the area-weighted concentration averaging described below.
- GE-WAA-11 – the estimated initial Tc-99 concentration at this well is 14 ng/L; however, the Tc-99 concentration at this well is expected to increase as higher concentrations within the SSB-transition zone-alluvium Tc-99 plume, located to the southwest, are drawn toward this well (see Attachment 3.0B). For influent concentration modeling purposes, the Tc-99 concentration at this well is assumed to increase to approximately 23.94 ng/L, based on the area-weighted concentration averaging described below.

The future Tc-99 concentration increases for the wells listed above were estimated by conducting incremental, area-weighted concentration averaging within the SSB-transition zone-alluvium Tc-99 plume areas captured by the respective extraction components. The resulting area-weighted average concentrations were then used to represent future Tc-99 concentration increases at GE-WAA-03 and GE-WAA-11. The results of SSB-transition zone-alluvium Tc-99 plume concentration averaging were also used to calculate future maximum Tc-99 concentrations for other extraction wells expected to capture Tc-99 impacted groundwater (i.e., GE-WAA-06 through GE-WAA-10). The future maximum Tc-99 concentrations for these wells do not exceed the respective initial concentrations; however, they were used in the WATF influent Tc-99 concentration flow rate-weighted averaging and concentration decay modeling described in Section 5.0.

Area-weighted concentration averaging was also conducted for the SSA plume in the WU-UP1 and WU-UP2-SSA remediation areas located upgradient of GE-WAA-03 and GE-WAA-06

through GE-WAA-11. However, the resulting concentrations were less than those calculated for the SSB-transition zone-alluvium plume areas; therefore, area-weighted average concentrations for the SSA plume were not used in the WATF influent Tc-99 concentration flow rate-weighted averaging and concentration decay modeling described in Section 5.0.

The areas developed for concentration averaging within the SSA and SSB-transition zone-alluvium Tc-99 plumes are illustrated on figures included in Attachment 4.0. As shown on these figures (Attachments 4.0A and 4.0B) and the area-weighted averaging results presented in Attachment 4.0C, Tc-99 isopleths developed for SSA and SSB-transition zone-alluvium Tc-99 plumes (see Section 2.0) were used to conduct the area-weighted concentration averaging. For GE-WAA-03 and GE-WAA-06 through GE-WAA-11, future maximum Tc-99 concentrations were estimated by conducting area-weighted concentration averaging within the approximate SSB-transition zone-alluvium extraction capture zones for these wells (see Attachment 4.0B and 4.0C).

Results from the area-weighted averaging analysis completed for each applicable remediation area and groundwater extraction component are presented in Attachment 4.0C. Calculation files in native (MS Excel®) format can be provided to facilitate review of calculation methods (i.e., formulas, references, inputs, etc.) by Nuclear Regulatory Commission (NRC) and Oklahoma Department of Environmental Quality (DEQ) personnel.

5.0 Tc-99 Influent Concentration Estimates

The estimated concentration of Tc-99 in WATF influent was calculated to support treatment system design and assess the impact of Tc-99 on treatment process waste characteristics. A detailed description of the processes used to estimate treatment system influent Tc-99 concentrations is provided below.

5.1 As discussed in Section 4.0, future maximum Tc-99 influent concentrations are anticipated to be higher than initial concentrations for wells GE-WAA-03 and GE-WAA-11, while future maximum Tc-99 influent concentrations are anticipated to be lower than initial concentrations for all other wells capturing Tc-99-impacted groundwater (GE-WAA-06 through GE-WAA-10). Because Tc-99 concentrations are expected to increase in groundwater captured by extraction wells located in both groundwater extraction areas impacted by Tc-99 (GE-WAA-11 in the WAA-BLUFF area and GE-WAA-03 in the WAA U>DCGL area), initial (i.e., time zero) influent Tc-99 concentrations (C_0) and future maximum (i.e., time "t") influent Tc-99 concentrations (C_t) were estimated for each groundwater extraction component located in these areas.

The C_0 Tc-99 concentration for each extraction component was estimated by manual concentration isopleth interpolation using the isopleth maps (see Section 2.0). Area-weighted concentration averaging (see Section 4.0) was used to calculate the C_t concentration that will occur following remediation startup at extraction wells capturing Tc-99-impacted groundwater (GE-WAA-03 and GE-WAA-06 through GE-WAA-11). The area-weighted concentration averaging result for the GE-WAA-09 through GE-WAA-11 capture zone within the SSB/transition zone/alluvium hydrostratigraphic unit (23.94 ng/L – see Attachment 4.0C) was applied as the C_t for extraction wells GE-WAA-09 through GE-WAA-11. The area-weighted concentration averaging result for the GE-WAA-06 through GE-WAA-08 capture zone within the SSB/transition zone/alluvium hydrostratigraphic unit (9.58 ng/L – see Attachment 4.0C) was applied as the C_t for extraction wells GE-WAA-06 through GE-WAA-08. The area-weighted concentration averaging result for the GE-WAA-03 capture zone within the SSB/transition zone/alluvium hydrostratigraphic unit (11.0 ng/L – see Attachment 4.0C) was applied as the C_t for extraction well GE-WAA-03. The C_0 and C_t influent Tc-99 concentrations are summarized for each WAA-BLUFF and WAA U>DCGL groundwater extraction component in Attachment 5.1. Calculation files in native (MS Excel®) format can be provided to facilitate review of calculation methods (i.e., formulas, references, inputs, etc.) by NRC and DEQ personnel.

5.2 Results of the particle tracking analysis presented in Attachment 4.0B were used to estimate the time (i.e., time "t") at which C_t concentrations would occur at WAA-BLUFF and WAA U>DCGL extraction wells capturing Tc-99-impacted groundwater (GE-WAA-03 and GE-WAA-06 through GE-WAA-11, respectively). Based on the particle tracking results, the estimated time required for groundwater with elevated Tc-99 concentrations currently located in the WU-UP2-SSB remediation area to reach GE-WAA-11 is approximately 365 days; consequently, future maximum Tc-99 groundwater concentrations were assumed occur in the WAA-BLUFF extraction well influent approximately 1 year (365 days) following remediation startup. The estimated time required for the western edge of Tc-99 plume located in the WAA-BLUFF remediation area to reach GE-WAA-03 is approximately 120 days (see Attachment 4.0B); consequently, future maximum Tc-99 groundwater concentrations were assumed to occur in the WAA U>DCGL extraction well influent approximately 4 months (120 days) following remediation startup. Estimated time "t" values are presented for the WAA-BLUFF and WAA U>DCGL remediation areas in Attachment 5.1.

5.3 Following calculation of C_0 and C_t Tc-99 influent concentrations for individual extraction components, and the estimation of time "t" for WAA-BLUFF and WAA U>DCGL remediation areas, flow rate-weighted averaging was used to calculate the estimated C_0 and C_t influent concentrations for each remediation area (i.e., influent treatment stream). The estimated C_0 and C_t flow rate-weighted average Tc-99 influent concentrations for the WAA U>DCGL remediation area are 0.0 and 2.7 ng/L, respectively (see Attachment 5.1). The estimated C_0 and C_t flow rate-weighted average Tc-99 influent concentrations for the WAA-BLUFF remediation area are 14.5 and 12.8 ng/L, respectively. Although C_t is less than C_0 for the WAA-BLUFF influent, C_t is greater than the WAA-BLUFF influent concentration after 365 days of WATF operations, based on 365 days of decay from C_0. Therefore, the WAA-BLUFF C_t concentration represents an increase in the influent Tc-99 concentration at 365 days. The Tc-99 C_0 and C_t for the WAA-BLUFF and WAA U>DCGL influent treatment streams are summarized in Attachment 5.1. The concentration decay function and model results are discussed below in Sections 5.4 and 5.5, respectively.

5.4 A first-order kinetic sorption equation was used to model the decline in Tc-99 concentration for influent streams associated with each remediation area contributing to the combined WATF influent. The estimated/calculated Tc-99 C_0 and C_t values, and the time "t" values for the WAA-BLUFF and WAA U>DCGL influent treatment streams were used to model the concentration decline for those remediation areas, while a 0.0 ng/L Tc-99 influent concentration was assumed throughout the WATF operational timeframe for the five WA remediation areas that will not capture Tc-99 impacted groundwater (see Attachment 5.1). The aquifer retardation parameters used in the kinetic sorption equation to predict declining Tc-99 influent concentrations for the WATF are summarized in Attachment 5.4.

5.5 A flow rate-weighted average of the combined WATF influent stream was calculated for each concentration decay time interval (i.e., month of operation) to model the decline in WATF Tc-99 influent concentration over the operational life of the system. The results of the WA analysis are presented in Attachment 5.5. In addition, calculation files in native (MS Excel®) format can be provided to facilitate review of calculation methods (i.e., formulas, references, inputs, etc.) by NRC and DEQ personnel.

5.6 The combined WATF influent Tc-99 concentration at the time of system startup was calculated to be 6.04 ng/L (equivalent to 102.6 picocuries per liter [pCi/L]). The concentration is projected to decrease to 5.06 ng/L (equivalent to 86.1 pCi/L after 4

months of operation, at which time the concentration is projected to increase to 5.90 ng/L (equivalent to 100.3 pCi/L) as a result of Tc-99 impacted groundwater arriving at GE-WAA-03. From Month 5 through Month 12, the influent Tc-99 concentration then decreases to 4.14 ng/L (equivalent to 70.3 pCi/L), at which time the concentration increases to 5.85 ng/L (equivalent to 99.5 pCi/L) as a result of increasing Tc-99 concentrations in the groundwater captured by GE-WAA-06 through GE-WAA-11. Concentration reductions resume following this increase and the concentration falls below 1 pCi/L (equivalent to 0.06 ng/L) after 116 months of operation. The time series concentration decline analysis for each WA remediation area influent stream was concluded in the month in which uranium and nitrate remediation criteria are predicted to be achieved, as determined by previous remediation duration estimate calculations.[1] At the conclusion of remediation operations, following 150 months of operation, the combined influent concentration is expected to have decreased to 0.01 ng/L (equivalent to 0.22 pCi/L).

