FINAL

Reevaluation of Soil Remedial Goals for Operable Unit 1 in Support of a Five-Year Review Amendment, Iowa Army Ammunition Plant, Middletown, Iowa

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U.S. Army Corps of Engineers
Louisville District

600 Dr. Martin Luther King Jr. Place
Louisville, Kentucky 40202-2232

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1. Introduction

This document describes the approach and calculations used to evaluate the protectiveness of existing Operable Unit 1 (OU-1) soil remedial goals (RGs) for five chemicals of concern (COCs) at the Iowa Army Ammunition Plant (IAAAP), in Middletown, Iowa. The IAAAP has been placed under the U.S. Department of Defense Installation Restoration Program, which follows the process under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act. This work was conducted under U.S. Army Corps of Engineers, Louisville District (USACE), Contract W912QR21D0019, Delivery Order W912QR21F0421.

OU-1 addresses soil on the IAAAP, excluding soil contaminated by use or testing of military munitions or by radiological chemicals. There are twenty OU-1 sites (Leidos, 2019), which are shown on Figure 1. The remedial action for OU-1 is documented in an Interim Record of Decision (ROD) (USACE, 1997) and ROD (USACE, 1998), It includes the following components: excavation of soils contaminated above RGs, segregation and staging of excavated soil based on type and level of contamination, treatment of contaminated soil (as needed, to meet disposal criteria), and disposal of soil. The OU-1 RODs have been modified by five ESDs: a 2003 ESD (USACE, 2003), 2006 ESD (USACE, 2006), 2008 ESD (USACE, 2008a), 2009 ESD (USACE, 2009), 2011 ESD (USACE 2011a), and 2018 ESD (USACE, 2018). The 2018 ESD established land use controls (LUCs) as the long-term component of the remedy. LUCs include prohibition of residential land use and development/use of properties as elementary and secondary schools, childcare facilities, and playgrounds, access restrictions to prevent inadvertent exposure to contaminated soil, engineering controls (fences, signs, covers), construction restrictions, and routine inspections. RGs for OU-1 were defined in the 1998 Interim ROD (USACE, 1997) and modified in the 1998 ROD (USACE, 1998), 2006 ESD (USACE, 2006), 2008 ESD (USACE, 2008a), and 2011 ESD (USACE, 2011a).

Four five-year reviews (FYRs) have been conducted for OU-1 since 2006 as part of the CERCLA process. The fourth FYR report for IAAAP (USACE and Dawson 2021) identified the following issue for OU-1: "The soil remediation goals for antimony, cadmium, hexavalent chromium, thallium, and mercury are no longer protective." It provided the following recommendation: "[…] OU-1 remediation goals should be evaluated and revised to incorporate current toxicity, exposure assumptions, and cumulative risk and ensure they are protective of human health and the environment. A post-ROD [Record of Decision] change document will be required to document any changes to the remediation goals."

This document provides the results of a detailed evaluation of the existing OU-1 RGs for five COCs (antimony, cadmium, hexavalent chromium, thallium, and mercury) based on current toxicity and exposure assumptions. When warranted, it also provides the basis for new OU-1 RGs for the COCs based on current and potential future receptors at the OU-1 sites. This document presents the results of preliminary human health risk assessment (HHRA) screening and calculations for each of the OU-1 sites, which can be used to help decide whether additional risk assessment, investigation, or remedial action is warranted at the OU-1 sites.

2. OU-1 RG Protectiveness Evaluation

2.1 Exposure Assumption and Toxicity Value Assessment

Based on the conclusions of the 2021 FYR, the existing OU-1 RGs for the five identified COCs (antimony, cadmium, hexavalent chromium, thallium, and mercury) were further evaluated to determine whether they are still protective based on current toxicity values and exposure assumptions. This evaluation was conducted using the following technical approach:

- Compare the U.S. Environmental Protection Agency's (EPA's) current industrial worker exposure assumptions to assumptions used during development of the existing OU-1 RGs.

- Compare EPA's current toxicity values to values used during development of the existing OU-1 RGs.
- Identify EPA's exposure assumptions for current and potential future receptors at OU-1.

A comparison of exposure assumptions for the five COCs between when the RGs were established (1996) and EPA's current (2023) regional screening level (RSL) values is provided in Table 1. Differences between the two time periods are bulleted below:

- The existing RGs are based on soil exposures to a site worker via ingestion only.
  - The EPA default ingestion rate for soil in 1996 was 50 milligrams per kilogram (mg/kg) .
  - EPA's RSL values for an industrial scenario, presented in the online generic RSL table, are based on soil exposures to a composite worker via ingestion, dermal contact, and inhalation of particulate and/or volatile emissions. The 2023 EPA default ingestion rate for soil is 100 mg/kg for that receptor.
- EPA's RSL for an indoor worker (available in the online RSL calculator) are based on soil exposures via ingestion and inhalation of particulate and/or volatile emissions. The EPA default ingestion rate for soil is 50 mg/kg (the same ingestion rate used to derive the existing RGs).
- The default body weight for workers has increased from 70 kg to 80 kg.

A comparison of toxicity values for the five COCs between when the RGs were established (1996/1997) and now (2023) is provided in Table 2. Noted differences between the two time periods are bulleted below:

- There are no changes in the toxicity values for antimony.
- For cadmium, the oral reference dose (RfD) decreased, and a dermal absorption fraction was established. The current oral RfD is based on the subchronic toxicity value because it is more protective than the chronic value.
- For hexavalent chromium, the existing RG is based on noncarcinogenic toxicity. The oral RfD has decreased slightly, and a carcinogenic toxicity value has been established.
- In the fourth FYR, the existing RG for mercury was compared to the RSL for elemental mercury to determine whether it was still protective. However, the form of mercury that the existing RG is based on is not identified. The RSL for elemental mercury is based only on an inhalation toxicity value. The existing RG has an oral RfD, which is the same as the current oral RfD for mercuric chloride. Mercuric chloride is typically used as a surrogate for mercury when there is no indication that elemental mercury is present at a site, which is the case for IAAAP.
- For thallium, the oral RfD decreased. Note this most recent thallium toxicity value is the Provisional Peer-Reviewed Toxicity Value Appendix A screening value.

2.2 Comparison of Existing OU-1 RGs to Soil RSLs

The existing OU-1 RGs for the five COCs (antimony, cadmium, hexavalent chromium, thallium, and mercury) were compared to RSLs for a composite worker and an indoor worker, as presented on Table 3.

- The RSLs for the composite worker are the values that were used in comparison to the existing RGs in the fourth FYR to determine whether the RGs are still protective. These RSLs were obtained from the May 2020 RSL table for industrial soil. The 2020 industrial RSLs incorporate ingestion, dermal, and inhalation routes where toxicity data is available and are based on exposure parameters for a composite worker, which has a default soil ingestion value of 100 mg/kg.

- The RSLs for an indoor worker were calculated using EPA's online calculator (updated May 2023)and incorporate a soil ingestion rate of 50 mg/kg and include inhalation routes where toxicity data are available. As mentioned previously, the fourth FYR presented an RSL for elemental mercury, when the RSL for mercuric chloride should have been considered. Therefore, the value for mercuric chloride was calculated for this assessment.

The 2020 RSLs (composite worker) are all lower than the existing OU-1 RGs. Note that the 2020 RSLs are included in the table, as these were the values presented in the 2021 FYR, which is the basis for this assessment. The (2023) calculated RSLs for the indoor worker are also lower than the OU-1 RGs, with the exception of antimony and mercury (as mercuric chloride). This is attributed to the increase in body weight.

