Pacific Gas and Electric Company

FINAL POST-SOIL NON-TIME-CRITICAL REMOVAL ACTION HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT REPORT

Topock Compressor Station, Needles, California

June 2026

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ACRONYMS AND ABBREVIATIONS

µg/dL	microgram per deciliter
$(\mu g/m^3)^{-1}$	incremental lifetime cancer risk per microgram of chemical per cubic meter of air
2019 HHERA	2019 Soil Human Health and Ecological Risk Assessment Report
95UCL	95% upper confidence limit on the mean
Action Memorandum	Request for a Non-Time-Critical Soil Removal Action at Areas of Concern and Solid Waste Management Units
ADAF	age-dependent adjustment factor
AHR	aryl hydrocarbon receptor
Alisto	Alisto Engineering Group
AOC	Area of Concern
Arcadis	Arcadis U.S., Inc.
ATSDR	Agency for Toxic Substances and Disease Registry
ATV	all-terrain vehicle
BAF	bioaccumulation factor
B(a)PEQ	benzo(a)pyrene equivalent
BCa	bias-corrected accelerated
BCW	Bat Cave Wash
bgs	below ground surface
BLM	U.S. Bureau of Land Management
BNSF	Burlington Northern Santa Fe
BTAG	Biological Technical Assistance Group
BTV	background threshold value
CACA	Corrective Action Consent Agreement
CalEPA	California Environmental Protection Agency
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations

CH2M	CH2M Hill, Inc.
CMS	corrective measures study
CNRA	California Natural Resources Agency
COC	constituent of concern
COPC	constituent of potential concern
COPEC	constituent of potential ecological concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSF	cancer slope factor
CSM	conceptual site model
DOI	U.S. Department of the Interior
DTSC	California Department of Toxic Substances Control
EC	exposure concentration
EcoSSL	ecological soil screening level
EE/CA	engineering evaluation/cost analysis
EPC	exposure point concentration
ERA	ecological risk assessment
Final RFI/RI Report Volume 1	Revised Final RCRA Facility Investigation/Remedial Investigation Soil Investigation, Volume 1—Site Background and History
Final RFI/RI Report Volume 2	Final RFI/RI Report, Volume 2 Addendum Report
Final RFI/RI Report Volume 3	Final RCRA Facility Investigation/Remedial Investigation Report, Volume 3—Results of Soil and Sediment Investigation
FMIT	Fort Mojave Indian Tribe
FS	feasibility study
Galbraith	Galbraith Environmental Sciences LLC
GANDA	Garcia and Associates
HHERA	human health and ecological risk assessment
HHRA	human health risk assessment
HI	hazard index
HMW	high molecular weight
HNWR	Havasu National Wildlife Refuge
HpCDD	heptachlorodibenzo-p-dioxin
HpCDF	heptachlorodibenzofuran

HQ	hazard quotient
HxCDD	hexachlorodibenzo-p-dioxin
HxCDF	hexachlorodibenzofuran
ICS	inside the compressor station
ILCR	incremental lifetime cancer risk
IM	interim measure
ITRC	Interstate Technology and Regulatory Council
kg	kilogram
LMW	low molecular weight
LOAEL	lowest-observed adverse effects level
LOE	line of evidence
mg/kg	milligram per kilogram
mg/kg-bw/day	milligram per kilogram of body weight per day
mg/kg/day	milligrams per kilogram per day
$(mg/kg/day)^{-1}$	inverse milligrams per kilogram per day
mg/kg dw	milligram per kilogram dry weight
mg/m^3	milligram per cubic meter
$(mg/m^3)^{-1}$	inverse milligram per cubic meter
NA	not applicable
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	non-detect
ng/kg	nanogram per kilogram
ng/kg-bw/day	nanogram per kilogram of body weight per day
ng TEQ/kg-bw/day	nanogram of toxicity equivalent per kilogram of body weight per day
NOAEL	no-observed adverse effects level
NORR	north of the railroad
NTCRA	non-time-critical removal action
NTCRA Completion Report	Soil Non-Time-Critical Removal Action Completion Report
NTCRA Work Plan	Work Plan for Soil Non-Time-Critical Removal Action
OCDD	octachlorodibenzo-p-dioxin
OCDF	octachlorodibenzofuran

OCS	outside the compressor station
OEHHA	Office of Environmental Health Hazard Assessment
OHV	off-highway vehicle
OSRTI	Office of Superfund Remediation and Technology Innovation
PAA	potential action area
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzodioxin
PCDF	polychlorinated dibenzofuran
PeCDD	pentachlorodibenzo-p-dioxin
PeCDF	pentachlorodibenzofuran
PEF	particulate emission factor
PG&E	Pacific Gas and Electric Company
Post-NTCRA HHERA	Post-Soil Non-Time-Critical Removal Action Human Health and Ecological Risk Assessment
RAG	removal action goal
RAO	remedial action objective
RAWP	Human Health and Ecological Risk Assessment Work Plan
RAWP Addendum 2	Final Human Health and Ecological Risk Assessment Work Plan Addendum 2
RBRG	risk-based remedial goal
RCRA	Resource Conservation and Recovery Act
REL	reference exposure level
RfC	reference concentration
RfD	reference dose
RFI	Resource Conservation and Recovery Act facility investigation
RI	remedial investigation
RL	reporting limit
RME	reasonable maximum exposure
RPD	relative percent difference
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
site	Pacific Gas and Electric Company Topock Compressor Station

SUF	site use factor
SWMU	Solid Waste Management Unit
TAA	target action area
TCDD	tetrachlorodibenzo-p-dioxin
TCDF	tetrachlorodibenzofuran
TCRA	time-critical removal action
TCS	Topock Compressor Station
T&E	threatened and endangered
Technical Memo	Soil Risk Assessment Addendum: Proposed Approach to Update the Human Health and Ecological Risk Assessment after Completion of the 2023 Non-Time-Critical Removal Action
TEF	toxicity equivalency factor
TEQ	toxicity equivalent
TPH	total petroleum hydrocarbon
TRV	toxicity reference value
UA	undesignated area
UCL	upper confidence limit
URF	unit risk factor
USBR	U.S. Bureau of Reclamation
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound
WHO	World Health Organization
WOE	weight of evidence

EXECUTIVE SUMMARY

ES.1 Introduction

This Post-Soil Non-Time-Critical Removal Action Human Health and Ecological Risk Assessment Report (Post-NTCRA HHERA) was prepared on behalf of Pacific Gas and Electric Company (PG&E) to evaluate the potential for unacceptable risk to human and ecological receptors following completion of a soil non-time-critical removal action (NTCRA) conducted at and around the PG&E Topock Compressor Station (TCS) (the site) located in Needles, California. The TCS occupies approximately 15 acres of a 65-acre parcel of PG&E-owned land. The study area for investigative and remedial activities covers additional surrounding land including portions of a 100-acre parcel owned by the Fort Mojave Indian Tribe (FMIT) and land owned and/or managed by government agencies including the U.S. Bureau of Land Management, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service (USFWS), San Bernardino County, California Department of Transportation, and Burlington Northern Santa Fe Railroad. The TCS and the additional surrounding areas investigated together are referred to as the site in this report.

The California Department of Toxic Substances Control (DTSC) is the lead state agency charged with directing investigation and remedial activities at the site in accordance with the Resource Conservation and Recovery Act. The U.S. Department of the Interior (DOI) is the lead federal agency for land under its jurisdiction, custody, or control and is responsible for oversight of response actions being conducted by PG&E pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980.

Concurrent with ongoing soil investigations at the site, the USFWS and DOI determined that there were specific areas outside of the TCS where concentrations of constituents of potential concern (COPCs) and constituents of potential ecological concern (COPECs) exceeded risk-based screening levels. These areas were located within or adjacent to active desert washes subject to potential scouring during rain events that could transport contamination toward the Colorado River or spread the contamination footprint over a larger area. Because of this potential threat to public health and the environment, DOI (2018) directed PG&E to conduct an engineering evaluation/cost analysis to evaluate the need for an NTCRA to address contaminated soil. Ultimately, DOI (2021) directed PG&E to conduct a soil NTCRA to address contaminated soil in these areas.

The NTCRA activities were conducted between July 2022 and May 2024 and included removal of contaminated soil and debris at target action areas within the site. The NTCRA was conducted according to the DOI-approved Work Plan for Soil Non-Time-Critical Removal Action (Jacobs 2022) and as described in the Soil Non-Time-Critical Removal Action Completion Report (Jacobs 2025).

This Post-NTCRA HHERA was prepared to:

1. Document that removal action objective 1 from the NTCRA was achieved, specifically by presenting exposure area-specific exposure point concentrations (EPCs) for comparison to the numerical removal action goals (RAGs) (e.g. based on risk-based remedial goals [RBRGs]) in areas outside of the TCS fence line where NTCRA removals were conducted; and,

2. Provide updated risk estimates for human health and the environment based on potential exposures to current soil conditions in the NTCRA areas.

The approach used in this Post-NTCRA HHERA was detailed in the January 30, 2024 Soil Risk Assessment Addendum: Proposed Approach to Update the Human Health and Ecological Risk Assessment after Completion of the 2023 Non-Time-Critical Removal Action (Technical Memo; Arcadis U.S., Inc. [Arcadis] 2024a) and follows the approach used in the Agencies-approved 2019 Final Soil Human Health and Ecological Risk Assessment Report (2019 HHERA; Arcadis 2019, 2020; DOI and DTSC 2020), as presented in the Agencies-approved Human Health and Ecological Risk Assessment Work Plan (RAWP) and related documents (Arcadis 2008, 2009, 2015; DOI 2009a,b, DOI 2015, DTSC 2009, DTSC 2015) and DTSC-issued directive letter (DTSC 2017)).

Consistent with the Technical Memo (Arcadis 2024a), the updated risk characterization included in this Post-NTCRA HHERA is presented only for the risk-driving human receptors (camper, hiker, and off-highway vehicle [OHV] rider) and ecological receptors (small invertivorous mammals represented by the desert shrew) identified in the 2019 HHERA (Arcadis 2019) and exposure areas where NTCRA removal activities were conducted. The NTCRA activities were conducted in the following areas outside of the TCS: Area of Concern (AOC) 1/Solid Waste Management Unit (SWMU) 1, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27. NTCRA activities were also conducted in a limited area located inside the TCS associated with AOC 16. AOC 16 is evaluated qualitatively in this Post-NTCRA HHERA.

This Final Post-NTCRA HHERA incorporates comments received from DTSC, DOI, FMIT, and the Fort Yuma Quechan Indian Tribe on the Post-NTCRA HHERA draft reports (Arcadis 2024b, 2026). Stakeholder comments were discussed during meetings on October 9, 2025, October 16, 2025, January 7, 2026, March 4, 2025, and March 25, 2026 in alignment with the RTC process for the Site current at the time (DOI and DTSC 2015). The comments, PG&E responses, and comment resolutions are presented in Appendix RTC.

ES.2 Dataset and Methodology

Consistent with the approach detailed in the January 30, 2024 Technical Memo (Arcadis 2024a), the human health risk assessment (HHRA) evaluated post-NTCRA exposures (i.e., EPCs considering NTCRA-related excavation and final surface elevation) to hexavalent chromium, total chromium, copper, and dioxin toxicity equivalent (TEQ) and pre-NTCRA exposures for the remaining non-risk-driving COPCs (i.e., EPCs from the 2019 HHERA [Arcadis 2019]). Thus, two different datasets were used to calculate EPCs for the HHRA:

- For risk-driving COPCs/COPECs identified in the 2019 HHERA (i.e., dioxin TEQ, hexavalent chromium, total chromium, and copper): all soil sampling locations currently in place (i.e., not excavated as part of the NTCRA) in each exposure area were evaluated in this Post-NTCRA HHERA. The Post-NTCRA HHERA dataset includes results for in-place samples evaluated in the 2019 HHERA and in-place NTCRA confirmation samples.
- For all remaining constituents identified as non-risk-driving COPCs in the 2019 HHERA: soil EPCs from the 2019 HHERA were evaluated (pre-NTCRA conditions) in the HHRA associated with this Post-NTCRA HHERA.

