



Health Consultation

Evaluation of Community Exposure to PM₁₀ in Outdoor Air, and Heavy Metals
in Outdoor Air, Groundwater, and Surface Soil

City of Cottonwood, Yavapai County, Arizona

Prepared by:

Arizona Department of Health Services

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Acronyms

ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
ATSDR	Agency for Toxic Substances and Disease Registry
AQI	Air Quality Index
CalEPA	California Environmental Protection Agency
COC	Contaminant of concern
CTE	Central tendency (typical) exposure
CV	Comparison value
EPA	U.S. Environmental Protection Agency
HQ	Hazard quotient
IARC	International Agency for Research on Cancer
mg/kg	Milligrams per kilogram
mg/kg/day	Milligrams per kilogram per day
µg/L	Micrograms per liter
µg/m³	Micrograms per cubic meter
MRI	Minerals Research, Inc.
MRL	Minimal risk level
NTP	National Toxicology Program
OSHA	Occupational Safety and Health Administration
PI	(ADEQ's) Preliminary Investigation
PM₁₀	Particulate matter (diameter of 10 µm or less)
REL	Reference exposure level
RfC	Reference concentration
RfD	Reference dose
RME	Reasonable maximum exposure
ROW	Right-of-way
VFW	Veterans of Foreign Wars Post 7400
WHO	World Health Organization
XRF	X-ray fluorescence

Summary

Introduction

The Arizona Department of Health Services (ADHS) completed this report in response to requests from the Arizona Department of Environmental Quality (ADEQ) and a petition from a community member. This report evaluates whether potential environmental exposures in the vicinity of the Minerals Research, Inc. (MRI) facility in Cottonwood, AZ, could impact the health of nearby residents. ADHS evaluated outdoor air, groundwater, and surface soil data provided by ADEQ to determine if the levels of PM₁₀ or heavy metals may pose a health risk to the community. This report does not identify the source of any environmental conditions.

Outdoor Air Conclusion 1

ADHS concludes that high wind events (sustained wind speed >15 mph) with elevated PM₁₀ or prolonged (long-term) exposure can harm the health of sensitive individuals with pre-existing conditions (e.g., heart or lung disease) living or recreating north of MRI. Under normal (non-high wind) conditions, PM₁₀ levels north of MRI are not expected to harm healthy individuals. PM₁₀ levels east of MRI are not expected to harm residents.

Basis for Conclusion

- At the VFW (north of MRI), PM₁₀ reached the moderate range on EPA's Air Quality Index (AQI) scale on 11 of 35 monitored days. These levels can worsen symptoms in sensitive individuals but are not expected to harm healthy people.
- The annual PM₁₀ average at the VFW was slightly above the WHO guideline. This exceedance is common across the U.S..
- At the Kid's Park (east of MRI), 24-hour and annual average levels of PM₁₀ were below health guidelines, and all daily PM₁₀ levels were in the "Good" AQI range, indicating conditions not expected to pose a health concern.

Outdoor Air Conclusion 2

ADHS concludes that breathing in arsenic and other metals in outdoor air is not expected to harm the health of residents living or recreating to the north or east of MRI.

Basis for Conclusion

- At the VFW, both short-term (<14 days) and long-term (>365 days) arsenic concentrations were below the health-based guidelines, and estimated cancer risks were within EPA's target risk range. Arsenic was not detected at the Kid's Park.
- Thallium and thorium were not detected in outdoor air at the VFW or Kid's park and are not expected to cause harm at typical environmental levels.
- Zinc levels at the VFW exceeded health-based screening values; however, based on measured concentrations and toxicological evidence, inhalation exposure is not expected to pose a public health risk for nearby residents.

Groundwater Conclusion 1

ADHS concludes that regular consumption of untreated groundwater from some private wells with elevated arsenic levels could harm people's health. Other metals detected in private wells are not expected to harm people's health.

Basis for Conclusion

- For private Wells 1 and 3, the estimated long-term exposure doses for arsenic under both central tendency exposure (CTE, typical conditions) and reasonable maximum exposure (RME, high-end, less common conditions where exposures may be greater) scenarios exceeded the EPA's Reference Dose (RfD) for all age groups. Because the RfD includes a small safety margin, these exposures indicate built-in safety margin has been reduced, and non-cancer health effects could occur. Additionally, estimated cancer risks exceeded EPA's target risk range, indicating a potential increased cancer risk.
- For private Wells 2, 8, and 11, arsenic was not detected, and concentrations were below the non-cancer comparison value (CV), indicating non-cancer health effects are not expected. However, the detection limit (4.4 µg/L) was above the cancer-based CV (0.42 µg/L), indicating the actual concentration could range from 0 and 4.4 µg/L. As a result, ADHS cannot determine whether long-term use of these wells could increase cancer risk without additional data.
- All other metals (antimony, barium, cadmium, copper, iron, lead, manganese, nickel, silver, and zinc) measured in private wells 1-3, 8, and 11 were below the health-based CV and are not expected to harm people's health.

Groundwater Conclusion 2

ADHS concludes that swallowing metals, including arsenic, in public, monitoring, and irrigation wells is not expected to harm people's health.

Basis for Conclusion

- Public well water (Wells 5, 9, 10) is treated for arsenic before reaching the consumer and is in compliance with federal regulations. No other metals were detected above their CVs in these wells, and exposures are not expected to cause harm.
- Residents do not have contact with water from capped (Wells 6 and 12) or monitoring wells (Wells 13-17), and all metals were below levels of health concern.
- For irrigation Wells 4 and 7, all estimated long-term arsenic exposure doses under both CTE and RME scenarios were below health guidelines, and cancer risks were within EPA's target risk range.

Surface Soil Conclusion 1

ADHS concludes that incidental ingestion of arsenic or copper in surface soil could harm people's health at some locations under specific exposure conditions. Health concerns were identified primarily for young children with soil-pica behavior (the intentional ingestion of soil, not typical

hand-to-mouth activity) and for long-term arsenic exposure in certain residential right-of-way (ROW) areas.

Private Residences:

- Short-term health effects: Children who exhibit soil-pica behavior (the intentional ingestion of soil, not typical hand-to-mouth activity) could experience short-term health effects from localized hotspot soil concentrations of
 - Arsenic and copper at Residence 1, and
 - Copper at Residence 2.

Residential Right-of-Ways (ROW):

- Short-term health effects: Children who exhibit soil-pica behavior could experience short-term health effects from
 - Arsenic at Residential ROW 13, 14, or 19, and
 - Copper at Residential ROW 1 or 5.
- Long-term non-cancer health effects: Long-term ingestion of arsenic in soil could harm children's health at several Residential ROW locations under long-term exposure scenarios:
 - Central Tendency Exposure (CTE; typical conditions): Residential ROW 1, 4, 7, 11, and 15
 - Reasonable Maximum Exposure (RME; high-end, less common conditions where exposures may be greater): Residential ROW 1, 4, 5, 6, 7, 9, 11, 12, and 15.
- Cancer risk: Long-term arsenic exposure in soil could increase the risk of developing cancer:
 - For children (CTE and RME) and adults (RME) at Residential ROW 1, 4, 5, 7, 9, 11, 12, and 15.
 - For children (RME) at Residential ROW 6 and adults (RME) at Residential ROW 2.

Recreational Areas:

- Short-term health effects: Children who exhibit soil-pica behavior could experience short-term health effects from copper at Recreational areas 1 or 6.

Trespass Areas:

- Short-term health effects: Children who exhibit soil-pica behavior could experience short-term health effects from copper at Trespass Area 1.

Industrial Areas:

- Cancer risk: Long-term incidental ingestion of arsenic in soil could increase the risk of developing cancer in indoor and outdoor workers with reasonable maximum exposure (RME) at Industrial Area 1.

Basis for Conclusion

- Arsenic and copper were detected at elevated concentrations at several private residences, Residential ROWs, recreational areas, trespass areas, and industrial areas.
- Short-term health concerns were identified where estimated soil-pica exposure doses exceeded the acute health-based guidelines.

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- Long-term health concerns were identified when estimated chronic exposure doses exceeded the EPA's Reference Dose (RfD). The long-term soil incidental ingestion doses were calculated for CTE and RME scenarios.
 - Cancer risk concerns were identified based on estimated excess cancer risk for long-term incidental soil ingestion exceeding EPA's target cancer risk range of 1 in 1,000,000 to 1 in 10,000 (10^{-6} to 10^{-4}).

Surface Soil Conclusion 2

ADHS does not have sufficient information to determine whether exposure to arsenic, hexavalent chromium (chromium(VI)), or manganese in surface soil could harm people's health at the following locations under certain exposure scenarios.

Private Residences:

- Arsenic: long-term exposure (non-cancer and cancer effects) at Residence 1-6.
- Chromium(VI): long-term exposure (cancer effects) at Residence 3 and 10.
- Manganese:
 - Long-term exposure (non-cancer effects) at Residence 1, 3, or 6.
 - Short-term exposure at a localized hotspot at Residence 6 for children.

Residential Right-of-Ways (ROW):

- Arsenic: long-term exposure (non-cancer and cancer effects) at Residential ROW 3, 8, 10, 13, 14, 18, 19, 20
- Chromium(VI): long-term exposure (cancer effects) at Residential ROW 1, 2, 4-10, 12.
- Manganese:
 - Long-term exposure (non-cancer effects) at Residential ROWs 10, 13, 14, or 19.
 - Short-term exposure at a localized hotspot at Residential ROW 13 for children.

Recreational Areas:

- Arsenic: long-term exposure (non-cancer and cancer effects) at Recreation Areas 2 and 4.
- Chromium(VI): long-term exposure (cancer effects) at Recreation Areas 1-5.

Trespass Areas:

- Chromium(VI): long-term exposure (cancer effects) at Trespass 1.

Commercial Areas:

- Arsenic: long-term exposure (non-cancer and cancer effects) at Commercial 4 and 6.
- Chromium(VI): long-term exposure (cancer effects) at Commercial 1 and 3.

Daycare:

- Arsenic and Copper: Short-term and long-term exposures for workers and children.
- Manganese: Short-term exposure at a localized hotspot for children.

Basis for Conclusion

- Available data were insufficient to evaluate chronic health effects in several locations due to clustered or judgmental sampling based on prior knowledge, limited spatial coverage, or an insufficient number of samples to represent long-term exposure conditions. Therefore, ADHS

cannot reliably evaluate chronic exposure to arsenic, manganese, or chromium(VI) exposure or draw definitive health conclusions.

- For chromium(VI), only 1 of the 20 sampled properties had sufficient data to assess long-term health effects. At seven locations, chromium(VI) was not detected, but the laboratory reporting limit was above the cancer-based comparison value; thus, ADHS cannot properly evaluate the risk in these areas.
- For manganese, no acute ATSDR health-based guideline is available, so ADHS used a state reference value. At the Daycare hotspot, Residence 6, and Residential ROW 13, estimated short-term exposure doses for young children exceeded this value, indicating a reduced safety margin; data were insufficient to determine whether acute adverse health effects would occur, particularly for children under 6 years of age.
- At the Daycare, the available data are insufficient to fully characterize hotspots or assess health effects from arsenic and copper exposure in surface soil. The playground is covered with woodchips, which likely reduces direct contact with the underlying soil and lowers potential exposure. However, dust may still settle on top of the wood chips, leading to possible incidental exposure. Because there is a lack of data on how effectively the wood chips prevent soil ingestion over time, ADHS cannot fully characterize the more realistic risk in this area.

Surface Soil Conclusion 3

ADHS concludes that incidental ingestion of metals in surface soil are not expected to harm people's health at most locations evaluated. This conclusion applies to all metals and exposure scenarios, except for those mentioned in Surface Soil Conclusion 1 (where health effects may occur) or Conclusion 2 (where there is insufficient information).

Basis for Conclusion

- Surface soil samples were analyzed for 17 metals across various land-use areas.
- In some cases where initial screening levels were exceeded, a more detailed, site-specific review showed that exposures were not high enough to cause harm.
- Estimated exposure concentration or exposure doses were below levels known to cause health problems, based on health guidelines and scientific evidence.

Next Steps

Based on the findings of this evaluation, the following recommendations are provided to reduce potential exposures and address remaining data gaps.

Outdoor Air Recommendations

- Continued efforts by ADEQ to work with MRI to optimize dust control and permitting to reduce PM₁₀ and heavy metals levels in the air.
- Community members are encouraged to take steps to protect themselves by reducing exposures. This includes subscribing to the weather forecast and monitoring wind conditions.

During high wind events (sustained wind speed >15 mph), avoid unnecessary outdoor activities and keep windows and doors closed.

Groundwater Recommendations

- Additional sampling of Private Wells 2, 8, and 11 may better characterize arsenic concentrations.
- For Private Wells 1 and 3, treat the water for arsenic or use an alternative water source for drinking and cooking purposes.
- Private well owners are encouraged to take steps to protect themselves by reducing exposure. This includes following the recommended well testing schedule and treatment guidance available at [azdhs.gov/WellWater](https://www.azdhs.gov/WellWater).

Surface Soil Recommendations

- Continued efforts by ADEQ to work with MRI in addressing concerns at the VFW.
- Additional soil sampling in residential yards, childcare facilities, and recreational areas could better characterize the site contamination and support evaluation of exposures and health risks.
- All parents or guardians are encouraged to carefully monitor young children to limit their intake of soil. If parents or guardians suspect their child is showing signs of pica behavior, they should talk with their pediatrician.
- Community members are encouraged to take general steps to protect themselves from exposure to heavy metals in dust and soil. Additional tips are available at: <https://www.azdhs.gov/documents/preparedness/epidemiology-disease-control/environmental-toxicology/adhs-dust-2025.pdf>.
 - Wash hands often, especially after coming inside or before eating.
 - Avoid eating in dusty areas.
 - Regularly wash children's toys with soap and water and clean dust with a wet mop or cloth.
 - Encourage children to play in areas other than dirt and soil, like grass or mulch.
 - If you garden, use a raised garden bed with store-bought soil and wash all produce before eating it.

Public Health Action Plan

- ADHS will notify ADEQ, Yavapai County Community Health Services, and the City of Cottonwood regarding the conclusions of this report.
- ADHS will continue to collaborate with the community, and state and local agencies to promote public health in Cottonwood.
- ADHS will provide support for public meetings to discuss this report and conduct additional evaluations upon request, as appropriate data becomes available.
- ADHS will provide education and awareness to community members and leaders on ways to reduce their exposure and protect their health. They will continue to address community questions and concerns regarding this report and site.

For More Information

If you have concerns about your health, please contact your healthcare provider. Please email ADHS at EnvironmentalToxicology@azdhs.gov if you have questions about this report.

Background

Statement of Issues and Purpose

The Arizona Department of Health Services (ADHS) conducted this health consultation (HC) in response to concerns raised by the Arizona Department of Environmental Quality (ADEQ) and community members about emissions from Minerals Research, Inc. (MRI).

In September 2023, ADEQ cited MRI for operating without the appropriate air quality permit. MRI applied for a new permit and continues to operate under a Consent Order. ADEQ aims to incorporate potential community health impacts into its decision-making processes. ADEQ provided ADHS with data on outdoor air, groundwater, and soil from their investigations in Cottonwood.

ADHS also received community concerns about the potential health impacts of MRI's operations. In January 2024, one resident submitted a petition letter to the Agency for Toxic Substances and Disease Registry (ATSDR), highlighting severe respiratory issues and other health problems potentially linked to black dust emissions from the facility. In response, and in agreement with ATSDR, ADHS agreed to complete this health consultation under their cooperative agreement.

This HC assesses whether exposure to particulate matter (PM₁₀) in outdoor air, or the levels of arsenic and other heavy metals in outdoor air, groundwater, or surface soil, may pose a health risk to the community with the current use of the area. This evaluation does not identify or determine the source of any environmental conditions.

Site Description and Timeline

Site Location

MRI is located in the City of Cottonwood in Yavapai County, Arizona. It neighbors the Veterans of Foreign Wars Post 7400 (VFW), Cottonwood Kid's Park, and the Verde Valley Fairgrounds (Figure A1). The surrounding area includes a mix of homes, businesses, light industry, parks, and other public spaces. Cottonwood is a 28.5 square-mile town located in the Verde Valley, eight miles southeast of Jerome, four miles southeast of Clarkdale, and 100 miles north of Phoenix. The town has a rich history of mining activity, which continues to shape the landscape. The land slopes down to the northwest, and the winds change direction every day. Winds were generally out of southerly directions, blowing towards the north, during the study period (ADEQ 2024c).

Site Activity:

Table 1. Site Activity Timeline.

Date	Site Activity
1917 - 1936	Clemenceau Smelter operated in what is now Cottonwood, leaving a copper slag pile that remains. Slag is a by-product of the smelting process.
2007	The City of Cottonwood Public Water System installed and began using an arsenic treatment system.
2014	MRI began operating a slag recycling facility using the slag pile remaining from the Clemenceau Smelter

Date	Site Activity
	operations. The slag pile sits ~200 feet south of MRI's building (Figure A1). Their activities include drilling, blasting, and storage operations.
2017	ADEQ began receiving public complaints about MRI operations and emissions (ADEQ 2025a).
September 2023	ADEQ cited MRI for operating without the appropriate air quality permit (ADEQ 2024a).
October 2023	MRI applied for a new permit and continued to operate under a consent order (ADEQ 2024a).
November 2023	ADHS began receiving concerns from community members about the health impacts of MRI's emissions and ADEQ requested ADHS conduct a health consultation.
January 2024	A community member submitted a petition request to ATSDR.
February - June 2024	ADEQ collected outdoor air data at the VFW and Kid's Park, as well as groundwater and soil data, as part of the Preliminary Investigation (PI) for the 6th Street and Birch Street site.
April 2024	ATSDR formally referred the petition to ADHS.
March 2025	ADEQ collected additional soil data as part of the PI Addendum for the 6th St and Birch Street site.

Community Description and Concerns

Community Demographics

Approximately 12,000 people live in the City of Cottonwood (U.S. Census Bureau 2020). The town is moderately densely populated with 724.8 people per square mile (U.S. Census Bureau 2024).

Additionally, the Cottonwood population is generally older than that of most Arizona communities, with approximately one in three people being 65 years or older (U.S. Census Bureau 2020). See Table B1 for the community demographics of the City of Cottonwood in comparison to Yavapai County and Arizona.

Community Concerns

ADHS began receiving and documenting community concerns about the health impacts of MRI emissions in November 2023. ADHS talked with community members one-on-one, in small groups, and via phone and email. They also attended four community meetings between December 2023 and February 2025. Through these interactions, ADHS identified resident concerns about:

- Particular health issues, including breathing problems, rashes, cancer, and other conditions.
- Specific contaminants, such as aluminum, arsenic, barium, copper, lead, and uranium.
- Copper slag characteristics, including sharp edges and abrasiveness.
- High wind events in Cottonwood.
- Specific local spaces, such as the Cottonwood Kid's Park and low-income housing.
- Particular groups of residents, like children, pregnant women, and older adults.

This health consultation uses available data collected for outdoor air, groundwater, and surface soil to assess the likelihood of exposure to contaminants and any associated potential health impacts. ADHS considered all of the contaminants of concern identified by the community in the evaluation, except for crystalline silica, as it was not included in the data provided by ADEQ. The evaluation considers residents most sensitive to environmental contaminants, including children, pregnant women, and older adults. Community concerns are further addressed in the *Addressing Community Concerns* section of this report.

Available Environmental Data

ADEQ provided ADHS with data on outdoor air, groundwater, and surface soil from their investigations in Cottonwood. They also provided weather data collected at the Cottonwood Airport every 20 minutes between February 12 and June 11, 2024, MRI production reports for January to June 2024, and slag metals concentration data for January to May 2024. For additional background on ADEQ's evaluation of potential contamination sources, please refer to *Preliminary Investigation Report Summary* (ADEQ 2025a).

ADHS also considered 'slag pile dust' data provided by a community member (Appendix C1). However, the laboratory and method used for analysis were not state-certified, and the collection methods were unknown, making it impossible to assess them for quality assurance/quality control (QA/QC). Therefore, ADHS did not use the data for the evaluation, but discusses the data further in the *Addressing Community Concerns* section of this report.

Outdoor Air Sampling Data

ADEQ provided ADHS with data for PM₁₀ and heavy metals in outdoor air collected at two monitoring stations near the slag pile: the VFW (about 340 feet north) and the Cottonwood Kid's Park (about 810 feet east) (Figure A2). ADEQ selected these locations due to their proximity to areas of high public use and the MRI slag pile (ADEQ 2024c). ADEQ confirmed that the air monitoring data collected from these stations are representative of the nearby area at a neighborhood scale (about 0.3 to 2.5 miles) at a minimum, but could potentially be representative beyond this scale. ADEQ stated that the data from the VFW site represents an area of concern located to the north of the facility, near public areas and commercial operations. In contrast, the Kid's Park data represents an area of concern located east of the facility, close to residential housing and a public children's park.

Air monitoring data was collected every three days from February 15 to June 9, 2024. Samples were analyzed by ESML Analytical (from March 26 to April 18, 2024) and LA Testing (from May 22 to June 9, 2024) using ADEQ-approved methods. ADHS understands that adequate QA/QC procedures were followed throughout the sampling and analysis process to ensure the reliability of the data.