3. OU-1 RG Reevaluation Approach

Based on the comparison of existing RGs to RSLs in Section 2, not all of the RGs are protective of human health based on exposures to a site worker, composite or indoor. Because activities at the OU-1 sites have changed over the past decades, the site worker may no longer be the only receptor exposed to soil. Therefore, the following approach was taken to further evaluate the existing OU-1 RGs for the five COCs (antimony, cadmium, hexavalent chromium, mercury, and thallium):

- Identify current and potential future receptors at each of the OU-1 sites.
- Calculate proposed RGs for a range of receptors and their exposure routes (based on target risk = 10^{-6}, hazard quotient [HQ] = 1).
- Compare existing RGs to proposed RGs and soil background threshold values (BTVs).

3.1 Current and Potential Future Receptors at OU-1 Sites

The following current and potential future receptors have been identified for OU-1 sites at IAAAP:

- Inside site worker—works only inside buildings.
- Occasional site worker—works only occasionally inside buildings.
- Maintenance worker—visits sites only occasionally, for grass mowing, landscaping, repair work, other inside/outside maintenance work.
- Light construction worker—constructs new buildings or conducts other construction work but does not dig into ground.
- Heavy construction worker—conducts subsurface construction work; digs trenches, footers, foundations for buildings; works in culverts.

3.2 Proposed RGs and BTVs

Proposed RGs for each of the five identified COCs (antimony, cadmium, hexavalent chromium, thallium, and mercury) were calculated for three receptors: indoor worker, outdoor worker, and construction worker. These proposed RGs could be used as new (updated) RGs for OU-1. The proposed RGs, calculated using EPA's online RSL calculator, considered the current and potential future receptors and exposure routes for those receptors:

- Indoor worker (includes indoor site worker and occasional site worker listed in Section 3.1)

  - Ingestion and inhalation exposures; EPA default exposure parameter values.
  - Protective of inside site worker and occasional site worker.
- Outdoor worker (includes maintenance worker and light construction worker listed in Section 3.1)
  - Ingestion, dermal contact, and inhalation exposures; EPA default exposure parameter values.
  - Protective of maintenance worker and light construction worker.
  - Since the outdoor worker receptor performs tasks resulting in subchronic exposures (maintenance/repairs or light construction work), consistent with prior calculated IAAP RGs and consistent with how EPA assesses subchronic exposures; subchronic toxicity values were used for the RG calculations.
- Construction worker (includes heavy construction worker listed in Section 3.1).
  - Ingestion, dermal contact, and inhalation exposures; EPA default exposure parameter values for soil unpaved.
  - Uses subchronic toxicity values based on subchronic exposure (consistent with the May 2023 EPA RSL calculator).
  - Protective of heavy construction worker.

A summary of the existing RGs, proposed RGs, and the soil BTVs are presented in Table 4. Mercury is evaluated as mercuric chloride since that is the appropriate form of this metal for OU-1. A comparison of the existing versus proposed RGs is bulleted below.

- Antimony—the existing RG of 816 mg/kg is lower than the proposed RG for an indoor worker (934 mg/kg) but higher than the proposed RGs for an outdoor worker (519 mg/kg) and construction worker (134 mg/kg).
- Cadmium—the existing RG of 1,000 mg/kg is higher than the proposed RGs for an indoor worker (233 mg/kg), outdoor worker (550 mg/kg) and construction worker (62.6 mg/kg).
- Hexavalent chromium—the existing RG of 10,000 mg/kg is higher than the proposed RGs for an indoor worker (12.3 mg/kg), outdoor worker (7.04 mg/kg) and construction worker (7.84 mg/kg).
- Mercury—the existing RG of 310 mg/kg is lower than the proposed RGs for an indoor worker (701 mg/kg), outdoor worker (3,890 mg/kg) and construction worker (773 mg/kg).
- Thallium—the existing RG of 143 mg/kg is higher than the proposed RGs for an indoor worker (23.4 mg/kg), outdoor worker (51.9 mg/kg) and construction worker (13.6 mg/kg).

3.3 Summary of Protectiveness Evaluation

The existing RG for one COC (mercury, as mercuric chloride) remains protective based on current toxicity values and current/future exposure assumptions:

- The proposed mercury RGs for receptors are higher than existing RG.
- This conclusion is different from the 2021 FYR, since that assessment used elemental mercury, which was not used at IAAAP. Since elemental mercury was not used, this is not the appropriate form of mercury to evaluate protectiveness at IAAAP.
- Mercury fulminate was used as an explosive during IAAAP operations at OU-1 sites Line 1 and Line 6, and potentially Line 2. The Explosives Disposal Area (burn pads) historically included the open

burning of explosives-contaminated metals. In addition, fuzes and detonators, which may have contained mercury, were assembled at Lines 4A and 4B, Line 9, and the Central Test Area. Mercury was identified as a primary soil COC at Line 6, Line 9, Demolition Area, PDS, North Burn Pads, and West Burn Pads, and was addressed during OU-1 removal actions.

The existing RGs for four COCs (antimony, cadmium, hexavalent chromium, and thallium) may not be protective based on current toxicity values and current/future exposure assumptions:

- Current toxicity values for cadmium, hexavalent chromium, and thallium indicate higher toxicity than when the existing RGs were established, or additional toxicity values were established.
- Proposed antimony, cadmium, hexavalent chromium, and thallium RGs for current and future receptors at OU-1 are lower than existing RGs.
- This is consistent with the 2021 FYR, which concluded that the existing RGs for these four COCs may not be protective based on current toxicity values and current/future exposure assumptions.

4. Proposed OU-1 RGs for Future Assessment

Table 5 summarizes proposed RGs for each of the four COCs (antimony, cadmium, hexavalent chromium, and thallium) with existing OU-1 RGs that may no longer be protective. The proposed RGs are based on individual site activities and anticipated receptors current and potential future receptors that may be present at the OU-1 sites (indoor worker, outdoor worker, and construction worker). Proposed RGs are the lower value of the noncarcinogenic and carcinogenic RGs from Table 4. The existing OU-1 RGs and soil BTVs are also provided in Table 5. Note, if new speciated chromium data are collected in the future, then the BTV for hexavalent chromium may be adjusted to reflect the current hexavalent/total chromium ratio. Current and potential receptors and the proposed RGs for the individual sites at OU-1 are summarized in Table 6.

5. Preliminary Human Health Risk Assessment

A preliminary human health risk assessment (HHRA) was conducted to evaluate whether existing soil concentrations of four COCs (antimony, cadmium, hexavalent chromium, and thallium) at the OU-1 sites could pose unacceptable risk based on the proposed RGs calculated using current toxicity and receptor-specific exposure parameters. A multistep approach was used and is described in the following subsections.

5.1 Step 1: Identify Data for HHRA Calculations

The analytical data used in the HHRA calculations consist of soil samples collected at 20 of the OU-1 sites. Soil samples that were analyzed for the four COCs (antimony, cadmium, hexavalent chromium, and thallium) were collected between 1981 and 2007. Numerous soil removal actions have been conducted at the OU-1 sites. The existing soil data were evaluated to determine whether a soil sample was removed during any of the removal actions. If the soil sample was removed during an excavation, then it was removed from the HHRA data set. Older soil data that were not removed during removal actions are considered to still be representative of the site for these calculations. The soil data retained for calculations are available in Attachment 1. The locations of OU-1 soil samples used in the calculations are shown on figures included in Attachment 2.