For the ecological risk assessment (ERA), ecological receptor exposure was evaluated individually for each COPEC. Evaluation of COPECs was limited to hexavalent chromium, total chromium, copper, and dioxin TEQ (identified as risk-driving COPCs and/or COPECs in one or more site AOCs) consistent with the approach detailed in the January 30, 2024 Technical Memo (Arcadis 2024a).

Engineering controls, such as the placement of backfill, or future institutional controls were not included in this Post-NTCRA HHERA. Use of remaining native soil samples (not accounting for backfill) in the EPC calculations is consistent with the EPC calculation methods used in the 2019 HHERA (Arcadis 2019), as presented in the DTSC-approved RAWP (Arcadis 2008) and related documents (Arcadis 2009, 2015). These methods are expected to result in conservative exposure estimates that overestimate risk but would not materially change the conclusions of this Post-NTCRA HHERA that there is no unacceptable risk to human or ecological receptors in the NTCRA areas.

Exposure and Effects Assumptions

As described in the January 30, 2024 Technical Memo (Arcadis 2024a), the updated risk characterization included in this Post-NTCRA HHERA is presented only for the risk-driving human receptors (camper, hiker, and OHV rider) and ecological receptors (desert shrew) identified in the 2019 HHERA (Arcadis 2019) and exposure areas where NTCRA removal activities were conducted. Except for updating toxicity values to currently recommended values for human health risk estimation, the remaining methodology is consistent with the 2019 HHERA and is summarized in Exhibit ES-1.

Human Health Risk Characterization Methodology

For risk characterization in the HHRA, incremental lifetime cancer risks and noncancer hazard indices (HIs) for exposures to constituents in soil were estimated using standard calculation approaches required in regulatory guidance. To draw risk conclusions, DTSC's target excess risk level of one in one million (1×10^{-6}) and target HI of 1 were used, along with consideration of the National Oil and Hazardous Substances Pollution Contingency Plan acceptable cancer risk-management range (40 Code of Federal Regulations 300) of one in one million (1×10^{-6}) to 100 in a million (1×10^{-4}) and the USFWS's cancer risk threshold level of 10 in a million (1×10^{-5}) for soil deeper than 2 feet below ground surface (February 12, 2021 Topock Soil EE/CA Response to Comment Consultation Meeting Agenda).

Ecological Risk Characterization Methodology

The 2019 HHERA (Arcadis 2019) concluded that potential risk to ecological receptors, including special-status species, at the site was limited to small invertivorous mammals represented by the desert shrew potentially exposed to a few risk-driving COPECs (i.e., total chromium, copper, and dioxin TEQ) in surface soil in one or more potential exposure areas. Therefore, risk estimates for desert shrew are presented only for the risk-driving COPECs in surface soil that reflect current conditions following soil remediation associated with the NTCRA. For consistency, risk estimates for hexavalent chromium, total chromium, copper, and dioxin TEQ are provided for each exposure area even if the constituents were not considered to be risk drivers (i.e., no unacceptable risk) in that area impacted by NTCRA soil removal activities (e.g., hexavalent chromium is not an ecological risk-driving COPEC but was identified as a human health risk-driving COPC).

Additionally, the 2019 HHERA (Arcadis 2019) did not identify a potential for unacceptable risk to sensitive species, and therefore protection of individual invertivorous small mammals is not warranted. This Post-NTCRA HHERA presents hazard quotients (HQs) based on no-observed adverse effects levels

(NOAELs) for completeness; however, HQs based on lowest-observed adverse effects levels (LOAELs) were used to evaluate populations of invertivorous small mammals like desert shrew.

In the ERA, risk estimates were based on HQs. The HQs were estimated using the standard calculation approaches required in regulatory guidance. The risk estimates for each COPEC within a potential exposure area were interpreted based on a semi-quantitative weight-of-evidence approach using multiple lines of evidence (LOEs) to reduce uncertainty and draw risk conclusions. In this Post-NTCRA HHERA, the additional LOEs were evaluated and discussed when LOAEL-based HQs greater than 1 were estimated.

In the ERA, no unacceptable risk to desert shrew populations was identified for COPECs with LOAEL-based HQs less than 1; NOAEL-based HQs less than 1 indicate de minimis risk to wildlife individuals and populations. For COPECs, three risk outcomes are possible for desert shrew based on the LOAEL-based HQs greater than 1 and weight-of-evidence approach: (1) unacceptable risk to wildlife populations is possible (i.e., indicated by sufficient and strong supporting LOEs), (2) unacceptable risk to wildlife populations is unlikely (i.e., indicated by sufficient and strong LOEs supporting a conclusion of no unacceptable risk), or (3) unacceptable risk to wildlife populations is uncertain (i.e., indicated by insufficient LOEs).

Methodology used in the ERA is consistent with the 2019 HHERA and is summarized in Exhibit ES-1.

Exhibit ES-1 Summary of HHERA Datasets and Methods

Risk Input	HHRA	ERA
EPCs	Depth-weighted EPCs and area-weighted EPCs	Depth-weighted EPCs and area-weighted EPCs
Exposure areas	AOC-specific areas outside the TCS: BCW (including SWMU-1/AOC 1), AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 were evaluated quantitatively. AOC 16, located inside the TCS, was evaluated qualitatively. Although DTSC (DTSC 2017) required evaluation of these AOC-specific exposure areas due to NTCRA activities, the conclusions and recommendations for the 2019 HHERA (Arcadis 2019) were based on the risks estimated for the OCS potential exposure area. The OCS exposure area encompasses multiple AOC-specific exposure areas, including areas where NTCRA removals were conducted and areas where no NTCRA removals were conducted and is believed to provide a more appropriate representation of the potential exposures for the human populations that could be present in the areas outside the TCS.	AOC-specific areas outside the TCS: BCW (including SWMU-1/AOC 1), AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27
Receptors	Camper, hiker, and OHV rider	Desert shrew
Scouring scenarios	Baseline (i.e., current conditions) 2-foot and 5-foot scouring scenarios were each evaluated in BCW and AOC 10.	Baseline (i.e., current conditions) 2-foot and 5-foot scouring scenarios were each evaluated in BCW and AOC 10.

Risk Input	HHRA	ERA
Exposure parameters	Same as 2019 HHERA (Arcadis 2019)	Same as 2019 HHERA (Arcadis 2019) For dioxin TEQ (i.e., the 2,3,7,8-TCDD TEQ for dioxin and furan congeners), multiple BAFs were evaluated. Generic BAFs based on uptake of a single congener (2,3,7,8-TCDD) were evaluated as well as the congener-specific BAFs used to derive the soil risk-based remedial goals selected as cleanup goals in the NTCRA.
Toxicity assumptions	The hierarchy of sources for the toxicity criteria that is used in this Post-NTCRA HHERA has been updated from the 2019 HHERA (Arcadis 2019) and is compliant with the September 4, 2018 Toxicity Criteria for Human Health Risk Assessments, Screening Levels, and Remediation Goals (Title 22, California Code of Regulations, Sections 68400.5, 69020-69022) at the time of preparation of the Post-NTCRA HHERA.	Same as 2019 HHERA (Arcadis 2019) A range of risks was estimated using NOAEL TRVs and LOAEL TRVs. The risk characterization was based on the LOAEL-based TRVs used to derive the soil risk-based remedial goals selected as cleanup goals in the NTCRA.

Notes:

BAF = bioaccumulation factor

BCW = Bat Cave Wash

LOAEL = lowest-observed adverse effects level

NOAEL = no-observed adverse effects level

TCDD = tetrachlorodibenzo-p-dioxin

TRV = toxicity reference value

ES.3 HHRA Results

The HHRA evaluates the likelihood that COPCs detected in post-NTCRA soil in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas of the site could adversely impact potential recreational receptors' health under the assumed set of current and reasonable future land-use scenarios described in the 2019 HHERA (Arcadis 2019) for the areas outside the TCS fence line.

As requested by DTSC (DTSC 2017) and consistent with the approach in the 2019 HHERA (Arcadis 2019), the risks/hazards estimated in this Post-NTCRA HHERA for individual AOC/SWMU/undesignated area potential exposure areas outside the fence line where NTCRA removal activities were conducted were based on the assumption that lifetime soil contact for these potential receptors would be limited to that single specific area. It is highly unlikely that activities of the recreational users would be limited to such a small area. Therefore, the risks/hazards estimated presented in this Post-NTCRA HHERA for the camper, hiker, and OHV rider potentially exposed to COPCs detected in post-NTCRA soil in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas of the site are likely overestimated. In the 2019 HHERA, the risks/hazards estimated for the potential exposure area outside the compressor station (OCS) are believed to provide a more appropriate representation of the potential exposures for the human populations that could be present in the areas outside the TCS. As stated previously, this Post-NTCRA HHERA provides updated risk estimates for human health and the environment based on potential exposures to current soil conditions in the NTCRA areas. Therefore, updated risk estimates were not performed for the OCS potential exposure area in this Post-NTCRA HHERA. It is noted that due to NTCRA soil removal, the potential post-NTCRA soil risks for the OCS are likely lower than estimated in the 2019 HHERA. The HHRA results and conclusions of the 2019 HHERA and of this Post-NTCRA HHERA will be considered for making risk-management decisions for the site in the corrective measure study/feasibility study to be conducted for the site.

The 2-foot and 5-foot potential scouring scenarios were also evaluated for both BCW and AOC 10. In Appendix BCW, the estimated receptor-specific risks were similar across each of the evaluated scenarios (i.e., baseline and both scouring scenarios). Likewise, in Appendix AOC 10, the estimated receptor-specific risks were similar for the baseline and both scouring scenarios. The similarity in risk estimates for the baseline and scouring scenarios indicates that the overall risk estimates for the baseline scenario are an appropriately conservative representation of potential risks, including potential for post-scouring exposures, for the potential exposure area.

A summary of the post-NTCRA risk estimates for the AOC-specific areas as well as conclusions for the HHRA are provided below.

- The incremental lifetime cancer risks and HIs for the campers, hikers, and OHV riders were at or slightly above 1×10^{-6} and 1, respectively, for both depth- and/or area-weighted EPCs for the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas evaluated under post-NTCRA conditions when contribution of background arsenic risks were excluded. **Based on the results of the HHRA, the levels of COPCs in post-NTCRA soil in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas are safe and protective all potential recreational receptors evaluated.**

- The depth- and area-weighted EPCs for lead in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas evaluated under post-NTCRA conditions are not expected to result in an increase in blood lead levels above the Office of Environmental Health Hazard Assessment benchmark value of 1 microgram per deciliter for the child camper, hiker, or OHV rider evaluated. **Based on the results of the HHRA, the levels of lead in post-NTCRA soil in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas are safe and protective for all potential recreational receptors evaluated.**
- **The OCS potential exposure area is considered the most representative baseline scenario for potential human exposures and associated risks for soil contact outside the TCS.** Human populations that could be present at the site would more likely be exposed randomly, over the course of a lifetime, to soil present in all areas located outside the TCS, rather than have a lifetime of contact limited to a single AOC/SWMU/undesignated area. No unacceptable risk to human recreator receptors (camper, hiker, and OHV rider) was identified at the site potential exposure areas evaluated in this Post-NTCRA HHRA. Given the reduction in overall estimated cumulative risks and hazards under Post-NTCRA conditions in these potential exposure areas, which were identified with elevated concentrations of risk-driver COPCs in the 2019 HHERA (Arcadis 2019), estimated cumulative risks and hazards for recreational users, camper, hikers, and OHV riders for the OCS potential exposure area under post-NTCRA conditions are likely lower than estimated in the 2019 HHERA (Arcadis 2019) and likely at or slightly above 1×10^{-6} and well within the risk-management range of 1×10^{-6} and 1×10^{-4}. Accordingly, **the levels of COPCs in soil from the OCS potential exposure area under post- NTCRA conditions are safe and protective for campers, hikers, and OHV riders.**
- Given the limited removal in AOC 16, which is inside the TCS fence line, and the levels of COPCs/COPECs in the confirmation samples, **the levels of COPCs in soils inside the compressor station under post-NTCRA conditions remain safe and protective of commercial and short- and long-term maintenance workers for current and anticipated future operational conditions and practices as concluded in the 2019 HHERA (Arcadis 2019).**

ES.4 ERA Results

The ERA evaluates likelihood that COPECs detected in post-NTCRA soil in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas of the site could adversely impact populations of invertivorous small mammals (as represented by desert shrew) under the assumed set of current and reasonable future land-use scenarios described in the 2019 HHERA (Arcadis 2019) for the areas outside the TCS fence line. For ecological receptors, the areas outside the TCS were assumed to contain suitable habitat for ecological receptors and were evaluated as potential ecological exposure areas.