Groundwater Sampling Data

ADEQ provided ADHS with groundwater data from 17 wells (seven private, five city, and five monitoring) collected between March 20-29, 2024, as part of the Preliminary Investigation (PI) for the 6th Street and Birch Street site (ADEQ 2025a). The wells were located mainly east and west of the MRI slag pile. The samples were analyzed by Pace Analytical for 11 metals using EPA Method 6010D. After consulting with ADEQ and reviewing the data, ADHS understands that adequate QA/QC procedures were followed.

The ADEQ groundwater data reflect contaminant concentrations before treatment. To supplement this data, ADHS also reviewed the drinking water data for Cottonwood's public water system (PWS#

AZ0413025) from March 10, 1994, to April 11, 2025, from [ADEQ's Safe Drinking Water Database](#) (ADEQ 2025b). This data reflects contaminant concentrations after treatment, before distribution to consumers.

Surface Soil Sampling Data

ADEQ provided ADHS with soil sampling results collected from the 6th Street and Birch Street site (ADEQ 2025a). Their sampling efforts and results are described further below.

X-Ray Fluorescence (XRF) Screening Data

ADEQ used X-ray fluorescence (XRF) to analyze 28 metals in surface soil between March 20 and March 29, 2024, and June 4 to June 6, 2024. They used the Olympus Delta Professional XRF in March and the Olympus Vanta C Series XRF in June. ADEQ chose the sampling locations based on proximity to the former smelter and current MRI operations, but only properties that granted access or were located in right-of-way (ROW) and stormwater pathways were included (ADEQ 2025a). ADHS reviewed the XRF data and determined that they are unsuitable for use in the risk assessment. For this purpose, the XRF readings must closely match the laboratory test results. According to the EPA, the correlation values¹ should be 0.7 or higher. In this investigation, the correlation values ranged from 0.24 to 0.44 (Fehling 2024). These results indicated that, especially in slag-affected materials, yields tend to be higher than those obtained in laboratory analysis (ADEQ 2025a). Thus, ADHS only used laboratory testing results for the evaluation.

Laboratory Sampling Data

ADHS evaluated soil samples collected by ADEQ in 2024 and 2025. As described in ADEQ's PI report (ADEQ 2025a), a total of 74 confirmatory samples were collected and analyzed for 13 metals in March and June 2024 by Pace Analytical using EPA Method 6010D/6020B. These samples were used by ADEQ to check the accuracy and quality of the field XRF readings. ADEQ also collected 29 samples to test for hexavalent chromium (Cr(VI), a more harmful form of chromium), 14 of which were collected at shared locations with the confirmatory samples (ADEQ 2025). Cr(VI) was analyzed using EPA Method 7199. The samples were collected in areas where the XRF had detected total chromium.

In March 2025, 224 more soil samples were collected from the focus areas identified in ADEQ's PI (ADEQ 2025a). For this evaluation, ADHS only used the surface soil (0-3 inches deep) data because it best represents what community members may be exposed to (ATSDR 2022). After consulting with ADEQ, ADHS understands that adequate QA/QC procedures were followed.

¹ Correlation values tell us how closely the XRF readings match laboratory test results, which are the most reliable and trusted source of data. A higher correlation value means more of the XRF and lab results match, or are similar (NERL 2006). A correlation value close to 1 means a strong match, and 0 means not a match at all. The EPA recommends a value of 0.7 or higher to use XRF in risk assessment (EPA 2007).

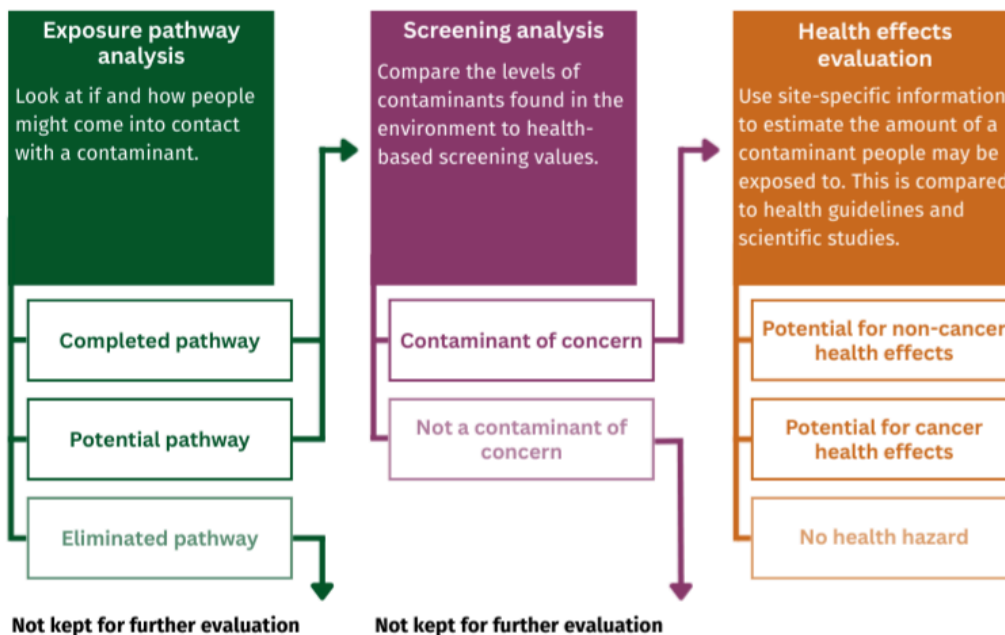
Discussion

Public Health Assessment Process

ADHS conducts public health consultations (or assessments) to determine if people have been exposed to harmful chemicals at a contaminated site, and if so, whether that exposure could harm their health. These are known as public health assessment (PHA) activities, and the goal is to determine if any action needs to be taken to reduce or prevent exposure to protect the community's health. The PHA process involves several scientific evaluation steps, including an exposure pathway analysis, screening analysis, and health effects evaluation (Figure 1).

At the end of the assessment, ADHS makes conclusions and may recommend public health actions to protect people from harmful exposure. More information about each PHA step can be found in the ATSDR Public Health Assessment Guidance Manual (ATSDR 2022).

Figure 1. Flowchart showing the scientific evaluation steps completed during the PHA process.



Exposure Pathway Analysis

In this step, ADHS assesses if and how people might be exposed to harmful chemicals at the site. ADHS answers questions like: (1) who may be exposed? (2) how, when, and under what conditions might they be exposed?

To determine if people might be exposed to harmful chemicals, ADHS looks at how a contaminant could reach individuals and enter their bodies. This process is known as an exposure pathway analysis, which

helps ADHS identify areas where further assessment is necessary to evaluate health risks. ADHS considers five key elements:

1. **Contamination source:** where the contaminant comes from, like an industrial facility.
2. **Environmental fate and transport:** how the contaminant moves through air, water, or soil.
3. **Exposure point:** the location where people can come into contact with the contaminant.
4. **Exposure route:** how the contaminant enters the body (by breathing, swallowing, or touching).
5. **Potentially exposed population:** who could come into contact with the contaminant.

These five elements help determine if people have been exposed to contaminants in the past, are currently being exposed, or could be exposed in the future. Exposure pathways are categorized as completed, potential, or eliminated:

- **Completed exposure pathway:** All five elements of the pathway are there. These pathways are kept for further evaluation.
- **Potential exposure pathway:** At least one of the elements is uncertain, so exposure may have occurred or could occur in the future. These pathways are kept for further evaluation.
- **Eliminated exposure pathway:** One or more elements are missing or cannot occur, making exposure extremely unlikely. These pathways are not kept for further evaluation.

The following exposure pathway analysis identifies the potential exposure pathways for individuals residing in Cottonwood, including those that may have been exposed to contaminants in the air, groundwater, and soil (Table 2).

Table 2. Evaluation of exposure pathways from the MRI site, historical mining remains, and naturally occurring contaminants to residents.

Source	Environmental Medium and Transport	Exposure Point(s)	Exposure Route(s)	Potentially Exposed Population(s)	Exposure Pathway Determination
MRI emissions, historical mining remains, and/or naturally occurring	Outdoor air	Ambient (outdoor) air	Inhalation	Residents	Past & present: completed
	Indoor air	Air inside homes and buildings	Inhalation	Residents	Past & present: potential
	Groundwater in a private well	Residential tap	Ingestion	Residents	Past & present: completed
	Groundwater in a public water supply well	Residential tap	Ingestion	Residents	Past & present: completed
	Groundwater in a monitoring well, injection well, or capped private well	_____	_____	_____	Past & present: eliminated
	Groundwater in an irrigation well	Park or playground sprinklers	Incidental ingestion	Visitors	Past & present: potential
	Surface soil	Residential yards and ROWs	Incidental ingestion	Residents	Past & present: potential
		Recreational areas	Incidental ingestion	Visitors	Past & present: potential
		Commercial ROWs	Incidental ingestion	_____	Past & present: eliminated
		Empty lots, land with restricted access	Incidental ingestion	Trespassers	Past & present: potential

ADHS considers exposures to contaminants in outdoor air at some residential properties near MRI to be a completed exposure pathway, both historically and currently. Groundwater in the area may contain contaminants, which residents may be exposed to through domestic uses, representing a completed exposure pathway. This means that people living in these areas have been, and continue to be, exposed to these contaminants. Indoor air and surface soil are also potential exposure pathways; however, there is insufficient data to fully evaluate the risk for everyone. Additional context for each exposure pathway determination is below.

Outdoor Air: Exposure to contaminants in the outdoor air is considered a completed exposure pathway, meaning the nearby community has been and continues to be exposed to any pollutants from MRI.

Indoor Air: Outdoor particles (like particulate matter, or PM) can move indoors, meaning pollutants from the outdoor air can also end up inside people's homes. Other sources, such as cooking, cigarette smoking, or using a fireplace, can also contribute to increased PM levels inside the house. In homes that do not engage in many of these activities, the amount of PM indoors would likely be about the same as, or lower than, the amount in outdoor air (EPA 2020).

Groundwater: Heavy metals are not volatile and generally have limited absorption through skin; therefore, inhalation during showering and skin contact with water are not expected to significantly contribute to overall exposure (ATSDR 2022; EPA 2004). As a result, skin contact and inhalation exposure pathways are not considered in this evaluation. The primary exposure pathway of concern is ingestion (swallowing water). Ingestion occurs when the water is used directly for drinking or cooking. Incidental ingestion may also occur during activities such as showering, bathing, brushing teeth, or playing in parks where irrigation systems are in use. Residents are unlikely to be exposed to groundwater through monitoring wells, injection wells, or capped private wells, as there is no direct exposure point. Data from private, public, and irrigation wells are included in the screening analysis because residents may inadvertently or intentionally swallow water from these sources.

Surface Soil: Emissions from MRI may have caused metals and other particles to settle in nearby residential yards, both recently and in the past. Additionally, the surface soil in these areas may contain varying levels of metals due to the region's unique geology and historical mining activities. Not all individual yards were sampled. Most samples were taken from public right-of-way (ROW) areas, which ADHS uses as a surrogate (proxy) to understand possible contamination in nearby yards. Although data from most people's yards is not available, residents may still be exposed to these contaminants. Residents may also be exposed in recreational areas or if they trespass on empty land. Because of this, exposure through surface soil is considered a potential exposure pathway.

ADHS evaluated incidental ingestion as the primary exposure pathway through surface soil. Skin contact with soil and inhalation of resuspended soil particles were considered but not further evaluated because they were expected to contribute minimally to overall exposure (ATSDR 2022; EPA 2004). Inhalation of airborne particles was evaluated separately in the Outdoor Air exposure pathway. Additional samples were taken from public ROW on commercial streets. ADHS eliminated this pathway from further evaluation because residents are unlikely to come into contact with this soil, thereby eliminating any potential exposure points.

Screening Analysis

For potential and completed exposure pathways, ADHS conducts a screening analysis comparing site contamination levels to health-based comparison values (CVs)². This analysis helps decide if contaminant levels are either: (1) not expected to result in harmful health effects, or (2) need closer evaluation to understand possible health risks.

Cancer-causing chemicals have two different CVs: one for cancer risk screening and another for non-cancer health effects, like breathing issues. For these chemicals, ADHS compares site concentrations to each CV. If a concentration is below a CV, adverse health effects are not expected, and no additional evaluation is needed. If any detected concentrations exceed a CV, ADHS labels them as contaminants of concern (COCs) and carries them forward for further evaluation. COCs do not necessarily indicate that adverse health effects are expected, but rather signify that they need more evaluation using site-specific information. ADHS also carries forward contaminants as COCs if they do not have a CV or were not detected during sampling but had detection limits (DLs), or reporting limits (RLs)³, above their CVs. More information about the CVs used by ADHS in this evaluation can be found in Table B2.

ADHS completed a screening analysis and identified COCs for outdoor air data at the VFW (Table B3) and Kid’s Park (Table B4), groundwater data collected from private, public, and irrigation wells (Table B5), and surface soil data (Table B6). Table 3 summarizes all the COCs identified by ADHS in the screening analysis.

Table 3: Summary of contaminants of concern identified across all media.

Contaminant	Outdoor Air	Groundwater	Surface Soil
Arsenic	✓	✓	✓
Cadmium	✓	✗	✓
Chromium VI	✗	—	✓
Copper	✗	✗	✓
Lead	✗	✗	✓
Manganese	✗	✗	✓
Mercury	✗	—	✓
PM ₁₀	✓	—	—
Thallium	✓	—	✓
Thorium	✓	—	—
Zinc	✓	✗	✗

Note: only includes contaminants identified as a COC for at least one media

✓ = COC ; ✗ = not a COC ; — = not analyzed

² CVs are health-protective screening values developed for a specific chemical in an exposure media, such as air, water or soil. They are based on scientific studies and include safety factors to ensure they protect even the most sensitive people, such as children (ATSDR 2022).

³ A laboratory’s detection, or reporting limit, is the lowest concentration of a chemical that can be reliably measured and confidently reported (ATSDR 2022). When a concentration is reported as ‘not detected’, it means that the concentration was too small to measure accurately, and the actual concentration may be anywhere between 0 and the reporting limit.

Health Effects Evaluation

Before evaluating for any potential health risks, ADHS first examined how the community used the area to help them assign IDs based on possible exposures. Since the VFW and Kid's Park were the only two areas sampled for air data, they were referred to by name. The VFW represents the area to the north of MRI, which includes nearby public places and businesses. The Kid's Park represents the area to the east, located near residential homes and a public park. ADHS assigned each well an ID (Table B7) and evaluated them individually. Lastly, ADHS used the soil sample locations to identify 42 areas that they separately evaluated based on their location and land use (Table B8). These areas were classified and evaluated as one of the following:

- **Private Residence:** Data for these areas included sample(s) taken from the yard at a private residence.
- **Residential ROW:** Much of the data was collected from public right-of-ways (ROW). To conduct the most protective evaluations, ADHS grouped the ROW soil samples collected near one another in residential areas (e.g., throughout a neighborhood). Although these data were not collected from individual residential yards, ADHS used them as a proxy, meaning they represent the soil conditions in the nearby yards.
- **Daycare:** ADHS classified an area as a "Daycare" if its purpose is to provide child care services to young children 6 years and under.
- **Recreational:** ADHS classified an area as "Recreational" if it is a location where people may visit to recreate (e.g., play, exercise, engage in community activities).
- **Commercial:** ADHS considered visitor exposures to these properties where they visit to purchase goods or receive services.
- **Industrial:** ADHS considered occupational scenarios in industrial areas to evaluate possible environmental exposures that could occur at the workplace, but not related to employees' jobs. These exposures may reflect background or ambient conditions within the industrial area.
- **Trespass:** ADHS classified an area as "Trespass" if it is empty land with no designated use. These areas are typically difficult to reach and/or have limited access.

For each identified COC, ADHS calculated an exposure point concentration (EPC) using ATSDR's EPC Tool. An EPC is a conservative statistical estimate of the average amount of a COC in soil, water, or air in an area where people could come into contact with it. This estimate usually represents a higher, but still realistic, concentration based on the 95% upper confidence limit (UCL)⁴ or the highest measured value.

ADHS then used the EPCs to calculate exposure doses. An exposure dose is the estimated amount of the chemical that could get into a person's body after contact with it. Many factors influence the dose, so ADHS utilizes the ATSDR Public Health Assessment Site Tool (PHAST) to calculate exposure doses for various age groups and exposure scenarios. ADHS considered both central tendency exposure (CTE) and reasonable maximum exposure (RME) scenarios. CTE refers to people who have average or typical

⁴ 95% upper confidence limits (UCL) are estimates that make sure the average amount of a chemical at a site is not underestimated. They are likely a little higher than the true average, so it helps keep people safe.

exposure, whereas RME scenarios assess exposures that are higher than average but still within a realistic exposure range. Unless otherwise specified in Table 4, ADHS used ATSDR’s default exposure parameters (ATSDR 2018; ATSDR 2020).

Table 4. Areas where ADHS did not use ATSDR’s default exposure parameters, along with any assumptions used in their evaluations.

ID	Exposure Assumptions
Residential ROW 2	There are a few mobile homes located in the southeast corner of the VFW property. ADHS assumed that these units have full-time residents. Based on the understanding that the property serves America’s veterans, ADHS assumed that only adults live on the property.
Commercial 1	Based on the property type, ADHS assumed that individuals who repeatedly visit this property do so for work-related purposes. Therefore, they only considered the chronic exposure doses for adults, who are expected to spend up to 10 minutes walking through the parking lot and into the building at each visit.
Commercial 2	ADHS assumed that individuals may visit this location monthly over their lifetime, spending up to 10 minutes walking through the parking lot and into the building at each visit.
Commercial 3	ADHS assumed that residents who visit this location may do so an average of 1 day per month over the course of a couple of years.
Recreational 1, 2	The community questionnaire, conducted as part of the Cottonwood Parks and Recreation Master Plan , reveals that, although few, there are residents who use the public parks in Cottonwood on a daily basis. For recreational parks (Recreation 1 and 2), ADHS assumed daily use by both youth (121 minutes/day spent in parks) and adults 21 and older (30 minutes/day spent running or walking) (EPA 2011).
Recreational 3	ADHS used available information about the VFW to assume that adult veterans who visit do so up to three times per week, spending up to 10 minutes walking through the parking lot and into the building at each visit.
Recreational 4	ADHS used available information about this property to assume that adult visitors do so up to five times per week, spending up to 10 minutes walking through the parking lot and into the building at each visit.
Recreational 5	The Cottonwood Parks and Recreation Master Plan describes community centers in Cottonwood as places where residents frequently visit, often on a daily basis. Therefore, while not everyone is expected to recreate regularly here, ADHS assumed that at most, residents would visit daily throughout their life, spending up to 10 minutes walking through the parking lot and into the building at each visit.
Recreational 6	While most individuals who recreate in this area only do so for a day or weekend (acute exposure), ADHS also evaluated a maximum exposure scenario, in which individuals are assumed to visit three weekends per year for events.
Industrial 1, 2	ADHS used ATSDR’s default occupational scenario, where the CTE scenario represents a typical length of employment (5 years), and the RME scenario considers long-term employees (20 years).
Trespass 1	Trespass area 1 exhibits clear signs of trespassing and recreation. Given the nature and location of a path, ADHS made the conservative assumption that children and adults using it do so as part of their regular exercise route or play area, approximately 121 minutes/day for youth and 30 minutes per day for adults (EPA 2011).
Trespass 2	ADHS assumed that this area was accessed less frequently than Trespass 1. The area is hidden and difficult to access, with no signs of trespassing. With this understanding, ADHS evaluated a conservative scenario in which individuals aged 16 and older pass through the area on a weekly basis.

ID	Exposure Assumptions
Trespass 3	ADEQ described this area as steep and treacherous, showing limited signs of trespassing. ADHS considered a conservative scenario in which individuals 16 years and older passed through or recreated weekly in the area.

Non-cancer health effects from a contaminant of concern (COC)

To determine if further evaluation was necessary, ADHS compared the estimated exposure doses to health guidelines.⁵ These guidelines are based on scientific research and are established at levels where adverse health effects are not expected to occur.

If the exposure dose is below the guideline, non-cancer health effects are unlikely. If the exposure dose exceeds the guideline, it does not necessarily mean health effects will occur. But it indicates the need for a closer examination. In these cases, ADHS used scientific studies to evaluate potential health effects.

Cancer health effects from a contaminant of concern (COC)

ADHS calculated cancer risks for COCs that are considered carcinogenic. The goal is to evaluate whether exposure to this COC could increase the chance of developing cancer in the exposed population. To determine cancer risk, ADHS calculated the cancer exposure dose and used the formulas:

For ingestion exposure:

$$(\text{cancer exposure dose mg/kg/day}) \times (\text{CSF (mg/kg/day)}^{-1}) = \text{Cancer Risk}$$

For inhalation exposure:

$$(\text{average exposure concentration } \mu\text{g/m}^3) \times (\text{IUR (}\mu\text{g/m}^3\text{)}^{-1}) = \text{Cancer Risk}$$

Both cancer slope factors (CSFs) and inhalation unit risks (IURs) are developed by the EPA to indicate the strength of a chemical's association with cancer. The higher the CSF or IUR, the greater the potential cancer risk. These values help scientists understand how harmful a contaminant could be to people's health, based on the way they are exposed.

The estimated cancer risk tells us the extra chance of developing cancer in a large group of people similarly exposed to the chemical over a lifetime, compared to people who were not exposed. A common way to express estimated cancer risk is as a "1 in 1,000,000" chance. This means that, in a group of 1 million people exposed to the same amount of a chemical over a lifetime, one additional person might develop cancer because of that chemical. This is in addition to the number of people who would get cancer otherwise, due to other factors, like genetics or lifestyle.