5.2 Step 2: Data Screening

For each of the OU-1 sites, the maximum detected concentration for each of the four COCs (antimony, cadmium, hexavalent chromium, and thallium) in surface soil (0–0.5 feet below ground surface [bgs]) and combined surface and subsurface soil (0–10 feet bgs) was compared to the proposed OU-1 RGs based on current/future site receptors (i.e., indoor worker, outdoor worker, and construction worker). Table 7 summarizes the COCs exceeding the proposed RGs for each OU-1 site evaluated. Total chromium data were conservatively assumed to be 100 percent hexavalent chromium.

5.3 Steps 3 and 4: Exposure Point Concentrations and Risk Ratios

At each of the OU-1 sites, if any of the maximum detected concentrations of the COCs exceeded the proposed RG, then an exposure point concentration (EPC) and risk ratios were calculated for that COC. The calculated EPCs and risk ratio values for surface soil and combined surface and subsurface soil are included in Tables 1 and 2 in Attachment 3. These tables also provide the soil BTVs, maximum detected concentrations, and frequency of detection.

5.4 Step 5: Hexavalent Chromium EPCs and Risk Ratios

Speciated hexavalent chromium data for soil has not been collected at any of the OU-1 sites. Because hexavalent chromium is typically present as a fraction of the total chromium, an approach for evaluating chromium at IAAAP sites for which no hexavalent chromium data are available is provided in Figure 2. Hexavalent chromium EPCs can be calculated using area-specific ratios of hexavalent chromium concentrations to chromium concentrations in soil, as documented in the final OU-9 RI report addendum (Leidos 2020) and final OU-4 RI report (Leidos and Jacobs 2022). As described in the Round 3 response to EPA comments on the OU-4 RI report, it is reasonable to assume that all areas at the IAAAP with no known history of chromium use, storage, or release can be characterized as having similar hexavalent chromium/total chromium ratios. This should be especially true for areas with media concentrations comparable to background. Therefore, it is also reasonable to assume that the extensive OU-9 soil data set (> 50 data points) of speciated chromium data should present hexavalent chromium/total chromium ratios that would be similar to ratios in other areas of IAAAP that are unaffected by the presence of hexavalent chromium in environmental media. The use of hexavalent chromium/total chromium ratios calculated based on actual area-specific data across IAAAP areas of similar characteristics and history relative to the use of hexavalent chromium at a particular site is more reasonable than the application of a generic assumption that 100% of total chromium is in the hexavalent form. As shown on Figure 2, different hexavalent chromium ratios are assumed for sites where chromium may have been used and sites where there is no history of chromium use; a ratio of 0.03 is applied for sites with no known use of hexavalent chromium and a ratio of 0.06 is applied to sites with known use of hexavalent chromium. In comparison, EPA uses a ratio of 0.17 (1:6) in their RSL calculation for hexavalent chromium (https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide). Historical use of chromium at OU-1 sites is identified in Table 8 and Attachment 3, Tables 3 and 4. The calculated EPCs and risk ratio values for surface soil and combined surface and subsurface soil, using hexavalent chromium EPCs are included in Tables 3 and 4 in Attachment 3.

5.5 Preliminary HHRA Results

For surface soil (0–0.5 feet bgs), the following COC risks and/or hazards exceeded EPAs excess lifetime cancer risk (ELCR) threshold (1×10^{-6} to 1×10^{-4}) or HQ target (HQ= 1):

- Antimony: North Burn Pads—HQ = 2

- Thallium: North Burn Pads—HQ = 2
- Total chromium (assuming 100 percent chromium): All 20 OU-1 sites evaluated—ELCR > 1×10^{-6}.
- Hexavalent chromium (EPC calculated via ratio): North Burn Pads—ELCR > 1×10^{-6}.
- Cadmium: No exceedances at any sites.

In combined surface and subsurface soil (0–10 feet bgs), the following are COCs that exceeded cancer risk or hazard index:

- Total chromium (assuming 100 percent chromium): All OU-1 sites evaluated (21 sites for combined soil)—ELCR > 1×10^{-6}.
- Hexavalent chromium (EPC calculated via ratio): No exceedances at any sites.
- Antimony: No exceedances at any sites.
- Cadmium: No exceedances at any sites.
- Thallium: No exceedances at any sites.

6. Conclusions and Recommendations

Based on an evaluation of exposure assumptions and toxicity values for five OU-1 COCs (antimony, cadmium, hexavalent chromium, thallium, and mercury) that were identified in the fourth FYR, it is recommended that the OU-1 RGs for antimony, cadmium, hexavalent chromium, and thallium be updated to remain protective of human health and the environment. No change to the OU-1 RG for mercury is warranted, as it remains protective of human health and the environment based on the fact that mercuric chloride (and not elemental mercury) should be the form of mercury considered for potential human health risk at IAAAP. Either the selected new RGs can vary at each of the OU-1 sites, based on that site's current and potential future use, or the most conservative proposed RG across all of the OU-1 sites can be selected. The new OU-1 RGs can be documented in an Explanation of Significant Difference to the OU-1 ROD.

Based on the preliminary HHRA calculations, it is recommended that full-scale risk assessment be completed for antimony, thallium, and hexavalent chromium in soil at the North Burn Pads site to further assess protectiveness at this OU-1 site. No additional HHRA is warranted at any of the other OU-1 sites. So that EPCs are based on current conditions, it is recommended that new soil samples be collected from the North Burn Pads for antimony, thallium, and chromium speciation to assess if additional removal actions may be warranted. If the chromium speciation data indicate that the hexavalent chromium/total chromium ratio for this area is different, then a new background value will be calculated for this area. This new background value will be used for future risk assessments and for use in future risk management decisions.

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Tables

Table 1. Exposure Assumption Comparison

Parameter Code	Parameter Definition	Units	1996 RI HHRA Value[a] (Site Worker)	2023 EPA Generic RSL Table (Composite Industrial Worker)[b]	2023 EPA Default Value for Indoor Industrial Worker[c]
IR-S	Ingestion rate of soil	mg/day	50	100	50
EF	Exposure frequency	days/year	250	250	250
ED	Exposure duration	years	25	25	25
CF	Conversion factor	kg/mg	1.00E-06	1.00E-06	1.00E-06
BW	Body weight	kg	70	80	80
AT-N	Averaging time (noncancer)	days	9,125	9,125	9,125
AT-C	Averaging time (cancer)	days	25,550	25,550	25,550
SA	Skin surface area available for contact	cm^2	NA[d]	3,527	3,527
SSAF	Soil to skin adherence factor	mg/cm^2-day	NA[d]	0.12	0.12
ET	Exposure time	hr	NA[d]	8	8

[a] 1996 Region III RBC default values are not available online. Values presented are those from the 1996 HHRA.

[b] Industrial soil RSLs are based on a composite worker. Default parameter values are the same for the 2020 and 2023 RSLs.

[c] EPA's default indoor worker based on ingestion of soil and inhalation of particulates.

[d] 1996 BHHRA = worker only evaluated for ingestion of soil, so these exposure parameters were not used in 1996.

Highlighted 2023 values differ from the values used in the 1996 RI HHRA.

Table 2. Toxicity Value Comparison

OU-1 COC	Oral Reference Dose (mg/kg-day)				Oral Slope Factor (mg/kg-day)$^{-1}$			Dermal Absorption Fraction (ABS_d)
	1996 RI HHRA	1997 FFS, 1998 IROD & ROD	2015 & 2021 FYR	2023 RfD_O/Sub-chronic RfD_O	1996 RI HHRA	1997 FFS	2002 SF_o	
Antimony	4.0E-04	4.0E-04	4.0E-04	4.0E-04/4.0E-04	—	—	—	—
Cadmium	1.0E-03	5.0E-04	5.0E-04	1.0E-04/5.0E-04	—	—	—	0.001
Hexavalent chromium	5.0E-03	5.0E-03	5.0E-03	3.0E-03/5.0E-3	—	—	5.0E-01	—
Mercury	3.0E-04	NA[a]	NA[a]	—	—	NA[a]	—	—
Thallium	7.0E-05	7.0E-05	7.0E-05	1.0E-05/4.0E-05	—	—	—	—

[a] Human health RGs were not calculated for mercury in these documents.