6.0 Limitations and Assumptions Associated with Concentration Estimates

The accuracy of the Tc-99 groundwater concentration estimates presented above are potentially limited by the quantity of available data, subsurface heterogeneity, variability in the concentration and distribution of contaminants in the aquifer units targeted for remediation, and other factors. In developing this assessment, Burns & McDonnell and EPM consistently applied reasonably conservative assumptions to minimize the potential for Tc-99 concentrations to be underestimated. This in turn reduced the probability that long-term remediation costs would be underestimated. These assumptions included the following:

- As discussed above in Section 5.0, the larger of the following concentration values were used as the future maximum groundwater concentration for the purposes of modeling the concentration decay over time:
  - The area-weighted Tc-99 concentration average over the Sandstone A formation (determined as described in Section 4.0)
  - The area-weighted Tc-99 concentration average over the Sandstone B, transition zone, and alluvium formations (determined as described in Section 4.0)
- As discussed in the 2018 Basis of Design, conservatively high bulk soil density, distribution coefficient (K_d), and saturated thickness values were applied in retardation parameter estimates.
- The methods used to model the concentration decline analysis assume Tc-99 is evenly distributed throughout the entire saturated thickness of each remediation area.

7.0 Conclusions and Recommendations

The following conclusions and recommendations were provided as a result of the assessment presented herein:

- Sampling and analysis for Tc-99 performed in 2019 verified that Tc-99 is not present in BA1 groundwater.
- Sampling and analysis for Tc-99 performed in 2019 provided sufficient information to estimate initial and maximum Tc-99 concentrations in the influent to the WATF.
- The estimated Tc-99 concentration in the combined WATF influent at the time of remediation system startup is 6.04 ng/L (equivalent to 102.6 pCi/L). The influent Tc-99 concentration is not projected to increase above this initial concentration during system operations.
- Tc-99 was not detected outside of areas addressed by the existing groundwater remediation design; therefore, no revision to the groundwater remediation design is necessary.
- The concentration of Tc-99 in the influent to the WATF is not expected to approach the drinking water standard; therefore, no revision to the groundwater treatment system is necessary.
- A concentration decline analysis for monitor wells exceeding the EPA drinking water criterion was not completed, based on the following:
    - Tc-99 concentrations exceeded the EPA drinking water criterion at only three out of 35 monitor wells sampled.
    - Tc-99 concentrations exceeded the EPA drinking water criterion by less than 10% at 2 of the 3 wells exhibiting exceedances.
- Although Tc-99 will not impact the groundwater treatment system design, it may accumulate in water treatment media or wastes and impact treatment system operations (e.g., disposition of resin or waste).

Attachments:

Attachment 1.0 – Tc-99 Data Table
Attachment 2.0 – Tc-99 Isopleth Maps
Attachment 3.0 – Remediation Component Locations
Attachment 4.0 – Area-Weighted Averaging Boundaries and Results

Attachment 5.1 – Initial Influent Tc-99 Concentrations
Attachment 5.4 – Tc-99 Retardation Parameters
Attachment 5.5 – Influent Concentration Decline Analysis

Attachment 1.0 – Tc-99 Data Table

Attachment 1.0
Tc-99 Data Table
Cimarron Remediation Site

Rev. A
1/30/2020

Technetium-99 Activity and Mass Concentration Results

Area	Location ID	Collection Date	Activity Concentration (pCi/L)	Mass Concentration (ng/L)[1,2]	Uncertainty (pCi/L)	Lab or Data Review Qual	MDC (pCi/L)
WAA U>DCGL	T-62	8/26/2019	80.1	4.7	30.9		48.7
	T-64	8/26/2019	24.4	1.4	23	U	38.3
	T-76	8/26/2019	101	5.9	27.3		41.3
	T-79	8/26/2019	-1.59	N/A	22.1	U, R	38.5
WAA-WEST	T-97	9/3/2019	24.8	1.5	24.5	U	41
WAA-BLUFF	T-54	9/3/2019	567	33.4	43.8		47.8
	T-55	9/3/2019	341	20.1	35.2		43
	T-56	9/3/2019	45.6	2.7	26.4		43.1
	T-57	9/3/2019	185	10.9	33.7		47.8
	T-58	9/3/2019	368	21.6	36.4		43.6
	T-63	9/3/2019	272	16.0	34.1		44.2
	T-86	9/3/2019	57.5	3.4	26.3		42.1
	T-87	9/3/2019	175	10.3	31		43.7
WAA-EAST	T-59	9/3/2019	15.2	0.9	25.6	U	43.5
	T-60	9/3/2019	46.4	2.7	25.7		41.8
	T-90	9/3/2019	19.5	1.1	25.1	U	42.4
WU-1348	1348	9/4/2019	-6.01	N/A	26.8	U, R	46.9
WU-UP1	1312	9/4/2019	662	38.9	40.8		40
	1313	9/4/2019	251	14.8	32.4		42.4
	1313DUP	9/4/2019	299	17.6	32.1		39.5
	1395	9/4/2019	-16.5	N/A	25.1	U, R	44.7
	1396	9/4/2019	-9.17	N/A	25.8	U, R	45.4
WU-UP2	1336A	9/4/2019	982	57.8	48.1		40.7
	1336ADUP	9/4/2019	963	56.6	48.5		41.7
	1337	9/4/2019	-13.4	N/A	22.8	U, R	40.6
	1346	9/5/2019	1650	97.1	59.4		40.9
	1346DUP	9/5/2019	1600	94.1	58.3		40.5
	1347	9/4/2019	4.98	0.3	24.7	U	42.7
	1387	9/4/2019	23.5	1.4	25.5	U	42.9
	1389	9/4/2019	35.4	2.1	24.6	U	40.4
	1401	9/5/2019	705	41.5	44.5		43.6
	1402	9/5/2019	941	55.4	49.8		44.1
WU-BA3	1351	8/26/2019	28.2	1.7	23.5	U	39.1
	1351DUP	8/26/2019	13.2	0.8	23	U	39.2
	1352	8/26/2019	12.3	0.7	22.2	U	37.7
	1356	8/26/2019	51.4	3.0	24.1		38.7
WU-PBA	1319B-1	9/4/2019	5.26	0.3	25.2	U	43.5
	1319B-2	9/4/2019	-9.58	N/A	22.9	U, R	40.5

Attachment 1.0
Tc-99 Data Table
Cimarron Remediation Site

Rev. A
1/30/2020

Technetium-99 Activity and Mass Concentration Results

Area	Location ID	Collection Date	Activity Concentration (pCi/L)	Mass Concentration (ng/L)[1,2]	Uncertainty (pCi/L)	Lab or Data Review Qual	MDC (pCi/L)
1206-NORTH	MWWA-03	8/27/2019	11.4	0.7	22.8	U	38.9
	MWWA-09	8/27/2019	46	2.7	24.7		40
SURFACE WATER	1201 (Upstream)	8/27/2019	-1.8	N/A	22.5	U, **R**	39.2
	1202 (Downstream)	8/27/2019	2.27	0.1	27.3	U	47.3
BA1-A	1314	8/27/2019	-5.81	N/A	21.5	U, **R**	37.7
	1315R	9/5/2019	23	1.4	24.4	U	40.9
	TMW-08	8/28/2019	-4	N/A	22.4	U, **R**	39.1
	TMW-09	8/28/2019	12.5	0.7	22.2	U	37.7
	TMW-09DUP	8/28/2019	-8.09	N/A	23.5	U, **R**	41.3
BA1-B	02W06	8/27/2019	-5.14	N/A	21.2	U, **R**	37.2
	02W08	8/28/2019	6.17	0.4	21.7	U	37.3
	02W19	9/5/2019	11.2	0.7	22.8	U	38.9
	02W44	8/28/2019	-3.96	N/A	23.6	U, **R**	41.2
	1363	9/5/2019	4	0.2	23.8	U	41.2
	TMW-13	8/28/2019	-4.22	N/A	21.2	U, **R**	37.2
	TMW-24	9/5/2019	-17.2	N/A	22	U, **R**	39.4

Notes:

[1]Activity to mass conversion factor for Tc-99 is 1.7E-02 Ci/g (17 pCi/ng) [49 CFR 173.435 Table of A1 and A2 values for radionuclides].

[2]Any results qualified with a U were adjusted to the MDC of 50 pCi/L (2.9 ng/L) in subsequent assessments.

Tc-99 exceeds 900 pCi/L (MCL)

Red bold font indicates qualifier was added during internal data validation

Qualifier Definitions:

J - Qualified as estimated during the data evaluation
R - Rejected during the reasonableness review
U - Analyte not detected above the minimum detectable concentration (MDC)
MDC - Minimum Detectable Concentration
pCi/L - PicoCuries per liter
ng/L - Nanograms per liter

Attachment 2.0 – Tc-99 Isopleth Maps

ATTACHMENT 2.0A
Tc-99 ISOPLETH IN THE WESTERN AREA
SANDSTONE A
Tc-99 GROUNDWATER ASSESSMENT MEMO
CIMARRON SITE, OKLAHOMA

BURNS McDONNELL. CREATE AMAZING.

environmental properties management, LLC

LEGEND

- SANDSTONE A MONITOR WELL
- EXTRACTION WELL
- INJECTION WELL
- EXTRACTION TRENCH
- INJECTION TRENCH
- US EPA Tc-99 CONCENTRATION LIMIT OF 52.9 ng/L (900 pCi/L)
- 10 ng/L (170 pCi/L)
- 20 ng/L (340 pCi/L)
- 30 ng/L (510 pCi/L)
- 40 ng/L (680 pCi/L)
- 50 ng/L (850 pCi/L)

NOTES

1. AERIAL IMAGE MOSAICKED USING GOOGLE EARTH 2017 AERIAL PHOTOS.
2. SOME CONCENTRATIONS EXCEEDED THE US EPA ACTIVITY CONCENTRATION LIMIT OF 900 pCi/L (52.9 ng/L):1336a - 56.9 ng/L AND 1402 - 54.52 ng/L. NO CONCENTRATIONS EXCEEDED THE NRC Tc-99 ACTIVITY CONCENTRATION LIMIT OF 3,790 pCi/L (222.9 ng/L).