The Post-NTCRA ERA conclusions were based on (1) whether COPECs remain for which unacceptable population-level risk was predicted using LOAEL-based HQs calculated from the most refined exposure and effects assumptions and (2) LOEs supporting the conclusion of unacceptable risk.

For total chromium, hexavalent chromium, copper, and dioxin TEQ, no unacceptable risk was identified for invertivorous small mammal populations, represented by desert shrew, in any potential exposure area where NTCRA removals were conducted. The risk conclusions were similar for all the exposure areas as summarized below:

- For dioxin TEQ, LOAEL-based HQs are less than 1 for all evaluated exposure areas and scouring scenarios when calculated using the most refined exposure and effects assumptions for this constituent (i.e., using a site use factor [SUF] of 1, congener-specific BAFs, and alternate TRVs) and depth-weighted EPCs. **The LOAEL-based HQs less than 1 indicate no unacceptable risk to populations of invertivorous small mammals potentially exposed to soil in these areas following completion of the NTCRA.** Supporting LOEs, evaluated in some of the less refined scenarios, which include conservative dietary and uptake assumptions, the dispersed nature of the remaining highest dioxin TEQ concentrations, and the small home range of the shrew, also support this conclusion.
- For total chromium, LOAEL-based HQs are less than 1 for all evaluated exposure areas and scouring scenarios when calculated using the most refined exposure and effects assumptions for this constituent (i.e., using an SUF of 1, selected BAFs, and selected TRVs) and area-weighted EPCs. **The LOAEL-based HQs less than 1 indicate no unacceptable risk to populations of invertivorous small mammals potentially exposed to soil in these areas following completion of the NTCRA.** Except for the 2-foot scouring scenario in BCW, NOAEL-based HQs were less than 1 in all evaluated exposure areas and scouring scenarios, indicating de minimis risk to individuals and populations of desert shrew in these areas.
- For hexavalent chromium and copper, NOAEL-based and LOAEL-based HQs are less than 1 in all evaluated exposure areas and scouring scenarios. **The NOAEL-based HQs less than 1 indicate de minimis risk to individuals and populations of invertivorous small mammals potentially exposed to soil in these areas following completion of the NTCRA.** Risk conclusions are based on HQs estimated in the most refined exposure and effects assumptions applicable to these constituents (i.e., using an SUF of 1, selected BAFs, and selected TRVs) and area-weighted EPCs.

ES.5 Conclusions

For the post-NTCRA HHRA, no unacceptable risk to human recreator receptors (camper, hiker, and OHV rider) was identified at the site potential exposure areas. Based on the results of this Post-NTCRA HHERA, levels of COPCs in soil from the OCS potential exposure area under post-NTCRA conditions are lower than those estimated in the 2019 HHERA and are still safe and protective for campers, hikers, and OHV riders. For potential human worker exposures at AOC 16, located inside the TCS, the levels of COPCs in soils inside the compressor station under post-NTCRA conditions remain safe and protective of commercial workers and short- and long-term maintenance workers for current and anticipated future operational conditions and practices, as concluded in the 2019 HHERA (Arcadis 2019).

For the post-NTCRA ERA, no unacceptable risk to wildlife receptor populations was identified at the site potential exposure areas. For desert shrew, the conclusions are based on post-NTCRA conditions as evaluated in this Post-NTCRA HHERA. For the remaining ecological receptors, the conclusions of no unacceptable risk are based on pre-NTCRA conditions as evaluated in the 2019 HHERA (Arcadis 2019).

In this Post-NTCRA HHERA, risk was evaluated based on exposure to remaining native soil samples (not accounting for backfill). While exclusion of backfill in the EPC calculations is expected to result in conservative exposure estimates that overestimate risk, the EPC calculation methods are consistent with those used in the 2019 HHERA (Arcadis 2019) and provide a relevant comparison to the 2019 exposure and risk estimates. Additionally, as stated above, inclusion of backfill material in the EPC calculations would not materially change the conclusions of this Post-NTCRA HHERA that there is no unacceptable risk to human or ecological receptors in the NTCRA areas.

Based on these results, no further remediation is warranted for protection of human or ecological receptors in the areas evaluated in this Post-NTCRA HHERA based on current post-NTCRA conditions.

ES.6 References

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1. INTRODUCTION

This Post-Soil Non-Time-Critical Removal Action Human Health and Ecological Risk Assessment Report (Post-NTCRA HHERA) was prepared on behalf of Pacific Gas and Electric Company (PG&E) to evaluate the potential risks to human and ecological receptors following completion of a soil non-time-critical removal action (NTCRA) conducted at and around the PG&E Topock Compressor Station (TCS) (the site). The site is located in Needles, California. The NTCRA activities were conducted between July 2022 and May 2024 and included removal of contaminated soil and debris at target action areas (TAAs) within the site.

This Post-NTCRA HHERA was prepared to:

1. Document that removal action objective (RAO) 1 of the NTCRA was achieved, specifically by presenting exposure area-specific exposure point concentrations (EPCs) for comparison to the numerical removal action goals (RAGs) (e.g., based on risk-based remedial goals [RBRGs]) in areas outside of the TCS fence line where NTCRA removals were conducted; and,
2. Provide updated risk estimates for human health and the environment based on potential exposures to current soil conditions in the NTCRA areas.

The approach used in this Post-NTCRA HHERA follows the approach used in the Agencies-approved 2019 Final Soil Human Health and Ecological Risk Assessment Report (2019 HHERA; Arcadis U.S., Inc. [Arcadis] 2019, 2020; DOI and DTSC 2020), as presented in the Agencies-approved Human Health and Ecological Risk Assessment Work Plan (RAWP) and related documents (Arcadis 2008b, 2009a, 2015; DOI 2009a,b, DOI 2015, DTSC 2009a, DTSC 2015a) and DTSC-issued directive letter (DTSC 2017b). The Post-NTCRA HHERA approach was detailed in the January 30, 2024 Soil Risk Assessment Addendum: Proposed Approach to Update the Human Health and Ecological Risk Assessment after Completion of the 2023 Non-Time-Critical Removal Action (Technical Memo; Arcadis 2024a), which was submitted to the U.S. Department of the Interior (DOI) and DTSC. Consistent with the Technical Memo, the updated risk characterization included in this Post-NTCRA HHERA is presented only for the risk-driving human receptors (camper, hiker, and off-highway vehicle [OHV] rider) and ecological receptors (desert shrew) identified in the 2019 HHERA and exposure areas where NTCRA removal activities were conducted. The NTCRA activities were conducted in the following areas: Area of Concern (AOC) 1/Solid Waste Management Unit (SWMU) 1, AOC 9, AOC 10, AOC 11, AOC 14, AOC 16, and AOC 27. The risk assessment exposure areas associated with these NTCRA removal areas are described in Section 2.1.

This Final Post-NTCRA HHERA incorporates comments received from DTSC, DOI, Fort Mohave Indian Tribe (FMIT), and the Fort Yuma Quechan Indian Tribe on the draft Post-NTCRA HHERA (Arcadis 2024b, 2026). Stakeholder comments were discussed during meetings on October 9, 2025, October 16, 2025, January 7, 2026, March 4, 2025, and March 25, 2026 in alignment with the RTC process for the Site current at the time (DOI and DTSC 2015). The comments, PG&E responses, and comment resolutions are presented in Appendix RTC.

The evaluation of post-NTCRA conditions at the outside areas of the TCS presented in this Post-NTCRA HHERA includes two primary components:

- A human health risk assessment (HHRA), which evaluated three potential human recreator receptors and associated soil exposure pathways (discussed in Section 5); and
- An ecological risk assessment (ERA), which evaluated desert shrew and associated soil exposure pathways (discussed in Section 6).

NTCRA activities were also conducted in a limited area located inside the TCS, AOC 16. AOC 16 is evaluated qualitatively in this Post-NTCRA HHERA.

The TCS is an active natural gas compressor station located in the southern portion of the Mohave Valley, along the California/Arizona border in eastern San Bernardino County, California. It is located approximately 15 miles southeast of Needles, California (Figure 1-1). The TCS facility is fenced and occupies approximately 15 acres of a 65-acre parcel of land owned by PG&E. However, the study area for investigative and remedial activities covers additional surrounding land, including portions of a 100-acre parcel owned by the FMIT and land owned and/or managed by a number of government agencies including the U.S. Bureau of Land Management (BLM), U.S. Bureau of Reclamation (USBR), U.S. Fish and Wildlife Service (USFWS), San Bernardino County, California Department of Transportation, and Burlington Northern Santa Fe (BNSF) railroad (Figure 1-2). The PG&E TCS and the additional surrounding areas investigated together are referred to as the site in this report.

FMIT owns a 100-acre parcel of land located 0.25 mile north of the site (Figure 1-2). The nearest communities are mobile home parks in Topock, Arizona, and Moabi Regional Park, California. Topock is located on the Arizona (or eastern) side of the Colorado River, about 0.5 mile east-northeast of the TCS. Moabi Regional Park is located on the California (or western) side of the Colorado River approximately 1 mile northwest of the TCS. The community of Golden Shores, Arizona, the largest nearby community, is located approximately 5 miles north of the TCS on the east side of the Colorado River.

A complete description of the site background can be found in the Revised Final RCRA Facility Investigation/Remedial Investigation Soil Investigation, Volume 1—Site Background and History (Final RFI/RI Report Volume 1; CH2M Hill, Inc. [CH2M] 2007b).

1.1. Regulatory Framework

PG&E is conducting investigative and remedial activities at the site pursuant to the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). Under CERCLA, the primary purpose of a baseline risk assessment is to provide risk managers with an understanding of the potential adverse health effects (current or future) to human and ecological receptors posed by the release of hazardous substance from the site in the absence of any actions to control or mitigate those releases. This information may be useful in determining whether a potential current or future threat to human health or the environment exists that warrants an action. The 2019 HHERA (Arcadis 2019), in conjunction with the Final Groundwater Human Health and Ecological Risk Assessment (Arcadis 2009c), represents the baseline risk assessment. In a manner consistent with the RCRA facility investigation (RFI)/remedial investigation (RI) requirements, RCRA/CERCLA process requirements, and agency requirements for this site, the 2019 HHERA was conducted to identify the constituents in the soil that are related to historical site operations and activities at the TCS that could pose potential human health and ecological risk above acceptable levels and should be carried forward to the corrective measures study (CMS)/feasibility study (FS).

The DTSC is the lead state agency charged with directing investigation and remedial activities at the site in accordance with RCRA. In February 1996, PG&E and DTSC entered into a Corrective Action Consent Agreement (CACA) pursuant to Section 25187 of the California Health and Safety Code (DTSC 1996).

The DOI is the lead federal agency on land under its jurisdiction, custody, or control and is responsible for oversight of response actions being conducted by PG&E pursuant to CERCLA. Portions of the site affected by operations at the TCS are on land managed by the BLM, USFWS, and USBR. In July 2005, PG&E and the BLM, USFWS, and USBR entered into an Administrative Consent Agreement (DOI 2005) to implement response actions at the site as set forth in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] Part 300).

Under the terms of the CACA (DTSC 1996) and the Administrative Consent Agreement (DOI 2005), PG&E agreed to conduct an RFI and an RI to identify and evaluate the nature and extent of hazardous waste and constituent releases at the site. The 2019 HHERA (Arcadis 2019) relied on information and analytical data collected for the site and, together with the Final RCRA Facility Investigation/Remedial Investigation Report, Volume 3—Results of Soil and Sediment Investigation (Final RFI/RI Report Volume 3; Jacobs 2024), completes the final element of the RFI/RI process for the SWMUs, AOCs, and other areas being investigated at the site.