Noted changes were the following:

- Cadmium: Chronic oral reference dose decreased, and dermal absorption fraction established.
- Hexavalent chromium: Value previously based on non-carcinogenic toxicity. A carcinogenic toxicity value has since been established.
- Mercury RG was based on RSL for elemental mercury, which is only based on an inhalation toxicity value. RG should have been based on mercuric chloride, which has an oral RfD of 3.0E-04 and subchronic oral RfD of 3.0E-03 (the oral RfD is still current).
- Thallium: Oral reference dose decreased.
- Highlighted 2023 values differ from the values used in the 1996 RI HHRA.

Table 3. OU-1 RG and RSL Comparison

OU-1 COC	Existing RG (Based on Site Worker)	RSL Presented in FYR[a] (Based on Composite Worker)	RSL (Based on Indoor Worker)[b]
Antimony	816 (nc)	470 (nc)	934 (nc)
Cadmium	1,000 (nc)	100 (nc)	233 (nc)
Hexavalent chromium	10,000 (nc)	6 (ca)	12 (ca)
Mercury	310 (nc)[c]	—	—
Mercury (elemental)	—	46 (nc)[d]	—
Mercuric chloride	—	—	701 nc
Thallium	143 (nc)	12 (nc)	23 (nc)

[a] May 2020 Industrial soil RSLs: a) incorporate ingestion, dermal, and inhalation routes where toxicity data is available; and b) based on exposure parameters for a composite worker, which has a default soil ingestion value of 100 mg/kg.

[b] Calculated using EPA's on-line calculator (May 2023); based on soil ingestion rate of 50 mg/kg and includes inhalation routes where toxicity data is available.

[c] Based on ecological risk, not human health.

[d] Based solely on inhalation route, which is not used in the existing RG.

Units in milligrams per kilogram.

ca = cancer

nc = noncancer

Table 4. Comparison of Proposed RGs by Receptor

OU-1 COC	Existing OU-1 RG	Combined Soil BTV	Indoor Worker[a]		Outdoor Worker[b]		Construction Worker[c]	
			Noncancer (HQ=1)	Cancer (ELCR=10^{-6})	Noncancer (HQ=1)	Cancer (ELCR=10^{-6})	Noncancer (HQ=1)	Cancer (ELCR=10^{-6})
Antimony	816	19.6	934	—	519	—	134	—
Cadmium	1,000	0.89	233	9,260	550	10,300	62.6	434
Hexavalent chromium	10,000	21[d]	6,930	12.3	6,470	7.04	1,110	7.8
Mercury (as mercuric chloride)	310	0.49	701	—	3,890	—	773	—
Thallium	143	18.2	23.4	—	51.9	—	13.6	—

[a] Protective of inside site worker and occasional site worker; exposure routes: ingestion and inhalation.

[b] Protective of maintenance worker and light construction worker; exposure routes: ingestion, dermal, and inhalation.

[c] Protective of heavy construction worker; exposure routes: ingestion, dermal, and inhalation.

[d] There is no BTV available for hexavalent chromium. The BTV value presented in the table is for total chromium.

Units in milligrams per kilograms.

Table 5. Proposed Remedial Goals for Current and Future Receptors

OU-1 COC	Existing OU-1 RG	Combined Soil BTV	Proposed RGs for Current and Potential Future Receptors		
			Indoor Worker	Outdoor Worker	Construction Worker
Antimony	816 (nc)	19.6	934 (nc)	519 (nc)	134 (nc)
Cadmium	1,000 (nc)	0.89	233 (nc)	550 (nc)	62.6 (nc)
Hexavalent chromium	10,000 (nc)	21[a]	12.3 (ca)	7.04 (ca)	7.8 (ca)
Thallium	143 (nc)	18.2	23.4 (nc)	51.9 (nc)	13.6 (nc)

[a] There is no BTV available for hexavalent chromium. The BTV value presented in the table is for total chromium.

Units in milligrams per kilograms.

Based on target hazard quotient (HQ) =1 and target risk =10^{-6}.

Final proposed RGs would be based on individual site activities and anticipated receptors.

ca = cancer

nc = noncancer

Table 6. Receptors & Proposed RG Basis

OU-1 Site	Current and Potential Receptors	Proposed RG Basis
Line 1	Indoor worker, outdoor worker, and construction worker	Lower RG of indoor worker and outdoor worker; and construction worker
Line 2		
Line 3		
Line 3A		
Line 4A and 4B		
Line 5A and 5B	Outdoor worker and construction worker	
Line 6		
Line 8		
Line 9		
Line 800/Pinkwater Lagoon		
East Burn Pads	Outdoor worker	
Demolition Area and Deactivation Furnace	Indoor worker, outdoor worker, and construction worker	Lower RG of indoor worker and outdoor worker; and construction worker
Burn Cages, Burn Cage Landfill, West Burn Pads, West Burn Pads Landfill	Outdoor Worker	
North Burn Pads		
North Burn Pads Landfill		
Roundhouse Transformer Storage Area	Indoor worker, outdoor worker, and construction worker	Lower RG of indoor worker and outdoor worker; and construction worker
Incendiary Disposal Area	Outdoor worker and construction worker	
Possible Demolition Site		
Central Test Area		
Fire Training Pit		

Table 7. Screen Maximum Detected Concentrations against Proposed RGs

Site	Surface Soil (0–0.5 ft bgs)[a] Indoor and/or Outdoor Worker				Surface and Subsurface Soil Combined (0–10 ft bgs)[b] Construction Worker			
	Antimony	Cadmium	Chromium	Thallium	Antimony	Cadmium	Chromium	Thallium
Central Test Area	ND	X	X	ND	—	X	X	ND
Deactivation Furnace	—	—	X	ND	—	—	X	ND
Demolition Area	—	—	X	—	—	X	X	X
East Burn Pads	—	—	X	—	NA	NA	NA	NA
Fire Training Pit	—	—	X	—	—	—	X	X
Incendiary Disposal Area	ND	—	X	ND	—	—	X	ND
Line 1	—	—	X	X	—	—	X	X
Line 1 Impoundment	ND	ND	X	ND	ND	ND	X	ND
Line 2	—	—	X	X	X	—	X	X
Line 3	X	—	X	X	X	—	X	X
Line 3A	—	—	X	—	—	—	X	X
Line 4A	ND	—	X	—	ND	—	X	X
Line 4B	ND	—	X	ND	ND	—	X	ND
Line 5A	—	—	X	—	—	—	X	X
Line 5B	ND	—	X	—	ND	—	X	X
Line 6	—	—	X	—	X	—	X	X
Line 8	—	—	X	—	—	—	X	X
Line 800	—	X	X	—	—	X	X	X
Line 9	—	—	X	—	—	—	X	X
North Burn Pads	X	—	X	X	NA	NA	NA	NA
Possible Demolition Site	—	—	X	ND	—	—	X	ND

Table 7. Screen Maximum Detected Concentrations against Proposed RGs

Site	Surface Soil (0–0.5 ft bgs)[a] Indoor and/or Outdoor Worker				Surface and Subsurface Soil Combined (0–10 ft bgs)[b] Construction Worker			
	Antimony	Cadmium	Chromium	Thallium	Antimony	Cadmium	Chromium	Thallium
Roundhouse	ND	—	X	ND	ND	—	X	ND
West Burn Pads Area	—	—	X	X	NA	NA	NA	NA

[a] Surface soil concentrations compared to lower value of proposed RG for indoor and outdoor workers.