N

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SCALE IN FEET

NAD 1983 2011 StatePlane Oklahoma North FIPS 3501 Ft US

GE-WAA-14
GE-WAA-15
GE-WAA-13
GE-WAA-12
GE-WAA-11
GE-WAA-10
GE-WAA-09
GE-WAA-08
GE-WAA-07
GE-WAA-06
GE-WAA-04
GE-WAA-03
GE-WAA-02
GE-WAA-01
GETR-WU-02A
1389 - 2.9
1385
1336A - 57.8
1393
1381
GWI-UP2-02
GWI-UP2-03
GWI-UP2-04B
GWI-UP2-04A
1347 - 2.9
1337
1387 - 2.9
1403
1402 - 55.4
1401 - 41.5
TR-04
1383
TR-05
GWI-UP2-01D
GWI-UP2-01A
1320
1397
TR-03
1396
1313 - 14.8
GWI-UP1-02A
1395
1340
GWI-UP1-03A
1398
1312 - 38.9
GWI-UP1-01A
1400
TR-01
GWI-UP1-04A
1311
1399
1324
1335A
1378
1379
1354
1355
1377
1331
1352 - 2.9
1357
1334
1356 - 3
1358
1333
GWI-WU-01A
1351 - 2.9
1325
1380
1349
1359

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ATTACHMENT 2.0B
Tc-99 ISOPLETH IN THE WESTERN AREA
SANDSTONE B, TRANSITION ZONE, ALLUVIUM
Tc-99 GROUNDWATER ASSESSMENT MEMO
CIMARRON SITE, OKLAHOMA

BURNS McDONNELL. CREATE AMAZING.

environmental properties management, LLC

LEGEND

- ALLUVIUM MONITOR WELL
- SANDSTONE B MONITOR WELL
- TRANSITION ZONE MONITOR WELL
- EXTRACTION WELL
- INJECTION WELL
- EXTRACTION TRENCH
- INJECTION TRENCH
- US EPA Tc-99 CONCENTRATION LIMIT OF 52.9 ng/L (900 pCi/L)
- 10 ng/L (170 pCi/L)
- 20 ng/L (340 pCi/L)
- 30 ng/L (510 pCi/L)
- 40 ng/L (680 pCi/L)
- 50 ng/L (850 pCi/L)
- 60 ng/L (1020 pCi/L)
- 70 ng/L (1190 pCi/L)
- 80 ng/L (1360 pCi/L)
- 90 ng/L (1530 pCi/L)

NOTES

1. AERIAL IMAGE MOSAICKED USING GOOGLE EARTH 2017 AERIAL PHOTOS.
2. SOME CONCENTRATIONS EXCEEDED THE US EPA ACTIVITY CONCENTRATION LIMIT OF 900 pCi/L (52.9 ng/L):1346 - 95.6 ng/L.
   NO CONCENTRATIONS EXCEEDED THE NRC Tc-99 ACTIVITY CONCENTRATION LIMIT OF 3,790 pCi/L (222.9 ng/L).

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SCALE IN FEET

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Attachment 3.0 – Remediation Component Locations

ATTACHMENT 3.0A
REMEDIATION COMPONENT LOCATIONS
SANDSTONE A Tc-99 CONTOURS
Tc-99 GROUNDWATER ASSESSMENT MEMO
CIMARRON SITE, OKLAHOMA

BURNS McDONNELL
CREATE AMAZING

environmental properties management LLC

GE-WAA-05
GE-WAA-14
GE-WAA-15
GE-WAA-13
GE-WAA-12
GE-WAA-11
GE-WAA-10
GE-WAA-09
GE-WAA-08
GE-WAA-07
GE-WAA-06
GE-WAA-04
GE-WAA-01
GE-WAA-02
GE-WAA-03
GETR-WU-02A
GWI-UP1-02A
GWI-UP1-03A
GWI-UP1-01A
GWI-UP1-04A
GWI-WU-01A
GETR-WU-01A
GE-WU-01
GWI-UP2-03
GWI-UP2-04B
GWI-UP2-02
GWI-UP2-04A
GWI-UP2-01D
GWI-UP2-01A

LEGEND

- MONITOR WELL IN ALLUVIUM
- MONITOR WELL IN SANDSTONE A
- MONITOR WELL IN SANDSTONE B
- MONITOR WELL IN SANDSTONE C
- MONITOR WELL IN TRANSITION ZONE
- PROPOSED MONITOR WELL IN ALLUVIUM
- EXTRACTION WELL
- INJECTION WELL
- EXTRACTION TRENCH
- INJECTION TRENCH
- INJECTION PIPING
- EXTRACTION PIPING
- TREATMENT FACILITY AREA
- US EPA Tc-99 CONCENTRATION LIMIT OF 52.9 ng/L (900 pCi/L)
- WAA-BLUFF
- WAA-EAST
- WAA-WEST
- WAA U>DCGL
- 1206-NORTH
- WU-PBA
- WU-UP1
- WU-1348
- WU-UP2-SSA
- WU-UP2-SSB
- 10 ng/L (170 pCi/L)
- 20 ng/L (340 pCi/L)
- 30 ng/L (510 pCi/L)
- 40 ng/L (680 pCi/L)
- 50 ng/L (850 pCi/L)

NOTES
1. AERIAL IMAGE MOSAICKED USING GOOGLE EARTH 2017 AERIAL PHOTOS.
2. GROUNDWATER TREATMENT STRUCTURES ARE FROM THE 90% DESIGN.

N

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SCALE IN FEET

NAD 1983 StatePlane Oklahoma North FIPS 3501 Feet

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ATTACHMENT 3.0B
REMEDIATION COMPONENT LOCATIONS
SANDSTONE B, TRANSITION ZONE, ALLUVIUM
Tc-99 CONTOURS
Tc-99 GROUNDWATER ASSESSMENT MEMO
CIMARRON SITE, OKLAHOMA

BURNS McDONNELL. CREATE AMAZING.

environmental properties management, LLC

GE-WAA-05
GE-WAA-14
GE-WAA-15
GE-WAA-13
GE-WAA-12
GE-WAA-11
GE-WAA-10
GE-WAA-09
GE-WAA-08
GE-WAA-07
GE-WAA-06
GE-WAA-04
GE-WAA-01
GE-WAA-02
GE-WAA-03
GWI-UP2-03
GWI-UP2-04B
GWI-UP2-02
GWI-UP2-04A
GWI-UP2-01D
GWI-UP2-01A
GWI-UP1-02A
GWI-UP1-03A
GWI-UP1-01A
GWI-UP1-04A
GETR-WU-02A
GWI-WU-01A
GETR-WU-01A
GE-WU-01

LEGEND

- MONITOR WELL IN ALLUVIUM
- MONITOR WELL IN SANDSTONE A
- MONITOR WELL IN SANDSTONE B
- MONITOR WELL IN SANDSTONE C
- MONITOR WELL IN TRANSITION ZONE
- PROPOSED MONITOR WELL IN ALLUVIUM
- EXTRACTION WELL
- INJECTION WELL
- EXTRACTION TRENCH
- INJECTION TRENCH
- INJECTION PIPING
- EXTRACTION PIPING
- TREATMENT FACILITY AREA
- US EPA Tc-99 CONCENTRATION LIMIT OF 52.9 ng/L (900 pCi/L)
- WAA-BLUFF
- WAA-EAST
- WAA-WEST
- WAA U>DCGL
- 1206-NORTH
- WU-PBA
- WU-UP1
- WU-1348
- WU-UP2-SSA
- WU-UP2-SSB
- 10 ng/L (170 pCi/L)
- 20 ng/L (340 pCi/L)
- 30 ng/L (510 pCi/L)
- 40 ng/L (680 pCi/L)
- 50 ng/L (850 pCi/L)
- 60 ng/L (1020 pCi/L)
- 70 ng/L (1190 pCi/L)
- 80 ng/L (1360 pCi/L)
- 90 ng/L (1530 pCi/L)

NOTES

1. AERIAL IMAGE MOSAICKED USING GOOGLE EARTH 2017 AERIAL PHOTOS.
2. GROUNDWATER TREATMENT STRUCTURES ARE FROM THE 90% DESIGN.

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SCALE IN FEET

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Attachment 4.0 – Area-Weighted Averaging Boundaries and Results

ATTACHMENT 4.0A
AREA-WEIGHTED AVERAGING BOUNDARIES
AND RESULTS
SANDSTONE A
Tc-99 GROUNDWATER ASSESSMENT MEMO
CIMARRON SITE, OKLAHOMA

BURNS McDONNELL. CREATE AMAZING.

environmental properties management, LLC

LEGEND

- SANDSTONE A MONITOR WELL
- EXTRACTION WELL
- INJECTION WELL
- EXTRACTION TRENCH
- INJECTION TRENCH
- REVERSE PARTICLE TRACKING
- REVERSE PARTICLE TRACKING ARROWS
- US EPA Tc-99 CONCENTRATION LIMIT OF 52.9 ng/L (900 pCi/L)
- AWCA BOUNDARY FOR GE-WAA-03 & GE-WAA-06 TO GE-WAA-08
- AWCA BOUNDARY FOR GE-WAA-09 TO GE-WAA-11
- 10 ng/L (170 pCi/L)
- 20 ng/L (340 pCi/L)
- 30 ng/L (510 pCi/L)
- 40 ng/L (680 pCi/L)
- 50 ng/L (850 pCi/L)

NOTES

AWCA - AREA-WEIGHTED CONCENTRATION AVERAGE

1. AERIAL IMAGE MOSAICKED USING GOOGLE EARTH 2017 AERIAL PHOTOS.
2. SOME CONCENTRATIONS EXCEEDED THE US EPA ACTIVITY CONCENTRATION LIMIT OF 900 pCi/L (52.9 ng/L):1336a - 56.9 ng/L AND 1402 - 54.52 ng/L. NO CONCENTRATIONS EXCEEDED THE NRC Tc-99 ACTIVITY CONCENTRATION LIMIT OF 3,790 pCi/L (222.9 ng/L).
3. PARTICLE TRACKING ARROWS DENOTE 60 DAY INTERVALS.