⁵ Health guidelines are estimates of daily exposures to a contaminant that are not expected to cause harm (ATSDR 2022). They include ATSDR's minimal risk level (MRL), EPA's reference dose (RfD), and EPA's reference concentration (RfC).

To put this in perspective, about 1 in 3 people in the U.S. will develop cancer at some point in their lives (ACS 2025). So, in a group of 1 million people, about 333,000 will get cancer even without exposure to the chemical. For example, if all 1 million people in the group were exposed to “chemical A” with a risk of 1 in 1,000,000, then the total number of cancer cases would theoretically go up from 333,000 to 333,001. This increase is about 0.0003%, a minimal change.

When examining different community sizes, the additional cancer cases associated with this risk level are very low. Here is what a 1 in 1,000,000 cancer risk might look like in different communities:

- In a town of 10,000 people, this extra risk means about 0.01 extra cancer cases (less than one extra case).
- In a city of 100,000 people, this translates to approximately 0.1 extra cases.
- In a large city of 1,000,000 people, it means about 1 extra cancer case.

Understanding these cancer risks allows agencies to take appropriate steps to protect communities and prevent avoidable harm. These numbers do not predict who will get cancer or how many actual cases will occur in a community, as many factors affect a person’s overall cancer risk. While small increases in estimated cancer risk usually do not significantly change a person’s overall chance of getting cancer, they are still useful for identifying potential concerns.

PM₁₀

Particulate matter (PM) refers to small solid particles and liquid droplets in the air that originate from both human and natural sources, such as dust, smoke, industrial emissions, and vehicle exhaust. PM is composed of a variety of substances, including metals, soot, and organic compounds.

PM varies in size, and is usually described by the particle's diameter in micrometers (μm). PM₁₀ refers to particles that are 10 μm or smaller in diameter, which can be inhaled and enter the lungs. It consists of:

- Coarse particles (between 2.5 and 10 μm) that come from sources like construction, road dust, and wind-blown soil.
- Fine particles (smaller than 2.5 μm , PM_{2.5}) primarily originate from combustion sources, such as vehicle exhaust and the burning of fuels.

Both types of particles are found in urban areas, but the amount and makeup of each can vary depending on local conditions, such as weather, geography, and the source of pollution (EPA 2025e).

Breathing in PM₁₀ can cause coughing, throat or eye irritation, shortness of breath, and asthma flare-up, especially in children, older adults, and people with heart or lung disease. Over time, exposure to PM₁₀ can lead to reduced lung function and increased risk of heart and lung diseases (EPA 2025c).

Discussion for Outdoor Air

VFW:

PM₁₀ was identified as COC because the concentrations exceeded both the acute (24-hour) and chronic (annual average) CVs. As a result, ADHS evaluated potential non-cancer health effects from both short-term and long-term exposure.

Short-term (24-hour) Average: 34% of samples exceeded the acute CV of 45 µg/m³. ADHS evaluated short-term PM₁₀ data using the U.S. EPA's Air Quality Index (AQI). This color-coded system enables the public to understand, in real-time, whether air quality is healthy and if any precautions are necessary. It is based on EPA's [National Ambient Air Quality Standards](#) (NAAQS), which set regulatory limits to protect public health and the environment.

In contrast, ATSDR's CVs are non-regulatory and are designed to be more health-protective to support public health interpretation, especially for sensitive populations. For PM₁₀, the ATSDR CV is based on the WHO Air Quality Guideline. Because the AQI and WHO guidelines are designed for different purposes, their numerical thresholds may differ; however, both rely on the same underlying health science and help identify when sensitive groups may benefit from simple precautions as PM₁₀ levels increase.

On 11 out of 35 days (31%), PM₁₀ levels were in the moderate range on the EPA's AQI scale (55-154 µg/m³) (EPA 2018; ATSDR 2024). On these days, people with existing health conditions, especially those related to heart or lung diseases, may be more likely to have breathing symptoms. They may also notice that their condition is worsening. These levels are not expected to harm healthy individuals.

Long-term (Annual) Average: Prolonged exposure to PM₁₀ levels above the long-term health guideline (15 µg/m³) may slightly increase the risk of health effects for individuals with pre-existing conditions, such as heart or lung disease (e.g., cardiopulmonary disease).

Kid's Park:

The 24-hour and annual average levels of PM₁₀ were below the health guidelines at the Kid's Park. None of the daily levels went above the "Good" range on the AQI. Thus, the PM₁₀ at the Kid's Park is not expected to cause adverse health effects.

Arsenic

Arsenic is a natural element in the earth's crust and can be found in air, water, and soil.

Short-term Health Effects: If you get a lot of arsenic in your body at once, it can make you sick right away, causing stomachache, nausea, and diarrhea. You may also have fewer blood cells, an abnormal heartbeat, or a "pins and needles" feeling in your hands and feet. Breathing in high levels of arsenic can cause a sore throat and irritate your lungs, and your skin may get red and swollen if it touches high levels. In extreme cases, arsenic can be deadly. For example, drinking water with more than 60,000 ppb of arsenic (6,000 times higher than the safe level set by the EPA) can cause death (ATSDR 2007).

Long-term Health Effects: Exposure to lower levels of arsenic over a prolonged period can lead to changes in your skin. You might get dark patches (known as hyperpigmentation) or small, thick, rough patches called “corns” or “warts” on your palms, soles of your feet, or torso.

Arsenic is classified as a known human carcinogen based on sufficient evidence that it causes cancer in humans (NTP 2021). So, long-term exposure may also increase your risk of developing certain cancers, such as skin, bladder, kidney, and lung cancer (ATSDR 2007).

Discussion for Outdoor Air:

ADHS evaluated 30 samples collected from the VFW and 25 samples from the Cottonwood Kid’s Park.

Non-Cancer Health Effects:

Short-term Exposure (0-14 days)

ATSDR does not currently have an acute MRL for arsenic inhalation, but the California Environmental Protection Agency (CalEPA) has developed an acute Reference Exposure Level (REL) at 0.2 $\mu\text{g}/\text{m}^3$. ADHS also considered a separate study, in which female mice were exposed to arsenic for three hours daily over five days, which showed immune system impacts. The lowest-observed-adverse-effect-level (LOAEL)⁶ from short-term arsenic inhalation was 271 $\mu\text{g}/\text{m}^3$ (ATSDR 2007).

Long-Term Exposure (>1 year)

There is currently no chronic MRL or RfC available. ADHS used CalEPA’s chronic REL (0.015 $\mu\text{g}/\text{m}^3$) to evaluate chronic exposure. This value is based on studies that found ten-year-old children exposed to high levels of arsenic in their drinking water have slightly lower IQ and learning scores (Wasserman et al., 2004; Tsai et al., 2003). CalEPA converted the arsenic drinking water level into an equivalent air concentration of 0.23 $\mu\text{g}/\text{m}^3$, then applied safety factors to establish the guideline of 0.015 $\mu\text{g}/\text{m}^3$. CalEPA set the same guideline to evaluate daily (8-hour) exposures that might happen over weeks or months. Because arsenic builds up in the body and clears slowly, repeated short-period exposures can add up over time, similar to continuous exposure.

Cancer Health Effects:

The EPA’s IUR for arsenic is 0.0043 ($\mu\text{g}/\text{m}^3$), based on occupational studies of smelter workers who were exposed to arsenic dust for many years. The workers had increased rates of lung cancer and lung cancer-related death (EPA 2025a).

⁶ The lowest-observed-adverse-effect level (LOAEL) is the lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals (ATSDR 2022).

VFW

Non-Cancer Health Effects:

Short-term Exposure (0-14 days)

The reported 24-hour average arsenic concentrations in air at VFW ranged from <0.002 to 0.034 $\mu\text{g}/\text{m}^3$. These levels are more than 7,900 times lower than the lowest reported LOAEL (271 $\mu\text{g}/\text{m}^3$) in the mice study. Additionally, the highest 24-hour concentration is well below the acute REL (0.2 $\mu\text{g}/\text{m}^3$). This means that acute inhalation health effects from breathing in arsenic in the air are not expected.

Long-Term Exposure (>1 year)

During the 3-month sampling period, two samples at the VFW exceeded the chronic REL (0.015 $\mu\text{g}/\text{m}^3$), with concentrations ranging from 0.022 to 0.0034 $\mu\text{g}/\text{m}^3$. These higher results happened on windy days when PM_{10} levels were also elevated. Since samples were taken every three days, they reflect the specific conditions on those days, not daily averages. Given that these higher values were rare and the long-term average (0.0127 $\mu\text{g}/\text{m}^3$) was below the chronic REL (0.015 $\mu\text{g}/\text{m}^3$), health effects are not expected.

Cancer Health Effects:

At the VFW, 23 samples were above the ATSDR CREG⁷. For the CTE scenario, the estimated cancer risks for children and adults are about 8 extra cases in 1,000,000 exposed people (8×10^{-6}). For the RME scenario, the estimated cancer risk is 1 extra case in 100,000 exposed children (1×10^{-5}) and 2 extra cases in 100,000 exposed adults (2×10^{-5}). The estimated cancer risks are within EPA's target cancer risk range (10^{-6} to 10^{-4}) and are not expected to pose a public health concern.

Kid's Park

Non-Cancer Health Effects:

Short-term Exposure (0-14 days)

The 24-hour average arsenic concentrations were all <0.0029 $\mu\text{g}/\text{m}^3$, meaning that it was not detected in the air. So, acute inhalation health effects from breathing arsenic-contaminated air are not expected.

Long-Term Exposure (>1 year)

Arsenic was not detected in the air at the Kid's Park. All measurements were <0.0029 $\mu\text{g}/\text{m}^3$. Thus, ADHS does not expect adverse health effects in people living or regularly recreating at or near the park from breathing in arsenic.

Cancer Health Effects:

While arsenic was not detected in the air at the Kid's Park, the reporting limits ranged from 0.002 $\mu\text{g}/\text{m}^3$ to 0.0029 $\mu\text{g}/\text{m}^3$, which are above the ATSDR CREG. This means ADHS cannot confirm whether arsenic is

⁷ An ATSDR CREG is an estimated contaminant concentration that is expected to result in no more than one excess cancer in a million (1×10^{-6}) persons exposed during their lifetime (ATSDR 2022).

present at concentrations below the CREG. However, even when using the highest reporting limit (0.002 µg/m³) as the EPC, the estimated cancer risk is still low. Under a CTE scenario, the highest potential risk is about 2 extra cases in 1,000,000 similarly exposed people (2 x 10⁻⁶). Under the RME scenario, the highest risk is about 6 extra cases in 1,000,000 similarly exposed people (6 x 10⁻⁶). These estimated cancer risks are within EPA's target risk range and are not expected to pose a public health concern.

Discussion for Groundwater:

Arsenic concentrations in the ten private, public, and irrigation wells ranged from <4.4 to 22.8 µg/L. ADHS focused the groundwater assessment on long-term and cancer health risks because the highest arsenic concentration in these wells was below the acute CV (35 µg/L). According to ADEQ, the arsenic found in groundwater is most likely from naturally occurring minerals in the aquifer rather than from something at the surface moving downward (ADEQ 2025a).

Non-Cancer Health Effects:

Long-Term Exposure (>1 year)

For children and adults, ADHS used EPA's RfD of 0.00006 mg/kg/day to evaluate long-term arsenic exposure in groundwater wells. The RfD is based on a benchmark dose (BMDL₀₅)⁸ of 0.000171 mg/kg/day for increased incidence of diabetes and ischemic heart disease in humans (EPA 2025a).

Cancer Health Effects:

ADHS used the EPA's oral cancer slope of 32 (mg/kg/day)⁻¹ to calculate cancer risks for youth and adults. The EPA's slope factor is based on Bayesian dose-response meta-analyses of 11 studies for bladder cancer, and six studies for lung cancer associated with long-term oral arsenic exposure (EPA 2025a).

Public Wells

Arsenic detections in the public well samples ranged from 15 to 21.7 µg/L; however, since 2007, the public water in Cottonwood has been treated to reduce arsenic levels before it reaches homes or other buildings (EPA 2009b, Figure A4). To better understand the concentrations to which residents are exposed, ADHS reviewed monitoring data from ADEQ's Safe Drinking Water database (ADEQ 2025b) and the latest Consumer Confidence Report for PWS #AZ0413025 (ADEQ 2024b). This review confirmed that PWS #AZ0413025 is in compliance with current arsenic drinking water standards, and residents who use this water are not exposed to the pre-treatment concentrations detected in ADEQ's sampling results. Therefore, ADHS did not conduct further evaluations of the three public wells, as the public water residents are exposed to meet federal arsenic regulations.

Irrigation Wells

Two wells used for irrigation were sampled, and arsenic was detected in both Well 4 (21.6 µg/L) and Well 7 (16.9 µg/L). ADHS further evaluated these two wells, using default intake rates for swimming scenarios

⁸ A BMDL₀₅ is a dose where scientists see a small (5%) increase in a health effect, like ischemic heart disease, compared to people who were not exposed. They use this number as a starting point and add safety factors to set a reference dose that protects everyone, including the most sensitive populations (ATSDR 2022).

as the intake rates to represent individuals playing in sprinklers. These rates are higher than what is likely during sprinkler play, which gives a health-protective estimate of exposure. ADHS evaluated the incidental ingestion scenarios with the assumptions that residents come into contact with the sprinklers during the summer (when it is warm) and that during that time, the grass is irrigated three times per week for 30 minutes. Since only one sample was taken per well, ADHS used the single measurement as the EPC to estimate CTE and RME exposure doses.

Non-Cancer Health Effects:

Long-Term Exposure (>1 year)

- Wells 4 and 7: All CTE and RME exposure doses were below the RfD. Under the RME scenario, doses ranged from 0.0000008 mg/kg/day (adults, Well 7) to 0.000008 mg/kg/day (2 to <6 years, Well 4). Thus, ADHS does not expect adverse health effects to occur in visitors from incidental ingestion of irrigation water from Wells 4 and 7.

Cancer Health Effects:

- Wells 4 and 7: Under the most conservative scenario, the RME cancer risks ranged from about 1 extra case per 1,000,000 (adults, Well 7) to 2 extra cases per 100,000 (children, Well 4). These estimated cancer risks are within EPA's target risk range and not expected to pose a public health concern.

Private Wells

Five private wells were sampled, and arsenic was detected in Well 1 (22.8 µg/L) and Well 3 (21.6 µg/L). ADHS further evaluated these two wells. Since only one sample was taken per well, ADHS used the single measurement as the EPC to estimate CTE and RME exposure doses.

Non-Cancer Health Effects:

Long-Term Exposure (>1 year)

- Wells 1 and 3: All CTE and RME exposure doses were above the RfD for residents of all ages. For these wells combined, estimated exposure doses ranged from 0.00021 mg/kg/day (11 to <16 years old youth, Well 3) to 0.0017 mg/kg/day (birth to <1 year, Well 1) under the CTE scenario, and from 0.00067 mg/kg/day (11 to <21 years old youth, Well 3) to 0.0032 mg/kg/day (birth to <1 year, Well 1) under the RME scenario. Thus, residents who regularly drink water from Private Wells 1 or 3 without treatment could experience adverse health effects.
- Wells 2, 8, and 11: Arsenic was not detected in these wells; however, the detection limit (4.4 µg/L) was higher than the CV (0.42 µg/L). This means that the arsenic concentrations were too small for the machine to measure accurately, so the actual concentration may be anywhere between 0 and 4.4 µg/L. Due to this limitation, ADHS cannot determine whether there is an increased lifetime risk of adverse health effects from the long-term use of these wells without arsenic treatment.

Cancer Health Effects:

- **Wells 1 and 3:** CTE cancer risks for Wells 1 and 3 were about 1 to 3 extra cases in 1,000 (1×10^{-3}) for children and adults, and all RME risks for Wells 1 and 3 were greater than 6 extra cancer cases in 1,000 (6×10^{-3}). The EPA's toxicological review (EPA 2025a) states that the linear slope factor becomes uncertain at higher lifetime doses, corresponding to 6 extra cancer cases in 1,000 (6×10^{-3}). Because of this uncertainty, the actual cancer risk at these doses cannot be precisely determined. Therefore, we report them as greater than 6 in 1,000. Overall, all estimated cancer risks are above 1 extra case in 10,000 people, indicating a concern for increased cancer risk if residents use Wells 1 and 3 for domestic purposes without treatment.
- **Wells 2, 8, and 11:** Arsenic was not detected in these wells; however, the detection limit (4.4 $\mu\text{g/L}$) was higher than the CV (0.00076 $\mu\text{g/L}$). This means the actual concentration may be anywhere between 0 and 4.4 $\mu\text{g/L}$. Because of this limitation, ADHS cannot determine whether there is any increased lifetime cancer risk from long-term use of these wells without arsenic treatment.

Discussion for Surface Soil

Natural arsenic background levels in soil typically range from 1 to 40 mg/kg. However, higher levels may occur in mining areas, at waste sites, near high geological deposits of arsenic-rich minerals, or following the application of pesticides (ATSDR 2007). According to ADEQ's PI report, the background arsenic level in the City of Cottonwood soil is 29.5mg/kg (ADEQ 2025a).

ADHS further evaluated the areas where arsenic was identified as a soil COC (see Table B8). To estimate potential health risks, ADHS used ATSDR's default arsenic relative bioavailability factor (60%) to calculate exposure doses. This is a health-protective value used to account for the fact that 40% of the arsenic that enters the body is not absorbed and does not contribute to possible health effects. Due to the limitations regarding soil sampling described in the *Summary of Limitations* section, long-term and cancer evaluations were not conducted for: private residences 1-6; residential ROWs 3, 8, 10, 13, 14, 18, and 19; commercial 4 and 6; or Recreational 2 and 4.

Non-Cancer Health Effects:

Short-term Exposure (0-14 days)

ADHS used ATSDR's MRL of 0.005 mg/kg/day to evaluate short-term exposure to arsenic in surface soil under both the CTE and RME scenarios. The MRL is based on a LOAEL of 0.05 mg/kg/day for gastrointestinal health effects observed during an episode of arsenic contamination in soy sauce in Japan (ATSDR 2007).

Soil-pica consideration: It is normal for young children to put their hands and other objects in their mouths as part of their exploratory behavior. However, about 4-20% of preschool-aged kids show soil-pica behaviors (ATSDR 2018). This occurs when a child consumes high amounts of soil (1,000 to 5,000 mg, or approximately a teaspoon or more, per day) (ATSDR 2018). ADHS calculated the soil-pica

exposure doses for preschool children (1 to <6 years old) using ATSDR's soil-pica exposure assumptions (3 pica events/week; intake of 5,000 mg of soil per event).

Long-Term Exposure (>1 year)

When long-term exposure could be evaluated, ADHS used the EPA's oral RfD of 0.00006 mg/kg/day for arsenic (EPA 2025a). If estimated exposure exceeds the RfD, it may indicate a potential public health concern. The RfD includes only a three-fold safety factor because it is based on human studies. Because this uncertainty factor is small, any exceedance is considered a potential non-cancer health concern. Long-term exposure was evaluated only for properties with sufficient representative soil data and land uses where people might repeatedly come into contact with soil over many years, under both the CTE and RME scenarios.

Cancer Health Effects:

ADHS used the EPA's oral cancer slope of 32 (mg/kg/day)¹ to estimate CTE and RME cancer risks from arsenic exposure for children and adults at properties where long-term exposure could be supported. Because cancer risk calculations require a long-term average daily dose, cancer risk was not evaluated for properties that lacked adequate soil data.

Private Residences

Non-Cancer Health Effects:

Short-term Exposure (0-14 days): A location is considered to pose no acute health concern when the EPC is below the acute arsenic CV. Locations where the EPC was above the CV were further evaluated, as summarized below.

- Residence 10: This residence was not analyzed for arsenic, so ADHS is unable to evaluate possible acute health risks from arsenic at this location.
- Residences 2, 4, 5: The highest soil concentrations at these residences were all below the acute CV of 260 mg/kg. Thus, no acute or soil-pica concerns were identified for any age group.
- Residence 1: Clustered samples were taken in three locations on the property. The locations with clustered sampling were evaluated separately.
 - Sampling Location 1: There is no acute health concern based on typical hand-to-mouth exposure. All acute CTE and RME doses were below the acute MRL. The highest estimated dose was 0.0019 mg/kg/day (birth to <1 year) under the RME scenario. For soil-pica exposure, only children 1 to <2 years old had an estimated dose (0.0063 mg/kg/day) above the MRL; however, this was still much lower than the levels that caused effects in the study used to set the guideline (LOAEL: 0.05 mg/kg/day). Therefore, ADHS does not expect short-term health effects from soil-pica exposure at this location.
 - Sampling Location 2: For typical hand-to-mouth exposure, the estimated RME doses for children < 1 year and 2 to <6 years old ranged from 0.0058 mg/kg/day to 0.0088 mg/kg/day. These values are above the acute MRL but still much lower than the LOAEL.

Therefore, ADHS does not expect short-term health effects under typical hand-to-mouth behavior. All other acute CTE and RME doses for this location were below the acute MRL. The estimated soil-pica dose was 0.031 mg/kg/day for children aged 1 to <2 years, and 0.021 mg/kg/day for children aged 2 to <6 years. These values exceed the MRL and are closer to the level associated with effects in the study; therefore, soil-pica behavior at this location could lead to acute health effects for children aged 1 to <6 years old.