[b] Combined surface soil and subsurface soil concentrations compared to proposed RG for construction worker.

— = COC did not exceed proposed RG.

NA = receptor not applicable to site.

ND = COC not detected in data set.

X = COC exceeded proposed RG.

Maximum detected concentrations are included in Attachment 3 of this document.

Table 8. Potential Use of Chromium at OU-1 Sites

OU-1 Area	Potential Site-Related Source for Chromium
Central Test Area	None
Demolition Area/ Deactivation Furnace	None
East Burn Pads	None
Fire Training Pit	None
Incendiary Disposal Area	None
Line 1	Hexavalent chromium used to control corrosion at cooling towers
Line 2	Chromium used for anti-corrosion in melt operations
Line 3	Hexavalent chromium used in metal cleaning operations (chromic acid): chromium-based paints used
Line 3A	Chromium used for anti-corrosion in melt operations
Lines 4A/4B	None
Lines 5A/5B	None
Line 6	Delay powder was mixed with nickel and chromate
Line 8	None
Line 9	Not specifically identified, but metal cleaning operations could have used chromic acid
Line 800/ Pinkwater Lagoon	Sludge, contaminated with hexavalent chromium, was deposited, chromate-contaminated wastes were filtered, metal cleaning operations conducted
North Burn Pads	None
North Burn Pads Landfill	None
Possible Demolition Site	None
Roundhouse Transformer Storage Area	None
West Burn Pads Area	None

N

0 3,300

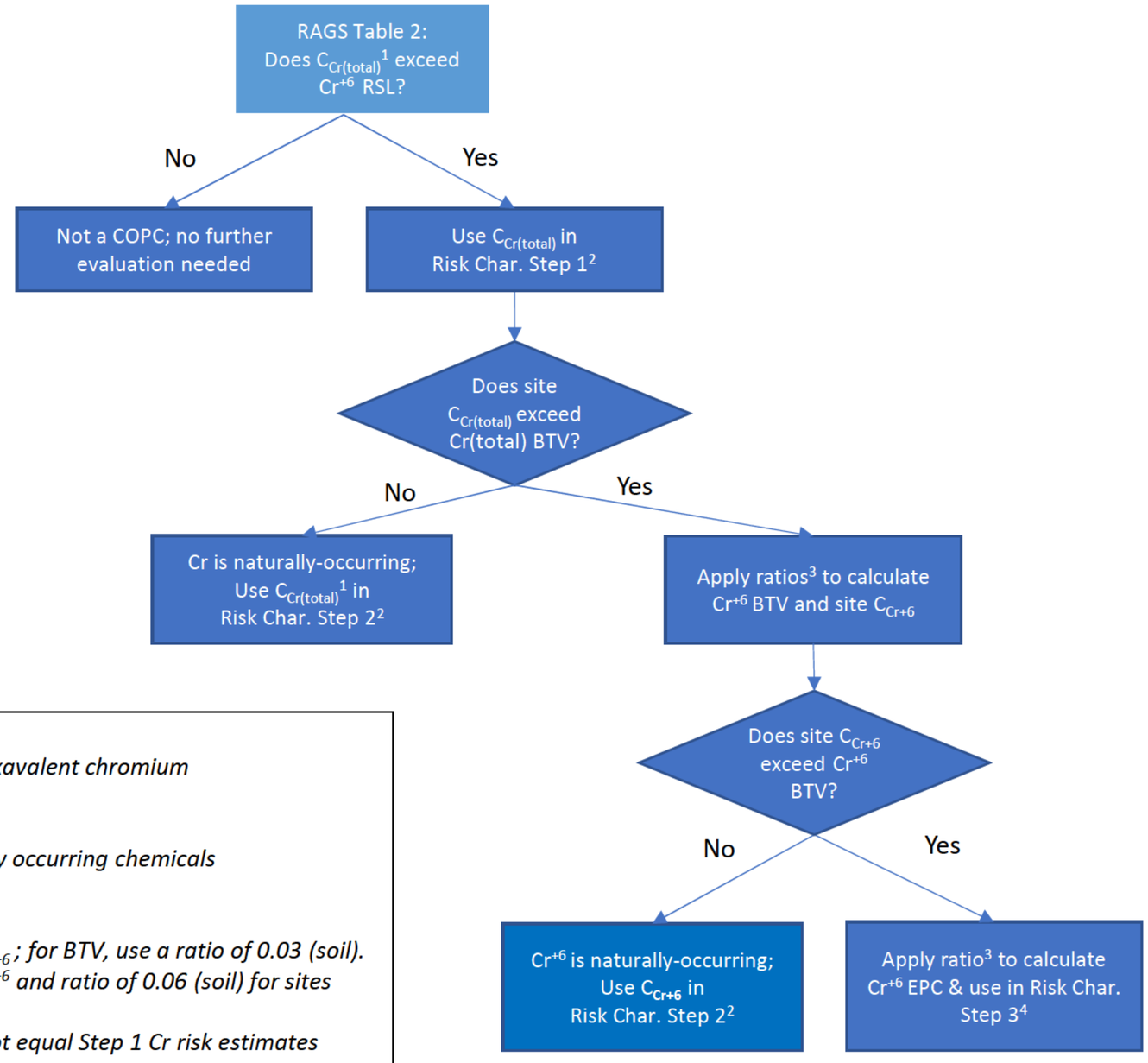
Feet

FIGURE 1
OU-1 Site Boundaries
Iowa Army Ammunition Plant
Middletown, Iowa

ch2m:

SCO \\DC1VS01\GISPROJ\U\USACE\IAAAP_679172\MAPF LES\SITEWIDE\FIGURE_1_SITEBOUNDAR ES_OU1.MXD GTWIGG 8/24/2022 2:10:43 PM

Figure 2
Sites with Cr (total) Data Only



Notes:

$C_{Cr(total)}$ = concentration of total chromium; C_{Cr+6} = concentration of hexavalent chromium

1 - Assuming total chromium is 100% hexavalent chromium

2 – Risk characterization steps:

Step 1 – calculate combined risks for site-related COPCs and naturally occurring chemicals

Step 2 – calculate risks for naturally occurring chemicals

Step 3 – calculate risks for site-related COPCs

3 – OU-9 Cr^{+6} to Cr(total) ratios used to calculate Cr^{+6} BTV and site C_{Cr+6}; for BTV, use a ratio of 0.03 (soil). For site conc., use ratio of 0.03 (soil) for sites with no known use of Cr^{+6} and ratio of 0.06 (soil) for sites with known use of Cr^{+6}.

4 – Risk Char. Step 3 Cr risk estimates (which apply a Cr^{+6} ratio) will not equal Step 1 Cr risk estimates (which assume 100% Cr^{+6} as a simplifying approach).