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ATTACHMENT 4.0B
AREA-WEIGHTED AVERAGING BOUNDARIES AND RESULTS
SANDSTONE B, TRANSITION ZONE, ALLUVIUM
Tc-99 GROUNDWATER ASSESSMENT MEMO
CIMARRON SITE, OKLAHOMA

BURNS McDONNELL. CREATE AMAZING.

environmental properties management, LLC

LEGEND

- ALLUVIUM MONITOR WELL
- SANDSTONE B MONITOR WELL
- TRANSITION ZONE MONITOR WELL
- EXTRACTION WELL
- INJECTION WELL
- EXTRACTION TRENCH
- INJECTION TRENCH
- REVERSE PARTICLE TRACKING
- REVERSE PARTICLE TRACKING ARROWS
- US EPA Tc-99 CONCENTRATION LIMIT OF 52.9 ng/L (900 pCi/L)
- AWCA BOUNDARY FOR GE-WAA-03 & GE-WAA-06 TO GE-WAA-08
- AWCA BOUNDARY FOR GE-WAA-09 TO GE-WAA-11
- ASSUMED GE-WAA-03A CAPTURE ZONE
- 10 ng/L (170 pCi/L)
- 20 ng/L (340 pCi/L)
- 30 ng/L (510 pCi/L)
- 40 ng/L (680 pCi/L)
- 50 ng/L (850 pCi/L)
- 60 ng/L (1020 pCi/L)
- 70 ng/L (1190 pCi/L)
- 80 ng/L (1360 pCi/L)
- 90 ng/L (1530 pCi/L)

NOTES

AWCA - AREA-WEIGHTED CONCENTRATION AVERAGE

1. AERIAL IMAGE MOSAICKED USING GOOGLE EARTH 2017 AERIAL PHOTOS.
2. SOME CONCENTRATIONS EXCEEDED THE US EPA ACTIVITY CONCENTRATION LIMIT OF 900 pCi/L (52.9 ng/L):1346 - 95.6 ng/L.
   NO CONCENTRATIONS EXCEEDED THE NRC Tc-99 ACTIVITY CONCENTRATION LIMIT OF 3,790 pCi/L (222.9 ng/L).
3. PARTICLE TRACKING ARROWS DENOTE 60 DAY INTERVALS.

N

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SCALE IN FEET

NAD 1983 StatePlane Oklahoma North FIPS 3501 Feet

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Attachment 5.1 – Initial Influent Tc-99 Concentrations

Attachment 5.1
Initial and Future Maximum Influent Tc-99 Concentrations
Cimarron Remediation Site

Rev. A
1/16/2020

Remediation Area[1]	Well ID	Extraction Well Tc-99 Influent Groundwater C_0 (ng/L)[2]	Extraction Well Tc-99 Influent Groundwater C_t [AWCA - SSB/Alluvium/Trans. Zone] (ng/L)	AWCA - SSA (ng/L)	Influent Treatment Stream Tc-99 Influent Groundwater C_0 (ng/L)[3]	Influent Treatment Stream Tc-99 Influent Groundwater C_t (ng/L)[4]	Assumed C_t Time "t" (days)
WAA U>DCGL	GE-WAA-01	0	0	NA	0.0	2.7	120
	GE-WAA-02	0	0				
	GE-WAA-03	0	11.00				
	GE-WAA-04	0	0				
WAA-BLUFF	GE-WAA-06	15	9.58	7.28	14.5	12.8	365
	GE-WAA-07	18	9.58	7.28			
	GE-WAA-08	14	9.58	7.28			
	GE-WAA-09	29	23.94	14.95			
	GE-WAA-10	25	23.94	14.95			
	GE-WAA-11	14	23.94	14.95			
	GE-WAA-12	0	0	0			
	GE-WAA-13	0	0	0			
WAA-EAST	GE-WAA-14	0	0	NA	0.0	0.0	NA
	GE-WAA-15	0	0				
WAA-WEST	GE-WAA-05	0	0	NA	0.0	0.0	NA
1206-NORTH	GETR-WU-02	0	0	NA	0.0	0.0	NA
WU-1348	GETR-WU-01	0	0	NA	0.0	0.0	NA
WU-PBA	GE-WU-01	0	0	NA	0.0	0.0	NA

Definitions:
AWCA - Area-Weighted Concentration Average
C_0 - initial concentration
C_t - concentration at time "t"
ng/L - nanogram per liter
SSA - Sandstone A
SSB - Sandstone B
Trans. - transition

Notes:
[1]Only Western Area Remediation Areas containing groundwater extraction components are listed.
[2]Concentrations estimated from hand drawn isopleths (10 ng/L contours)
[3]Estimated by flow rate-weighted averaging of initial Tc-99 groundwater concentrations for WAA U>DCGL extraction wells.
[4]Estimated by flow rate-weighted averaging of initial Tc-99 groundwater concentrations for WAA-BLUFF extraction wells.

Attachment 5.4 – Tc-99 Retardation Parameters

Attachment 5.4
Tc-99 Retardation Parameters
Cimarron Remediation Site

Rev. A
1/30/2020

$$R = 1 + \frac{\rho_b}{n} K_d$$

Remediation Area	Bulk Density (g/mL)	Porosity[1]	Tc-99 K_d (mL/g)[2]	R
WU-PBA (GE-WU-01)	1.81	0.05	0.1	4.62
WU-1348 (GETR-WU-01)	1.81	0.10	0.1	2.81
WAA U>DCGL (GE-WAA-01 through GE-WAA-04)	1.81	0.30	0.1	1.60
1206-NORTH (GETR-WU-02)	1.81	0.11	0.1	2.65
WAA-WEST (GE-WAA-05)	1.81	0.30	0.1	1.60
WAA-EAST (GE-WAA-14 and GE-WAA-15)	1.81	0.30	0.1	1.60
WAA-BLUFF (GE-WAA-06 through GE-WAA-13)	1.81	0.18	0.1	2.03

Definitions:

R - retardation

ρ_b - bulk density

n - porosity

K_d - distribution coefficient

g/mL - grams per milliliter

mL/g - milliliters per gram

Notes:

[1]Assumes 30% transmissive porosity for alluvial sand, as presented in the Technical Memorandum (TM002), September 10, 2018, page 3. Assumes 11% transmissve porosity for BA1 transition zone, as presented in Environmental Sequence Stratigraphy (ESS) and Porosity Analysis, Burial Area 1, dated April 6, 2018. Assumes 5% porosity for competent SSB bedrock. Assume half influent area comes from SSB and half comes from alluvial sand for WAA-BLUFF, resulting in an average transmissive porosity of 18%.

[2]Kd value sourced from Krupka et al. (2004) and PNNL-16531 (2007)

Attachment 5.5 – Influent Concentration Decline Analysis

Attachment 5.5
Influent Concentration Decline Analysis
Cimarron Remediation Site

Rev. E
1/30/2020

Remediation Area	Extraction Well/Trench	Influent Flow Rate (gpm)	Adjusted Flow Rate (gpm)	Nitrate (mg/L)	Uranium (ug/L)	Fluoride (mg/L)	Technetium-99 (ng/L)	Weighted Nitrate (mg/L)	Weighted Uranium (ug/L)	Weighted Fluoride (mg/L)	Weighted Technetium-99 (ng/L)	Comments:
		q	q*%	c_{max}				q^*c_{max}				
Western Area												*Governing Assumptions:* *- Maximum uranium, nitrate, and fluoride influent concentrations will not occur at time zero for extraction wells GE-WAA-6 through -13; however maximum uranium, nitrate, and fluoride influent concentrations will occur at time zero for all other extraction wells and trenches.* *- Intitial (time zero) uranium, nitrate, and fluoride influent nitrate concentrations for GE-WAA-6 through -13 are based on representative SSB/TZ/Alluvium concentrations.* *- Future (time 't') uranium, nitrate, and fluoride influent nitrate concentrations for GE-WAA-6 through -13 are based on representative, upgradient (UP1 & UP2) SSA concentrations. 100% of this SSA groundwater contribution is assumed to be driven by the proposed injection features (i.e., natural groundwater flux from SSA is assumed to be negligible).*
1206-NORTH	GETR-WU-02	8	--	38.6	304	7	--	309.1	2428.4	56.3	--	- Linear, incremental concentration averaging along trench alignment using isoconcentration contours [see Incr. AWCA Calcs_Rev. C (12-17-19)].
WU-PBA	GE-WU-01	5	--	61.7	29.0	0.3	--	308.7	145.1	1.6	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
WU-1348	GETR-WU-01	4	--	10.14	62.0	1.0	--	40.6	247.9	4.0	--	- Linear, incremental concentration averaging along trench alignment using isoconcentration contours [see Incr. AWCA Calcs_Rev. C (12-17-19)].
WAA U>DCGL	GE-WAA-01	25	--	25.3	134	1	--	632.8	3354.5	35.0	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
	GE-WAA-02	30	--	29.0	163	3	--	869.4	4903.2	78.6	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
	GE-WAA-03	24	--	67.1	163	3	0.00	1610.9	3908.4	81.8	0.0	- ***Initial Influent Concentration:*** Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
				67.1	163	3	11.00	1610.9	3908.4	81.8	264.0	- ***Maximum Influent Concentration*** : [SSB/TZ/Alluvium] GE-WAA-03 capture zone area-weighted incremental concentration averaging using isoconcentration contours [see Incr. AWCA Calcs_Rev. C (12-17-19)].
	GE-WAA-04	20	--	21.4	119	1	--	427.4	2380.6	28.8	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
WAA-WEST	GE-WAA-05	10	--	10.2	58.6	0.5	--	102.4	586.4	4.5	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
WAA-BLUFF	GE-WAA-06	13	--	90.8	64.0	3.3	15	1180.8	832.4	42.4	195.0	- ***Initial Influent Concentration*** **:** [SSB/TZ/Alluvium] interpolated concentrations calculated in Surfer for nitrate, fluoride, and uranium. Interpolated concentrations calculated from hand drafted contours for Tc-99 [see Incr. AWCA Calcs_Rev. C (12-17-19)].
				204	15.6	18.8	9.58	2652.0	202.8	244.4	124.5	- ***Maximum Influent Concentration:*** [SSA] UP1 area-weighted incremental concentration averaging using isoconcentration contours for uranium, nitrate, and fluoride. - ***Future Influent Concentration:*** [SSB/TZ/Alluvium] WAA-BLUFF Capture Zone (GE-WAA-06 through GE-WAA-08) area-weighted incremental concentration averaging using isoconcentration contours for Tc-99 [see Incr. AWCA Calcs_Rev. C (12-17-19)].