Concurrent with the RFI/RI soil investigation, the USFWS and DOI determined that there were specific areas outside of the TCS where concentrations of constituents of potential concern (COPCs) and constituents of potential ecological concern (COPECs) exceeded risk-based screening levels. These areas were located within or adjacent to active desert washes subject to potential scouring during rain events that could move contamination toward the Colorado River or spread the contamination footprint over a larger area. Because of this potential threat to public health and the environment, DOI directed PG&E via the 2018 Engineering Evaluation/Cost Analysis (EE/CA) Approval Memorandum (DOI 2018) to conduct an engineering evaluation/cost analysis (EE/CA) to evaluate the need for an NTCRA to address contaminated soil. Based on the results of the EE/CA (Jacobs 2021), the DOI selected a removal action of excavation of contaminated soil and debris at TAAs within the site (DOI 2021).

DOI subsequently directed PG&E via the Request for a Non-Time-Critical Soil Removal Action at Areas of Concern and Solid Waste Management Units (Action Memorandum; DOI 2021) to conduct a soil NTCRA to address contaminated soil in these areas. That memorandum states the objectives of the soil NTCRA as follows:

> “This non-time-critical removal action is intended to stabilize and mitigate the threat of release of contaminated material surrounding and within the Refuge and reduce the overall threat to human health and the environment. This action may not be the final remedy for the AOCs/SWMUs. The soil RI process will continue for the Site.”

The NTCRA was completed according to the DOI-approved Work Plan for Soil Non-Time-Critical Removal Action (NTCRA Work Plan; Jacobs 2022a), as described in the Soil Non-Time-Critical Removal Action Completion Report (NTCRA Completion Report; Jacobs 2025).

This Post-NTCRA HHERA presents the updated risk characterization for potential exposure areas outside of the TCS fence line (i.e., Bat Cave Wash [BCW], AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27) following completion of the NTCRA activities. Areas where NTCRA activities were not conducted and/or where risk was determined to be acceptable in the soil risk assessment (e.g., inside the compressor station [ICS] and outside compressor station [OCS] exposure areas) were not evaluated in this Post-NTCRA HHERA. Exposures and risks associated with post-NTCRA conditions would be expected to be equal to or lower than those estimated in the 2019 HHERA (Arcadis 2019) (i.e., risk conclusions will not change for those areas) due to soil removals associated with the NTCRA. NTCRA activities were also conducted at AOC 16, located inside the TCS; AOC 16 is evaluated qualitatively in this Post-NTCRA HHERA.

1.1 Objectives and Overview

The objectives of this Post-NTCRA HHERA are the following:

- Document that RAO 1 of the NTCRA was achieved, specifically by presenting exposure area-specific EPCs for comparison to the numerical RAGs (e.g. RBRGs) in areas outside of the TCS fence line where NTCRA removals were conducted; and
- Provide updated risk estimates for human health and the environment based on potential exposures to current soil conditions in the NTCRA areas.

The NTCRA, including the RAOs, is summarized in Section 2.3.3.2.

During the NTCRA, contaminated soil at the TAAs was identified using numerical RAGs, which were selected from RBRGs calculated in the 2019 HHERA (Arcadis 2019) (see Section 2.3.2). The updated risk characterization provided in this Post-NTCRA HHERA evaluates potential human and ecological exposures to current conditions in the potential exposure areas outside of the TCS fence line following completion of the NTCRA activities using the same methodology as used in the 2019 HHERA, including the same potential exposure areas, exposure assumptions, effects assumptions, and risk characterization methods. The approach, methods, and assumptions used in this Post-NTCRA HHERA and in the 2019 HHERA are consistent with standard regulatory guidance under CERCLA, RCRA, and DTSC as described the RAWP (Arcadis 2008b), Revised Addendum to the Revised Human Health and Ecological Risk Assessment Work Plan (Arcadis 2009a), and Final Human Health and Ecological Risk Assessment Work Plan Addendum 2 (RAWP Addendum 2; Arcadis 2015). DTSC and DOI reviewed and approved these three risk assessment documents (DTSC 2009a, 2015a; DOI 2009a, 2009b, 2015), and DTSC issued a subsequent Directive Letter instructing PG&E to include additional risk evaluations (DTSC 2017b). In addition to the evaluations described in the RAWP documents, that Directive Letter required, among other things, that separate quantitative baseline risk assessments must also be conducted for individual SWMUs, AOCs, and other investigation areas outside the TCS fence line. As directed by DTSC, the additional evaluations detailed in the Directive Letter were included in the 2019 HHERA and form the basis for evaluations of the soil exposure areas outside the TCS fence line impacted by the NTCRA, The current post-NTCRA soil conditions for those impacted exposure areas are evaluated for potential risk to human health and the environment in this Post-NTCRA HHERA.

As stated by DOI (2021), the NTCRA may not be the final remedy for the AOCs/SWMUs where removal actions were conducted. This Post-NTCRA HHERA was prepared as part of a larger environmental program at the TCS with the ultimate goal of remediating site media, if needed, to protect public health and the environment. For soil, the RI process will continue for the site and will include development of the CMS/FS for the site to identify and evaluate remedial alternatives that are protective of potential human and ecological receptors. Ultimately, the conclusions reached in the 2019 HHERA (Arcadis 2019) and this Post-NTCRA HHERA along with RFI/RI information will be used to establish an overall site risk-management strategy. These objectives are consistent with the U.S. Environmental Protection Agency's (USEPA's) defined functions of a risk assessment (USEPA 1989, 1997a).

1.2 Report Organization

After this introductory section, the remainder of this Post-NTCRA HHERA is organized as follows:

- **Section 2: Site History and Characteristics**—This section summarizes the historical operations, previous and recent investigations (including the 2019 HHERA [Arcadis 2019] and NTCRA), and physical characteristics of the site including the conceptual site model (CSM), which describes the potential sources of impact, and the primary and secondary mechanisms through which impacts can be transported form one environmental media to another.
- **Section 3: Data Evaluation**—This section describes the available dataset for soil and the steps taken in determining the usability of the data for risk assessment purposes. It also describes the approach used in developing representative potential exposure areas and datasets, and the methodology for selection of risk-driving COPCs and COPECs identified in the 2019 HHERA to be evaluated in this Post-NTCRA HHERA.
- **Section 4: Estimation of Exposure Point Concentrations**—This section describes the data groupings and methods used to estimate EPCs for both potential human and ecological receptor populations for each of the defined potential exposure areas.
- **Section 5: Human Health Risk Assessment for Soil**—This section describes the potential risk-driving receptors (i.e., campers, hikers, and OHV riders), potential exposure pathways, and methods of evaluation (including toxicity assessment and risk characterization). It also summarizes the risk results presented in the area-specific appendices, and discusses key uncertainties associated with the quantitative soil post-NTCRA HHRA.
- **Section 6: Ecological Risk Assessment for Soil**—This section describes the potential risk-driving receptors (i.e., desert shrew), potential exposure pathways, methods of evaluation, summary of the risk results, and key uncertainties associated with the soil post-NTCRA ERA. It also summarizes the risk results presented in the area-specific appendices and discusses key uncertainties associated with the quantitative soil post-NTCRA ERA.
- **Section 7: Conclusions and Recommendations**—This section presents the conclusions of both the HHRA and the ERA.
- **Section 8: References**—This section presents the references cited in this Post-NTCRA HHERA.
- **Appendices:** Statistical outputs for the EPC calculations and detailed exposure area-specific HHRAs and ERAs are presented in the appendices. To facilitate review, the title of each human health and ecological risk assessment (HHERA) appendix is the name of the potential exposure area (e.g.,

Appendix AOC 9 contains the detailed HHERA for the AOC 9 potential exposure area) and associated tables, figures, and attachments use acronyms of the exposure area name (e.g., Figure AOC 9-1.1, Table AOC 9-1.1, Table AOC 9-A1).

2 SITE HISTORY AND CHARACTERISTICS

This section presents information on historical and current operations and summarizes previous and recent soil investigations and interim measures (IMs) for soil. The information presented herein is primarily from the Final RFI/RI Report Volume 1 (CH2M 2007b), the Revised Final Soil RFI/RI Work Plan (CH2M 2013), 2019 HHERA (Arcadis 2019), Final RFI/RI Report Volume 3 (Jacobs 2024), NTCRA Completion Report (Jacobs 2025), and communications with Jacobs. The physical and ecological characteristics of the site were also obtained from the Final RFI/RI Report Volume 1 and the programmatic biological assessment reports (CH2M 2007a, 2014a). More detail is provided in those reports and can also be found in the 2019 HHERA.

A groundwater risk assessment was also completed for the site (Arcadis 2009c) and a groundwater CMS/FS for SWMU 1/AOC 1 and AOC 10 was completed to identify RAOs and alternatives for the groundwater remedial action (CH2M 2009c). In addition, the DOI identified the applicable or relevant and appropriate requirements for the groundwater remedy. Based on the alternatives evaluation, In-situ Treatment with Fresh Water Flushing (Alternative E) was recommended based on its ability to provide a balance of advantages and tradeoffs. DTSC approved the CMS/FS in December 2009 (DTSC 2009b). The known groundwater plume and selected remedy are discussed in detail in the 2009 Final Groundwater Human Health and Ecological Risk Assessment (Arcadis 2009c) and CMS/FS (CH2M 2009c).

Sediment and porewater sediment data were also collected from two sediment investigation study areas present along the Colorado River. These areas include both saturated sediments along the edge of the Colorado River that are ephemerally (temporarily) flooded. One sediment area is located at the mouth of BCW, northeast of AOC 1 between National Trails Highway and the Colorado River. The other sediment area is located at the mouth of East Ravine (east of AOC 10). These data were evaluated in the Pore Water and Seepage Study Report (CH2M 2006a) and 2019 HHERA (Arcadis 2019), and more detail can be found in those documents.

2.1 Site Historical Operations

The TCS is fenced and occupies approximately 15 acres of a 65-acre parcel of PG&E-owned land. In December 1951, the TCS began operations to compress natural gas supplied from the southwestern United States for transport through pipelines to PG&E’s service territory in central and northern California. The state of California owned the property on which the TCS was built. From 1951 to 1965, PG&E leased the property from the state. In 1965, PG&E purchased the property from the state (CH2M 2007b). FMIT owns a 100-acre parcel of land located 0.25 mile north of the site (Figure 1-2).

Current TCS operations are very similar to the operations that occurred from the start of facility operations in 1951, including these six major activities:

- Compression of natural gas;
- Cooling of the compressed natural gas and compressor lubricating oil;
- Water conditioning;

- Wastewater treatment;
- Facility and equipment maintenance; and
- Miscellaneous operations.

The greatest use of chemical products at the TCS involves the treatment of cooling water, and the greatest volume of waste produced consists of blowdown from the cooling towers, which is water that is routinely removed from the towers to prevent chemical buildup and scale formation.

Historically, hexavalent chromium was added to cooling water to inhibit corrosion, minimize scale formation, and control biological growth. From 1951 to 1964, untreated wastewater containing hexavalent chromium was discharged to the BCW, an ephemeral drainage that extends from the Chemehuevi Mountains to the north. From 1964 to 1969, PG&E treated the wastewater by converting the hexavalent chromium to trivalent chromium. In 1969, the process was expanded to two steps that converted hexavalent chromium to trivalent chromium (Step 1) and then removed trivalent chromium via precipitation (Step 2). Beginning in May 1970, treated wastewater was discharged to an injection well (PGE-08) located on PG&E property inside the TCS, and discharges to BCW generally ceased. A description of BCW is presented in Appendix BCW.

In 1971, after wastewater discharge to BCW ceased, four single-lined evaporation ponds were constructed, and in 1985, PG&E discontinued use of hexavalent chromium in its cooling water. In 1989, the single-lined ponds were replaced with four new, Class 2 (double-lined) ponds, located approximately 1.2 miles northwest of the former single-lined ponds. The wastewater treatment system and the single-lined ponds were physically removed and clean-closed between 1988 and 1993. The four Class 2, double-lined ponds are still in use and are operated under jurisdiction of the Regional Water Quality Control Board, Colorado River Basin Region (CH2M 2007b).

2.2 Soil Investigation Areas

The SWMUs, AOCs, and other investigation areas included in the 2019 HHERA (Arcadis 2019) include six SWMUs, 29 AOCs, and seven additional investigation areas located inside and outside the TCS fence line (Figures 2-1 and 2-2). All investigation areas that had not received regulatory closure were included in the 2019 risk assessment. The specific SWMUs, AOCs, and additional investigation areas identified and evaluated in the 2019 HHERA are summarized in Section 2.3.2.