Attachment 3

Table 1. Risk Ratio Screening, 95% UCL Concentration—Surface Soil (0–0.5 ft bgs)

Exposure Point / Receptor(s)	Analyte	Surface Soil BTV	Maximum Detected Concentration (Qualifier) (mg/kg)	Detection Frequency	Exposure Point Concentration[a] (mg/kg)	Rationale	Carcinogenic Indoor/Outdoor Worker SL[b] (mg/kg)	Target Risk Level of SL	Cancer Risk	Non-carcinogenic Indoor/Outdoor Worker SL[b] (mg/kg)	Target Hazard Level of SL	Hazard Index	Target Organ
Line 800/	Cadmium	1.2	757	26 / 81	5.2E+01	95% KM (Chebyshev) UCL	1.0E+04	1E-06	5E-09	5.5E+02	1	0.09	Urinary
Pinkwater Lagoon	Chromium	21	126	74 / 75	3.6E+01	95% KM (Chebyshev) UCL	7.0E+00	1E-06	5E-06	6.5E+03	1	0.006	NOE
Outdoor Worker													
Line 9	Chromium	21	67.9	92 / 92	2.4E+01	95% Modified-t UCL	7.0E+00	1E-06	3E-06	6.5E+03	1	0.004	NOE
Outdoor Worker													
North Burn Pads	Antimony		1100	2 / 18	1.1E+03	Maximum (<4 detects)	--	1E-06	NA	5.2E+02	1	2	Hematologic
Outdoor Worker	Chromium	21	2110	18 / 18	6.5E+02	95% Chebyshev (Mean, Sd) UCL	7.0E+00	1E-06	9E-05	6.5E+03	1	0.1	NOE
	Thallium	10.4	110	2 / 18	1.1E+02	Maximum (<4 detects)	--	1E-06	NA	5.2E+01	1	2	Dermal
Possible	Chromium	21	40	42 / 42	2.0E+01	95% Adjusted Gamma UCL	7.0E+00	1E-06	3E-06	6.5E+03	1	0.003	NOE
Demolition Site													
Outdoor Worker													
Roundhouse	Chromium	21	27.8	9 / 9	2.3E+01	95% Modified-t UCL	7.0E+00	1E-06	3E-06	6.5E+03	1	0.004	NOE
Outdoor Worker													
West Burn Pads Area	Chromium	21	212	70 / 70	5.8E+01	95% Chebyshev (Mean, Sd) UCL	7.0E+00	1E-06	8E-06	6.5E+03	1	0.009	NOE
Outdoor Worker	Thallium	10.4	197	13 / 65	1.7E+01	95% KM Approximate Gamma UCL	NA	1E-06	NA	5.2E+01	1	0.3	Dermal

Notes:

[a] Exposure concentration based on data in which samples within remediation areas were removed from data sets.

ProUCL (EPA 2022) used to calculate UCLs on mean when at least 8 samples and 4 detects were available for a COC.

[b] Screening levels for surface soil based on current/future site use - outdoor worker or lower value of indoor worker and outdoor, if both anticipated to be present.

Green highlighted maximum concentrations are less than the BTV

Orange highlighted (and bold) values exceed the ELCR target of 10^{-6} or HQ target of 1

Table 2. Risk Ratio Screening, 95% UCL Concentration—Combined Surface and Subsurface Soil (0–10 ft bgs)

Exposure Point / Receptor(s)	Analyte	Surface Soil BTV	Subsurface Soil BTV	Maximum Detected Concentration (Qualifier) (mg/kg)	Detection Frequency	Exposure Point Concentration[a] (mg/kg)	Rationale	Carcinogenic Construction Worker SL[b] (mg/kg)	Target Risk Level of SL	Cancer Risk	Non-carcinogenic Construction Worker SL[b] (mg/kg)	Target Hazard Level of SL	Hazard Index	Target Organ
Central Test Area	Cadmium	1.2	0.89	1100	15 / 84	7.6E+01	95% KM (Chebyshev) UCL	4.3E+02	1E-06	2E-07	6.3E+01	1	1	Urinary
	Chromium	21	31.7	152	80 / 80	2.0E+01	95% Modified-t UCL	7.8E+00	1E-06	2E-06	1.1E+03	1	0.02	NOE
Deactivation Furnace	Chromium	21	31.7	19.6	19 / 19	1.4E+01	95% Student's-t UCL	7.8E+00	1E-06	2E-06	1.1E+03	1	0.01	NOE
Demolition Area	Cadmium	1.2	0.89	180	103 / 260	6.7E+00	95% KM (Chebyshev) UCL	4.3E+02	1E-06	2E-08	6.3E+01	1	0.1	Urinary
	Chromium	21	31.7	613	260 / 260	3.7E+01	95% Chebyshev (Mean, Sd) UCL	7.8E+00	1E-06	5E-06	1.1E+03	1	0.03	NOE
	Thallium	10.4	18.2	23.2	6 / 217	1.1E+00	95% KM (t) UCL	NA	1E-06	NA	1.4E+01	1	0.08	Dermal
Fire Training Pit	Chromium	21	31.7	823	29 / 29	2.2E+02	95% Chebyshev (Mean, Sd) UCL	7.8E+00	1E-06	3E-05	1.1E+03	1	0.2	NOE
	Thallium	10.4	18.2	29.3	6 / 29	1.1E+01	95% KM (t) UCL	NA	1E-06	NA	1.4E+01	1	0.8	Dermal
Incendiary Disposal Area	Chromium	21	31.7	50	57 / 57	1.9E+01	95% Chebyshev (Mean, Sd) UCL	7.8E+00	1E-06	2E-06	1.1E+03	1	0.02	NOE
Line 1	Chromium	21	31.7	1530	383 / 387	6.0E+01	95% KM (Chebyshev) UCL	7.8E+00	1E-06	8E-06	1.1E+03	1	0.05	NOE
	Thallium	10.4	18.2	43	93 / 196	1.8E+01	KM H-UCL	NA	1E-06	NA	1.4E+01	1	1	Dermal
Line 1 Impoundment	Chromium	21	31.7	17.2	1 / 1	1.7E+01	Maximum	7.8E+00	1E-06	2E-06	1.1E+03	1	0.02	NOE
Line 2	Antimony	19.6	19.6	212	103 / 291	6.0E+00	95% KM (Chebyshev) UCL	NA	1E-06	NA	1.3E+02	1	0.04	Hematologic
	Chromium	21	31.7	257	290 / 291	4.1E+01	95% KM (Chebyshev) UCL	7.8E+00	1E-06	5E-06	1.1E+03	1	0.04	NOE
	Thallium	10.4	18.2	172	75 / 295	9.3E+00	95% KM (Chebyshev) UCL	NA	1E-06	NA	1.4E+01	1	0.7	Dermal
Line 3	Antimony	19.6	19.6	2820	255 / 418	3.8E+01	95% KM (Chebyshev) UCL	NA	1E-06	NA	1.3E+02	1	0.3	Hematologic
	Chromium	21	31.7	1460	410 / 412	6.9E+01	95% KM (Chebyshev) UCL	7.8E+00	1E-06	9E-06	1.1E+03	1	0.06	NOE
	Thallium	10.4	18.2	67.3	69 / 412	4.9E+00	KM H-UCL	NA	1E-06	NA	1.4E+01	1	0.4	Dermal
Line 3A	Chromium	21	31.7	526	195 / 198	5.3E+01	95% KM (Chebyshev) UCL	7.8E+00	1E-06	7E-06	1.1E+03	1	0.05	NOE
	Thallium	10.4	18.2	22.3	20 / 198	2.7E+00	95% KM (t) UC	NA	1E-06	NA	1.4E+01	1	0.2	Dermal
Line 4A	Chromium	21	31.7	39.8	58 / 58	2.2E+01	95% Modified-t UCL	7.8E+00	1E-06	3E-06	1.1E+03	1	0.02	NOE
	Thallium	10.4	18.2	22.3	8 / 20	1.7E+01	95% KM (t) UCL	NA	1E-06	NA	1.4E+01	1	1	Dermal
Line 4B	Chromium	21	31.7	32.9	52 / 57	2.0E+01	95% KM (t) UCL	7.8E+00	1E-06	3E-06	1.1E+03	1	0.02	NOE
Line 5A	Chromium	21	31.7	34.6	30 / 30	2.3E+01	95% Student's-t UCL	7.8E+00	1E-06	3E-06	1.1E+03	1	0.02	NOE
	Thallium	10.4	18.2	20.6	4 / 30	5.7E+00	95% KM (t) UCL	NA	1E-06	NA	1.4E+01	1	0.4	Dermal
Line 5B	Chromium	21	31.7	48.5	53 / 53	2.7E+01	95% Modified-t UCL	7.8E+00	1E-06	3E-06	1.1E+03	1	0.02	NOE
	Thallium	10.4	18.2	16.5	3 / 53	1.7E+01	Maximum (<4 detects)	NA	1E-06	NA	1.4E+01	1	1	Dermal