Attachment 5.5
Influent Concentration Decline Analysis
Cimarron Remediation Site

Rev. E
1/30/2020

Remediation Area	Extraction Well/Trench	Influent Flow Rate (gpm) q	Adjusted Flow Rate (gpm) q*%	Nitrate (mg/L)	Uranium (ug/L)	Fluoride (mg/L)	Technetium-99 (ng/L)	Weighted Nitrate (mg/L)	Weighted Uranium (ug/L)	Weighted Fluoride (mg/L)	Weighted Technetium-99 (ng/L)	Comments:
				c_{max}				q^*c_{max}				
WAA-BLUFF	GE-WAA-07	13	--	73.2	10.9	2.6	18.0	952.0	142.1	33.9	234.0	- ***Initial Influent Concentration*** : [SSB/TZ/Alluvium] interpolated concentrations calculated in Surfer for nitrate, fluoride, and uranium. Interpolated concentrations calculated from hand drafted contours for Tc-99 [see Incr. AWCA Calcs Rev. C (12-17-19)].
				204	15.6	18.8	9.58	2652.0	202.8	244.4	124.5	- ***Maximum Influent Concentration:*** [SSA] UP1 area-weighted incremental concentration averaging using isoconcentration contours for uranium, nitrate, and fluoride. - ***Future Influent Concentration:*** [SSB/TZ/Alluvium] WAA-BLUFF Capture Zone (GE-WAA-06 through GE-WAA-08) area-weighted incremental concentration averaging using isoconcentration contours for Tc-99 [see Incr. AWCA Calcs Rev. C (12-17-19)].
	GE-WAA-08	13	--	141	7.70	3.54	14	1833.0	100.1	46.0	182.0	- ***Initial Influent Concentration*** : [SSB/TZ/Alluvium] interpolated concentrations calculated in Surfer for nitrate, fluoride, and uranium. Interpolated concentrations calculated from hand drafted contours for Tc-99 [see Incr. AWCA Calcs Rev. C (12-17-19)].
				204	15.6	18.8	9.58	2652.0	202.8	244.4	124.5	- ***Maximum Influent Concentration:*** [SSA] UP1 area-weighted incremental concentration averaging using isoconcentration contours for uranium, nitrate, and fluoride. - ***Future Influent Concentration:*** [SSB/TZ/Alluvium] WAA-BLUFF Capture Zone (GE-WAA-06 through GE-WAA-08) area-weighted incremental concentration averaging using isoconcentration contours for Tc-99 [see Incr. AWCA Calcs Rev. C (12-17-19)].
	GE-WAA-09	13	--	218	4.77	2.46	29	2829.7	62.0	32.0	377.0	- ***Initial Influent Concentration*** : [SSB/TZ/Alluvium] interpolated concentrations calculated in Surfer for nitrate, fluoride, and uranium. Interpolated concentrations calculated from hand drafted contours for Tc-99 [see Incr. AWCA Calcs Rev. C (12-17-19)].
				378	26.3	7.8	23.94	4914.0	341.9	101.4	311.2	- ***Maximum Influent Concentration:*** [SSA] UP2 area-weighted incremental concentration averaging using isoconcentration contours for uranium, nitrate, and fluoride. - ***Future Influent Concentration:*** [SSB/TZ/Alluvium] WAA-BLUFF Capture Zone (GE-WAA-09 through GE-WAA-11) area-weighted incremental concentration averaging using isoconcentration contours for Tc-99 [see Incr. AWCA Calcs Rev. C (12-17-19)].
	GE-WAA-10	13	--	207	6.40	2.03	25	2692.4	83.2	26.4	325.0	- ***Initial Influent Concentration*** : [SSB/TZ/Alluvium] interpolated concentrations calculated in Surfer for nitrate, fluoride, and uranium. Interpolated concentrations calculated from hand drafted contours for Tc-99 [see Incr. AWCA Calcs Rev. C (12-17-19)].
				378	26.3	7.8	23.94	4914.0	341.9	101.4	311.2	- ***Maximum Influent Concentration:*** [SSA] UP2 area-weighted incremental concentration averaging using isoconcentration contours for uranium, nitrate, and fluoride. - ***Future Influent Concentration:*** [SSB/TZ/Alluvium] WAA-BLUFF Capture Zone (GE-WAA-09 through GE-WAA-11) area-weighted incremental concentration averaging using isoconcentration contours for Tc-99 [see Incr. AWCA Calcs Rev. C (12-17-19)].

Attachment 5.5
Influent Concentration Decline Analysis
Cimarron Remediation Site

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Remediation Area	Extraction Well/Trench	Influent Flow Rate (gpm)	Adjusted Flow Rate (gpm)	Nitrate (mg/L)	Uranium (ug/L)	Fluoride (mg/L)	Technetium-99 (ng/L)	Weighted Nitrate (mg/L)	Weighted Uranium (ug/L)	Weighted Fluoride (mg/L)	Weighted Technetium-99 (ng/L)	Comments:
		q	q*%	c_{max}				q^*c_{max}				
WAA-BLUFF	GE-WAA-11	14	--	128	6.80	1.76	14	1794.9	95.2	24.6	196.0	***- Initial Influent Concentration :*** [SSB/TZ/Alluvium] interpolated concentrations calculated in Surfer for nitrate, fluoride, and uranium. Interpolated concentrations calculated from hand drafted contours for Tc-99 [see Incr. AWCA Calcs Rev. C (12-17-19)].
				378	26.3	7.8	23.94	5292.0	368.2	109.2	335.2	***- Maximum Influent Concentration:*** [SSA] UP2 area-weighted incremental concentration averaging using isoconcentration contours for uranium, nitrate, and fluoride. [SSB/TZ/Alluvium] WAA-BLUFF Capture Zone (GE-WAA-09 through GE-WAA-11) area-weighted incremental concentration averaging using isoconcentration contours for Tc-99 [see Incr. AWCA Calcs Rev. C (12-17-19)].
	GE-WAA-12	13	--	24.5	5.48	0.92	--	318.2	71.2	12.0	--	***- Initial Influent Concentration:*** [SSB/TZ/Alluvium] interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
				378	26.3	7.8	--	4914.0	341.9	101.4	--	***- Maximum Influent Concentration:*** [SSA] UP2 area-weighted incremental concentration averaging using isoconcentration contours for uranium, nitrate, and fluoride. [see Incr. AWCA Calcs_Rev. C (12-17-19)].
	GE-WAA-13	12	--	22.1	8.15	0.84	--	265.3	97.8	10.1	--	***- Initial Influent Concentration:*** [SSB/TZ/Alluvium] interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
				378	26.3	7.8	--	4536.0	315.6	93.6	--	***- Maximum Influent Concentration:*** [SSA] UP2 area-weighted incremental concentration averaging using isoconcentration contours for uranium, nitrate, and fluoride. [see Incr. AWCA Calcs_Rev. C (12-17-19)].
WAA-EAST	GE-WAA-14	10	--	79.1	61.9	0.46	--	791.0	619.0	4.6	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
	GE-WAA-15	10	--	65.4	40.4	0.4	--	653.5	403.6	4.3	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
Initial $\sum q^*c_{max}$		*250*	*0*					17612	20461	527	1509	
Initial $\sum q$								250	250	250	250	
Initial Influent Concentration								**70.4**	**81.8**	**2.1**	**6.0**	

Attachment 5.5
Influent Concentration Decline Analysis
Cimarron Remediation Site

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Remediation Area	Extraction Well/Trench	Influent Flow Rate (gpm) q	Adjusted Flow Rate (gpm) q*%	Nitrate (mg/L) c_{max}	Uranium (ug/L) c_{max}	Fluoride (mg/L) c_{max}	Technetium-99 (ng/L) c_{max}	Weighted Nitrate (mg/L) q^*c_{max}	Weighted Uranium (ug/L) q^*c_{max}	Weighted Fluoride (mg/L) q^*c_{max}	Weighted Technetium-99 (ng/L) q^*c_{max}	Comments:
Burial Area 1												*Governing Assumptions:* *- Maximum uranium influent concentrations for all extraction wells and trenches will occur at time zero.*
BA1-A	GETR-BA1-01	7	--	--	1,360	--	--	--	9,520.00	--	--	- Linear, incremental concentration averaging along trench alignment using isoconcentration contours see Incr. AWCA Calcs_Rev. C (12-17-19).
	GETR-BA1-02	7	--	--	2,080	--	--	--	14,560.00	--	--	- Linear, incremental concentration averaging along trench alignment using isoconcentration contours see Incr. AWCA Calcs_Rev. C (12-17-19).
BA1-B	GE-BA1-02	24	--	--	2,420	--	--	--	58,080.00	--	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
	GE-BA1-03	18	--	--	2,420	--	--	--	43,560.00	--	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
	GE-BA1-04	24	--	--	2,420	--	--	--	58,080.00	--	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
BA1-C	GE-BA1-05	0	--	--	2,420	--	--	--	0.00	--	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
	GE-BA1-06	0	--	--	2,420	--	--	--	0.00	--	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
	GE-BA1-07	0	--	--	43.3	--	--	--	0.00	--	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
	GE-BA1-08	10	--	--	32.1	--	--	--	321.00	--	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
	GE-BA1-09	10	--	--	37.2	--	--	--	372.00	--	--	- Interpolated concentrations calculated in Surfer [see Incr. AWCA Calcs_Rev. C (12-17-19)].
$\sum q^*c_{max}$		*100*							184493.00			
$\sum q$									100			
Max Influent Concentration									**1845**			