- Sampling Location 3: A single laboratory sample was taken elsewhere in the yard, where the arsenic concentration was below the acute CV, and no acute adverse health effects are expected.

At Residence 1, Sampling Location 1 showed no acute or soil-pica health concerns for any age group under CTE or RME exposure scenarios. Sampling Location 2 also showed no acute concern for any age group for both CTE and RME exposure scenarios; however, a soil-pica concern was identified for young children (ages 1 to <6) at this location.

- Residence 3: There is no acute health concern with typical hand-to-mouth exposure, as all acute CTE and RME doses were below the acute MRL. The highest estimated exposure dose was 0.0034 mg/kg/day (birth to <1 year) under the RME scenario. The estimated soil-pica doses were 0.00072 mg/kg/day for children aged 1 to <2 years, and 0.00031 mg/kg/day for children aged 2 to <6 years. These values exceed the MRL, but are still well below the level associated with effects in the study. Therefore, ADHS does not expect short-term health effects from soil-pica exposure at this location.
- Residence 6: ADEQ collected a cluster of five samples on the edge of this property. There is no acute health concern with typical hand-to-mouth exposure, as the EPC is below the acute arsenic CV. For soil-pica exposure, only children 1 to <2 years old had an estimated dose (0.0057 mg/kg/day) slightly above the MRL, but it is well below the level associated with effects in the study. The soil-pica dose for children aged 2 to <6 years was 0.0037 mg/kg/day, which is below the MRL. Therefore, ADHS does not expect short-term health effects from soil-pica exposure at this location.

Residential ROWs:

Non-Cancer Health Effects:

Short-term Exposure (0-14 days): A location is considered to pose no acute health concern when the EPC is below the acute arsenic CV. Locations where the EPC was above the CV were further evaluated, as summarized below.

- Residential ROWs 1-12, 15, 18: The highest soil concentrations at these residences were all below the acute CV of 260 mg/kg. No acute or soil-pica concerns were identified for any age group.

- Residential ROW 13: There is no acute health concern based on typical hand-to-mouth exposure. All acute CTE and RME doses were below the acute MRL. The highest estimated exposure dose was 0.004 mg/kg/day (birth to <1 year) under the RME scenario. The estimated soil-pica doses were 0.039 mg/kg/day for children aged 1 to <2 years, and 0.025 mg/kg/day for children aged 2 to <6 years. These values exceed the MRL and are closer to the level associated with effects in the study; therefore, soil-pica behavior at this location could lead to acute health effects for children aged 1 to <6 years old.
- Residential ROW 14: There is no acute health concern based on typical hand-to-mouth exposure. All acute CTE and RME doses were below the acute MRL. The highest estimated exposure dose was 0.003 mg/kg/day (birth to <1 year) under the RME scenario. The estimated soil-pica dose was 0.029 mg/kg/day for children aged 1 to <2 years, and 0.019 mg/kg/day for children aged 2 to <6 years. These values exceed the MRL and are approaching the level associated with effects in the study; therefore, soil-pica behavior at this location could lead to acute health effects for children aged 1 to <6 years old.
- Residential ROW 19: There is no acute health concern based on typical hand-to-mouth exposure. All acute CTE and RME doses were below the acute MRL. The highest estimated exposure dose was 0.0029 mg/kg/day (birth to <1 year) under the RME scenario. The estimated soil-pica doses were 0.028 mg/kg/day for children aged 1 to <2 years, and 0.018 mg/kg/day for children aged 2 to <6 years. These values exceed the MRL and are approaching the level associated with effects in the study; therefore, soil-pica behavior at this location could lead to acute health effects for children aged 1 to <6 years old.

Long-Term Exposure (>1 year): A location is considered to pose no chronic health concern when the EPC is below the chronic arsenic CV. Locations where the EPC was above the CV were further evaluated, as summarized below.

- Residential ROW 1: Under the CTE scenario, all estimated exposure doses were below the RfD except for children birth to < 1 year and 1 to <2 years. For all other age groups, the highest estimated dose was 0.000045 mg/kg/day for children 2 to <6 years. Under the RME scenario, estimated exposure doses RME doses ranged from 0.000016 mg/kg/day (adults) to 0.00025 mg/kg/day (birth to < 1 year), with those for children birth to <11 years old exceeding the RfD. These results indicate that incidental ingestion of arsenic in soil in this area could lead to adverse health effects for children <2 years old under CTE conditions and for children <11 years old under RME conditions.
- Residential ROW 2: For adults, both the CTE (0.000015 mg/kg/day) and RME (0.000052 mg/kg/day) exposure doses were below the RfD, indicating adverse health effects are not expected.

- Residential ROW 4: Under the CTE scenario, the estimated exposure doses were below the RfD for all age groups except for children from birth to 1 and 1 to <2 years. CTE doses ranged from 0.000033 mg/kg/day (adults) to 0.000063 mg/kg/day (1 to <2 years). Under the RME scenario, exposure doses for children from birth to <11 years old exceeded the RfD, with values ranging from 0.000011 mg/kg/day (adults) to 0.00017 mg/kg/day (birth to <1 year). These results indicate that incidental soil ingestion in this area could lead to adverse health effects for children <2 years old under CTE conditions, and for children <11 years old under RME conditions.
- Residential ROW 6: All CTE exposure doses were below the RfD, with the highest dose of 0.000036 mg/kg/day for children 1 to <2 years. Under the RME scenario, exposure doses were below the RfD for most age groups, except for children aged birth to <1 year and 1 to <2 years old. In this scenario, exposure doses ranged from 0.0000058 mg/kg/day (adults) to 0.000089 mg/kg/day (birth to < 1 year). These results indicate that incidental soil ingestion in this area is not expected to cause adverse health effects for any age group under CTE conditions. However, under RME conditions, incidental soil ingestion could lead to adverse health effects for children <2 years old.
- Residential ROW 11: Under the CTE scenario, the estimated exposure doses were above the RfD for children <11 years old. CTE doses ranged from 0.000014 mg/kg/day (adults) to 0.00029 mg/kg/day (1 to <2 years). Under the RME scenario, the estimated exposure doses were above the RfD for children <16 years old, ranging from 0.000046 mg/kg/day (adults) to 0.0007 mg/kg/day (birth to <1 year). These results indicate that incidental soil ingestion in this area could lead to adverse health effects for children <11 years old under CTE conditions, and for children <16 years old under RME conditions.
- Residential ROWs 5, 9, 12: These ROW areas had similar soil concentrations and resulted in similar exposure dose ranges. For these areas combined, estimated CTE exposure doses ranged from 0.0000022 mg/kg/day (adults, Residential ROW 5) to 0.000054 mg/kg/day (1 to 2 years, Residential ROW 12), and RME doses from 0.0000074 mg/kg/day (adults, Residential ROW 5) to 0.00013 mg/kg/day (birth to <1 year, Residential ROW 12). Under the CTE scenario, all exposure doses were below the RfD. Under the RME scenario, exposure doses were below the RfD for most age groups, except for children <6 years old. These results indicate that incidental soil ingestion in this area is not expected to cause adverse health effects for any age groups under CTE conditions. However, under RME conditions, incidental soil ingestion could lead to adverse health effects for children <6 years old.
- Residential ROWs 7 and 15: These ROW areas had similar soil concentrations, resulting in similar exposure dose ranges. For these areas combined, estimated exposure doses ranged from 0.000003 mg/kg/day (adults, Residential ROW 7) to 0.000066 mg/kg/day (1 to 2 years, Residential ROW 15) under the CTE scenario, and from 0.0000099 mg/kg/day (adults, Residential ROW 7) to 0.00016 mg/kg/day (birth to <1 year, Residential ROW 15) under the RME scenario. CTE doses were below the RfD for most age groups, except for children 1 to <2 years old, and RME doses were below the RfD for most age groups, except for children <6 years old. These results indicate that incidental soil ingestion in this area could cause adverse health effects for children 1 to <2 years old under CTE conditions, and for children <6 years old under RME conditions.

Cancer Health Effects:

See Table 5 for all estimated cancer risks. Under the CTE scenario, adult cancer risks ranged from 9×10^{-6} (Residential ROW 6) to 8×10^{-5} (Residential ROW 2), and children’s cancer risks ranged from 7×10^{-5} (Residential ROW 6) to 6×10^{-4} (Residential ROW 11). Under the RME scenario, adult cancer risks ranged from 8×10^{-6} (Residential ROW 6) to 7×10^{-4} (Residential ROW 2), and children’s cancer risks ranged from 3×10^{-4} (Residential ROW 6) to 2×10^{-3} (Residential ROW 11).

Table 5. Cancer risk estimates for chronic ingestion of arsenic in soil at Residential ROWs (CSF: 32 (mg/kg/day)⁻¹).

Residence ID	Exposure Scenario	Exposure Group	
		Child	Adult
Residential ROW 1	CTE	2 in 10,000	2 in 100,000
	RME	7 in 10,000	2 in 10,000
Residential ROW 2	CTE	-	8 in 100,000
	RME	-	7 in 10,000
Residential ROW 4	CTE	1 in 10,000	2 in 100,000
	RME	5 in 10,000	2 in 10,000
Residential ROW 5	CTE	9 in 10,000	1 in 100,000
	RME	3 in 10,000	1 in 10,000
Residential ROW 6	CTE	7 in 100,000	9 in 1,000,000
	RME	3 in 10,000	8 in 100,000
Residential ROW 7	CTE	1 in 10,000	2 in 100,000
	RME	4 in 10,000	1 in 10,000
Residential ROW 9	CTE	1 in 10,000	1 in 100,000
	RME	3 in 10,000	1 in 10,000
Residential ROW 11	CTE	6 in 10,000	7 in 100,000
	RME	2 in 1,000	6 in 10,000
Residential ROW 12	CTE	1 in 10,000	1 in 100,000
	RME	4 in 10,000	1 in 10,000
Residential ROW 15	CTE	1 in 10,000	2 in 100,000
	RME	4 in 10,000	1 in 10,000

Bold cancer risks are above EPA’s target risk range (10^{-6} to 10^{-4}).

Cancer risks are presented as extra cancer cases in a population, translated from scientific notation.

For example: $8 \times 10^{-6} \rightarrow 8$ extra cancer cases in 1,000,000 similarly exposed people.

Across the Residential ROW areas, estimated cancer risks ranged from about 9 extra cases per 1,000,000 people (9×10^{-6}) to about 2 extra cases per 1,000 people (2×10^{-3}). Under the CTE scenario, all adult cancer risks were within EPA's target risk range; however, almost all children's cancer risks were above EPA's range, except at Residential ROW 6. Under the RME scenario, cancer risks increase for both children and adults. All children's RME cancer risks and most adult RME cancer risks were above the EPA's target risk range, except at Residential ROW 6. The results indicate there is a concern for increased risk of arsenic-related cancers for children under CTE conditions, and for both children and adults under RME conditions.

Commercial, Recreational, Industrial, and Trespass Areas:

Non-Cancer Health Effects:

Short-term Exposure (0-14 days):

EPCs in recreational, commercial, industrial, and trespass areas ranged from 4.12 to 243.3 mg/kg, all of which were below the acute CV. Therefore, ADHS does not expect any adverse health effects in individuals visiting these areas for short periods of time from incidental soil ingestion. ADHS considered soil-pica exposures, and Recreational 6 was evaluated further. No concerns were identified in any other areas.

- **Recreational 6:** The estimated soil-pica dose was 0.0061 mg/kg/day for children aged 1 to <2 years, which is above the acute MRL; however, due to safety factors, it is still much lower than the levels that caused effects in the study used to set the guideline. The soil-pica dose for children 2 to <6 years was 0.0040 mg/kg/day, which is below the MRL. Therefore, ADHS does not expect adverse health effects from soil-pica exposure at this location.

Long-Term Exposure (>1 year): A location is considered to pose no chronic health concern when the EPC is below the chronic arsenic CV or the estimated dose is below the health guideline. Locations where the EPC was above the CV were further evaluated (Commercial 1-3; Recreational 1, 3, 5, 6; Industrial 1-2; Trespass 1-3). All estimated CTE and RME doses were below the RfD. Therefore, ADHS does not expect any adverse health effects in individuals with repeated exposure to soil arsenic in these areas, as described in the scenario assumptions in Table 3.

For these areas combined, estimated CTE exposure doses ranged from 0.0000000071 (7.1×10^{-9}) mg/kg/day (adults, Commercial 2) to 0.0000091 (9.1×10^{-6}) mg/kg/day (1 to <2 years, Recreational 1). RME doses ranged from 0.000000024 (2.4×10^{-8}) mg/kg/day (adults, Commercial 2) to 0.000022 (2.2×10^{-5}) mg/kg/day (birth to <1 year, Recreational 1).

Cancer Health Effects:

See Table 6 for all estimated cancer risks under both CTE and RME scenarios. Across these land uses, estimated cancer risks were within the EPA’s target risk range, except for indoor and outdoor workers at Industrial 1 under the RME scenario.

Under the CTE scenario, all land-use scenarios showed cancer risks within EPA’s target risk range and are not expected to pose a public health concern. Under the RME scenario, cancer risks for commercial, recreational, and trespasser scenarios were also within the range. Only the Industrial 1 RME scenario exceeded EPA’s target risk range for both indoor and outdoor workers, indicating an increased risk of arsenic-related cancers in this scenario.

Table 6. Cancer risk estimates for chronic arsenic ingestion in soil at Commercial, Recreational, Trespass, and Industrial Areas: (CSF: 32 (mg/kg/day)⁻¹).

Residence ID	Exposure Scenario	Exposure Group			
		Child	Adult	Indoor worker	Outdoor worker
Commercial 1	CTE	3 in 1,000,000	<1 in 1,000,000	-	-
	RME	1 in 100,000	2 in 1,000,000	-	-
Commercial 2	CTE	< 1 in 1,000,000	< 1 in 1,000,000	-	-
	RME	1 in 1,000,000	<1 in 1,000,000	-	-
Commercial 3	CTE	3 in 1,000,000	< 1 in 1,000,000	-	-
	RME	8 in 1,000,000	< 1 in 1,000,000	-	-
Recreational 1	CTE	2 in 100,000	2 in 1,000,000	-	-
	RME	6 in 100,000	5 in 1,000,000	-	-
Recreational 3	CTE	-	1 in 1,000,000	-	-
	RME	-	4 in 1,000,000	-	-
Recreational 5	CTE	2 in 1,000,000	1 in 1,000,000	-	-
	RME	5 in 1,000,000	4 in 1,000,000	-	-
Recreational 6	CTE	6 in 1,000,000	<1 in 1,000,000	-	-
	RME	2 in 100,000	1 in 1,000,000	-	-
Trespass 1	CTE	2 in 100,000	1 in 1,000,000	-	-
	RME	5 in 100,000	4 in 1,000,000	-	-
Trespass 2	CTE	< 1 in 1,000,000	<1 in 1,000,000	-	-
	RME	<1 in 1,000,000	2 in 1,000,000	-	-
Trespass 3	CTE	<1 in 1,000,000	2 in 1,000,000	-	-
	RME	2 in 1,000,000	1 in 100,000	-	-
Industrial 1	CTE	-	-	3 in 100,000	9 in 100,000
	RME	-	-	1 in 10,000	4 in 10,000
Industrial 2	CTE	-	-	7 in 1,000,000	2 in 100,000

Residence ID	Exposure Scenario	Exposure Group			
		Child	Adult	Indoor worker	Outdoor worker
	RME	-	-	3 in 100,000	10 in 100,000

Bold cancer risks are above EPA's target risk range (10^{-6} to 10^{-4}).

Cancer risks are presented as extra cancer cases in a population, translated from scientific notation. For example: 8×10^{-6} → 8 extra cancer cases in 1,000,000 similarly exposed people.

Daycare:

At Daycare 1, the playground is covered with wood chips, as evidenced by ADEQ's photographic and anecdotal evidence. This cover likely reduces direct contact with soil and lowers potential exposure to arsenic. However, because high winds occur periodically, dust may still settle on top of the wood chips, leading to possible incidental exposure.

During sampling, the wood chips were removed, and nine soil samples were collected from the bare soil beneath. Detected concentrations ranged from below detection (<0.837 mg/kg) to 219 mg/kg. Based on a statistical review, ADHS identified one location (219 mg/kg) as a hotspot. A hotspot in the soil refers to a smaller area with much higher contaminant levels compared to the surrounding soil. This hotspot was located in a right-of-way area in front of the daycare, and not part of the yard. Because children are not expected to frequently access this location, the hotspot was not included in the EPC calculation. For the purpose of estimating yard-wide chronic exposure, the remaining eight samples were used to calculate the yard-wide EPC (9.165 mg/kg).

Non-Cancer Health Effects:

Short-term Exposure (0-14 days):

The yard-wide EPC is below the acute CV. No acute or no soil-pica concerns were identified for any age group under either the CTE or RME exposure scenarios.

For the hotspot, all acute exposure doses were below the MRL for every age group under both the CTE and RME exposure scenarios. Under the more conservative RME scenario, doses ranged from 0.00016 mg/kg/day (full-time worker) to 0.0025 mg/kg/day (birth to <1 year). The estimated soil-pica doses (0.0082 mg/kg/day for children aged 1 to <2 years and 0.0054 mg/kg/day for children aged 2 to <6 years) are slightly above the MRL but still significantly lower than the LOAEL (0.05 mg/kg/day). As a result, no acute or soil-pica health concerns are expected for anyone using the playground. Based on available information, arsenic appears to be elevated only in one small location, and additional sampling would be needed to fully characterize this hotspot.

Long-Term Exposure (>1 year)

For yard-wide exposure, all exposure doses under the CTE scenario were below the RfD, ranging from 0.0000014 mg/kg/day (for full-time and part-time workers) to 0.000027 mg/kg/day (birth to <1 year). This indicates that there are no expected non-cancer health concerns associated with the typical use of

the playground. Under the RME scenario, exposure doses were also below the RfD for most age groups, except for children <1 year old and 1 to <2 years, whose estimated doses slightly exceeded the RfD. RME doses ranged from 0.000069 mg/kg/day (1 to <2 years) to 0.000076mg/kg/day(birth to <1 year). This suggests that, if the yard were not covered, repeated incidental ingestion of arsenic in the soil could lead to adverse health effects for children <2 years old.

In practice, the wood-chip layer limits direct contact with the underlying soil and is expected to lower actual long-term exposure. However, because there is a lack of data on how effectively the wood chips prevent soil ingestion over time, ADHS cannot fully characterize the more realistic long-term risk.

Cancer Health Effects:

For yard-wide exposure, the estimated CTE cancer risks were approximately 2 extra cases per 1,000,000 (2×10^{-6}) people (part-time workers), 3 extra cases per 1,000,000 (3×10^{-6}) people (full-time workers), and 5 extra cases per 100,000 (5×10^{-5}) people (children). The estimated RME cancer risks were approximately 4 extra cases per 100,000 (4×10^{-5}) (full-time workers) to 2 extra cases per 10,000 (2×10^{-4}) people (children).

For children, the RME estimate slightly exceeded the EPA's target risk range, suggesting that long-term ingestion of uncovered soil could lead to a higher-than-recommended cancer risk. The playground is covered with wood chips, which reduces the likelihood of soil contact for children, but there is not enough information to estimate the actual long-term risk with the wood-chip cover in place.

Cadmium

Cadmium is a heavy metal that is naturally present in the earth's crust and can enter the environment through industrial activities, such as mining and manufacturing, or through the burning of fossil fuels and waste materials (ATSDR 2012b). One can be exposed to cadmium through food, cigarette smoking, ingesting contaminated water or soil, and breathing contaminated air (ATSDR 2012b).

Breathing in high levels of cadmium can irritate and damage the lungs, especially in workers exposed to cadmium dust or fumes. Prolonged exposure can lead to decreased lung function and emphysema, as well as damage to the olfactory function and nasal epithelium (ATSDR 2012b).

Swallowing large amounts of cadmium at once can irritate the stomach, causing nausea, vomiting, or diarrhea. With long-term ingestion, cadmium can build up in the kidneys and may lead to kidney damage. It may also weaken the bones, making them more likely to break (ATSDR 2012b).

Inhaling certain cadmium compounds has caused lung tumors in rats, and limited worker studies suggest a similar cancer concern, but with uncertainties. There is no evidence that ingesting cadmium causes cancer. Thus, the EPA and International Agency for Research on Cancer (IARC) classify cadmium as a probable human carcinogen by inhalation (EPA 1989).

Discussion for Outdoor Air

Cancer Health Effects:

The EPA estimated the IUR $0.0018 (\mu\text{g}/\text{m}^3)^{-1}$, which is used to estimate cancer risk from breathing cadmium. Although cadmium was not detected in the air at the VFW or Kid's Park, the reporting limits ($0.0021 \mu\text{g}/\text{m}^3$ and $0.0029 \mu\text{g}/\text{m}^3$, respectively) were above the ATSDR air CREG ($0.00056 \mu\text{g}/\text{m}^3$). This means we cannot tell whether cadmium is present at concentrations below the CREG. However, even when using the reporting limits in the calculation, the cancer risks remain low. Under the CTE scenario, the highest risk is well below 1 extra case in 1,000,000 (1×10^{-6}) people at both the VFW and Kid's park. Under the RME scenario, the highest risk was about 2 in 1,000,000 (2×10^{-6}) at both locations. These values are considered low excess cancer risks and are not expected to be a public health concern.