Six SWMUs (SWMUs 2, 3, 4, 7, and 10 and Unit 4.6) and two AOCs (AOCs 2 and 3) had already been closed and did not require further investigation (CH2M 2007b). The closure process and criteria for those investigation areas that have already received regulatory closure are described in Section 5 of the Final RFI/RI Report Volume 1 (CH2M 2007b).

For this Post-NTCRA HHERA, updated risk characterization is provided for areas where NTCRA removals were conducted. The soil NTCRA completed removal activities at the locations identified in the Action Memorandum (DOI 2021) at the following areas (Figure 2-3):

- SWMU 1—Former Percolation Bed (3 TAAs);
- AOC 1—Area Around Former Percolation Bed (3 TAAs);
- AOC 9—Southeast Fence Line (1 TAA);

- AOC 10—East Ravine (4 TAAs);
- AOC 11—Topographic Low Areas (1 TAA);
- AOC 14—Railroad Debris Site (1 TAA);
- AOC 16—Former Sandblast Shelter (1 TAA); and
- AOC 27—MW-24 Bench (1 TAA).

Except for AOC 16, these TAAs are outside the TCS fence line on federal lands or at locations where constituents have the potential to migrate to federal land, including Havasu National Wildlife Refuge (HNWR). AOC 16 is located within the western TCS fence line and above SWMU 1 and AOC 1 (Figure 2-3). While AOC 16 was not designated as a potential action area (PAA) in the EE/CA, it was included in the Action Memorandum (DOI 2021) and was addressed during the soil NTCRA as a TAA. Because limited removal was conducted in AOC 16, located inside the TCS, and AOC 16 was evaluated as part of the ICS exposure area in the 2019 HHERA (Arcadis 2019), a qualitative HHRA was conducted for AOC 16, as presented in Section 5.4.2.7.

The source, nature, and extent of the contamination in soil at the TAAs before the soil NTCRA are presented in the Final RFI/RI Report Volume 3 (Jacobs 2024). Tables and figures presenting the detailed screening of data for individual constituents against the corresponding numerical RAGs are included in the EE/CA (Jacobs 2021).

The relationship between historical investigation areas, NTCRA TAAs, and potential risk assessment exposure areas are presented in Exhibit 2-1.

Exhibit 2-1 HHERA Investigation Areas Associated with NTCRA TAAs

Historical Investigation Area	Description	TAA	Applicable HHERA Exposure Area
SWMU 1	Former Percolation Bed	TAA1, TAA2, TAA3	BCW
AOC 1	Area Around Former Percolation Bed	TAA1, TAA2, TAA3	BCW
AOC 9	Southeast Fence Line	TAA1	AOC 9
AOC 10	East Ravine	TAA1, TAA2, TAA3, TAA4	AOC 9 (TAA1), AOC 10 (TAA2, TAA3, TAA4)
AOC 11	Topographic Low Areas	TAA1	AOC 11
AOC 14	Railroad Debris Site	TAA1	AOC 14
AOC 16	Former Sandblast Shelter	TAA1	ICS
AOC 27	MW-24 Bench	TAA1	AOC 27

Details related to the features and historical site use in each of these areas are discussed in the 2019 HHERA (Arcadis 2019) and in each exposure area appendix to this Post-NTCRA HHERA.

2.3 History of Soil Investigations and Interim Measures

TCS investigative and remedial activities date back to the 1980s with the identification of SWMUs through a RCRA facility assessment. Closure activities associated with former hazardous waste management facilities and the former oily water treatment system at the TCS were performed between 1988 and 1993. The RFI began in 1996 with the signing of the CACA (DTSC 1996), and numerous phases of data collection and evaluation have been completed under the CACA. Since 2005, investigative and remedial activities (RFI/RI) have been performed pursuant to both RCRA corrective action and CERCLA for groundwater and soil.

To date, the RFI/RI has been completed, several IMs have been implemented, and a groundwater remedy has been selected/approved, and construction of the remedy was started in October 2018. The status of the soil investigative and remedial activities is summarized in this section.

2.3.1 RCRA Facility Investigation/Remedial Investigation

As directed by DTSC (2006), the final RFI/RI report is separated into three volumes to efficiently manage the large amount of information associated with the RFI/RI and accelerate site remediation by allowing earlier remediation of the groundwater plume. Each volume of the final RFI/RI report is described as follows:

- **Final RFI/RI Report Volume 1—Site Background and History**. Volume 1 was completed in August 2007 (CH2M 2007b) and approved by DTSC (2007a) and DOI (2007) in 2007. Volume 1 identifies the 20 SWMUs, AOCs, and other undesignated areas (UAs) at the site to be carried forward in the final RFI/RI. An addendum to the Final RFI/RI Report Volume 1 was completed in May 2014 (CH2M 2014b) and provides additional site background and history information for SWMUs and AOCs that were identified subsequent to the original RFI. The addendum was approved by DTSC (2014) and DOI (2014b) in 2014.
- **Revised Final RFI/RI Report, Volume 2—Hydrogeologic Characterization and Results of Groundwater and Surface Water Investigation and Final RFI/RI Report, Volume 2 Addendum Report** (Final RFI/RI Report Volume 2). Volume 2 and its addendum were completed in February and June 2009, respectively (CH2M 2009a, 2009c), and approved by DTSC (2009b) and DOI (2009c). This volume completes the RFI/RI requirements for groundwater impacts associated with the past discharge of wastewater to BCW (SMWU 1/AOC 1) and injection well PGE-08 (SWMU 2). It contains information on the hydrogeologic characterization and results of groundwater, surface water, porewater, and river sediment investigations to evaluate and characterize the nature and extent of groundwater contamination resulting from past discharge of wastewater from the TCS.
- **Final RFI/RI Report Volume 3—Results of Soil and Sediment Investigation.** Volume 3 of the RFI/RI report (Jacobs 2024) includes final characterization data to complete the RFI/RI requirements for remaining TCS operations, including the results of soil investigations and data collection conducted at the site from 2008 through 2020 and the storm drain alignment investigation. PG&E conducted the soil RFI/RI to identify and evaluate the nature and extent of soil contamination at the site and assess the extent to which the release poses a potential threat to human health and the environment. Data described and presented in that report are the basis of the evaluations in the 2019 HHERA (Arcadis 2019) and represent pre-NTCRA conditions in the NTCRA removal areas.

2.3.2 2019 Soil Human Health and Ecological Risk Assessment

The 2019 HHERA (Arcadis 2019) evaluated all constituents detected in the soil during the RFI/RI and identified those constituents that could potentially pose an unacceptable risk to either human health or the environment using the methodology presented in the approved RAWP documents (Arcadis 2008b, 2009a, 2015) and DTSC-issued Directive Letter (DTSC 2017b). RBRGs were also developed to guide remedial action at the site.

2.3.2.1 HHERA Summary

The 2019 HHERA (Arcadis 2019) evaluated primarily soil data, although other environmental media, including white powder, and soil gas were also evaluated as described below. A gradient analysis concluded that the soil transport pathway to sediment/porewater in the two riparian areas along the Colorado River (i.e., mouth of BCW and mouth of East Ravine in AOC 10) was insignificant. Therefore, sediment and porewater exposures were not evaluated in the 2019 HHERA.

For samples collected from terrestrial upland areas, soil (and, if present, white powder) samples were grouped into datasets for each potential exposure area and evaluated for the relevant human and/or ecological receptors. The potential exposure areas evaluated in the 2019 HHERA (Arcadis 2019) include those listed in Exhibit 2-2.

Exhibit 2-2 Potential Exposure Areas Evaluated in the 2019 HHERA

Potential Exposure Area	Sample Locations Representative of this Area	HHRA	ERA
Exposure Areas Based on Individual AOCs			
BCW	BCW (AOC 1, AOC 28d, SWMU 1, TCS-4, Tamarisk Thicket)	✓	✓
SWMU 1	SWMU 1 and TCS-4	✓	✓
BCWxSWMU 1	BCW excluding SWMU 1 and TCS-4	✓	✓
AOC 4	AOC 4	✓	✓
AOC 9	OC 9 and AOC 10a	✓	✓
AOC 10	AOC 10 and Subareas b, c, d	✓	✓
AOC 11	AOC 11	✓	✓
AOC 12	AOC 12	✓	✓
AOC 14	AOC 14	✓	✓
AOC 27	AOC 27	✓	✓
AOC 28	AOC 28	✓	✓
AOC 31	AOC 31	✓	✓
UA-2	UA-2	✓	✓
TT	Tamarisk Thicket	--	✓
NORR	AOC 1 North of the Railroad/USBLM land	✓	--
ICS	Inside the compressor station	✓	--

Potential Exposure Area	Sample Locations Representative of this Area	HHRA	ERA
Combined Exposure Areas			
OCS	Outside the compressor station: all soil exposure areas outside the TCS	✓	✓
OCSxBCW	Outside the compressor station excluding BCW	✓	✓
BCW+AOC4	BCW and AOC 4	--	✓
OCSxBCW+AOC4	Outside the compressor station excluding BCW and AOC 4	--	✓

Notes:
✓ = potential exposure area included in 2019 HHERA (Arcadis 2019)
-- = potential exposure area not included in the 2019 HHERA (Arcadis 2019)
NORR = north of the railroad

The potential terrestrial exposure areas, based on individual AOCs/investigation areas were evaluated in the 2019 HHERA (Arcadis 2019) for relevant human receptors (maintenance workers, recreational users [camper, hiker, hunter, and OHV rider], and tribal users), ecological communities (plants and soil invertebrates), and small home-range wildlife receptors (Gambel’s quail, cactus wren, desert shrew, and Merriam’s kangaroo rat). Larger areas, based on combined potential exposure areas were evaluated for relevant human receptors (hypothetical residents, commercial workers, and maintenance workers) and large home-range wildlife receptors (desert kit fox, red-tailed hawk, and Nelson’s desert bighorn sheep). Data for each of these potential exposure areas were also grouped according to exposure depth intervals evaluated in the 2019 HHERA.

Exposure depths based on receptor-specific activities were evaluated. For human health, the potential receptors were assumed to contact soil at depths from 0 to 10 feet below ground surface (bgs), with interim intervals defined for specific receptor activities. For ecological populations, the potential receptors were assumed to contact soil at depths from 0 to 6 feet bgs with interim intervals defined for specific receptor activities.

EPCs were developed for each soil exposure depth interval for each potential exposure area. In accordance with the agency-approved RAWP (Arcadis 2008b), EPCs were calculated in the 2019 HHERA (Arcadis 2019) using depth-weighted data to account for variable depth profiles at each sampling location. For a given relevant exposure depth for the risk assessment, if only a single sample was available at a given location, that value was used to represent the concentration for the entire exposure depth. For locations with samples from multiple depths, the samples were weighted to account for the different lengths of the segments in the manner described in USEPA (1996a, 1996b) (also summarized in Section 4.2.1).

In the 2019 HHERA (Arcadis 2019), three types of EPCs were calculated based on the depth-weighted soil datasets: depth-weighted maximum, depth-weighted 95% upper confidence limit on the mean (95UCL), and depth- and area-weighted 95UCL (referred to as area-weighted EPCs for simplicity). In summary, the EPC for each soil dataset is either a 95UCL (upper confidence limit [UCL] method recommended by USEPA’s ProUCL version 5.1 software [USEPA 2016] for depth-weighted EPCs, bias-corrected accelerated [BCa] Bootstrap UCL for area-weighted EPCs) or the maximum depth-weighted concentration.

Soil gas samples were also collected from areas within the TCS (i.e., the ICS exposure area). For soil gas data, individual observations for each given chemical and exposure scenario were treated as separate estimates of exposure; no 95UCL calculations were made for soil gas.

Overall, the 2019 HHERA (Arcadis 2019) found no potentially unacceptable risk to most human and ecological receptors potentially exposed to COPCs/COPECs at the site, both within the TCS (ICS potential exposure area) and potential exposure areas outside the TCS. No unacceptable risk was identified for all relevant potential exposure areas for the following receptors:

- Potential human receptors:
    - Tribal users;
    - Hunter; and
    - Workers (commercial and short- and long-term maintenance workers).
- Potential ecological receptors:
    - Special-status species including ring-tailed cat (California fully protected species), cave myotis (California species of concern), and pallid bats (California species of concern);
    - Large home-range receptors (desert kit fox, Nelson's desert bighorn sheep, and red-tailed hawk);
    - Herbivorous and insectivorous birds (Gambel's quail and cactus wren); and
    - Herbivorous small mammals (Merriam's kangaroo rat).