Notes:
SSA - Sandstone A
SSA - Sandstone B
TZ - Transition Zone
gpm - gallons per minute
ug/L - micrograms per liter
mg/L - milligrams per liter

WATF - Technetium-99

Remediation Area	C_i (ng/L)	C_i Source	C_{max}[6] (ng/L)	C_{max}[6] Source	Is C_i representative of C_{max}? (Y/N)	Flow Rate (gpm)	R[1]	PV[1,2,3] (ft^3)	PV (liters)	Q (liters/day)	Time Required for Initial Conc. to Reach Max. Level (days)[2]	C_f (ng/L)	Combined Influent C_f (ng/L)
WU-PBA (GE-WU-01)	--	--	--	--	Y	5	4.6	231,264	6,548,662	27,255	0	--	
WU-1348 (GETR-WU-01)	--	--	--	--	Y	4	2.8	61,800	1,749,984	21,804	0	--	
WAA U>DCGL (GE-WAA-01 through GE-WAA-04	0.0	FWCA	2.7	AWCA/FWCA	N	99	1.60	4,177,559	118,295,089	539,648	120	0.00	
1206-NORTH (GETR-WU-02)	--	--	--	--	Y	8	2.7	3,014	85,334	43,608	0	--	0.013
WAA-WEST (GE-WAA-05)	--	--	--	--	Y	10	1.60	2,387,058	67,593,844	54,510	0	--	
WAA-BLUFF (GE-WAA-06 through GE-WAA-13)	14.51	FWCA	12.80	AWCA/FWCA	N	104	2.03	6,811,932	192,892,116	566,903	365	0.03	
WAA-EAST (GE-WAA-14 & GE-WAA-15)	--	--	--	--	Y	20	1.60	4,716,357	133,552,129	109,020	0	--	
Combined Treatment System Influent Flow Rate[5]						250							

$$C_t = C_0 e^{(-Q/(PV*R))t}$$

cubic foot = 28.3168 liters
gpm = 5451 liters per day

Notes:
C_i - initial concentration
C_f - final concentration
C_{max} - maximum concentration
gpm - gallons per minute
MCL - maximum contaminant level
mg/L - milligrams per liter
R - retardation

$$R = 1 + \frac{\rho_b}{n} K_d$$

PV - pore volume
Q - flow rate
AWCA - Area-weighted concentration averaging
FWCA - Flow rate-weighted concentration averaging
LWCA - Linear-weighted concentration averaging
SIC - Surfer-interpolated concentration

[1]Retardation (R) and pore volume (PV) taken from remediation duration estimate calculations [DRAFT_Remediation Duration Estimates_Rev. B (09-10-18)].

[2]Based on forward particle tracking results for WU-UP1 and WU-UP2 injection components, and uranium and nitrate plume distribution depicted on isopleth maps, maxium uranium and nitrate groundwater concentrations will report to WAA "BLUFF" extraction wells approximately 1 year following intiation of water injection at UP1 and UP2.

[3]The WAA "BLUFF" pore volume is inconsequential for remediation duration since the remediation timeframe for this area is predicated on UP1/UP2 remediation timeframe.

[4]Since intial nitrate groundwater concentrations for WU "1206 SOUTH" and WAA "U<DCGL" WEST are below the applicable remediation criteria, the highest representative nitrate concentration for any well in each area was used in the influent concentration decay analysis.

[5]The combined influent flow rate presented in the table reflects initial operating conditions. The influent flow rate is expected to decline over the course of the remediation campaign. Combined influent flow rates for each month of remediation are provided in the concentration decay analysis tables.

[6]The C_{max} value for the WAA-BLUFF remediation area incorporates the anticipated concentration increase at GE-WAA-11. C_{max} occurs at GE-WAA-11 approximately 365 days from startup, but the flow rate weighted average for WAA-BLUFF is less than C_i at time 0. However, the flow rate weighted average C_{max} at 365 days is greater than the concentration at 365 days, based on the concentration decay function. Therefore, C_{max} represents an increase in the concentration decay curve at time = 365 days.

Attachment 5.5
Influent Concentration Decline Analysis
Cimarron Remediation Site

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Western Area Combined Influent - Technetium-99

Area	WU-PBA (GE-WU-01)	WAA U>DCGL (GE-WAA-01 through GE-WAA-04)	WAA-WEST (GE-WAA-05)	WU-1348 (GETR-WU-01)	WAA-EAST (GE-WAA-14 & GE-WAA-15)	WAA-BLUFF (GE-WAA-06 through GE-WAA-13)	1206-NORTH (GETR-WU-02)
C_i (ng/L)	--	**0.00**	--	--	--	**14.51**	--
C_{max}[1] (ng/L)	--	**2.67**	--	--	--	**12.80**	--
Flow Rate (gpm)	**5**	**99**	**10**	**4**	**20**	**104**	**8**
R	4.6	1.6	1.6	2.8	1.6	2.03	2.7
PV (liters)	6,548,662	118,295,089	67,593,844	1,749,984	133,552,129	192,892,116	85,334
Q (liters/day)	27,255	539,648	54,510	21,804	109,020	566,903	43,608
Time Required for Initial Conc. to Increase to Future Level (months)	**0**	**120**	**0**	**0**	**0**	**365**	**0**

$$C_t = C_0 e^{(-Q/(PV*R))t}$$

Cumulative Time (Months)	WU-PBA	WAA U>DCGL	WAA-WEST	WU-1348	WAA-EAST	WAA-BLUFF	1206-NORTH	WEIGHTED AVERAGE (ng/L)	WEIGHTED AVERAGE[2] (pCi/L)	Combined Influent Flow Rate (gpm)
0	--	0.00	--	--	--	14.51	--	**6.04**	**102.61**	**250**
1	--	0.00	--	--	--	13.89	--	**5.78**	**98.20**	**250**
2	--	0.00	--	--	--	13.29	--	**5.53**	**93.98**	**250**
3	--	0.00	--	--	--	12.72	--	**5.29**	**89.94**	**250**
4	--	0.00	--	--	--	12.17	--	**5.06**	**86.07**	**250**
5	--	2.67	--	--	--	11.65	--	**5.90**	**100.32**	**250**
6	--	2.45	--	--	--	11.15	--	**5.61**	**95.29**	**250**
7	--	2.24	--	--	--	10.67	--	**5.33**	**90.53**	**250**
8	--	2.06	--	--	--	10.21	--	**5.06**	**86.03**	**250**
9	--	1.88	--	--	--	9.77	--	**4.81**	**81.78**	**250**
10	--	1.73	--	--	--	9.35	--	**4.57**	**77.76**	**250**
11	--	1.58	--	--	--	8.95	--	**4.35**	**73.95**	**250**
12	--	1.45	--	--	--	8.56	--	**4.14**	**70.34**	**250**
13	--	1.33	--	--	--	12.80	--	**5.85**	**99.49**	**250**
14	--	1.22	--	--	--	12.25	--	**5.58**	**94.86**	**250**
15	--	1.12	--	--	--	11.72	--	**5.32**	**90.45**	**250**
16	--	1.03	--	--	--	11.22	--	**5.07**	**86.26**	**250**
17	--	0.94	--	--	--	10.74	--	**4.84**	**82.27**	**250**
18	--	0.86	--	--	--	10.28	--	**4.62**	**78.48**	**250**
19	--	0.79	--	--	--	9.83	--	**4.40**	**74.87**	**250**
20	--	0.73	--	--	--	9.41	--	**4.20**	**71.44**	**250**
21	--	0.67	--	--	--	9.01	--	**4.01**	**68.17**	**250**
22	--	0.61	--	--	--	8.62	--	**3.83**	**65.06**	**250**
23	--	0.56	--	--	--	8.25	--	**3.65**	**62.10**	**250**
24	--	0.51	--	--	--	7.89	--	**3.49**	**59.28**	**250**
25	--	0.47	--	--	--	7.55	--	**3.33**	**56.59**	**250**
26	--	0.43	--	--	--	7.23	--	**3.18**	**54.03**	**250**
27	--	0.40	--	--	--	6.92	--	**3.03**	**51.59**	**250**
28	--	0.36	--	--	--	6.62	--	**2.90**	**49.27**	**250**
29	--	0.33	--	--	--	6.34	--	**2.77**	**47.05**	**250**
30	--	0.30	--	--	--	6.06	--	**2.64**	**44.94**	**250**
31	--	0.28	--	--	--	5.80	--	**2.52**	**42.92**	**250**