Discussion for Surface Soil

ADHS further evaluated the nine areas where cadmium was identified as a soil COC (Residence 1-2; Residential ROW 2; Commercial 3; Recreational 3, 6; Industrial 1, Trespass 3). Due to the limitations described in the *Summary of Limitations* section regarding soil sampling, long-term evaluations were not conducted for the samples taken at Residences 1 and 2.

Non-Cancer Health Effects:

Intermediate Exposure (14-365 days)

ATSDR has not established an acute health guideline. However, the EPCs ranged from 1.55 to 13.62 mg/kg, all of which were below the intermediate CV (26 mg/kg). Therefore, ADHS does not expect any adverse health effects in individuals visiting these areas for less than one year from incidental soil ingestion or soil-pica behavior.

Long-Term Exposure (>1 year)

Long-term exposure was evaluated only for properties with sufficient representative soil data and land uses where people are likely to repeatedly come into contact with soil over many years. When long-term exposure could be evaluated, ADHS used the ATSDR chronic oral MRL. ATSDR derived the MRL ($0.0001 \text{ mg}/\text{kg}/\text{day}$) for cadmium based on a UC DL_{10} ⁹ of $0.00033 \text{ mg}/\text{kg}/\text{day}$ for signs of kidney damage (ATSDR 2012b). An exposure dose exceeding the MRL is considered a potential public health concern because the MRL is based on human data and includes a 3-fold uncertainty factor to protect sensitive groups, including young children. Since the kidney effects used to set the MRL are well studied and the safety margin is small, any exceedance is treated as a potential non-cancer concern.

A location is considered to pose no chronic health concern when the EPC is below the chronic CV or the estimated dose is below the health guideline. Locations where the EPC was above the CV were further evaluated. For these areas combined, estimated CTE exposure doses ranged from $0.000000013 (1.3 \times 10^{-8}) \text{ mg}/\text{kg}/\text{day}$ (adults, Recreational 3) to $0.0000023 (2.3 \times 10^{-6}) \text{ mg}/\text{kg}/\text{day}$ (adult, Residential ROW 2).

⁹ An urinary cadmium level (UC DL_{10}) is a protective estimate of the lowest dose that could cause a 10% increase in kidney damage.

RME doses ranged from 0.000000043 (4.3×10^{-8}) mg/kg/day (adults, Recreational 3) to 0.0000078 (7.8×10^{-6}) mg/kg/day (adult, Residential ROW 2). Doses for indoor and outdoor workers were 0.0000029 (2.9×10^{-6}) and 0.0000095 (9.5×10^{-6}), respectively.

All estimated CTE and RME doses were below the MRL. Therefore, ADHS does not expect any adverse health effects in individuals with repeated exposure to cadmium in the soil at any of the areas evaluated.

Copper

Copper is found naturally in rocks, soil, water, and air, with soil levels typically ranging from 2 to 50 mg/kg. Our bodies require copper in small amounts, which is found in plants, animals, and various foods and supplements. The median intake of copper from food sources for US adults is approximately 1.0 to 1.6 mg/day, and 2.4 mg/day for individuals who take supplements (ATSDR 2024a).

Short-term Health Effects: If you swallow a large amount of copper at once or over the span of days, you may experience vomiting, nausea, abdominal pain, and diarrhea (ATSDR 2024a). People who ingest excessive copper are typically exposed through contaminated drinking water, usually from corroded pipes or plumbing.

Long-term Health Effects: Long-term exposure to too much copper can lead to liver damage, because the liver is the main organ that stores and controls copper levels in the body. Exposures that are much higher and prolonged may also affect the kidneys and red blood cells. However, these effects are generally associated with copper intakes well above normal dietary levels or with rare medical conditions, such as Wilson's disease, where the body cannot eliminate excess copper (ATSDR 2024a).

The scientific evidence on cancer is very limited. The effects of copper on cancer have not been evaluated by the IARC. The NTP also does not consider copper to be known or reasonably anticipated to cause cancer in humans. Based on the lack of human data, inadequate animal studies, and unclear mutagenicity results, the EPA classifies copper as Group D – not classifiable as to human carcinogenicity (EPA 1988; ATSDR 2024a).

Discussion for Surface Soil:

Non-Cancer Health Effects:

ADHS further evaluated the areas with copper as a soil COC (see Table B8).

Short-term Exposure (0-14 days)

ADHS used the ATSDR acute-duration MRL of 0.02 mg/kg/day to evaluate the short-term effects of copper. The MRL considers the amount of copper people usually get from their diet and is based on gastrointestinal effects in female adults ingesting copper sulfate in drinking water for 2 weeks, with a BMDL₁₀ of 0.055 mg/kg/day (ATSDR 2024a).

Residences:

A location is considered to pose no acute health concern when the EPC is below the acute CV. Locations where the EPC was above the CV were further evaluated, as summarized below. All CTE and RME doses were below the MRL, indicating that no acute adverse health effects are expected at any of the residences with typical hand-to-mouth behavior. The majority of residences had soil-pica doses below the MRL; however, all three sampling sites at Residence 1 and Residence 2 had soil-pica doses that exceeded the MRL. ADHS further evaluated these locations.

- Residence 10: This residence was not analyzed for copper, so ADHS is unable to evaluate possible acute health risks from copper at this location.
- Residence 3, 4, 5, 6: Copper exposure estimates at all four residences were below their respective CV or MRL, indicating that short-term health effects are not expected. At Residence 4, EPC was below the CV. For Residences 3, 5, and 6, all acute CTE, RME, and soil-pica exposure doses were below the MRL, indicating adverse health effects are not expected. The highest doses were 0.0061 mg/kg/day (birth to <1 year) at Residence 5 under the RME scenario.
- Residence 1:
 - Sampling Location 1: There is no acute health concern based on typical hand-to-mouth exposure, since the CTE and RME doses are below the MRL. The highest estimated exposure dose was 0.012 mg/kg/day (birth to <1 year) under the RME scenario. The estimated soil-pica doses were 0.040 mg/kg/day for children aged 1 to <2 years, and 0.026 mg/kg/day for children aged 2 to <6 years. These values exceed the MRL and are approaching the level associated with effects in the study; therefore, soil-pica behavior at this location could lead to acute health effects for children aged 1 to <6 years old.
 - Sampling Location 2: There is no acute health concern based on typical hand-to-mouth exposure, since the CTE and RME doses are below the MRL. The highest estimated exposure dose was 0.019 mg/kg/day (birth to <1 year) under the RME scenario. The estimated soil-pica doses were 0.062 mg/kg/day for children aged 1 to <2 years, and 0.041 mg/kg/day for children aged 2 to <6 years. These values exceed the MRL and the level associated with effects in the study for youth 1 to <2 years, and approach the study effect level for children 2 to <6 years. Therefore, soil-pica behavior at this location could lead to acute health effects for children aged 1 to <6 years old.
 - Sampling Location 3: There is no acute health concern based on typical hand-to-mouth exposure in this location. The highest estimated exposure dose was 0.011 mg/kg/day (birth to <1 year) under the RME scenario. The soil-pica doses were 0.037 mg/kg/day for children aged 1 to <2 years, and 0.024 mg/kg/day for children aged 2 to <6 years. These values exceed the MRL and are approaching the level associated with effects in the study; therefore, soil-pica behavior at this location could lead to acute health effects for children aged 1 to <6 years old.
- Residence 2: There is no acute health concern based on typical hand-to-mouth exposure since the CTE and RME doses are below the MRL. The highest estimated exposure dose was 0.018 mg/kg/day (birth to <1 year) under the RME scenario. The estimated soil-pica doses were 0.058 mg/kg/day for children aged 1 to <2 years, and 0.038 mg/kg/day for children aged 2 to <6 years.

These values exceed the MRL and the level associated with effects in the study for youth 1 to <2 years, and approach the study effect level for children 2 to <6 years. Therefore, soil-pica behavior at this location could lead to acute health effects for children aged 1 to <6 years old.

Residential ROWs:

ADHS further evaluated locations where the EPC was above the CV, as summarized below. All CTE and RME doses were below the MRL, indicating that no acute adverse health effects are expected in any of the Residential ROWs with typical hand-to-mouth behavior. The majority of Residential ROW areas evaluated had soil-pica doses below the MRL, with the exceptions of Residential ROWs 1 and 5. ADHS further evaluated these locations.

- Residential ROW 3, 6, 8, 9, 12, 18, 20: The highest soil concentrations in these areas were all below the acute CV of 110 mg/kg. Therefore, no acute or soil-pica concerns were identified for any age group.
- Residential ROW 2, 13, 14, 15, 19: These ROW areas had similar soil concentrations and resulted in similar exposure dose ranges, all below the MRL. For these areas combined, the highest estimated exposure dose was 0.02 mg/kg/day (birth to <1 year, Residential ROW 2) under the RME scenario. All soil-pica exposure doses were also below the MRL. Thus, ADHS does not expect adverse acute health effects from exposure to copper in this soil.
- Residential ROW 1: There is no acute health concern based on typical hand-to-mouth exposure. Under the RME scenario, the highest estimated exposure dose was 0.008 mg/kg/day (birth to <1 year). The estimated soil-pica doses were 0.078 mg/kg/day for children aged 1 to <2 years, and 0.051 mg/kg/day for children aged 2 to <6 years. These values exceed the MRL and the level associated with effects in the study for youth 1 to <2 years, and approach the study effect level for children 2 to <6 years. Therefore, there is an increased risk of experiencing acute health effects from soil-pica behavior from the soil living in or visiting this area.
- Residential ROW 5: There is no acute health concern based on typical hand-to-mouth exposure. Under the RME scenario, the highest estimated exposure dose was 0.012 mg/kg/day (birth to <1 year). The estimated soil-pica doses were 0.11 mg/kg/day for children aged 1 to <2 years, and 0.074 mg/kg/day for children aged 2 to <6 years. These values exceed the MRL and the level associated with effects. Therefore, there is an increased risk of experiencing acute health effects from soil-pica behaviour from the soil in this area.
- Residential ROW 10: There is no acute health concern based on typical hand-to-mouth exposure. Under the RME scenario, the highest estimated exposure dose was 0.0062 mg/kg/day (birth to <1 year). The estimated soil-pica dose was 0.020 mg/kg/day for children aged 1 to <2 years, which is equal to the MRL; however, due to the safety factors applied, it is below the level associated with health effects in the study. Therefore, ADHS does not expect adverse effects from a soil-pica event for those living in or visiting this area.
- Residential ROWs 4, 7, 11: These ROW areas had similar soil concentrations, resulting in similar exposure dose ranges. For these areas combined, the highest estimated RME exposure dose was 0.0028 mg/kg/day (birth to <1 year, Residential ROW 11), below the MRL. Therefore, there is no

acute health concern based on typical hand-to-mouth exposure. The estimated soil-pica doses ranged from 0.021 mg/kg/day to 0.027 mg/kg/day for children aged 1 to <2 years in these areas, which are above the acute MRL but still much lower than the level that caused effects in the study used to set the guideline. Therefore, ADHS does not expect short-term health effects from soil-pica exposure for children living in or visiting these areas.

Commercial, Recreational, Industrial, and Trespass Areas:

ADHS further evaluated locations where the EPC was above the CV, as summarized below. All CTE and RME doses were below the MRL, indicating that no acute adverse health effects are expected in any of these areas with typical hand-to-mouth behavior. The majority of areas evaluated had soil-pica doses below the MRL, except for Recreational 1 and 6, and Trespass 1. ADHS further evaluated these locations.

The soil-pica doses were all above the acute MRL, and those at Recreational 6 and Trespass 1 were also above levels that caused effects in the critical study. The soil-pica doses were below, but approached the study levels at Recreational 1. Thus, ADHS identified an increased risk of experiencing acute health effects from soil-pica behavior associated with the soil at these three areas, as described below.

- Commercial 1, 2: All CTE, RME, and soil-pica exposure doses were below the MRL. Under the RME scenario, the highest estimated exposure dose was 0.0054 mg/kg/day (birth to <1 year, Commercial 2). Thus, no acute or soil-pica concerns were identified for any age group.
- Commercial 3: There is no acute health concern based on typical hand-to-mouth exposure. The highest estimated RME exposure dose was 0.0072 mg/kg/day (birth to <1 year). The estimated soil-pica dose for children 1 to <2 years old is 0.023 mg/kg/day, which is above the acute MRL but still much lower than the levels that caused effects in the study used to set the guideline. Therefore, ADHS does not expect short-term health effects from soil-pica exposure at this location.
- Commercial 4: All CTE exposure doses were below the MRL. The highest estimated RME exposure dose was 0.023 mg/kg/day (birth to <1 year). The estimated soil-pica doses were 0.075 mg/kg/day (children 1 to <2 years old) and 0.049 mg/kg/day (children 2 to <6 years old), which are above the acute MRL. However, if parents were to bring their infant with them to this property, ADHS does not expect the child to be on the ground and assumes they would have very limited contact with the soil. Therefore, ADHS does not expect any adverse effects from acute copper exposure for residents or visitors to these areas.
- Recreational 1: All CTE and RME exposure doses were below the MRL. ADHS assumed daily use of the area by children, using the default soil-pica parameters (three pica events in a week). The estimated soil-pica dose for children aged 1 to <2 years is 0.046 mg/kg/day, and for children aged 2 to <6 years is 0.030 mg/kg/day. These doses are above the acute MRL and approach the levels that caused effects in the critical study. Thus, there may be an increased risk of experiencing acute health effects from soil-pica behaviour from the soil in this area.
- Recreational 2: Only one copper soil sample was available for evaluation in this location. Therefore, ADHS evaluated it as a single acute exposure. All CTE, RME, and soil-pica exposure doses were below the MRL. The highest estimated RME exposure dose was 0.0047 mg/kg/day

(birth to <1 year), and soil pica doses were 0.010 mg/kg/day (2 to <6 years) and 0.015 mg/kg/day (1 to <2 years). Thus, no acute or soil-pica concerns were identified.

- Recreational 3, 4: All CTE and RME exposure doses were below the MRL. The highest estimated RME exposure dose was 0.0013 mg/kg/day (adults). ADHS does not expect young children to visit these properties, so there are no concerns related to soil pica. No acute concerns were identified for adults visiting these locations.
- Recreational 5: All CTE, RME, and soil-pica exposure doses were below the MRL. The highest estimated RME exposure dose was 0.0027 mg/kg/day (birth to <1 year). ADHS assumed daily use of the area by children, using the default soil-pica parameters. The estimated soil-pica dose for children 1 to <2 years old is 0.026 mg/kg/day, and for children 2 to <6 years is 0.017 mg/kg/day. While the pica dose for children 1 to <2 years is slightly above the MRL, both pica doses are well below the effect levels in the critical study. Therefore, ADHS does not expect adverse effects from a soil-pica event from copper in the soil in this area.
- Recreational 6: There is no acute health concern based on typical hand-to-mouth exposure. The highest estimated RME exposure dose was 0.018 mg/kg/day (birth to <1 year). The estimated soil-pica dose for children 1 to <2 years old is 0.17 mg/kg/day, and the soil-pica dose for children 2 to <6 years is 0.11 mg/kg/day. These doses are above the acute MRL and the levels that caused effects in the critical study. Therefore, there is an increased risk of experiencing acute health effects from soil-pica behaviour from the soil in this area.
- Trespass 1: There is no acute health concern based on typical hand-to-mouth exposure. The highest estimated RME dose was 0.0051 mg/kg/day (birth to <1 year). The estimated soil-pica dose for children 1 to <2 years old is 0.049 mg/kg/day, and the soil-pica dose for children 2 to <6 years is 0.032 mg/kg/day. These doses are above the acute MRL and the levels that caused effects in the critical study. Therefore, there is an increased risk of experiencing acute health effects from soil-pica behaviour from the soil in this area.
- Trespass 3: All exposure doses were below the MRL. The highest estimated RME exposure dose was 0.000011 mg/kg/day (youth aged 16 to <21 years), and no pica concerns were identified. Thus, no acute concerns were identified for those trespassing in these areas.
- Industrial 1, 2: All estimated exposure doses were below the MRL. RME exposure doses ranged from 0.00023 mg/kg/day (indoor workers, Industrial 2) and 0.017 mg/kg/day (outdoor workers, Industrial 1). Thus, no acute concerns were identified for workers at these locations.

Daycare:

During sampling, the wood chips were removed, and nine soil samples were collected from the bare soil beneath. Detected copper concentrations ranged from 6.49 mg/kg to 132 mg/kg. Based on statistical review and professional judgement, ADHS identified three locations (117 mg/kg, 115 mg/kg, 132 mg/kg) as hotspots. The remaining six samples were used to calculate the yard-wide EPC (35.7 mg/kg). The three hotspots were evaluated separately.

- Yard-Wide: The yard-wide EPC is below the acute CV. No acute or soil-pica concerns were identified for any age group under the CTE, RME, or soil-pica exposure scenarios.

- Daycare Hotspots 2, 4, 5: All CTE, RME, and soil-pica exposure doses were below the MRL for children and workers. Thus, no acute or soil-pica health concerns are expected for anyone using the playground. Based on available information, copper appears to be elevated in a few of the small locations, and additional sampling would be needed to fully characterize the hotspots.

Long-Term Exposure (>1 year)

The acute MRL can also be used as the intermediate-duration oral MRL (0.02 mg/kg/day), but there is not enough data to establish a chronic oral MRL for copper (ATSDR 2024a). One animal study found that for long-term copper exposure, 7.5 mg Cu/kg/day was the LOAEL for lower hemoglobin levels in adult monkeys (ATSDR 2024a). For comparison, the highest observed RME exposure dose (0.0025 mg/kg/day, birth to <1) was well below the intermediate MRL (0.02 mg/kg/day) and about 3,000 times lower than this chronic LOAEL (7.5 mg/kg/day). Based on the large safety margin and toxicological evidence, ADHS does not expect health risks from intermediate or chronic-duration exposure to copper in soil.

Chromium VI

Chromium is a naturally occurring element found in air, soil, and water. It can also be released into the environment through industrial activities such as manufacturing, metal processing, and disposal of chromium-containing products. The two most common forms are trivalent chromium (Cr(III)) and hexavalent chromium (Cr(VI)). Cr(III) is generally less harmful, while Cr(VI) is associated with greater potential health effects (ATSDR 2012a). The EPA has determined that Cr(VI) compounds are known human carcinogens (EPA 2024a). Long-term ingestion may increase cancer risk in the digestive system. Cr(VI) exposure can also irritate the stomach and intestines and, at higher levels, may affect the liver and kidneys (ATSDR 2012a; EPA 2024a).

Discussion for Surface Soil

Only 20 of the 42 areas were sampled for Cr(VI), and many locations had only one or two samples. Additionally, Cr(VI) was not detected at seven of them, and the RL was above the CREG. As described in the *Summary of Limitations*, the Cr(VI) data were limited and were generally not adequate to support a cancer risk evaluation. Thus, cancer risk evaluations for Cr(VI) were not conducted for the following areas: Residence 3, 10; Residential ROW 1, 2, 4-10, 12; Commercial 1, 3; Recreational 1-5; Trespass 1.

Cancer Health Effects:

- Industrial 1: Cr(VI) was not detected in any of the three samples at this location. Two samples had laboratory reporting limits (1.00 mg/kg) above the CV (0.69 mg/kg). To conservatively evaluate potential risk, ADHS used the reporting limit as the EPC. Using this approach, the estimated cancer risk was less than 1 extra case per 1,000,000 people. The result indicates a low cancer risk, which would not be expected to pose a public health concern.

Manganese

Manganese is a naturally occurring metal used in various industries, including steel production. For most people, food is the primary source of manganese exposure. Our bodies require small amounts of manganese to support normal functions, but excessive intake can have adverse effects, with the nervous system being the primary concern (ATSDR 2012c).

Manganese is an essential nutrient; typical safe dietary intake ranges are estimated to be 2.5-5.0 mg/day for adults, 0.7-1.0 mg/day for infants, and 1.0-5.0 mg/day for toddlers (Kies 1987). Everybody's needs for and response to manganese differ. Therefore, while the RfD is a general estimate of exposures that are unlikely to cause adverse effects, intakes above it are not necessarily associated with toxicity, as some individuals may consume higher amounts without concern (EPA 1995). There is no evidence that manganese causes cancer in humans, and the EPA has classified manganese as group D (not classifiable as to human carcinogenicity) due to insufficient data.

Discussion for Surface Soil

ADHS further evaluated manganese at the ten areas where it was identified as a COC. Based on a statistical review, one location at the Daycare (2,220 mg/kg) was identified as a manganese hotspot. For the purpose of estimating yard-wide chronic exposure, this hotspot (Daycare HS 3) was evaluated separately from the rest of the Daycare yard, where no samples exceeded the CV.

As described in the *Summary of Limitations* section, long-term exposure evaluations were not conducted for the following areas due to data limitations: Daycare HS 3, Residence 1 Location 2, Residence 3 and 6, and Residential ROW 10, 13, 14, and 19.

Non-Cancer Health Effects:

Short-term Exposure (0-14 days)

There is no acute MRL available for manganese. Acute oral toxicity data for environmental manganese exposure are limited, and manganese-related health effects are primarily associated with repeated or long-term exposure.

For screening purposes only, ADHS considered a state-derived acute reference value of 0.083 mg/kg/day, developed by the Minnesota Department of Health (MDH). This value is based on neurological effects identified at an LOAEL of 25 mg/kg/day in an animal study, and incorporates conservative uncertainty factors (MDH 2023). It is intended to identify situations where potential concern cannot be ruled out, rather than to predict the occurrence of adverse health effects.