The potential for unacceptable risk was identified for communities of plants and soil invertebrates in a few potential exposure areas that are adjacent to the TCS fence line (BCW, SWMU 1, AOC 9, and AOC 10). Risk drivers in these potential exposure areas were limited to total chromium, hexavalent chromium, and copper. However, confidence in the risk estimates for plants and invertebrates is low based on only generic screening levels available to assess potential risk to these receptors. Vegetation communities observed at the site during the floristic surveys (Garcia and Associates [GANDA] and CH2M 2013; CH2M 2017b) are typical of Mojave Desert plant communities and are not consistent with impairment of the plant community at the site. Ultimately, remedial action to directly address potential risk to plants and soil invertebrates was not recommended in the 2019 HHERA (Arcadis 2019; see Section 2.3.2.2) or included in the NTCRA (Jacobs 2025). Because the key risk drivers for plants and soil invertebrates (hexavalent chromium and total chromium) tend to be co-located, risk-management or remedial actions implemented for the protection of human and wildlife receptors potentially exposed to total chromium also reduce risk to plants and invertebrates.

For the remaining potential human receptors (camper, hiker, and OHV rider) and wildlife receptors (desert shrew), the potential for unacceptable risk was identified as being driven by a limited number of constituents (i.e., dioxin toxicity equivalent [TEQ] and hexavalent chromium for human health; dioxin TEQ, total chromium, and copper for desert shrew) in areas within SWMU 1, AOC 9, and/or AOC 10.

2.3.2.2 Development of Risk-Based Remedial Goals

RBRGs were developed in the 2019 HHERA (Arcadis 2019) to help guide remediation actions onsite including the NTCRA. RBRGs are concentrations of COPCs/COPECs that do not present unacceptable risk to human health and ecological receptors. An RBRG is a proposed health-protective target cleanup concentration that can be used, in combination with other factors such as background concentrations, as a starting point for making risk-management decisions. RBRGs were calculated for risk-driving constituents in soil for a given potential receptor where the findings of the 2019 HHERA (Arcadis 2019) suggested some form of risk management or remediation may be warranted. RBRGs protective of human health and the environment were back-calculated using the most refined exposure and effects assumptions evaluated in the 2019 HHERA. Consistent with the HHERA approach, RBRGs were applied based on the potential exposure area of interest (i.e., the 95UCL for the potential exposure area should be less than or equal to the RBRG). The RBRGs are summarized in Exhibit 2-3.

Exhibit 2-3. Summary of Risk-Base Remedial Goals Calculated in the 2019 HHERA

Risk Driver	Human Health RBRG	Human Health RBRG Basis	Ecological RBRG	Ecological RBRG Basis
Total Chromium	NA	NA	145 mg/kg	Desert shrew; calculated using RAWP BAF and LOAEL TRV
Hexavalent Chromium	3.1 to 310 mg/kg	OHV rider; 10^{-6} to 10^{-4} excess lifetime cancer risk	NA	NA
Copper	NA	NA	145 mg/kg	Desert shrew; calculated using RAWP BAF and LOAEL TRV
Dioxin TEQ	100 to 10,000 ng/kg	Hiker; 10^{-6} to 10^{-4} excess lifetime cancer risk	190 to 360 ng/kg	Desert shrew; calculated using congener-specific BAFs and alternate LOAEL TRV

Notes:
BAF = bioaccumulation factor
LOAEL = lowest-observed adverse effects level
mg/kg = milligram per kilogram
NA = not applicable
ng/kg = nanogram per kilogram
TRV = toxicity reference value

The following locations identified in the 2019 HHERA (Arcadis 2019) were associated with potentially unacceptable risk for ecological receptors and risks above de minimis levels (target ELCR of 10^{-6}) for potential human receptors:

- Protection of potential human recreators (four total locations for the 0 to 3 feet bgs depth interval):
  - Dioxin TEQ: SWMU1-25 in OCS/SWMU1; and
  - Hexavalent chromium: AOC 10-20, #10 in AOC 9, and MW-58BR_S in AOC 10.
- Protection of desert shrew (up to seven total locations for the 0 to 0.5 foot bgs depth interval):
  - Dioxin TEQ (based on RBRG of 190 ng/kg): SWMU1-25 in BCW; PA-20, AOC 10-23, and PA-21 in AOC 9; and AOC 10c-4 in AOC 10; based on dioxin TEQ RBRG of 360 ng/kg: PA-20 and AOC 10-23 in AOC 9;
  - Total chromium: AOC 10-20 in AOC 9; and
  - Copper: AOC 10-21 in AOC 9.

In total, the nine locations fall within three main areas: SWMU 1 (within the BCW exposure area) near SWMU1-25, AOC 9 along the TCS fence line, and AOC 10 within the AOC 10c subarea (i.e., drainage depression behind the middle berm in East Ravine). The scouring scenarios for the BCW and AOC 10 potential exposure areas support the finding that the risk drivers are located in the top 2 to 3 feet of soil outside the TCS fence line. The use of RBRGs and identification of these locations helped focus remedial planning efforts for the NTCRA on those areas and COPCs/COPECs that contribute most significantly to levels of calculated unacceptable risk for ecological receptors and risks above de minimis levels for potential human receptors.

2.3.3 Soil Interim Measures

Two IMs have been conducted to address soil contamination outside the TCS. A time-critical removal action (TCRA) was conducted in 2009 in AOC 4, and a NTCRA was conducted between 2022 and 2024 in six exposure areas outside the TCS (BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27) and one area inside the TCS (AOC 16). The 2009 TCRA is not relevant to this Post-NTCRA HHERA and details of that IM can be found in 2019 HHERA (Arcadis 2019); the 2009 TCRA is summarized briefly below. The NTCRA is the basis for the updated risk characterization presented in this Post-NTCRA HHERA and is discussed in more detail in this section.

2.3.3.1 2009 Time-Critical Removal Action

In June 2009, the DOI issued a memorandum for a TCRA at AOC 4—Debris Ravine at the site (DOI 2009d). This memorandum required PG&E to initiate activities necessary to implement and perform TCRA activities at AOC 4. The TCRA was conducted in accordance with CERCLA and, as an IM, was intended to stabilize and mitigate the threat of release of contaminated material. The history of previous investigations and agency direction leading up to the AOC 4 TCRA are described in the DOI -approved Final Work Plan for Time-Critical Removal Action at AOC 4 (Alisto Engineering Group [Alisto] et al. 2009, DOI 2009e).

TCRA activities were performed at AOC 4 from December 2009 through December 2010 in compliance with the Final Work Plan for Time-Critical Removal Action at AOC 4 (Alisto et al. 2009). During the TCRA, work was conducted in safely accessible areas of AOC 4 and approximately 11,799 tons of waste were removed. Based on the confirmation dataset and installation of erosion control measures installed as part of the TCRA, the substantial threat of release of contaminated material from AOC 4 has been stabilized and mitigated (Alisto et al. 2011).

The TCRA was not intended as a substitute for additional investigative or remedial activities required under RCRA, or to be the final remedy for AOC 4. Rather, the TCRA was intended to be a complement to any subsequent remedial action in this area.

2.3.3.2 2023 Non-Time-Critical Removal Action

Concurrent with the RFI/RI soil investigation, the USFWS and DOI determined that there were specific areas outside of the TCS where concentrations of COPCs and COPECs exceed risk-based screening levels. These areas were located within or adjacent to active desert washes subject to potential scouring during rain events that could move contamination toward the Colorado River or spread the contamination footprint over a larger area. On October 30, 2018, the DOI issued the Engineering Evaluation/Cost Analysis (EE/CA) Approval Memorandum and directed PG&E to conduct an EE/CA to evaluate the need for a NTCRA to address contaminated soil (DOI 2018). The DOI approval memorandum identified 5 of the 11 AOCs/SWMUs located on or adjacent to federal land for evaluation in the EE/CA.

The EE/CA evaluated technologies and remedial alternatives to address contaminated soil in target areas, referred to as PAAs. Several removal action alternatives were identified. A recommended alternative was proposed based on a comparative analysis of the removal action alternatives against the criteria of effectiveness, implementability, and cost. DOI subsequently directed PG&E via the Action Memorandum to conduct a soil NTCRA to address contaminated soil in these PAAs, hereafter identified as TAAs (DOI 2021). While AOC 16 was not designated as a PAA in the EE/CA, the Action Memorandum identified AOC 16 for inclusion in the NTCRA, and this area was addressed during the soil NTCRA as a TAA.

To comply with the stated intent and objectives of the Action Memorandum (DOI 2021), the soil NTCRA implemented the alternative recommended in the EE/CA: Alternative 3—Excavation, Mechanical Separation, Offsite Disposal of Fines, and Reuse of Coarse Material. The scope of the removal action in accordance with Alternative 3 was limited to soil and other solid-phase matrices, including white powder, black sandy material, and debris (for example, wood, cans, machine parts, rebar, concrete, asphalt, railroad ties, piping) on federal land or in locations where constituents have the potential to migrate to federal land. The NTCRA was conducted in TAAs within the following areas: SWMU 1, AOC 1, AOC 9, AOC 10, AOC 11, AOC 14, AOC 16, and AOC 27. The areas targeted in the NTCRA were identified based on conclusions reached in the 2019 HHERA (Arcadis 2019) for risk-driving COPCs and COPECs and based on the observed presence of debris, burnt material, and/or discolored soil associated with elevated concentrations of hazardous substances. Numerical RAGs selected to guide removal actions were selected in the NTCRA Work Plan (Jacobs 2022a) from RBRGs developed in the 2019 HHERA. Details of the NTCRA activities are presented in the NTCRA Work Plan (Jacobs 2022a) and NTCRA Completion Report (Jacobs 2025) and summarized in the area-specific appendices attached to this Post-NTCRA HHERA.

The soil NTCRA was conducted between July 2022 and May 2024 in accordance with the soil NTCRA Work Plan (Jacobs 2022a) and approved variances, as described in the NTCRA Completion Report (Jacobs 2025). With limited exceptions, the removal action achieved the selected RAOs:

- RAO 1: Reduce human and ecological risk related to the COCs in soil up to 10 feet bgs on or adjacent to federal land by removing soil at locations identified as driving risk in the HHERA;
- RAO 2: Address elevated concentrations of contaminants in soil up to 10 feet bgs outside the TCS, in or adjacent to wash areas that are within, or have the potential to migrate to, HNWR during storm events; and
- RAO 3: Remove debris, burnt material, and discolored soil associated with elevated hazardous substances, as identified during the RFI/RI at SWMUs and AOCs up to 10 feet bgs.

Soil NTCRA activities were intended to remove contaminants exceeding the numerical RAGs and debris within 10 feet of the ground surface to achieve the RAOs. However, as shown on Figure 2-4 and listed in Table 2-1, soil with concentrations exceeding the numerical RAGs or debris remain in a few places associated with soil NTCRA removals as well as in a few isolated locations outside of the soil NTCRA removal areas because additional removal would do the following:

- Present a hazard to workers;
- Undermine critical infrastructure or utilities; or
- Encroach upon culturally sensitive areas.

Additionally, chromium- and dioxin/furan-impacted soil with concentrations exceeding the numerical RAGs remains in the floor of several TAAs at depths deeper than 10 feet bgs. Removal of contaminated material from deeper than 10 feet bgs was not conducted because the objectives of the soil NTCRA were to remove soils with contaminant concentrations exceeding the RAGs, which are only applicable within 10 feet of the ground surface, and the residual contaminated material is below the depth at which human and ecological receptors at the site could reasonably be exposed (DOI 2021). Additionally, residual concentrations in the excavation floor are unlikely to be associated with unacceptable risk to human or ecological receptors based on the finding of no unacceptable risk for potential exposures at this depth interval in the 2019 HHERA (prior to soil NTCRA removals) (Arcadis 2019).

In total, the soil NTCRA removed nearly 35,000 cubic yards of contaminated soil and debris. The extents of the soil NTCRA excavations are shown on Figure 2-3. Additional figures for the individual TAAs are presented in the NTCRA Completion Report (Jacobs 2025).