Table 2. Risk Ratio Screening, 95% UCL Concentration—Combined Surface and Subsurface Soil (0–10 ft bgs)

Exposure Point / Receptor(s)	Analyte	Surface Soil BTV	Subsurface Soil BTV	Maximum Detected Concentration (Qualifier) (mg/kg)	Detection Frequency	Exposure Point Concentration[a] (mg/kg)	Rationale	Carcinogenic Construction Worker SL[b] (mg/kg)	Target Risk Level of SL	Cancer Risk	Non-carcinogenic Construction Worker SL[b] (mg/kg)	Target Hazard Level of SL	Hazard Index	Target Organ
Line 6	Antimony	19.6	19.6	329	96 / 121	1.8E+01	95% KM (Chebyshev) UCL	NA	1E-06	NA	1.3E+02	1	0.1	Hematologic
	Chromium	21	31.7	1450	121 / 121	1.3E+02	95% Chebyshev (Mean, Sd) UCL	7.8E+00	1E-06	2E-05	1.1E+03	1	0.1	NOE
	Thallium	10.4	18.2	22.2	8 / 121	2.6E+00	95% KM (t) UCL	NA	1E-06	NA	1.4E+01	1	0.2	Dermal
Line 8	Chromium	21	31.7	45.8	78 / 83	1.8E+01	95% KM Approximate Gamma UCL	7.8E+00	1E-06	2E-06	1.1E+03	1	0.02	NOE
	Thallium	10.4	18.2	36.4	14 / 35	1.3E+01	95% KM (t) UCL	NA	1E-06	NA	1.4E+01	1	1	Dermal
Line 800	Cadmium	1.2	0.89	757	87 / 232	1.8E+01	95% KM (Chebyshev) UCL	4.3E+02	1E-06	4E-08	6.3E+01	1	0.3	Urinary
	Chromium	21	31.7	288	220 / 221	4.4E+01	95% KM (Chebyshev) UCL	7.8E+00	1E-06	6E-06	1.1E+03	1	0.04	NOE
	Thallium	10.4	18.2	41.5	25 / 182	3.1E+00	95% KM Approximate Gamma UCL	NA	1E-06	NA	1.4E+01	1	0.2	Dermal
Line 9	Chromium	21	31.7	67.9	93 / 93	2.4E+01	95% Modified-t UCL	7.8E+00	1E-06	3E-06	1.1E+03	1	0.02	NOE
	Thallium	10.4	18.2	19.6	7 / 29	7.0E+00	95% KM (t) UCL	NA	1E-06	NA	1.4E+01	1	0.5	Dermal
Possible Demolition Site	Chromium	21	31.7	40	63 / 63	1.8E+01	95% Approximate Gamma UCL	7.8E+00	1E-06	2E-06	1.1E+03	1	0.02	NOE
Roundhouse	Chromium	21	31.7	27.8	10 / 10	2.2E+01	95% Modified-t UCL	7.8E+00	1E-06	3E-06	1.1E+03	1	0.02	NOE

Notes:

[a] Exposure concentration based on data in which samples within remediation areas were removed from data sets.

ProUCL (EPA 2022) used to calculate UCLs on mean when at least 8 samples and 4 detects were available for a COC.

[b] Screening levels for combined surface and subsurface soil based on current/future site use for a construction worker.

Green highlighted maximum concentrations are less than the BTV

Orange highlighted (and bold) values exceed the ELCR target of 10^{-6} or HQ target of 1

Table 3. Risk Ratio Screening, 95% UCL Concentration—Surface Soil (0–0.5 ft bgs)

Hexavalent Chromium Concentrations Estimated from Chromium, Total Concentrations

Exposure Point / Receptor(s)	Analyte	Known Cr+6 Use?	Surface Soil BTV	Estimated Maximum Detected Concentration (Qualifier) (mg/kg)	Detection Frequency	Estimeated Exposure Point Concentration[a] (mg/kg)	Rationale	Carcinogenic Indoor/Outdoor Worker SL[b] (mg/kg)	Target Risk Level of SL	Cancer Risk
Central Test Area Outdoor Worker	Chromium	None	21	4.56	14 / 14	1.2E+00	95% Chebyshev (MVUE) UCL	7.0E+00	1E-06	2E-07
Deactivation Furnace Indoor & Outdoor Worker	Chromium	None	21	0.555	10 / 10	4.1E-01	95% Student's-t UCL	7.0E+00	1E-06	6E-08
Demolition Area Indoor & Outdoor Worker	Chromium	None	21	6.06	22 / 22	2.4E+00	95% Chebyshev (Mean, Sd) UCL	7.0E+00	1E-06	3E-07
East Burn Pads Outdoor Worker	Chromium	None	21	2.697	27 / 27	8.9E-01	95% Modified-t UCL	7.0E+00	1E-06	1E-07
Fire Training Pit Outdoor Worker	Chromium	None	21	24.69	21 / 21	8.7E+00	95% Chebyshev (Mean, Sd) UCL	7.0E+00	1E-06	1E-06
Incendiary Disposal Area Outdoor Worker	Chromium	None	21	0.993	8 / 8	9.9E-01	Maximum (UCL>Max)	7.0E+00	1E-06	1E-07
Line 1 Indoor & Outdoor Worker	Chromium	Yes	21	91.8	381 / 385	3.6E+00	95% KM (Chebyshev) UCL	7.0E+00	1E-06	5E-07
Line 1 Impoundment Indoor & Outdoor Worker	Chromium	Yes	21	1.032	1 / 1	1.0E+00	Maximum	7.0E+00	1E-06	1E-07
Line 2 Indoor & Outdoor Worker	Chromium	Yes	21	15.42	172 / 173	2.9E+00	95% KM (Chebyshev) UCL	7.0E+00	1E-06	4E-07
Line 3 Indoor & Outdoor Worker	Chromium	Yes	21	87.6	146 / 148	5.8E+00	95% KM (Chebyshev) UCL	7.0E+00	1E-06	8E-07
Line 3A Indoor & Outdoor Worker	Chromium	Yes	21	13.38	56 / 59	2.7E+00	95% KM (Chebyshev) UCL	7.0E+00	1E-06	4E-07
Line 4A Indoor & Outdoor Worker	Chromium	None	21	1.194	58 / 58	6.6E-01	95% Modified-t UCL	7.0E+00	1E-06	9E-08
Line 4B Outdoor Worker	Chromium	None	21	0.987	31 / 31	6.6E-01	95% Student's-t UCL	7.0E+00	1E-06	9E-08
Line 5A Outdoor Worker	Chromium	None	21	34.6	26 / 26	6.8E-01	95% Student's-t UCL	7.0E+00	1E-06	1E-07
Line 5B Outdoor Worker	Chromium	None	21	4.56	51 / 51	7.9E-01	95% Modified-t UCL	7.0E+00	1E-06	1E-07
Line 6 Outdoor Worker	Chromium	Chromate	21	27.96	28 / 28	7.9E+00	95% Chebyshev (Mean, Sd) UCL	7.0E+00	1E-06	1E-06