Long-term Exposure (>1 year)

Studies have shown that children with chronic exposure to manganese in water at levels ranging from 0.06 to 0.08 mg/kg/day may experience neurological impacts, like decreased intelligence scores and hyperactivity, after 5-10 years of exposure (ATSDR 2012c). The EPA established an RfD of 0.14 mg/kg/day

for chronic dietary oral exposure to manganese. This RfD is based on a NOAEL¹⁰ of 10 mg/day (0.14 mg/kg/day for 70 kg adults) based on a composite of data from several studies (EPA 1995). As recommended by the EPA, ADHS used a modifying factor of 3 to the RfD to account for exposures involving nondietary exposure ($0.14 \text{ mg/kg-day} \div 3 = 0.05 \text{ mg/kg/day}$) (EPA 1995).

Non-Cancer Health Effects:

Short-term Exposure (0-14 days)

Short-term manganese exposures were evaluated for Commercial 1, Daycare HS3, Residence 1 Sampling Location 2, Residence 3, Residence 6, and Residential ROW 10, 11, 13, 14, and 19 under their respective exposure scenarios.

With typical hand-to-mouth behavior, most estimated CTE and RME exposure doses were below the MDH reference value, indicating that acute health effects are not expected for those locations. Two exceptions were identified: Residence 6 and Residential ROW 13. At these locations, estimated exposure doses for children <6 years exceeded the MDH reference value under the RME scenario, but remained below the reference value under the CTE scenario. The highest exposure doses were 0.19 mg/kg/day for children birth to <1 year at Residence 6, and 0.11 mg/kg/day for children birth to <1 year at Residential ROW 13. These exceedances indicate that the safety margin has been reduced, and a potential health concern cannot be ruled out. However, available data are insufficient to determine whether acute adverse health effects would occur.

All estimated soil-pica exposure doses exceeded the MDH reference value, ranging from 0.091 mg/kg/day (Daycare HS3) to 0.61 mg/kg/day (Residence 6). These results indicate that the usual safety margin has been reduced, and a potential health concern cannot be ruled out. However, available data are insufficient to determine whether acute adverse health effects would occur.

Long-Term Exposure (>1 year)

Long-term manganese exposures were evaluated for Commercial 1 and Residential ROW 11 under their respective exposure scenarios. All estimated CTE and RME exposure doses were below the RfD and levels associated with childhood neurological effects reported in studies. The highest exposure dose was 0.037 mg/kg/day (birth to <1 year) at Residential ROW 11 under the RME scenario. Therefore, long-term adverse health effects are not expected for any age group from incidental ingestion of manganese in soil at either location.

Thallium

Thallium is a naturally occurring metal found in the earth's crust (ATSDR 2024b). In 1981, the production of thallium in the U.S. was discontinued. However, thallium can be still released into the environment through the combustion of fossil fuels, refinement of oil fractions, smelting of ferrous and non-ferrous

¹⁰ The No-observed-adverse-effect level (NOAEL) is the highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals (ATSDR 2022).

ores (including lead, copper, and zinc), and by some other industrial processes such as cement production and brickworks (EPA 2009a; WHO & ICPS 1996).

While typical environmental levels are not expected to cause adverse health effects, higher exposures to thallium can lead to health issues in humans. Thallium can enter the body through ingestion, inhalation, or skin contact, but ingestion is the most common route, particularly through eating fruits and vegetables grown in thallium-containing soil (ATSDR 2024b).

Short-term health effects:

Alopecia (hair loss) generally occurs within 2 weeks of exposure and is reversible when thallium exposure is removed (EPA 2009a).

Long-term health effects:

Currently, there is insufficient information to assess the potential non-cancerous effects of inhaling thallium in the air. While there are a small number of studies on workers exposed to airborne thallium and studies examining the health effects associated with the thallium content of PM_{2.5}, most available studies are from oral exposure studies (ATSDR 2024b). Because inhalation studies are limited and of insufficient quality, the EPA has not developed an inhalation RfC for thallium (EPA 2009a).

In studies of long-term, oral exposure to elevated levels of thallium have been shown to cause alopecia or low infant birth weight if a pregnant woman is exposed (ATSDR 2024b; EPA 2009a). Currently, there is insufficient information to determine whether thallium can cause cancer in humans (ATSDR 2024b).

Discussion for Outdoor Air

Non-Cancer Health Effects:

Long-Term Exposure (>1 year)

Thallium was not detected in the air at the VFW or Kid's Park, with a laboratory reporting limit of <0.0029 µg/m³. Available information indicates that typical outdoor air concentrations in U.S. cities range from 0.00002 to 0.0001 µg/m³, with similar levels reported in other regions (ATSDR 2024b). Even near industrial sources, thallium concentrations generally remain <1 µg/m³. Health effects from inhalation have occurred only at much higher levels in workplace settings, ranging from <1 µg/m³ to more than 20 µg/m³ during specific operations (ATSDR 2024b).

Because thallium was not detected in outdoor air and typical environmental levels are far below those known to cause harm, health effects from thallium in outdoor air are not expected.

Discussion for Surface Soil

Non-Cancer Health Effects:

Long-Term Exposure (>1 year)

The EPA has not established a finalized RfD for thallium because available studies are limited by small study populations and insufficient characterization of long-term exposure. However, the EPA developed a provisional, screening-level RfD (p-RfD) of 0.00001 mg/kg/day, based primarily on observed non-cancer health effects, such as hair loss, to support preliminary evaluation (EPA 2009a). This value is conservative and includes a large uncertainty factor (3,000) to account for differences between animals and humans, variability in the human population, and gaps in available toxicology studies. These uncertainty factors provide a wide safety margin to protect sensitive populations, such as children.

ADHS evaluated the six areas where thallium was detected above the CV (see Table B8). For these areas, EPC ranged from 0.66 mg/kg to 2.89 mg/kg. Thallium was not detected in an additional 37 sampled areas, but the RL was above the CV and ranged from 0.52 to 10 mg/kg. Because there were not enough detected results to calculate a statistical EPC for these areas, the EPC for each area was conservatively set equal to the highest reporting limit observed for that area. This approach is health-protective and avoids underestimating potential exposure.

For most locations, all estimated exposure doses under both CTE and RME scenarios were below the p-RfD, indicating that non-cancer health effects are not expected at those locations. Two locations were identified as exceptions: the Daycare and Residential ROW 11. The highest estimated exposure dose was 0.00005 mg/kg/day for children birth to <1 year under the RME scenario at Residential ROW 11. The highest estimated exposure dose at the Daycare was 0.000036 mg/kg/day for children birth to <1 under the RME scenario. Although these estimated doses slightly exceeded the p-RfD, the exceedances are due to conservative assumptions for non-detected data, not measured thallium concentrations. Additionally, the p-RfD incorporates a wide safety margin to protect sensitive populations. Based on this information, health effects from incidental exposure to thallium in soil are not expected.

Thorium

Thorium is a naturally occurring radioactive substance found in small amounts in rocks, soil, and water (ATSDR 2019). Thorium is not readily absorbed by the body. It is not likely that health effects will occur in the general population at typical environmental levels (ATSDR 2019).

Short and Long-term Health Effects:

There is minimal data on the health effects of thorium in humans or animals. Most existing information is based on workers exposed to higher-than-normal levels of thallium (ATSDR 2019). Thorium is considered a cancer-causing substance by the IARC because it is radioactive. However, the EPA and ATSDR lack sufficient scientific data to establish health guidelines or cancer risk values for thorium.

Discussion for Outdoor Air

Thorium was not detected in the air at the VFW ($<0.0021 \mu\text{g}/\text{m}^3$) or Kid's Park ($<0.0029 \mu\text{g}/\text{m}^3$), and there is no indication of elevated levels. The laboratory reporting limits were higher than the average background concentrations found across the U.S., which ranged from 0.0002 to $0.001 \mu\text{g}/\text{m}^3$ (Lambert and Wilshire 1979). This does not suggest a health concern. It simply means that thorium at these low levels could not be measured. ATSDR indicates that thorium is not expected to cause health effects at typical environmental levels, and the available results do not suggest elevated exposure (ATSDR 2019). Overall, health effects from thorium in outdoor air are not expected.

Zinc

Zinc is one of the most common elements found in the earth's crust, and is needed by your body in small amounts to stay healthy. It is a bluish-white shiny metal that can be found in the air, soil, water, and food. While zinc is essential for good health, consuming excessive amounts of it through food, water, or dietary supplements can have adverse health effects. Harmful effects generally begin at levels 10 to 15 times higher than the amount required for good health (ATSDR 2005).

Short-term Health Effects:

Breathing large amounts of zinc dust or fumes from smelting or welding can cause a short-term illness called metal fume fever. Symptoms may include chest pain, cough, dyspnea (shortness of breath), reduced lung volumes, nausea, chills, malaise (feeling unwell), and leukocytosis (high white blood cell count). These effects are usually temporary and resolve after exposure stops (ATSDR 2005).

Long-term Health Effects:

The long-term health effects of breathing zinc have not been well-documented. Animal studies show that extremely high zinc levels (about 1,000 times the Recommended Dietary Allowance) can cause serious health problems, including anemia, kidney and pancreas damage, infertility, and smaller babies in pregnant animals. These effects have been observed following oral exposure and are not associated with inhalation exposure to zinc.

The IARC has not classified zinc as a carcinogen, and based on incomplete information from human and animal studies, the EPA determined that zinc is not classifiable for human carcinogenicity (ATSDR 2005).

Discussion for Outdoor Air

ADHS evaluated 600 samples collected from the VFW and 500 samples from the Cottonwood Kid's Park.

Non-Cancer Health Effects:

Short-term Exposure (0-14 days)

Zinc concentrations in the outdoor air at the VFW ranged from $<0.042 \mu\text{g}/\text{m}^3$ to $1.2 \mu\text{g}/\text{m}^3$. Average levels of zinc in the air throughout the United States are less than $1 \mu\text{g}/\text{m}^3$, but range from 0.1 to 1.7

$\mu\text{g}/\text{m}^3$ in areas near cities, and may be higher near industrial areas (ATSDR 2005). The measured concentrations at VFW are within the reported range.

Health effects, such as metal fume fever, have only been reported at zinc levels significantly higher than those typically found in outdoor air. Exposure levels that can cause metal fume fever have not been specifically identified; however, they are generally reported to be in the range of 77,000–600,000 $\mu\text{g}/\text{m}^3$ (ATSDR 2005). Studies of individuals exposed to significantly lower zinc levels (14,000 $\mu\text{g}/\text{m}^3$ for 8 hours or 45,000 $\mu\text{g}/\text{m}^3$ for 20 minutes) did not report any symptoms (ATSDR 2005). Additionally, in occupational settings, workers exposed to zinc at levels of 8,000–12,000 $\mu\text{g}/\text{m}^3$ for 1–3 hours and 34 $\mu\text{g}/\text{m}^3$ for 6–8 hours did not experience metal fume fever (ATSDR 2005). Based on the available information, short-term health effects from zinc in outdoor air at this site are not expected.

Long-Term Exposure (>1 year)

No chronic inhalation MRLs or RfCs have been established for zinc due to the limited availability of long-term inhalation toxicity data. The estimated EPC for zinc in outdoor air at the VFW location was 0.42 $\mu\text{g}/\text{m}^3$. This concentration exceeded the Massachusetts Department of Environmental Protection (MassDEP) Allowable Ambient Air Limit (AAL) for zinc of 0.2 $\mu\text{g}/\text{m}^3$. The AAL is a conservative screening value used to guide further evaluation. It does not represent a concentration at which adverse health effects are expected (MassDEP 2021).

Although the EPC exceeded the MassDEP AAL, the measured zinc concentrations are within typical background ambient air levels reported in the U.S. Additionally, health effects from zinc inhalation have been associated primarily with much higher, short-term occupational exposures. Given the measured concentrations, the conservative nature of AAL, and the available toxicological evidence, chronic inhalation exposure to zinc at VFW is not expected to pose a public health concern for nearby residents.

Other Contaminants

Discussion for Lead in Surface Soil

Of the 255 lead soil samples, one was above the CV. Upon closer review, ADHS determined this measurement (651 mg/kg) was collected at Trespass 3. ADHS used anecdotal and photographic evidence from ADEQ, along with professional judgment, to evaluate access to the area where this sample was collected. Based on the location and unique features of the property, regular access or frequent trespassing, including by young children, is unlikely in most areas.

Since all other lead measurements, including those from Trespass 3, were below the CV, and this measurement was taken from a location with limited and difficult access, ADHS did not further evaluate lead. However, individuals who may trespass in this area should be aware that elevated lead levels may be present in the soil, and contact with soil in this area could pose a potential concern.

Discussion for Mercury in Surface Soil

Mercury was detected in 114 of the 182 samples collected, but only one sample exceeded the CV. ADHS took a closer look and determined this measurement was collected at Trespass 3. ADHS estimated chronic CTE and RME exposure doses for trespassers aged 16 to <21 years and adults.

ATSDR has not developed a chronic MRL; estimated exposure doses were compared to the intermediate MRL of 0.00001 mg/kg/day. All estimated exposure doses under both CTE and RME scenarios were below the MRL for both age groups, with the highest estimated dose of 0.000000059 mg/kg/day (16 to <21 years) under the RME scenario. Therefore, ADHS does not expect adverse health effects in individuals trespassing on this property from repeated incidental ingestion of mercury in the soil.

Discussion for Mixtures (Lead, Manganese, Zinc, and Copper)

Chemical mixtures can exhibit different types of interactions, with effects that may be additive, less than additive (antagonistic), or greater than additive (synergistic). According to the ATSDR Interaction Profile for Lead, Manganese, Zinc, and Copper (ATSDR 2004), the components of these mixtures interact in specific ways regarding their toxicity, particularly affecting neurological and hematological health.

For lead and manganese, the predicted joint action¹¹ is synergistic, meaning that manganese can enhance the neurological toxicity of lead. However, lead does not enhance the toxicity of manganese (ATSDR 2004). For lead and zinc, the predicted joint action is antagonistic. Zinc interferes with the biological mechanisms of lead, offering a protective effect that reduces lead's toxicity (ATSDR 2004). Similarly, in mixtures containing lead, zinc, and copper, the predicted joint action is also antagonistic. The presence of zinc and copper tends to lower the overall toxicity compared to lead alone, further acting as a protective measure (ATSDR 2004).

ADHS evaluated the potential effects of mixtures of lead, manganese, zinc, and copper at this site. Even though manganese has the potential to enhance lead-related neurological effects, this synergistic interaction is expected to be small under long-term exposure conditions, because manganese levels are below health-based guidelines and lead remains the primary contributor to potential health risk. ATSDR indicates that meaningful enhancement of lead toxicity occurs primarily at higher manganese exposures or under co-exposure conditions not present at this site (ATSDR 2004). Therefore, this mixture is not expected to significantly increase the risk of non-cancer health effects related to lead exposure in any specific area. Zinc and copper can interact with lead in the body and may reduce its effects in some situations. At the levels measured in the evaluated areas, they are not expected to increase lead toxicity.

Discussion for Aggregate Effects:

Aggregate effects refer to the combined impacts of exposure to a single chemical from multiple exposure pathways over time. This type of evaluation considers overall long-term exposure. Acute exposures and localized hotspots were excluded from the aggregate evaluation because they represent temporary or localized site-specific conditions and do not accurately reflect long-term exposure patterns (EPA 2003).

¹¹ A joint action refers to the combined effect of a mixture of chemicals or other stressors present simultaneously in an environment.

ADHS only evaluated aggregate effects for arsenic. Other COCs, including cadmium, copper, manganese, thallium, and zinc, were not evaluated further because their estimated exposures were below health-based guidelines (MRLs or RfDs), limited to a single exposure pathway, or associated with very low estimated cancer risk. Therefore, conducting an aggregate evaluation for these chemicals would not change the overall conclusions.

Arsenic was detected in outdoor air, groundwater, and surface soil, making it the primary contributor to aggregate exposure. People in some areas may be exposed to arsenic through multiple pathways, such as breathing outdoor air, drinking groundwater, and incidentally swallowing soil.

- Outdoor air: Arsenic concentrations were generally low, and estimated inhalation cancer risks were within EPA's target risk range (about 2 in 1,000,000 to 2 in 100,000).
- Groundwater: Public drinking water meets federal standards; however, untreated private wells showed elevated arsenic levels. Long-term use of groundwater from Private Wells 1 and 3 represents the largest contributor to aggregate risk, with cancer risks exceeding 1 in 1,000 (1×10^{-3}) and non-cancer doses above the RfD for all age groups.
- Surface soil: Arsenic levels varied widely, and some areas exceeded health-based guidelines at concentrations of concern. Long-term incidental soil ingestion, especially for young children, could increase cancer and non-cancer health risks in certain locations. The estimated RME cancer risk for children from soil ingestion ranges from about < 1 in 1,000,000 (1×10^{-6}) to 2 in 1,000 (2×10^{-3}).

When all exposure pathways are considered together, most overall arsenic exposure results from drinking groundwater and incidental ingestion of soil. Exposure to outdoor air is very small. The aggregate evaluation does not identify any additional health concerns beyond those already noted for each exposure pathway. The greatest potential health concerns remain for people who use untreated private well water and for young children with frequent soil contact in areas with high arsenic levels.

Child Health Concerns

ADHS recognizes that the unique sensitivities of infants and children indicate a need for special attention in communities exposed to contaminants in environmental media. A child's developing body systems can sustain permanent damage if toxic exposures occur during critical growth stages. Children, especially infants, drink more fluid per pound of body weight than adults (EPA 1999). Soil ingestion can occur from hand-to-mouth activity, mouthing toys, eating dropped food, and other activities as children interact with their environment (ATSDR 2018). Compared to adults, children also spend more time outside, tend to engage in more vigorous activity, and inhale more air, making them more sensitive to air contaminants than healthy adults (EPA 2025f). All health analyses in this report take into consideration the unique sensitivities of infants and children.

Addressing Community Concerns

Community-Provided Data

As previously mentioned, a community member provided ADHS with laboratory results from a 'slag pile dust' sample (Appendix C1). ADHS could not include these data in the full evaluation because the laboratory and method used for analysis were not state-certified, and the collection methods were unknown and could not be assessed for QA/QC. However, ADHS still reviewed and considered the contaminants of interest in the data provided. After converting the units from ng/g to mg/kg, the levels of aluminium, antimony, barium, cadmium, copper, iron, lead, manganese, nickel, selenium, thallium, uranium, and zinc are within the range of samples evaluated and below the CVs (Table B6). The arsenic and copper concentrations reported are also within the range of samples evaluated by ADHS (Table B6).

Copper Slag Characteristics

Community members expressed concerns that copper slag particles may be sharp or abrasive and could become airborne as part of particulate matter (PM) or pose a physical injury risk to children playing in the park. While this report primarily evaluates chemical exposures, physical hazards may also contribute to potential concerns. Copper slag typically fractures into angular, sharp-edged particles rather than smooth or rounded material (OSHA 2025).

The potential for physical irritation depends on particle size. Large dust particles can irritate the skin, eyes, and upper respiratory tract. Fine particles, including PM₁₀, may penetrate deeper into the respiratory tract and cause mechanical irritation due to their angular shape (OSHA 2025). This reflects a general physical property of dust, supporting the use of precautionary measures to reduce direct contact and dust exposure.

Evidence for mechanical irritation from abrasive dust primarily comes from occupational settings with repeated or high-intensive exposure (OSHA 2025; NIOSH 2016). Although these findings do not indicate that such effects are occurring in the community, they provide context for understanding how similar mechanical irritation could occur under certain exposure conditions. Because no health-based benchmark or standardised methods exist to quantify these risks in public health assessment consultation, this concern could not be quantitatively evaluated and is addressed qualitatively.

Community members also raised concerns about crystalline silica in copper slag. ADHS reviewed two Material Safety Data Sheets (MSDS). Both MSDS indicate that MRI copper slag contains 35-45% silicate (amorphous SiO₂). Crystalline silica (SiO₂) is reported at <0.4% in the 2017 MSDS, and <0.1% in the 2012 MSDS. Although both silicate and crystalline silica are forms of silicon dioxide (SiO₂), they are different in structure and potential health effects.

Crystalline silica has a highly ordered structure and has been linked to lung disease when inhaled as fine dust, particularly in occupational settings. Due to these concerns, NIOSH recommended in 1974 that silica sand, or materials containing more than 1% crystalline silica, not be used as abrasive blasting media because of the difficulty in controlling dust and the risk of silicosis (NTP 2020).

Amorphous silica is non-crystalline and behaves differently in the body than crystalline silica. It is generally less harmful than crystalline silica. Breathing in a large amount of amorphous silica can cause short-term lung irritation and inflammation, but these effects are mild and go away once exposure stops (EPA 1996; ATSDR 2020a). Studies have shown that amorphous silica does not cause silicosis (EPA 1996).

High-Wind Events

ADHS documented multiple concerns about the high wind events in Cottonwood impacting MRI emissions and any potential resulting health impacts. ADEQ provided ADHS with air monitoring data from a 3-month sampling period as well as wind data from the same time period. The average wind speed during the sampling period was about 5mph. ADHS considered any sustained wind event above 15mph as a high-wind event. As described in the air health effects evaluation, ADHS identified that the few arsenic samples above the chronic REL were taken on windy days when PM₁₀ levels were also elevated. Thus, ADHS recommends that residents avoid unnecessary outdoor activities and keep windows and doors closed during high-wind events.