Western Area Combined Influent - Technetium-99

Area	WU-PBA (GE-WU-01)	WAA U>DCGL (GE-WAA-01 through GE-WAA-04)	WAA-WEST (GE-WAA-05)	WU-1348 (GETR-WU-01)	WAA-EAST (GE-WAA-14 & GE-WAA-15)	WAA-BLUFF (GE-WAA-06 through GE-WAA-13)	1206-NORTH (GETR-WU-02)
C_i (ng/L)	--	**0.00**	--	--	--	**14.51**	--
C_{max}[1] (ng/L)	--	**2.67**	--	--	--	**12.80**	--
Flow Rate (gpm)	**5**	**99**	**10**	**4**	**20**	**104**	**8**
R	4.6	1.6	1.6	2.8	1.6	2.03	2.7
PV (liters)	6,548,662	118,295,089	67,593,844	1,749,984	133,552,129	192,892,116	85,334
Q (liters/day)	27,255	539,648	54,510	21,804	109,020	566,903	43,608
Time Required for Initial Conc. to Increase to Future Level (months)	**0**	**120**	**0**	**0**	**0**	**365**	**0**

$$C_t = C_0 e^{(-Q/(PV*R))t}$$

Cumulative Time (Months)	WU-PBA	WAA U>DCGL	WAA-WEST	WU-1348	WAA-EAST	WAA-BLUFF	1206-NORTH	WEIGHTED AVERAGE (ng/L)	WEIGHTED AVERAGE[2] (pCi/L)	Combined Influent Flow Rate (gpm)
32	--	0.26	--	--	--	5.55	--	**2.41**	**41.00**	**250**
33	--	0.24	--	--	--	5.31	--	**2.30**	**39.17**	**250**
34	--	0.22	--	--	--	5.09	--	**2.20**	**37.42**	**250**
35	--	0.20	--	--	--	4.87	--	**2.10**	**35.75**	**250**
36	--	0.18	--	--	--	4.66	--	**2.01**	**34.16**	**250**
37	--	0.17	--	--	--	4.46	--	**1.92**	**32.65**	**250**
38	--	0.15	--	--	--	4.27	--	**1.84**	**31.20**	**250**
39	--	0.14	--	--	--	4.08	--	**1.75**	**29.81**	**250**
40	--	0.13	--	--	--	3.91	--	**1.68**	**28.50**	**250**
41	--	0.12	--	--	--	3.74	--	**1.60**	**27.24**	**250**
42	--	0.11	--	--	--	3.58	--	**1.53**	**26.03**	**250**
43	--	0.10	--	--	--	3.42	--	**1.46**	**24.88**	**250**
44	--	0.09	--	--	--	3.28	--	**1.40**	**23.79**	**250**
45	--	0.08	--	--	--	3.14	--	**1.34**	**22.74**	**250**
46	--	0.08	--	--	--	3.00	--	**1.28**	**21.74**	**250**
47	--	0.07	--	--	--	2.87	--	**1.22**	**20.79**	**250**
48	--	0.06	--	--	--	2.75	--	**1.17**	**19.87**	**250**
49	--	0.06	--	--	--	2.63	--	**1.12**	**19.00**	**250**
50	--	0.05	--	--	--	2.52	--	**1.07**	**18.17**	**250**
51	--	0.05	--	--	--	2.41	--	**1.02**	**17.37**	**250**
52	--	0.05	--	--	--	2.31	--	**0.98**	**16.61**	**250**
53	--	0.04	--	--	--	2.21	--	**0.93**	**15.89**	**250**
54	--	0.04	--	--	--	2.11	--	**0.89**	**15.19**	**250**
55	--	0.03	--	--	--	2.02	--	**0.85**	**14.53**	**250**
56	--	0.03	--	--	--	1.93	--	**0.82**	**13.89**	**250**
57	--	0.03	--	--	--	1.85	--	**0.78**	**13.29**	**250**
58	--	0.03	--	--	--	1.77	--	**0.75**	**12.71**	**250**
59	--	0.02	--	--	--	1.70	--	**0.71**	**12.15**	**250**
60	--	0.02	--	--	--	1.62	--	**0.68**	**11.63**	**250**
61	--	0.02	--	--	--	1.55	--	**0.65**	**11.12**	**250**
62	--	0.02	--	--	--	1.49	--	**0.63**	**10.64**	**250**
63	--	0.02	--	--	--	1.42	--	**0.60**	**10.17**	**250**

Western Area Combined Influent - Technetium-99

Area	WU-PBA (GE-WU-01)	WAA U>DCGL (GE-WAA-01 through GE-WAA-04)	WAA-WEST (GE-WAA-05)	WU-1348 (GETR-WU-01)	WAA-EAST (GE-WAA-14 & GE-WAA-15)	WAA-BLUFF (GE-WAA-06 through GE-WAA-13)	1206-NORTH (GETR-WU-02)
C_i (ng/L)	--	**0.00**	--	--	--	**14.51**	--
C_{max}[1] (ng/L)	--	**2.67**	--	--	--	**12.80**	--
Flow Rate (gpm)	**5**	**99**	**10**	**4**	**20**	**104**	**8**
R	4.6	1.6	1.6	2.8	1.6	2.03	2.7
PV (liters)	6,548,662	118,295,089	67,593,844	1,749,984	133,552,129	192,892,116	85,334
Q (liters/day)	27,255	539,648	54,510	21,804	109,020	566,903	43,608
Time Required for Initial Conc. to Increase to Future Level (months)	**0**	**120**	**0**	**0**	**0**	**365**	**0**

$$C_t = C_0 e^{(-Q/(PV*R))t}$$

Cumulative Time (Months)	WU-PBA	WAA U>DCGL	WAA-WEST	WU-1348	WAA-EAST	WAA-BLUFF	1206-NORTH	WEIGHTED AVERAGE (ng/L)	WEIGHTED AVERAGE[2] (pCi/L)	Combined Influent Flow Rate (gpm)
64	--	0.02	--	--	--	1.36	--	**0.57**	**9.73**	**250**
65	--	0.01	--	--	--	1.30	--	**0.55**	**9.31**	**250**
66	--	0.01	--	--	--	1.25	--	**0.52**	**8.90**	**250**
67	--	0.01	--	--	--	1.19	--	**0.50**	**8.52**	**250**
68	--	0.01	--	--	--	1.14	--	**0.48**	**8.15**	**250**
69	--	0.01	--	--	--	1.09	--	**0.46**	**7.80**	**250**
70	--	0.01	--	--	--	1.05	--	**0.44**	**7.46**	**250**
71	--	0.01	--	--	--	1.00	--	**0.42**	**7.13**	**250**
72	--	0.01	--	--	--	0.96	--	**0.40**	**6.82**	**250**
73	--	0.01	--	--	--	0.92	--	**0.38**	**6.53**	**250**
74	--	0.01	--	--	--	0.88	--	**0.37**	**6.25**	**250**
75	--	0.01	--	--	--	0.84	--	**0.35**	**5.98**	**250**
76	--	0.01	--	--	--	0.80	--	**0.34**	**5.72**	**250**
77	--	0.01	--	--	--	0.77	--	**0.32**	**5.47**	**250**
78	--	0.00	--	--	--	0.74	--	**0.31**	**5.23**	**250**
79	--	0.00	--	--	--	0.70	--	**0.29**	**5.01**	**250**
80	--	0.00	--	--	--	0.67	--	**0.28**	**4.79**	**250**
81	--	0.00	--	--	--	0.64	--	**0.27**	**4.58**	**250**
82	--	0.00	--	--	--	0.62	--	**0.26**	**4.39**	**250**
83	--	0.00	--	--	--	0.59	--	**0.25**	**4.20**	**250**
84	--	0.00	--	--	--	0.57	--	**0.24**	**4.01**	**242**
85	--	0.00	--	--	--	0.54	--	**0.23**	**3.84**	**242**
86	--	0.00	--	--	--	0.52	--	**0.22**	**3.68**	**242**
87	--	0.00	--	--	--	0.50	--	**0.21**	**3.52**	**242**
88	--	0.00	--	--	--	0.47	--	**0.20**	**3.37**	**242**
89	--	0.00	--	--	--	0.45	--	**0.19**	**3.22**	**242**
90	--	0.00	--	--	--	0.43	--	**0.18**	**3.08**	**242**
91	--	0.00	--	--	--	0.42	--	**0.17**	**2.95**	**242**
92	--	0.00	--	--	--	0.40	--	**0.17**	**2.82**	**242**
93	--	0.00	--	--	--	0.38	--	**0.16**	**2.70**	**242**
94	--	0.00	--	--	--	0.36	--	**0.15**	**2.58**	**242**
95	--	0.00	--	--	--	0.35	--	**0.15**	**2.47**	**242**

Western Area Combined Influent - Technetium-99

Area	WU-PBA (GE-WU-01)	WAA U>DCGL (GE-WAA-01 through GE-WAA-04)	WAA-WEST (GE-WAA-05)	WU-1348 (GETR-WU-01)	WAA-EAST (GE-WAA-14 & GE-WAA-15)	WAA-BLUFF (GE-WAA-06 through GE-WAA-13)	1206-NORTH (GETR-WU-02)
C_i (ng/L)	--	**0.00**	--	--	--	**14.51**	--
C_{max}[1] (ng/L)	--	**2.67**	--	--	--	**12.80**	--
Flow Rate (gpm)	**5**	**99**	**10**	**4**	**20**	**104**	**8**
R	4.6	1.6	1.6	2.8	1.6	2.03	2.7
PV (liters)	6,548,662	118,295,089	67,593,844	1,749,984	133,552,129	192,892,116	85,334
Q (liters/day)	27,255	539,648	54,510	21,804	109,020	566,903	43,608
Time Required for Initial Conc. to Increase to Future Level (months)	**0**	**120**	**0**	**0**	**0**	**365**	**0**