Table 3. Risk Ratio Screening, 95% UCL Concentration—Surface Soil (0–0.5 ft bgs)

Hexavalent Chromium Concentrations Estimated from Chromium, Total Concentrations

Exposure Point / Receptor(s)	Analyte	Known Cr+6 Use?	Surface Soil BTV	Estimated Maximum Detected Concentration (Qualifier) (mg/kg)	Detection Frequency	Estimeated Exposure Point Concentration[a] (mg/kg)	Rationale	Carcinogenic Indoor/Outdoor Worker SL[b] (mg/kg)	Target Risk Level of SL	Cancer Risk
Line 8	Chromium	None	21	4.56	78 / 83	5.3E-01	95% KM Approximate Gamma UCL	7.0E+00	1E-06	8E-08
Outdoor Worker										
Line 800										
	Chromium	Yes	21	7.56	74 / 75	2.2E+00	95% KM (Chebyshev) UCL	7.0E+00	1E-06	3E-07
Outdoor Worker										
Line 9	Chromium	chromic acid	21	4.074	92 / 92	1.4E+00	95% Modified-t UCL	7.0E+00	1E-06	2E-07
Outdoor Worker										
North Burn Pads										
Outdoor Worker	Chromium	None	21	63.3	18 / 18	1.9E+01	95% Chebyshev (Mean, Sd) UCL	7.0E+00	1E-06	3E-06
Possible	Chromium	None	21	40	42 / 42	5.9E-01	95% Adjusted Gamma UCL	7.0E+00	1E-06	8E-08
Demolition Site										
Outdoor Worker										
Roundhouse	Chromium	None	21	4.56	9 / 9	6.9E-01	95% Modified-t UCL	7.0E+00	1E-06	1E-07
Outdoor Worker										
West Burn Pads Area	Chromium	None	21	6.36	70 / 70	1.7E+00	95% Chebyshev (Mean, Sd) UCL	7.0E+00	1E-06	2E-07
Outdoor Worker										

Notes:

[a] Exposure concentration based on data in which samples within remediation areas were removed from data sets.

ProUCL (EPA 2022) used to calculate UCLs on mean when at least 8 samples and 4 detects were available for a COC.

[b] Screening levels for surface soil based on current/future site use - outdoor worker or lower value of indoor worker and outdoor, if both anticipated to be present.

Green highlighted maximum concentrations are less than the BTV

Orange highlighted (and bold) values exceed the ELCR target of 10^{-6}

Table 4. Risk Ratio Screening, 95% UCL Concentration—Combined Surface and Subsurface Soil (0–10 ft bgs)

Hexavalent Chromium Concentrations Estimated from Chromium, Total Concentrations

Exposure Point / Receptor(s)	Analyte	Known Cr+6 Use?	Surface Soil BTV	Subsurface Soil BTV	Estimated Maximum Detected Concentration (Qualifier) (mg/kg)	Detection Frequency	Estimated Exposure Point Concentration[a] (mg/kg)	Rationale	Carcinogenic Construction Worker SL[b] (mg/kg)	Target Risk Level of SL	Cancer Risk
Central Test Area											
	Chromium	None	21	31.7	4.56	80 / 80	5.9E-01	95% Modified-t UCL	7.8E+00	1E-06	7E-08
Deactivation Furnace	Chromium	None	21	31.7	0.588	19 / 19	4.3E-01	95% Student's-t UCL	7.8E+00	1E-06	5E-08
Demolition Area											
	Chromium	None	21	31.7	18.39	260 / 260	1.1E+00	95% Chebyshev (Mean, Sd) UCL	7.8E+00	1E-06	1E-07
Fire Training Pit	Chromium	None	21	31.7	24.69	29 / 29	6.6E+00	95% Chebyshev (Mean, Sd) UCL	7.8E+00	1E-06	8E-07
Incendiary Disposal Area	Chromium	None	21	31.7	1.5	57 / 57	5.8E-01	95% Chebyshev (Mean, Sd) UCL	7.8E+00	1E-06	7E-08
Line 1	Chromium	Yes	21	31.7	91.8	383 / 387	3.6E+00	95% KM (Chebyshev) UCL	7.8E+00	1E-06	5E-07
Line 1 Impoundment	Chromium	Yes	21	31.7	1.032	1 / 1	1.0E+00	Maximum	7.8E+00	1E-06	1E-07
Line 2											
	Chromium	Yes	21	31.7	15.42	290 / 291	2.5E+00	95% KM (Chebyshev) UCL	7.8E+00	1E-06	3E-07
Line 3											
	Chromium	Yes	21	31.7	87.6	410 / 412	4.1E+00	95% KM (Chebyshev) UCL	7.8E+00	1E-06	5E-07
Line 3A	Chromium	Yes	21	31.7	31.56	195 / 198	3.2E+00	95% KM (Chebyshev) UCL	7.8E+00	1E-06	4E-07
Line 4A	Chromium	None	21	31.7	1.194	58 / 58	6.6E-01	95% Modified-t UCL	7.8E+00	1E-06	8E-08
Line 4B	Chromium	None	21	31.7	0.987	52 / 57	5.9E-01	95% KM (t) UCL	7.8E+00	1E-06	8E-08
Line 5A	Chromium	None	21	31.7	1.038	30 / 30	6.8E-01	95% Student's-t UCL	7.8E+00	1E-06	9E-08
Line 5B	Chromium	None	21	31.7	1.455	53 / 53	8.0E-01	95% Modified-t UCL	7.8E+00	1E-06	1E-07
Line 6											
	Chromium	Chromate	21	31.7	87	121 / 121	7.6E+00	95% Chebyshev (Mean, Sd) UCL	7.8E+00	1E-06	1E-06
Line 8	Chromium	None	21	31.7	1.374	78 / 83	5.3E-01	95% KM Approximate Gamma UCL	7.8E+00	1E-06	7E-08
Line 800											
	Chromium	Yes	21	31.7	17.28	220 / 221	2.6E+00	95% KM (Chebyshev) UCL	7.8E+00	1E-06	3E-07

Table 4. Risk Ratio Screening, 95% UCL Concentration—Combined Surface and Subsurface Soil (0–10 ft bgs)

Hexavalent Chromium Concentrations Estimated from Chromium, Total Concentrations

Exposure Point / Receptor(s)	Analyte	Known Cr+6 Use?	Surface Soil BTV	Subsurface Soil BTV	Estimated Maximum Detected Concentration (Qualifier) (mg/kg)	Detection Frequency	Estimated Exposure Point Concentration[a] (mg/kg)	Rationale	Carcinogenic Construction Worker SL[b] (mg/kg)	Target Risk Level of SL	Cancer Risk
Line 9	Chromium	Chromic Acid	21	31.7	4.074	93 / 93	1.4E+00	95% Modified-t UCL	7.8E+00	1E-06	2E-07
Possible Demolition Site	Chromium	None	21	31.7	1.2	63 / 63	5.4E-01	95% Approximate Gamma UCL	7.8E+00	1E-06	7E-08
Roundhouse	Chromium	None	21	31.7	0.834	10 / 10	6.7E-01	95% Modified-t UCL	7.8E+00	1E-06	9E-08

Notes:

[a] Exposure concentration based on data in which samples within remediation areas were removed from data sets.

ProUCL (EPA 2022) used to calculate UCLs on mean when at least 8 samples and 4 detects were available for a COC.

[b] Screening levels for combined surface and subsurface soil based on current/future site use for a construction worker.

Green highlighted maximum concentrations are less than the BTV

Orange highlighted (and bold) values exceed the ELCR target of 10^{-6} or HQ target of 1