Following soil removals, fill material was placed in some areas. Fill material sources and testing were described in Section 2.7.1 of the NTCRA Completion Report (Jacobs 2025) as follows:

> “DOI was notified of the proposed type of backfill material to be used. Clean onsite fill material conforming to the Topock Groundwater Remedy Soil Management Plan (SMP including updates to Table 2.4-1 (Reference List of Potentially Applicable Analytes and Associated Screening Levels Management Protocol for Handling and Disposition of Displaced Material; Jacobs 2022b) reuse criteria approved by DTSC and DOI (DTSC 2019, 2022; DOI 2018). When clean onsite material sources were depleted, in consultation with the Tribes, DOI approved the import of clean AB material from the Campbell quarry in Lake Havasu City, Arizona. DOI also approved the

> import of riprap from the Rio quarry in Mohave Valley, Arizona; however, the approval was later rescinded at the request of FMIT, and riprap was then imported from the McCrossan Quarry in Kingman, Arizona. Clean screened rock material from onsite mechanical separation operations was also used to backfill AOC 1 TAA2, SWMU1 TAA1, and SWMU1 TAA2 excavations."

The backfill material conformed to the Topock Groundwater Remedy Soil Management Plan (Jacobs 2022b) reuse criteria approved by DTSC (2022).

2.3.4 Soil Background Investigations

As part of the site investigation activities, selected soil sampling studies were conducted to characterize the background conditions for the presence of inorganic compounds, polycyclic aromatic hydrocarbons (PAHs), and dioxins/furans. The background data were used in the 2019 HHERA (Arcadis 2019) to identify those constituents present at concentrations above background levels that, therefore, per the RAWP (Arcadis 2008b), were included in the 2019 risk characterization. The background dataset was also used in the evaluation of the potential for inorganic constituents to leach to groundwater. The background studies conducted for inorganics and PAHs (CH2M 2009b) and dioxins/furans (CH2M 2017a) are summarized in the 2019 HHERA. It should be noted that background values were not developed for PAHs, as PAHs were not detected above the laboratory reporting limits (RLs) in the samples collected for the background study.

NTCRA numerical RAGs were not based on background concentrations, and background data were not re-evaluated in this Post-NTCRA HHERA.

2.4 Site Physical Characteristics

The site is located in the Mohave Valley, along the California–Arizona border in eastern San Bernardino County, California. The Chemehuevi Mountains are located to the south, and the Colorado River is located to the east and north. The site occupies approximately 3 square miles of the north-sloping piedmont alluvial terrace and floodplain along the northern margin of the mountains. A detailed description of the site geology and hydrogeology can be found in the Final RFI/RI Report Volume 1 (CH2M 2007b); the following sections briefly describe the site physical characteristics from that report. Figures associated with the descriptions in this section were originally presented in the RAWP (Arcadis 2008b).

2.4.1 Geology

Alluvial terraces and incised drainage channels characterize the landforms. BCW is a prominent desert wash that crosses the site from south to north. Floodplains lie adjacent on each side of the Colorado River, though they do not flood due to flow regulations of the Davis Dam, approximately 40 miles north of the site. On the study area side, the floodplain is approximately 500 feet in width. Topography ranges from 450 to 1,200 feet above mean sea level within 1 mile of the Colorado River (CH2M 2007b).

The site is in the Basin and Range geomorphic province, with parallel fault-block mountains separated by alluvial valleys. The Chemehuevi Mountains are the dominant geologic feature in the site vicinity, a metamorphic and plutonic basement core complex exposed in southeastern California and western Arizona. A prominent geologic structural feature is a Miocene-age, low-angle normal fault that forms the northern boundary of the mountains (CH2M 2007b). The TCS lies upon the north-sloping piedmont terrace along the northern margin of the mountains.

In the floodplain area, the unconsolidated alluvial and fluvial deposits are underlain by the Miocene conglomerate and pre-Tertiary metamorphic and igneous bedrock. In the upland area, the subsurface shallow aquifer zone consists of alluvial deposits. These unconsolidated deposits are up to 400 feet thick in the area of the site where wells have been installed. Up to 340 feet of the unit is saturated. Lithologic logs and hydraulic testing suggest that the alluvial materials undergo facies changes across the site. Additionally, some interfingering of coarser material is observed throughout the sediments (CH2M 2007b).

Furthermore, dredging of river sediments has occurred near the site. The historical aerial photographs for the study area (included in Section 3.3 of the Final RFI/RI Report Volume 1 [CH2M 2007b]) provide information on the general timeframes and locations of dredging, as evidenced by the extensive sand dune areas present in the historical photographs on both the western and eastern shorelines of the Colorado River. Sources of dredge sand were along main river channel and may include Topock Marsh (Arizona side near Marina) as well as California side Park Moabi.

2.4.2 Hydrology and Hydrogeology

The site is located within the Sonoran Desert region of the Basin and Range geomorphic province and is situated at the southern end of the Mojave groundwater basin (Anderson 1995, Anderson et al. 1992). The mountains are roughly parallel north/south and separated by alluvial basins. The Colorado River runs north to south through the basin. The site is located at the southern extent of unconsolidated alluvial aquifer material in the Mohave groundwater basin (CH2M 2007b).

Groundwater occurs under unconfined to semi-confined conditions within the alluvial fan and fluvial sediments beneath most of the site. The saturated portion of the alluvial fan and fluvial sediments are collectively referred to as the Alluvial Aquifer. In the floodplain area adjacent to the Colorado River, the fluvial deposits interfinger with, and are hydraulically connected to, the alluvial fan deposits. The unconsolidated alluvial and fluvial deposits are underlain by the Miocene Conglomerate and pre-Tertiary metamorphic and igneous bedrock with very low permeability; therefore, groundwater movement occurs primarily in the overlying unconsolidated deposits.

Water chemistry is generally dominated by sodium and chloride, and total dissolved solids vary considerably. Generally, groundwater flow is north to northeasterly, in contrast to the southerly flow of the majority of the Mohave Valley (CH2M 2007b). Groundwater moving south down Mohave Valley is diverted to an easterly-northeasterly direction by the low-permeability bedrock of the Chemehuevi Mountains. The measured saturated thickness of the alluvial aquifer at the site ranges from as little as 30 feet in the southern floodplain area (at MW32) to 260 feet in the IM 3 injection area and 340 feet in the northern floodplain area (MW-49) (CH2M 2007b).

Reducing conditions have been documented in most shallow to mid-depth fluvial wells and sediments near and underlying the river. South of the railroad tracks, these reducing conditions are also encountered in deep wells near and beneath the river. The observed reducing conditions are characterized by the presence of organic carbon, dissolved iron, dissolved manganese, and ammonia in groundwater samples. Under non-pumping conditions, as hexavalent chromium migrates in groundwater from non-reducing conditions in the alluvial and deep fluvial sediments to reducing conditions near and beneath the river, it undergoes chemical reduction and reverts to trivalent chromium, which is immobilized in the sediments.

The fluvial sediments in the floodplain are relatively recent in origin and contain abundant organic material from several sources. Following the construction of Parker Dam in 1938, the river channel near Topock began to accumulate silt. The river level rose approximately 27 feet, and the channel near Topock became a braided stream. Organic material, probably from vegetation in the Topock marsh area, was incorporated into the fluvial sediments. Some of these organic-rich sediments were deposited directly on the floodplain. In addition, dredging operations resulted in placement of additional organic-rich river bottom materials on the floodplain. The reducing conditions observed in the floodplain sediments are likely caused by microbial breakdown of the organic carbon present (regardless of the source) in these shallow fluvial deposits. These reducing conditions in the fluvial deposits play a key role in the attenuation of hexavalent chromium.

A detailed groundwater CSM was presented in the Final RFI/RI Report Volume 2 (CH2M 2009a). The integration of the groundwater CSM in relation to the soil CSM is discussed in the Final RFI/RI Report Volume 3 (Jacobs 2024).

2.5 Ecological Habitat Characteristics

The site is located adjacent to the 37,515-acre HNWR managed by USFWS. The area is characterized by arid conditions and high temperatures and consists of a series of terraces divided by dry desert washes (CH2M 2007b). The site is located either within the Mojave Desert province of California, the Colorado Desert, or the boundary between these two deserts (CH2M 2007b). The biological characteristics of the Action Area (which was previously referred to as the Area of Potential Effects) have been investigated and surveyed in great detail over the years. A general overview of the reports relevant to the ERA and a summary of the biological assessments and ecological characteristics for upland, BCW, and riparian habitats is presented in the 2019 HHERA (Arcadis 2019). Habitat information relevant to the NTCRA removal areas (i.e., upland terrestrial areas and BCW) is presented below along with information regarding habitat for special-status species.

2.5.1 Uplands/Terrestrial Areas

In general, the terrestrial habitats are typical of Mojave Desert uplands, and the plant communities consist of creosote bush scrub (*Larrea tridentate*), tamarisk thicket (*Tamarisk spp*.), arrow weed thickets (*Pluchea sericea*), blue verde woodlands (*Parkinsonia florida*), catclaw acacia thorn scrub (*Accacia greggi*), hillside palo verde (*Parkinsonia microphylla*), allscale scrub dominated by the cattle saltbush (*Atriplex polycarpa*), quailbrush scrub (*Atriplex lentiformis*), western honey mesquite bosque (*Prosopis glandulosa*), and screwbean mesquite bosque (*Prosopis pubescens*). Creosote bush scrub is the dominant upland plant community (CH2M 2014a, 2017b). The area is sparsely vegetated with widely distributed creosote bushes. Tamarisk thicket, arrow weed thicket, and blue palo verde woodland can be found along some of the ephemeral washes and low terraces adjacent to surface water. Upland plant species observed in the Action Area and/or within the site during the March 2017 pre-construction survey and reported in the 2017 Topock Groundwater Remediation Project Pre-Construction Floristic Survey Report—Spring 2017 (CH2M 2017b) are listed in Table 2-1 of the 2019 HHERA (Arcadis 2019).

Terrestrial wildlife diversity is considered low because of the disturbed nature of the land and the incomplete wildlife corridor (CH2M 2014a). Representative upland avian, mammalian, and reptilian species that can potentially be present or have been observed during surveys or incidentally are listed in Table 2-2 of the 2019 HHERA (Arcadis 2019).

2.5.2 Bat Cave Wash

BCW is one of the largest ephemeral drainages within the Action Area. The BCW is a primarily north-south-trending channel located west of the Colorado River, in the Mojave Wash habitat. This wash remains dry throughout most of the year due to arid desert conditions. Large volume surface flows are generally infrequent and occur only briefly in response to high intensity rainfall events. BCW is a tributary of the Colorado River and stormwater flows are conveyed directly into the river under a bridge along the National Trails Highway (PG&E 2013).

The upper reaches, where NTCRA TAAs are located, are confined by steep rocky slopes and have an approximately 30-foot-wide gravel-cobble floodplain (PG&E 2013, 2014) and are relatively barren of vegetation, consisting of scattered shrubs such as Anderson's box-thorn (*Lycium andersonii*), catclaw (*Senegalia greggii*), and desert lavender (*Hyptis emoryi)* (CH2M 2014a, 2017b). North of the NTCRA TAAs and as the wash continues down slope, the channel broadens to over 190 feet wide in some areas and multiple low-flow channels are present throughout the active floodplain. Vegetation cover also increases down slope with blue palo verde (*Parkinsonia florida*) and tamarisk salt cedar (*Tamarix ramosissima*) trees scattered throughout the active floodplain. In the Tamarisk Thicket area, palustrine scrub-shrub temporarily flooded wetland vegetation consists of dense stands of tamarisk and salt cedar that is present west of National Trails Highway (PG&E 2013). At the far east of the Tamarisk Thicket area on the west side of National Trails Highway, ponded water is typically present in a small area. Excluding this small pond, the wash sediments in the AOC 1/BCW area (including the Tamarisk Thicket area) are typically dry, except during seasonal rain events that can cause ephemeral flooding in this area. These dry wash soils transitioning to sediments were evaluated as part of the upland/terrestrial areas of BCW.

2.5.3 Special-Status Species

Habitat exists for special-status species including threatened or endangered (T&E) species (federal- and state-listed) as discussed in the programmatic biological assessment reports (CH2M 2007a, 2014a), reinitiation requests for the programmatic biological assessment reports (USFWS 2018a, 2018b), and other reports (DTSC 2018; CH2M 2015).