Other Health Concerns

ADHS is unable to determine the cause of any person's illness or condition, and any risks identified in this report do not mean that anyone is or will experience any adverse effects. ADHS documented a variety of health concerns from community members. The majority of these concerns were discussed in the health effects evaluation, except for those noted below.

- Skin rashes from arsenic exposure: Dermal absorption of arsenic is minimal. Skin may become irritated if you have direct skin contact, especially if you have open wounds or cuts. However, skin contact is unlikely to lead to any serious internal effects (ATSDR 2007).

Summary of Limitations and Uncertainties

ADHS notes the following limitations and uncertainties:

Data Completeness and Representiveness

- While QA/QC procedures were followed, some datasets did not meet the target completeness goals. ADEQ aimed for 75% data completeness (data to be accurate and reliable). The VFW PM₁₀ monitoring achieved 97% completeness, and metals monitoring achieved 86% completeness. The Kid's Park PM₁₀ monitoring achieved 80% completeness, but metals monitoring achieved only 69% completeness due to equipment failure and lab errors (ADEQ 2024c). As a result, there is less certainty about long-term air quality patterns.
- During the surface soil sampling, ADEQ noted that "if coarse gravel and/or cobbles were present on the ground surface, they were scraped aside with the trowel before sample collection and/or manually removed from the sample jar using the trowel or a gloved hand." ADHS is not aware of the properties in which this protocol occurred, and recognizes that in these cases, the samples taken may not be an accurate representation of what people may be exposed to. However, one case where ADHS is aware is at the Daycare. ADHS was unable to make conclusions about

exposures at the Daycare because of the wood chips on top of the soil, causing too many uncertainties about possible exposures.

- Data for Residential ROWs 1-20 were collected by ADEQ in right-of-way areas. This means that ADHS does not have data for individual yards in these communities and uses the ROW data as a proxy for all residential yards in the community. The data in these areas may under- or overestimate the exposure of people living in the area.

Temporal and Spatial Coverage

- Air monitoring occurred only from February to June 2024. It may not capture seasonal variations such as monsoon dust storms or winter weather patterns.
- Air monitoring stations were located north and east of MRI. ADHS can only evaluate areas north and east of MRI, and is unable to make any conclusions about regions to the south or west.
- Groundwater and soil sampling represent a single sampling event and may not capture seasonal variability or changes related to site activity.

Toxicological and Site-Specific Data Gap

- Some contaminants (e.g., thallium or thorium) lack well-established or widely accepted health-based guidelines, which limits the ability to fully characterize potential health risks.
- Cancer risk estimates for arsenic at higher exposure doses have uncertainty, as noted by the EPA (EPA 2025a).
- It is challenging to estimate how often a child with pica behavior consumes soil and, when they do, how much they ingest. ADHS used ATSDR's protective assumptions, but recognizes that exposures may differ.
- Due to the inability to utilize the XRF data in the evaluation, many areas had very few surface soil samples for evaluation. Therefore, ADHS closely examined sample locations in each area and conducted statistical analyses to determine if any of the results were potential hotspots. A hotspot in the soil refers to a smaller area with much higher contaminant levels compared to the surrounding soil. At many residences, most samples were taken from judgmental or potential hotspots. Due to this limited and targeted sampling, the results do not accurately represent the soil conditions across the entire yard. As a result, the available soil data for these properties cannot support long-term or cancer exposure estimates. For these locations, the soil information can only be used to look at short-term and soil-pica exposures. Long-term and cancer evaluations were only conducted at locations where sufficient soil samples were collected and where individuals have regular, long-term contact with soil, such as recreational areas.
- Many areas had fewer than eight samples, low contaminant detection (<20%), or only a few elevated concentrations. ATSDR's EPC Tool needs at least eight samples with a minimum of four detections to calculate a representative EPC (ATSDR 2022). When these criteria were not met, the maximum detected concentration was used as the EPC, which is health protective but may overestimate exposure and does not fully represent spatial variability.
- In the following media and chemicals, laboratory reporting limits exceed their respective CV, limiting the ability to determine whether concentrations are below levels of health concern. In

these cases, non-detect results do not confirm the absence of contamination, and potential health concerns cannot be ruled out.

- Air: Arsenic (CREG), Beryllium (CREG and EMEG), Cadmium (CREG), Cobalt, Nickel, Silver
- Groundwater: Arsenic (CREG), Antimony
- Soil: Thallium, Cr(VI)

Conclusions

Outdoor Air Conclusion 1

ADHS concludes that high wind events (sustained wind speed >15 mph) with elevated PM₁₀ or prolonged (long-term) exposure can harm the health of sensitive individuals with pre-existing conditions (e.g., heart or lung disease) living or recreating north of MRI. Under normal (non-high wind) conditions, PM₁₀ levels north of MRI are not expected to harm healthy individuals. PM₁₀ levels east of MRI are not expected to harm residents.

Basis for Conclusion

- At the VFW (north of MRI), PM₁₀ reached the moderate range on EPA's Air Quality Index (AQI) scale on 11 of 35 monitored days. These levels can worsen symptoms in sensitive individuals but are not expected to harm healthy people.
- The annual PM₁₀ average at the VFW was slightly above the WHO guideline. This exceedance is common across the U.S..
- At the Kid's Park (east of MRI), 24-hour and annual average levels of PM₁₀ were below health guidelines, and all daily PM₁₀ levels were in the "Good" AQI range, indicating conditions not expected to pose a health concern.

Outdoor Air Conclusion 2

ADHS concludes that breathing in arsenic and other metals in outdoor air is not expected to harm the health of residents living or recreating to the north or east of MRI.

Basis for Conclusion

- At the VFW, both short-term (<14 days) and long-term (>365 days) arsenic concentrations were below the health-based guidelines, and estimated cancer risks were within EPA's target risk range. Arsenic was not detected at the Kid's Park.
- Thallium and thorium were not detected in outdoor air at the VFW or Kid's park and are not expected to cause harm at typical environmental levels.
- Zinc levels at the VFW exceeded health-based screening values; however, based on measured concentrations and toxicological evidence, inhalation exposure is not expected to pose a public health risk for nearby residents.

Groundwater Conclusion 1

ADHS concludes that regular consumption of untreated groundwater from some private wells with elevated arsenic levels could harm people's health. Other metals detected in private wells are not expected to harm people's health.

Basis for Conclusion

- For private Wells 1 and 3, the estimated long-term exposure doses for arsenic under both central tendency exposure (CTE, typical conditions) and reasonable maximum exposure (RME, high-end, less common conditions where exposures may be greater) scenarios exceeded the EPA's Reference Dose (RfD) for all age groups. Because the RfD includes a small safety margin, these exposures indicate built-in safety margin has been reduced, and non-cancer health effects could occur. Additionally, estimated cancer risks exceeded EPA's target risk range, indicating a potential increased cancer risk.
- For private Wells 2, 8, and 11, arsenic was not detected, and concentrations were below the non-cancer comparison value (CV), indicating non-cancer health effects are not expected. However, the detection limit (4.4 µg/L) was above the cancer-based CV (0.42 µg/L), indicating the actual concentration could range from 0 and 4.4 µg/L. As a result, ADHS cannot determine whether long-term use of these wells could increase cancer risk without additional data.
- All other metals (antimony, barium, cadmium, copper, iron, lead, manganese, nickel, silver, and zinc) measured in private wells 1-3, 8, and 11 were below the health-based CV and are not expected to harm people's health.

Groundwater Conclusion 2

ADHS concludes that swallowing metals, including arsenic, in public, monitoring, and irrigation wells is not expected to harm people's health.

Basis for Conclusion

- Public well water (Wells 5, 9, and 10) is treated for arsenic before reaching the consumer, and is in compliance with federal regulations. No other metals were detected above their CVs in these wells, and exposures are not expected to cause harm.
- Residents do not have contact with water from capped (Wells 6 and 12) or monitoring wells (Wells 13-17), and all metals were below levels of health concern.
- For irrigation Wells 4 and 7, all estimated long-term arsenic exposure doses under both CTE and RME scenarios were below health guidelines, and cancer risks were within EPA's target risk range.

Surface Soil Conclusion 1

ADHS concludes that incidental ingestion of arsenic or copper in surface soil could harm people's health at some locations under specific exposure conditions. Health concerns were identified primarily for young children with soil-pica behavior (the intentional ingestion of soil, not typical hand-to-mouth activity) and for long-term arsenic exposure in certain residential right-of-way (ROW) areas.

Private Residences:

- Short-term health effects: Children who exhibit soil-pica behavior (the intentional ingestion of soil, not typical hand-to-mouth activity) could experience short-term health effects from localized hotspot soil concentrations of
 - Arsenic and copper at Residence 1, and
 - Copper at Residence 2.

Residential Right-of-Ways (ROW):

- Short-term health effects: Children who exhibit soil-pica behavior could experience short-term health effects from
 - Arsenic at Residential ROW 13, 14, or 19, and
 - Copper at Residential ROW 1 or 5.
- Long-term non-cancer health effects: Long-term ingestion of arsenic in soil could harm children's health at several Residential ROW locations under long-term exposure scenarios:
 - Central Tendency Exposure (CTE; typical conditions): Residential ROW 1, 4, 7, 11, and 15
 - Reasonable Maximum Exposure (RME; high-end, less common conditions where exposures may be greater): Residential ROW 1, 4, 5, 6, 7, 9, 11, 12, and 15.
- Cancer risk: Long-term arsenic exposure in soil could increase the risk of developing cancer:
 - For children (CTE and RME) and adults (RME) at Residential ROW 1, 4, 5, 7, 9, 11, 12, and 15.
 - For children (RME) at Residential ROW 6 and adults (RME) at Residential ROW 2.

Recreational Areas:

- Short-term health effects: Children who exhibit soil-pica behavior could experience short-term health effects from copper at Recreational areas 1 or 6.

Trespass Areas:

- Short-term health effects: Children who exhibit soil-pica behavior could experience short-term health effects from copper at Trespass Area 1.

Industrial Areas:

- Cancer risk: Long-term incidental ingestion of arsenic in soil could increase the risk of developing cancer in indoor and outdoor workers with reasonable maximum exposure (RME) at Industrial Area 1.

Basis for Conclusion

- Arsenic and copper were detected at elevated concentrations at several private residences, Residential ROWs, recreational areas, trespass areas, and industrial areas.
- Short-term health concerns were identified where estimated soil-pica exposure doses exceeded the acute health-based guidelines.
- Long-term health concerns were identified when estimated chronic exposure doses exceeded the EPA's Reference Dose (RfD). The long-term soil incidental ingestion doses were calculated for CTE and RME scenarios.
- Cancer risk concerns were identified based on estimated excess cancer risk for long-term incidental soil ingestion exceeded EPA's target cancer risk range of 1 in 1,000,000 to 1 in 10,000 (10^{-6} to 10^{-4}).

Surface Soil Conclusion 2

ADHS does not have sufficient information to determine whether exposure to arsenic, hexavalent chromium (chromium(VI)), or manganese in surface soil could harm people's health at the following locations under certain exposure scenarios.

Private Residences:

- Arsenic: long-term exposure (non-cancer and cancer effects) at Residence 1-6.
- Chromium(VI): long-term exposure (cancer effect) at Residence 3 and 10.
- Manganese:
 - Long-term exposure (non-cancer effects) at Residence 1, 3, or 6.
 - Short-term exposure at a localized hotspot at Residence 6 for children.

Residential Right-of-Ways (ROW):

- Arsenic: long-term exposure (non-cancer and cancer effects) at Residential ROW 3, 8, 10, 13, 14, 18, 19, 20
- Chromium(VI): long-term exposure (cancer effects) at Residential ROW 1, 2, 4-10, 12.
- Manganese:
 - Long-term exposure (non-cancer effects) at Residential ROWs 10, 13, 14, or 19.
 - Short-term exposure at a localized hotspot at Residential ROW 13 for children.

Recreational Areas:

- Arsenic: long-term exposure (non-cancer and cancer effects) at Recreation Areas 2 and 4.
- Chromium(VI): long-term exposure (cancer effects) at Recreation Areas 1-5.

Trespass Areas:

- Chromium(VI): long-term exposure (cancer effects) at Trespass 1.

Commercial Areas:

- Arsenic: long-term exposure (non-cancer and cancer effects) at Commercial 4 and 6.

- Chromium(VI): long-term exposure (cancer effects) at Commercial 1 and 3.

Daycare:

- Arsenic and Copper: Short-term and long-term exposures for workers and children.
- Manganese: Short-term exposure at a localized hotspot for children.

Basis for Conclusion

- Available data were insufficient to evaluate chronic health effects in several locations due to clustered or judgmental sampling, limited spatial coverage, or an insufficient number of samples to represent long-term exposure conditions. Therefore, ADHS cannot reliably evaluate chronic exposure to arsenic, manganese, or chromium(VI) exposure or draw definitive health conclusions.
- For chromium(VI), only 1 of the 20 sampled properties had sufficient data to assess long-term health effects. At seven locations, chromium(VI) was not detected, but the laboratory reporting limit was above the cancer-based comparison value; thus, ADHS cannot properly evaluate the risk in these areas.
- For manganese, no acute health-based guideline is available, so ADHS used a state-derived reference value. At the Daycare hotspot, Residence 6, and Residential ROW 13, estimated short-term exposure doses for young children exceeded this value, indicating a reduced safety margin; data were insufficient to determine whether acute adverse health effects would occur, particularly for children under 6 years of age.
- At the Daycare, the available data are insufficient to fully characterize hotspots or assess health effects from arsenic and copper exposure in surface soil. The playground is covered with woodchips, which likely reduces direct contact with the underlying soil and lowers potential exposure. However, dust may still settle on top of the wood chips, leading to possible incidental exposure. Because there is a lack of data on how effectively the wood chips prevent soil ingestion over time, ADHS cannot fully characterize the more realistic risk in this area.

Surface Soil Conclusion 3

ADHS concludes that incidental ingestion of metals in surface soil are not expected to harm people's health at most locations evaluated. This conclusion applies to all metals and exposure scenarios, except for those mentioned in Surface Soil Conclusion 1 (where health effects may occur) or Conclusion 2 (where there is insufficient information).

Basis for Conclusion

- Surface soil samples were analyzed for 17 metals across various land-use areas.
- In some cases where initial screening levels were exceeded, a more detailed, site-specific review showed that exposures were not high enough to cause harm.
- Estimated exposure concentration or exposure doses were below levels known to cause health problems, based on health guidelines and scientific evidence.

Recommendations

Based on the findings of this evaluation, the following recommendations are provided to reduce potential exposures and address remaining data gaps.

Outdoor Air

- Continued efforts by ADEQ to work with MRI to optimize dust control and permitting to reduce PM₁₀ and heavy metals levels in the air.
- Community members are encouraged to take steps to protect themselves by reducing exposures. This includes subscribing to the weather forecast and monitoring wind conditions. During high wind events (>15 mph), avoid unnecessary outdoor activities and keep windows and doors closed.

Groundwater

- Additional sampling of Private Wells 2, 8, and 11 may help better characterize arsenic concentrations.
- For Private Wells 1 and 3, treat the water for arsenic or use an alternative water source for drinking and cooking purposes.
- Private well owners are encouraged to take steps to protect themselves by reducing exposure. This includes following the recommended well testing schedule and treatment guidance available at azdhs.gov/WellWater.

Surface Soil

- Continued efforts by ADEQ to work with MRI in addressing concerns at the VFW.
- Additional soil sampling in residential yards, childcare facilities, and recreational areas could help better characterize the site contamination and support evaluation of exposures and health risks.
- All parents or guardians are encouraged to carefully monitor young children to limit their intake of soil. If parents or guardians suspect their child is showing signs of pica behavior, they should talk with their pediatrician.
- Community members are encouraged to take general steps to protect themselves from exposure to heavy metals in dust and soil. Additional tips are available at: <https://www.azdhs.gov/documents/preparedness/epidemiology-disease-control/environmental-toxicology/adhs-dust-2025.pdf>.
 - Wash hands often, especially after coming inside or before eating.
 - Avoid eating in dusty areas.
 - Regularly wash children's toys with soap and water and clean dust with a wet mop or cloth.
 - Encourage children to play in areas other than dirt and soil, like grass or mulch.
 - If you garden, use a raised garden bed with store-bought soil and wash all produce before eating it.

Public Health Action Plan

- ADHS will notify ADEQ, Yavapai County Community Health Services, and the City of Cottonwood regarding the conclusions of this report.
- ADHS will continue to collaborate with the community, and state and local agencies to promote public health in Cottonwood.
- ADHS will provide support for public meetings to discuss this report and conduct additional evaluations upon request, as appropriate data becomes available.
- ADHS will provide education and awareness to community members and leaders on ways to reduce their exposure and protect their health. They will continue to address community questions and concerns regarding this report and site.

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Authors

Breanna Gately, MS, Health Assessor
Environmental Toxicology Program

Mya Davis, MPH, Program Manager
Environmental Toxicology Program

Reviewers

Hsini Lin, ScD, MSPH, Office Chief
Environmental Epidemiology

Kathryn Wangsness, MHA, Deputy Bureau Chief
Arizona State Public Health Laboratory

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Appendix A: Figures

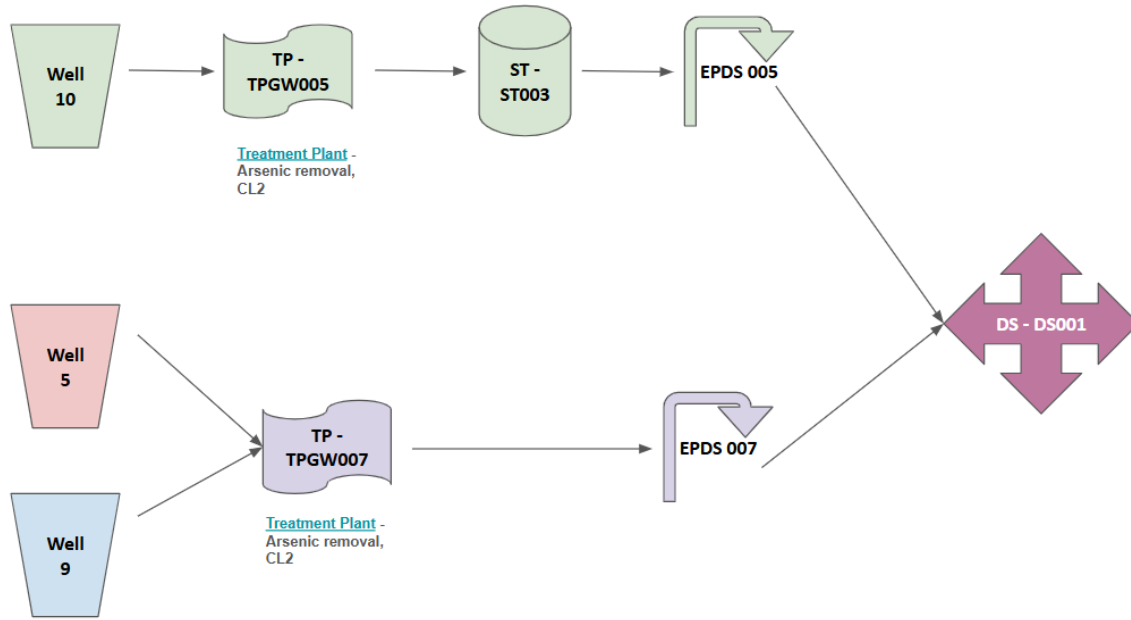
Figure A1. Google Earth image shows the slag pile and the neighboring Verde Valley Fairgrounds, VFW, and Cottonwood Kid's Park.



Figure A2. Map of North and East Monitoring Locations in relation to the MRI Slag Pile, provided by ADEQ.



Figure A3. Flow Chart of City Wells In the Site Area Supplying the Cottonwood Public Water System (PWS# AZ0413025) Distribution System (DS001)



Abbreviations: TP= Treatment Plant, ST=Storage Tank, EPDS= Entry Point to Distribution System, DS= Distribution System

Appendix B: Tables

Table B1: Demographics Comparison: Cottonwood, Yavapai County, and Arizona.