$$C_t = C_0 e^{(-Q/(PV*R))t}$$

Cumulative Time (Months)	WU-PBA	WAA U>DCGL	WAA-WEST	WU-1348	WAA-EAST	WAA-BLUFF	1206-NORTH	WEIGHTED AVERAGE (ng/L)	WEIGHTED AVERAGE[2] (pCi/L)	Combined Influent Flow Rate (gpm)
96	--	0.00 --	--	--	0.33 --			**0.14**	**2.36**	**242**
97	--	0.00 --	--	--	0.32 --			**0.13**	**2.26**	**242**
98	--	0.00 --	--	--	0.31 --			**0.13**	**2.17**	**242**
99	--	0.00 --	--	--	0.29 --			**0.12**	**2.07**	**242**
100	--	0.00 --	--	--	0.28 --			**0.12**	**1.98**	**242**
101	--	0.00 --	--	--	0.27 --			**0.11**	**1.90**	**242**
102	--	0.00 --	--	--	0.26 --			**0.11**	**1.82**	**242**
103	--	0.00 --	--	--	0.25 --			**0.10**	**1.74**	**242**
104	--	0.00 --	--	--	0.23 --			**0.10**	**1.66**	**242**
105	--	0.00 --	--	--	0.22 --			**0.09**	**1.59**	**242**
106	--	0.00 --	--	--	0.21 --			**0.09**	**1.52**	**242**
107	--	0.00 --	--	--	0.21 --			**0.09**	**1.46**	**242**
108	--	0.00 --	--	--	0.20 --			**0.08**	**1.39**	**242**
109	--	0.00 --	--	--	0.19 --			**0.08**	**1.33**	**242**
110	--	0.00 --	--	--	0.18 --			**0.08**	**1.28**	**242**
111	--	0.00 --	--	--	0.17 --			**0.07**	**1.22**	**242**
112	--	0.00 --	--	--	0.17 --			**0.07**	**1.17**	**242**
113	--	0.00 --	--	--	0.16 --			**0.07**	**1.12**	**242**
114	--	0.00 --	--	--	0.15 --			**0.06**	**1.07**	**242**
115	--	0.00 --	--	--	0.14 --			**0.06**	**1.02**	**242**
116	--	0.00 --	--	--	0.14 --			**0.06**	**0.98**	**242**
117	--	0.00 --	--	--	0.13 --			**0.06**	**0.94**	**242**
118	--	0.00 --	--	--	0.13 --			**0.05**	**0.90**	**242**
119	--	0.00 --	--	--	0.12 --			**0.05**	**0.86**	**242**
120	--	0.00 --	--	--	0.12 --			**0.05**	**0.82**	**242**
121	--	0.00 --	--	--	0.11 --			**0.05**	**0.79**	**242**
122	--	0.00 --	--	--	0.11 --			**0.04**	**0.75**	**242**
123	--	0.00 --	--	--	0.10 --			**0.04**	**0.72**	**242**
124	--	0.00 --	--	--	0.10 --			**0.04**	**0.69**	**242**
125	--	0.00 --	--	--	0.09 --			**0.04**	**0.66**	**242**
126	--	0.00 --	--	--	0.09 --			**0.04**	**0.63**	**242**
127	--	0.00 --	--	--	0.09 --			**0.04**	**0.60**	**242**

Attachment 5.5
Influent Concentration Decline Analysis
Cimarron Remediation Site

Rev. E
1/30/2020

Western Area Combined Influent - Technetium-99

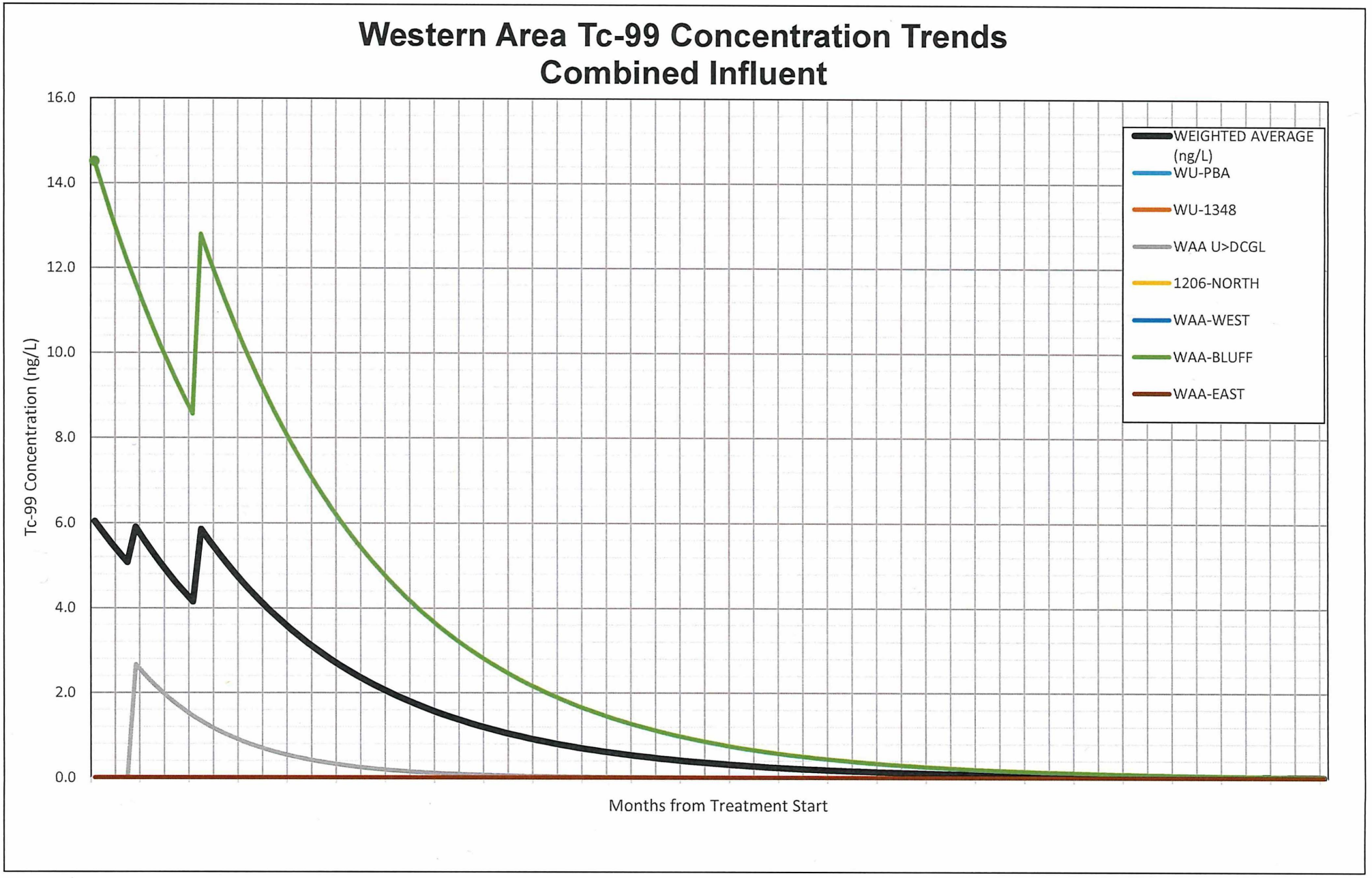
Area	WU-PBA (GE-WU-01)	WAA U>DCGL (GE-WAA-01 through GE-WAA-04)	WAA-WEST (GE-WAA-05)	WU-1348 (GETR-WU-01)	WAA-EAST (GE-WAA-14 & GE-WAA-15)	WAA-BLUFF (GE-WAA-06 through GE-WAA-13)	1206-NORTH (GETR-WU-02)
C_i (ng/L)	--	**0.00**	--	--	--	**14.51**	--
C_{max}[1] (ng/L)	--	**2.67**	--	--	--	**12.80**	--
Flow Rate (gpm)	**5**	**99**	**10**	**4**	**20**	**104**	**8**
R	4.6	1.6	1.6	2.8	1.6	2.03	2.7
PV (liters)	6,548,662	118,295,089	67,593,844	1,749,984	133,552,129	192,892,116	85,334
Q (liters/day)	27,255	539,648	54,510	21,804	109,020	566,903	43,608
Time Required for Initial Conc. to Increase to Future Level (months)	**0**	**120**	**0**	**0**	**0**	**365**	**0**

$$C_t = C_0 e^{(-Q/(PV*R))t}$$

Cumulative Time (Months)	WU-PBA	WAA U>DCGL	WAA-WEST	WU-1348	WAA-EAST	WAA-BLUFF	1206-NORTH	WEIGHTED AVERAGE (ng/L)	WEIGHTED AVERAGE[2] (pCi/L)	Combined Influent Flow Rate (gpm)
128	--	0.00	--	--	--	0.08	--	**0.03**	**0.58**	**238**
129	--	0.00	--	--	--	0.08	--	**0.03**	**0.55**	**238**
130	--	0.00	--	--	--	0.07	--	**0.03**	**0.53**	**238**
131	--	0.00	--	--	--	0.07	--	**0.03**	**0.51**	**238**
132	--	0.00	--	--	--	0.07	--	**0.03**	**0.48**	**238**
133	--	0.00	--	--	--	0.07	--	**0.03**	**0.46**	**238**
134	--	0.00	--	--	--	0.06	--	**0.03**	**0.44**	**238**
135	--	0.00	--	--	--	0.06	--	**0.03**	**0.43**	**238**
136	--	0.00	--	--	--	0.06	--	**0.02**	**0.41**	**238**
137	--	0.00	--	--	--	0.06	--	**0.02**	**0.39**	**238**
138	--	0.00	--	--	--	0.05	--	**0.02**	**0.37**	**238**
139	--	0.00	--	--	--	0.05	--	**0.02**	**0.36**	**238**
140	--	0.00	--	--	--	0.05	--	**0.02**	**0.34**	**238**
141	--	0.00	--	--	--	0.05	--	**0.02**	**0.33**	**238**
142	--	0.00	--	--	--	0.04	--	**0.02**	**0.31**	**238**
143	--	0.00	--	--	--	0.04	--	**0.02**	**0.30**	**238**
144	--	0.00	--	--	--	0.04	--	**0.02**	**0.29**	**238**
145	--	0.00	--	--	--	0.04	--	**0.02**	**0.27**	**238**
146	--	0.00	--	--	--	0.04	--	**0.02**	**0.26**	**238**
147	--	0.00	--	--	--	0.04	--	**0.01**	**0.25**	**238**
148	--	0.00	--	--	--	0.03	--	**0.01**	**0.24**	**238**
149	--	0.00	--	--	--	0.03	--	**0.01**	**0.23**	**238**
150	--	0.00	--	--	--	0.03	--	**0.01**	**0.22**	**238**

Notes:

[1]The C_{max} value for the WAA-BLUFF remediation area incorporates the anticipated concentration increase at GE-WAA-11. C_{max} occurs at GE-WAA-11 approximately 365 days from startup, but the flow rate weighted average for WAA-BLUFF is less than C_i at time 0. However, the flow rate weighted average C_{max} at 365 days is greater than the concentration at 365 days, based on the concentration decay function. Therefore, C_{max} represents an increase in the concentration decay curve at time = 365 days.

[2]The Tc-99 activity to mass conversion factor is 1.7E-02 Ci/g (49 CFR 173.435 Table of A1 and A2 values).

Attachment 5.5
Influent Concentration Decline Analysis
Cimarron Remediation Site