Census Demographic	Cottonwood	Yavapai County	State of Arizona
Total Population¹			
Total Population	12,029	236,209	7,151,502
Sex Distribution (%)¹			
Male	46.1	49.1	49.5
Female	53.9	50.9	50.5
Age Distribution (%)¹			
Less than 5 years	4.4	3.8	5.5
5 - 19 years	14.5	14.0	19.8
20 - 64 years	48.5	48.5	55.9
65 years and older	32.6	33.8	18.7
Economic²			
Median Household Income	\$47,162	\$66,106	\$76,872
Population Density³			
Population per square mile	724.8	29.1	62.9

¹ (U.S. Census Bureau, 2020); ² (U.S. Census Bureau, 2023); ³ (U.S. Census Bureau, 2024)

Table B2: Comparison Values Considered by ADHS

Comparison Value (CV)	Description
ATSDR Cancer Risk Evaluation Guides (CREGs)	CREGs represent the estimated concentration of a contaminant that is unlikely to cause no more than one extra case of cancer in a million people exposed over their lifetime (78 years) (ATSDR 2022).
ATSDR Environmental Media Evaluation Guides (EMEGs)	EMEGs are estimates for safe levels of contaminants in air, water, or soil, based on guidelines from ATSDR (ATSDR 2022). There are three types of EMEGs depending on exposure time: acute (EMEG-a), intermediate (EMEG-m), and chronic (EMEG-c) (ATSDR 2022).
ATSDR Pica	Values that consider young children with pica behaviors, which are the craving to eat nonfood items, such as soil, paint chips, and clay (ATSDR 2022).
ATSDR Reference Dose Media Evaluation Guides (RMEGs)	Estimates for a concentration of a contaminant in air, water, or soil that is unlikely to cause harmful non-cancerous health effects with daily chronic exposure (ATSDR 2022).
EPA's Regional Screening Levels Non-Cancer (RSL-nc) and Cancer (RSL-c)	Non-cancer (RSL-nc) and cancer (RSL-c) screening levels are concentrations of chemical contaminants used by the EPA as risk-based screening levels at hazardous waste sites (EPA 2025d).
EPA's Treatment Technique (EPA TT)	A treatment technique is an enforceable procedure or level of technological performance that public water systems must follow to ensure control of a contaminant (EPA 2025j).
EPA's Lifetime Health Advisory (EPA LTHA)	Advisory values indicate the level of a contaminant in drinking water that is not expected to cause health problems over a person's lifetime (EPA 2025b).
EPA National Ambient Air Quality Standards (NAAQS)	The Clean Air Act, which was last amended in 1990, requires the EPA to set National Ambient Air Quality Standards for six pollutants that can be harmful to public health and the environment (EPA 2025i).
Aquifer Water Quality Standards (AWQS)	These water standards are designed to protect the State's aquifers (ADEQ 2025c).
WHO Air Quality Guidelines (AQGs)	Used to screen for non-cancer health effects from particulate matter (PM ₁₀) for both annual and 24-hour exposure limits (WHO 2021).
California Environmental Protection Agency (CalEPA) Reference Exposure Levels (RELs)	California EPA's reference exposure level (REL). The REL is a concentration at or below which no adverse non-cancer health effects are anticipated for the specified exposure duration (EPA 2025d).
Massachusetts Department of Environmental Protection Allowable Ambient Air Limits (MassDEP AAL-nc)	MassDEP uses AALs primarily in its air pollution control permitting program (MassDEP 2024). The agency also uses AALs to evaluate the potential for non-cancer health effects from chemicals present in ambient and indoor air (MassDEP 2024).

Table B3. Comparison of particulate matter (PM10) and metals to health-based comparison values (CVs) at the VFW.

Contaminant	Concentration Range ($\mu\text{g}/\text{m}^3$)	Detections / Total Samples	CV ($\mu\text{g}/\text{m}^3$)	CV Type(s)	# of samples detected above CV	Contaminant of Concern?
PM ₁₀	2 - 150	35/35	15	WHO AQG annual	1	Yes
	2 - 150	35/35	45	WHO AQG 24-hour	12	Yes
Aluminum	<0.42 - 0.55	28/30	5	EPA PPRTV	0	No
Antimony	<0.021	0/30	0.3	ATSDR EMEG-c	0	No
Arsenic	<0.002 - 0.034	25/30	0.00065	ATSDR CREG	25*	Yes
			0.015	EPA RfC	7	Yes
Barium	<0.021 - 0.016	12/30	0.52	EPA RSL-nc	0	No
Beryllium	<0.004	0/30	0.00042	ATSDR CREG	0*	No**
			0.001	ATSDR EMEG-c	0	No
Cadmium	<0.0021	0/30	0.00056	ATSDR CREG	0*	Yes
			0.01	ATSDR EMEG-c	0	No
Chromium	<0.042	0/30	0.1 [†]	ATSDR EMEG-m [†]	0	No
Cobalt	<0.002 - 0.003	1/30	0.1	ATSDR EMEG-c	0	No
Copper	<0.01 - 0.78	29/30	100	Cal EPA	0	No
Lead	<0.002 - 0.024	26/30	0.15	EPA NAAQs	0	No
Manganese	<0.01 - 0.014	2/30	0.3	ATSDR EMEG-c	0	No
Molybdenum	<0.021	0/30	2	ATSDR EMEG-c	0	No
Nickel	<0.002 - 0.005	1/30	0.003	ATSDR EMEG-m	1*	No**
Selenium	<0.01	0/30	21	EPA RSL-nc	0	No
Silver	<0.0021	0/30	0.02	MassDEP AAL-nc	0*	No**
Thallium	<0.0021	0/30	NA	NA	0	Yes
Thorium	<0.0021	0/30	NA	NA	0	Yes
Uranium	<0.0021	0/30	0.042	EPA RSL-nc	0	No
Vanadium	<0.0021	0/30	0.1	ATSDR EMEG-c	0	No
Zinc	<0.042 - 1.2	27/30	0.2	MassDEP AAL-nc	6	Yes

NA: CV was not available; therefore, the contaminant was carried forward as a contaminant of concern.

*Only includes detected concentrations greater than the CV.

**Beryllium, Nickel, and Silver were not detected in the slag analysis; therefore, they were not carried forward.

[†]The CV for CrIII was used since Chromium (total) was not detected at this location.

Table B4. Comparison of particulate matter (PM10) and metals to health-based comparison values (CVs) at the Cottonwood Kid's Park.

Contaminant	Concentration Range (µg/m ³)	Detections / Total Samples	CV (µg/m ³)	CV Type(s)	# of samples detected above CV	Contaminant of Concern?
PM ₁₀	2 - 37	25/25	15	WHO AQG annual	0	No
	2 - 37	25/25	45	WHO AQG 24-hour	0	No
Aluminum	<0.42 - 0.33	22/25	5	EPA PPRTV	0	No
Antimony	<0.021	2/25	0.3	ATSDR EMEG-c	0	No
Arsenic	<0.0029	0/25	0.00065	ATSDR CREG	0*	Yes
			0.015	EPA RfC	0	No
Barium	<0.002 - 0.012	11/25	0.52	EPA RSL-c	0	No
Beryllium	<0.0004	0/25	0.00042	ATSDR CREG	0*	No**
			0.001	ATSDR EMEG-c	0*	No**
Cadmium	<0.0029	0/25	0.00056	ATSDR CREG	0*	Yes
			0.01	ATSDR EMEG-c	0	No
Chromium	<0.058	0/25	0.1 [†]	ATSDR EMEG-m [†]	0	No
Cobalt	<0.029	0/25	0.1	ATSDR EMEG-c	0	No
Copper	<0.01 - 0.037	6/25	100	Cal EPA	0	No
Lead	<0.002 - 0.003	4/25	0.15	EPA RSL-nc	0	No
Manganese	<0.011	2/25	0.3	ATSDR EMEG-c	0	No
Molybdenum	<0.029	0/25	2	ATSDR EMEG-c	0	No
Nickel	<0.002 - 0.002	2/25	0.003	ATSDR EMEG-m	0*	No
Selenium	<0.01	0/25	21	EPA RSL-nc	0	No
Silver	<0.029	0/25	0.02	MassDEP AAL-nc	0*	No**
Thallium	<0.0029	0/25	NA	NA	0	Yes
Thorium	<0.0029	0/25	NA	NA	0	Yes
Uranium	<0.0029	0/25	0.042	EPA RSL-nc	0	No
Vanadium	<0.029	0/25	0.1	ATSDR EMEG-c	0	No
Zinc	<0.021 - 0.052	2/25	0.2	MassDEP AAL-nc	0	No

NA: CV was not available; therefore, the contaminant was carried forward as a contaminant of concern.

*Only includes detected concentrations greater than the CV.

**Beryllium, Nickel, and Silver were not detected in the slag analysis; therefore, they were not carried forward.

[†]The CV for CrIII was used since Chromium (total) was not detected at this location.

Table B5. Comparison of contaminants in well water to health-based comparison values (CVs).

Contaminant	Concentration Range (µg/L)	Detections / Total Samples	CV (µg/L)	CV Type(s)	# of samples detected above CV	Contaminant of Concern?
Antimony	<4.30	0 / 10	2.8	ATSDR RMEG	0*	No*
			6	EPA LTHA	0	No
Arsenic	<4.4 – 22.8	6 / 10	35	ATSDR EMEG-a	0	No
			0.00076	ATSDR CREG	6*	Yes
			0.42	ATSDR RMEG	6*	Yes
Barium	47.2 – 553	10 / 10	1,400	ATSDR EMEG-c	0	No
Cadmium	<0.48 – 0.51	1 / 10	0.71	ATSDR EMEG-c	0	No
Copper	<3.68 – 17.8	7 / 10	140	ATSDR EMEG-m	0	No
Iron	<18.0	0 / 10	14,000	EPA RSL-nc	0	No
Lead	<2.99	0 / 10	10	EPA TT	0	No
Manganese	<0.94 – 5.35	2 / 10	300	EPA LTHA	0	No
Nickel	<1.61 – 5.22	1 / 10	140	ATSDR RMEG	0	No
			100	AWQS	0	No
Silver	<1.54	0 / 10	35	ATSDR RMEG	0	No
Zinc	36.2 – 365	10 / 10	2,100	ATSDR EMEG-c	0	No

*Only includes detected concentrations greater than the CV.

Table B6. Comparison of contaminants in surface soil to health-based comparison values (CVs).

Contaminant	Concentration Range (mg/kg)	Detections / Total Samples	CV (mg/kg)	CV Type(s)	# of samples detected above CV	Contaminant of Concern?
Antimony	<10.0	46 / 64	21	RMEG	0	No
Arsenic	<0.837 – 1,680	219 / 221	260	EMEG-a	7	Yes
			3.1	RMEG-c	214	Yes
Aluminum	882 – 37,500	157 / 157	52,000	EMEG-c	0	No
Barium	67.7 – 663	64 / 64	10,000	EMEG-c;RMEG	0	No
Cadmium	<0.0471 – 87.9	207 / 221	5.2	EMEG-c	22	Yes
Chromium VI	<0.255 – 1.38	14 / 27	0.69	CREG	6*	Yes
			47	EMEG;RMEG	0	No
Copper	6.49 – 13,700	221 / 221	110	ATSDR pica	136	Yes
Iron	1,380 – 171,000	221 / 221	NA**	–	–	No
Lead	1.25 – 651	221 / 221	200	RSL-nc	1	Yes
Manganese	32.9 – 9,680	221 / 221	1,800	RSL-nc	13	Yes
Mercury	<0.0206 – 7.76	95 / 157	0.52	EMEG-m	1	Yes
Nickel	7.77 – 157	64 / 64	1,000	RMEG	0	No
Selenium	<1.07 – 11.6	29 / 157	260	EMEG-c;RMEG	0	No
Silver	<0.127 – 7.8	51 / 64	260	RMEG	0	No

Thallium	<10.00	25 / 221	0.78	RSL-nc	6*	Yes
Uranium	0.0652 – 1.81	221 / 221	16	RSL-nc	0	No
Zinc	<0.127 – 7,650	220 / 221	16,000	EMEG-c;RMEG	0	No

*Only includes detected concentrations greater than the CV.

NA**No CV is available, and it is not typically harmful under most exposure scenarios. No further evaluation is needed (ATSDR 2022).

Table B7. Well IDs and Use

Well ID	Well Use	Potentially Exposed Populations
Well 1	Private	Residents
Well 2	Private	Residents
Well 3	Private	Residents
Well 4	Irrigation	Visitors
Well 5	City	Residents
Well 6	City*	N/A
Well 7	Irrigation	Visitors
Well 8	Private	Residents
Well 9	City	Residents
Well 10	City	Residents
Well 11	Private	Residents
Well 12	Private*	N/A
Well 13	Monitor	N/A
Well 14	Monitor	N/A
Well 15	Monitor	N/A
Well 16	Monitor	N/A
Well 17	Monitor	N/A

Abbreviations: N/A = Not Applicable

* Well is capped and not actively in use

Table B8. Surface soil evaluation area IDs and COCs.

Area ID	Potentially Exposed Populations	Arsenic	Cadmium	CrVI	Copper	Lead	Manganese	Mercury	Thallium
Residence 1	Residents	✓	✓	—	✓	✗	✓	—	✓
Residence 2	Residents	✓	✓	—	✓	✗	✗	—	✓
Residence 3	Residents	✓	✗	✗	✓	✗	✓	✗	✓
Residence 4	Residents	✓	✗	—	✗	✗	✗	—	✓
Residence 5	Residents	✓	✗	—	✓	✗	✗	—	✓
Residence 6	Residents	✓	✗	—	✓	✗	✓	✗	✓
Residence 10	Residents	—	—	✗	—	—	—	—	—
Residential ROW 1	Residents	✓	✗	✗	✓	✗	✗	✗	✓
Residential ROW 2	Residents	✓	✓	✓	✓	✗	✗	✗	✓
Residential ROW 3	Residents	✓	✗	—	✗	✗	✗	—	✓
Residential ROW 4	Residents	✓	✗	✓	✓	✗	✗	✗	✓
Residential ROW 5	Residents	✓	✗	✗	✓	✗	✗	✗	✗
Residential ROW 6	Residents	✓	✗	✓	✗	✗	✗	✗	✗
Residential ROW 7	Residents	✓	✗	✓	✓	✗	✗	—	✓
Residential ROW 8	Residents	✓	✗	✓	✗	✗	✗	—	✓
Residential ROW 9	Residents	✓	✗	✗	✗	✗	✗	—	✓
Residential ROW 10	Residents	✓	✗	✓	✓	✗	✓	—	✓
Residential ROW 11	Residents	✓	✗	—	✓	✗	✓	✗	✓
Residential ROW 12	Residents	✓	✗	✓	✗	✗	✗	✗	✓
Residential ROW 13	Residents	✓	✗	—	✓	✗	✓	✗	✓
Residential ROW 14	Residents	✓	✗	—	✓	✗	✓	✗	✓
Residential ROW 15	Residents	✓	✗	—	✓	✗	✗	—	✗
Residential ROW 18	Residents	✓	✗	—	✗	✗	✗	—	✗
Residential ROW 19	Residents	✓	✗	—	✓	✗	✓	✗	✓
Residential ROW 20	Residents	✗	✗	—	✗	✗	✗	—	✗
Daycare	Children and Workers	✓	✗	—	✓	✗	✓	✗	✓
Commercial 1	Visitors	✓	✗	✓	✓	✗	✓	—	✓
Commercial 2	Visitors	✓	✗	—	✓	✗	✗	✗	✓
Commercial 3	Visitors	✓	✓	✓	✓	✗	✗	✗	✓
Commercial 4	Visitors	✓	✗	—	✓	✗	✗	✗	✓
Commercial 6	Visitors	✓	✗	—	✗	✗	✗	—	✓
Industrial 1	Workers	✓	✓	✓	✓	✗	✗	✗	✓
Industrial 2	Workers	✓	✗	—	✓	✗	✗	✗	✓
Recreational 1	Visitors	✓	✗	✓	✓	✗	✗	✗	✓

Area ID	Potentially Exposed Populations	Arsenic	Cadmium	CrVI	Copper	Lead	Manganese	Mercury	Thallium
Recreational 2	Visitors	✓	✗	✓	✓	✗	✗	—	✓
Recreational 3	Residents and Visitors	✓	✓	✓	✓	✗	✗	✗	✓
Recreational 4	Visitors	✓	✗	✗	✓	✗	✗	—	✗
Recreational 5	Visitors	✓	✗	✓	✓	✗	✗	—	✓
Recreational 6	Visitors	✓	✓	—	✓	✗	✗	✗	✗
Trespass 1	Trespassers	✓	✗	✓	✓	✗	✗	—	✓
Trespass 2	Trespassers	✓	✗	—	✓	✗	✗	✗	✓
Trespass 3	Trespassers	✓	✓	—	✓	✓	✗	✓	✓

✓ = COC at the Area ID; ✗ = not a COC, and was not further evaluated for this area; — = not analyzed

Appendix C: Community Concerns

Appendix C1:



FOR RESEARCH USE ONLY.
NOT FOR USE IN DIAGNOSTIC PROCEDURES.

Client: [REDACTED]

Account Number: [REDACTED]

July 13, 2023

Sample: Slag Pile Dust
Lab Number: U230622-2093

Element	Results (ng/g)
Aluminum	3,500,000
Antimony	8,100
Arsenic	200,000
Barium	72,000
Beryllium	<detection limit
Bismuth	724
Boron	<detection limit
Cadmium	5,000
Cesium	174
Chromium	5,400
Cobalt	28,000
Copper	2,200,000
Gadolinium	302
Iron	51,000,000
Lead	120,000
Lithium	4,000
Manganese	65,000
Mercury	<detection limit
Molybdenum	3,600
Nickel	2,300
Palladium	<detection limit
Platinum	<detection limit
Selenium	5,000
Strontium	53,000
Tellurium	263
Thallium	337
Thorium	720
Tin	7,500
Tungsten	701
Uranium	1,500
Vanadium	8,770
Zinc	6,100,000

Analysis performed by Inductively Coupled Plasma - Mass Spectrometry (ICP-MS)
10 mg of sample digested in 2.5mL nitric acid, diluted to 50mL; run in triplicate

3755 Illinois Avenue, St. Charles, IL 60174-2420
630.377.8139 - FAX: 630.587.7860 - inquiries@doctorsdata.com - www.doctorsdata.com

Appendix D: Glossary of Environmental Health Terms

Term	Definition
Acute Exposure	Contact with a substance that occurs once or for only a short time (0-14 days) [compare with intermediate exposure and chronic exposure]. Also known as short-term exposure.
Aggregate Effect	Also referred to as a “combined” effect, it considers the combined effect of a single chemical across multiple routes and pathways (EPA 2003).
Additive Effect	A biological reaction to several substances that combines their individual effects.
Adverse Health Effect	A change in body function or cell structure can cause health problems or disease.
Antagonistic Effect	A reaction to exposure to several substances is weaker than expected if you add up their individual effects. Also known as “less than additive”.
Ambient	Surrounding (for example, ambient air).
Benchmark Dose Level (BMDL)	The lower limit of the benchmark dose (BMDL) tells us how much of a substance can cause a slight increase in health problems.
Cancer Risk (CR)	A theoretical chance of getting cancer if exposed to a contaminant. Cancer risks are calculated for carcinogens with available cancer risk values.
Cancer Risk Values (CSFs and IURs)	Oral cancer slope factors (CSFs) and inhalation unit risks (IURs) were developed by the EPA or others from toxicology or epidemiology studies (with safety factors applied) that are protective of human health.
Carcinogen	A substance that causes cancer.
Central Tendency Exposure (CTE)	Refers to individuals who have average or typical exposure to a contaminant.
Chronic Exposure	Contact with a substance that occurs over a long time (365 or more days). Also known as long-term exposure.
Comparison Value (CV)	ATSDR-developed media and contaminant-specific screening levels are used to identify contaminants for further evaluation. CVs are the calculated concentrations of a substance in a medium (e.g., air, water, soil) that are unlikely to harm exposed individuals.
Concentration	The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.
Contaminant of Concern (COC)	A label given to a contaminant if its concentration meets or exceeds screening levels, or its estimated exposure dose or cancer risk levels exceed acceptable levels.
Detection Limit (DL)	The lowest concentration of a chemical that can be reliably distinguished from a zero concentration.
Dose	The amount of a substance to which a person is exposed over some time period.
Environmental Media	Soil, water, air, or any other parts of the environment that can contain contaminants.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].
Exposure Pathway	The route a substance takes from its source (where it began) to its endpoint (where it ends), and how people can come into contact with (or get exposed to) it.
Groundwater	Water beneath the earth’s surface in the spaces between soil particles and between rock surfaces.
Health Guidelines	Values that serve as the basis for ATSDR’s non-cancer comparison values.
Health Hazard	One of three conclusion categories used by ATSDR for sites where there is a reasonable chance that health issues may have happened or could happen due to high exposure levels affecting people in the area.

Term	Definition
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects.
Inhalation	The act of breathing.
Intermediate Exposure	Contact with a substance that occurs for more than 14 days and less than a year (15-364 days).
Judgemental Sampling	Selection of samples based on professional judgment and prior information (EPA 2025k).
Lowest Observed Adverse Effect Level (LOAEL)	The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.
Minimal Risk Level (MRL)	Health guidelines for non-cancer effects were developed by ATSDR.
Population	A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).
Reasonable Maximum Exposure (RME)	Refers to people who are at the high end of the exposure distribution (approximately the 95th percentile), a scenario intended to assess exposures that are higher than average, but still within a realistic exposure range.
Reference Concentration (RfC)	Health guidelines derived by the EPA for non-cancer health effects related to exposures to contaminants in the air. RfCs estimate the daily amount of a contaminant that most people, including sensitive groups, can inhale throughout their lives without facing noticeable health risks.
Reference Dose (RfD)	Health guidelines derived by the EPA to examine exposure doses associated with non-cancer health effects. RfDs are estimates showing daily oral exposure to a contaminant that is unlikely to cause harmful effects in the general population, including sensitive groups, over a lifetime of exposure.
Reporting Limit (RL)	The lowest laboratory-reported concentration of a chemical that can be reliably distinguished from a zero concentration.
Sample	All observations from a data set or a physical quantity of an environmental medium – soil, water, air, and food items – that are collected for measurement.
Safety Factor	Mathematical adjustments are made for safety when knowledge is incomplete.
Substance	A chemical.
Surface Soil	The top 3 inches of soil.
Sustained Wind	The average wind speed over a two minute period (NOAA 2023).
Synergistic effect	A response where one substance makes the effect of another worse. When these substances work together, their combined effect is stronger than if they acted separately. Also known as “greater than additive”.
Wind Gusts	Rapid fluctuations in the wind speed (NOAA 2023).

Source: [ATSDR 2022] and [NOAA 2023]