No federal- or state-listed T&E plants or candidates for listing were found at the site. As described in the 2019 HHERA (Arcadis 2019), culturally sensitive species (ethnobotanical plants) under the California Desert Native Plant Act have been observed at the site or within the Action Area including blue palo verde, catclaw acacia, desert smoke tree, and the western honey mesquite. Mousetail suncup and the hillside palo verde are California Rare Plants.

Several wildlife species are known to occur or have potential to occur on or near the site. No federal-listed T&E species were observed at the site, except for a single observation of the federally listed T&E species, the southwestern willow flycatcher, in the Tamarisk Thicket area in 2009. Based on the lack of observations in protocol-level surveys conducted by GANDA (CH2M 2014a; GANDA 2014, 2017) and no observations of active nests for any migratory birds, southwest willow flycatchers are considered transient in this area (more detail is provided in the 2019 HHERA [Arcadis 2019]). Two large home-range species have been observed at the site (BCW): the ring-tailed cat and Nelson's desert bighorn sheep. The ring-tailed cat is a California fully protected species. Bat surveys indicated the presence of cave myotis and pallid bat (state species of concern) at BCW (Harvey 2015). Yuma myotis have also been observed onsite, although they are not listed species or species of concern. Special-status species include state- and federal-listed fully protected T&E species, state and federal species of concern, and traditionally culturally significant plants; however, protection at the no-observed adverse effects level (NOAEL) is warranted only for fully protected species. Special-status species were evaluated qualitatively in the 2019 HHERA, except for Nelson's desert bighorn sheep, which was evaluated quantitatively in 2019 HHERA, per the RAWP Addendum 2 (Arcadis 2015).

Tables 2-1 through 2-4 of the 2019 HHERA (Arcadis 2019) provide a lists of upland and riparian species with relevant habitat, feeding guild, and potential presence or absence based on site conditions.

2.6 Conceptual Site Model

The CSM for the site is used to show the relationships between a chemical source, potential exposure pathway, and potential receptor. The fate and transport components of a CSM include the following:

- Potential sources;
- Release mechanisms; and
- Retention and transport media.

These components constitute the fate and transport portions of the CSM and apply to both the HHRA and ERA. The CSM components are discussed in detail in the 2019 HHERA (Arcadis 2019) and are unchanged for this Post-NTCRA HHERA. The CSM also includes exposure routes and potential receptors, a subset of which were identified as having potential for unacceptable risk associated with soil exposure in the 2019 HHERA and are evaluated in this Post-NTCRA HHERA. Potential exposure routes and receptors are discussed in Sections 5.2 and 6.3.

The source-pathway-receptor relationships for human receptors illustrated on the CSM figures (Figures 2-5 and 2-6) provide the basis for the quantitative exposure assessment. CSMs for the potential recreational receptors evaluated in the post-NTCRA HHRAs are presented on Figures 2-5 and 2-6, as follows:

- Figure 2-5 presents a CSM for BCW (i.e., SWMU 1/TCS-4, AOC 1, and AOC 28d).
- Figure 2-6 presents a CSM for all other AOCs (excluding BCW) located outside the TCS.

The CSM for receptors (i.e., desert shrew) evaluated in the post-NTCRA ERAs is presented on Figure 2-7.

Based on data and observations from the NTCRA, Jacobs updated the CSMs for SMWU 1/AOC 1, AOC 10, and AOC 11, as presented in the Final NTCRA Completion Report (Jacobs 2025). For SWMU 1/AOC 1, observations and findings from the NTCRA indicate that, in the past, materials from the Former Percolation Bed were likely graded onto the hillside to the east and exceedance of the RAGs was more extensive than anticipated around TCS-4 and in TAA1. For AOC 10, observations and findings from the

NTCRA indicate that past discharges of waste material from the TCS to East Ravine occurred. Due to the presence of berms within East Ravine, surface flow to the Colorado River is not considered a significant potential migration pathway. For AOC 11, observations and findings from the NTCRA indicate that the distribution of contamination at the site is consistent with drainage and stormwater flows from the TCS. More details regarding the CSM updates for these areas are available in Section 3.18 of the NTCRA Completion Report (Jacobs 2025). Based on NTCRA findings, no CSM changes were needed for AOC 9, AOC 14, AOC 16, and AOC 27.

The human health and ecological CSMs presented on Figures 2-5 through 2-7 are consistent with current CSMs and conditions following completion of the NTCRA, as documented in the NTCRA Completion Report (Jacobs 2025).

2.7 Land Use

Current uses of the site and the surrounding areas, as well as the reasonably anticipated future land uses, are summarized in this section and described in detail in the 2019 HHERA (Arcadis 2019).

2.7.1 Current Land Use

The TCS is located in a sparsely populated, rural area. The surrounding area has important spiritual meaning to the FMIT and other lower Colorado River Indian tribes. The TCS occupies approximately 15 acres of a 65-acre parcel of PG&E-owned land. FMIT owns a 100-acre parcel located about 0.25 mile north of the TCS, currently being used to facilitate IMs. In addition to the 100-acre parcel owned by FMIT, the surrounding area includes land owned and/or managed by a number of government agencies, including the BLM, USBR, USFWS, San Bernardino County, California Department of Transportation, and BNSF railroad (Figure 1-2). Industrial or commercial developments within a 1-mile radius include the TCS and IM 3 treatment plant facility. Current land use does not include residential use in any part of the site.

Moabi Regional Park is a recreational facility operated by the San Bernardino County Department of Parks and Recreation. It is located on land leased from BLM, approximately 1 mile northwest of the TCS on the west shore of the Colorado River. The park encompasses approximately 1,050 acres, includes a boat marina and 105 campsites, and provides access to the river for various sport and recreational activities. The park is located on a side channel of the Colorado River, approximately 1 mile west of the main river channel. The mobile homes are used primarily as weekend residences. As a regional park, it has no full-time residences. No year-round residents live here because campers are limited to 5-month stays. The park does not keep records of residency; therefore, the number of people at the park at any given time is unknown.

Due to the openness of the federal land and limited restrictions to site access, recreational access is potentially present across much of the site. As indicated by DOI (2014a), recreational land use can encompass a variety of activities including (but not limited to) hiking, camping, hunting, visiting historic Route 66, and riding OHVs (also known as all-terrain vehicles [ATVs]).

The BLM-managed lands within the area are owned by BLM, San Bernardino County, and USBR. These lands are considered public. However, public use is discouraged, as the Topock Maze, a culturally significant area for several Native American tribes is located here.

The tribes indicated in a memorandum (FMIT 2012) and a letter (FMIT 2013) that the tribal use of the land in the area of the site including the Topock Maze is limited to the following:

- Tribal Group Activities several times a year for prayer and reflection;
- Tribal Education Activities for students and young people to visit the area to learn about its importance and spiritual significance; and
- Tribal Member Individual Visits to the Mojave Valley on a regular but infrequent basis for quiet time and reflection as part of religious practice and culture, to pay homage to the area and to honor their ancestors.

A major gas utility and transportation corridor is located within the site, including PG&E's two natural gas transmission pipelines, four natural gas transmission pipelines operated by other companies, BNSF railroad tracks, and the I-40 freeway. Other developed land uses within the site include the National Old Trails Highway, former Route 66, and various unnamed access roads. In addition, numerous groundwater well clusters, related to the ongoing groundwater investigation activities, are located throughout the site.

The HNWR is land that is managed by USFWS and encompasses approximately 37,515 acres along the Colorado River in Mojave and La Paz Counties, Arizona, and in San Bernardino County, California. Most of the HNWR extends from the upper end of the Topock Marsh southward, to the head of Lake Havasu on the Arizona side of the Colorado River. A small portion of the refuge borders the TCS. Recreational activities at the HNWR include sightseeing, bird watching, fishing, hunting, camping, and canoeing.

Figure 1-2 presents a map depicting the current owners and managers of the land in the area surrounding the TCS.

2.7.2 Future Land Use

PG&E plans to continue owning and operating the TCS and associated property inside and outside the fence line as an industrial operation for the foreseeable future. Accordingly, the reasonably anticipated future use of the TCS is for ongoing industrial operations.

Similarly, it is reasonable to assume that land that is owned by BNSF railroad and land that is leased by the California Department of Transportation will continue in the future to be used for the railroad and interstate highway, respectively.

As indicated previously, and as depicted on Figure 1-2, a large portion of the land near the TCS is owned and/or managed by the BLM and HNWR. Based on information provided by DOI, human use of the HNWR property will continue, in the future, to be restricted to recreational uses consistent with these statutory, regulatory, and policy guidelines. Future use of the BLM-owned land at the site, as recommended by DOI, should take into consideration the following three factors:

- It is reasonably foreseeable that the land may be transferred out of federal ownership.
- Human use of Park Moabi-leased portion will continue to include both seasonal use by the public and year-round residential use by a limited number of San Bernardino County staff.
- It is reasonably foreseeable that camping on the floodplain will occur under either San Bernardino's proposed expansion or BLM's future use of non-leased areas.

3 DATA EVALUATION

Data evaluation is the process of analyzing site characteristics and analytical data to identify constituents that are potentially related to the site and for which there are data of sufficient quality to be used in a quantitative risk assessment (USEPA 1989). The data evaluation process includes identifying the data available for the site, data usability criteria used to confirm that the soil dataset is suitable for risk assessment (the data useability evaluation is presented in the Final RFI/RI Report Volume 3 [Jacobs 2024]), the approach used in developing representative exposure areas and datasets, and the methodology for selection of COPCs and COPECs. The data evaluation process was conducted in the 2019 HHERA (Arcadis 2019) and is not repeated in this Post-NTCRA HHERA. In addition to RFI/RI data previously evaluated for data useability, new data included in the Post-NTCRA HHERA datasets (i.e., in-place NTCRA confirmation samples) were collected according to the Quality Assurance Project Plan (included as Appendix L to the NTCRA Work Plan; Jacobs 2022a) using the same data quality indicators as in the 2019 HHERA, and no samples were rejected. The in-place NTCRA confirmation samples are, therefore, considered useable for risk assessment. Data evaluation details relevant to this Post-NTCRA HHERA are summarized in the following sections for convenience.

3.1 Summary of Data

Consistent with the approach detailed in the January 30, 2024 Technical Memo (Arcadis 2024a), the HHRA evaluated post-NTCRA exposures (i.e., considering NTCRA-related excavation and placement of backfill) to hexavalent chromium, total chromium, copper, and dioxin TEQ, and pre-NTCRA exposures for the remaining non-risk-driving COPCs (i.e., EPCs from the 2019 HHERA [Arcadis 2019]). Thus, two different datasets were used to calculate EPCs for the HHRA:

- For risk-driving COPCs/COPECs identified in the 2019 HHERA (i.e., dioxin TEQ, hexavalent chromium, total chromium, and copper): all soil sampling locations currently in place (i.e., not excavated as part of the NTCRA) in each exposure area were evaluated in this Post-NTCRA HHERA. The Post-NTCRA HHERA datasets include results for in-place samples evaluated in the 2019 HHERA and in-place NTCRA confirmation samples.
- For all remaining constituents identified as non-risk-driving COPCs in the 2019 HHERA: soil EPCs from the 2019 HHERA were evaluated (pre-NTCRA conditions) in the HHRA associated with this Post-NTCRA HHERA.

For the ERA, ecological receptor exposure was evaluated individually for each COPEC; evaluation of COPECs is limited to hexavalent chromium, total chromium, copper, and dioxin TEQ (identified as risk-driving COPECs in one or more site AOCs), consistent with the approach detailed in the January 30, 2024 Technical Memo (Arcadis 2024a).

The sampling data include primarily soil data, although samples from other materials (e.g., debris, tar, white powder) were also collected during site investigations. The samples designated as white powder collected from AOC 9, AOC 10, AOC 14, and SWMU 1 are included in the datasets used in the quantitative risk assessments (2019 HHERA [Arcadis 2019] and this Post-NTCRA HHERA) as a conservative measure assuming that potential exposure to material described as white powder would not differ significantly from potential exposure to surrounding soil. White powder samples were analyzed for the same chemical analytical suites as soil.

Other matrices such as debris and tar are not included in the datasets used in the quantitative risk assessment because these materials are generally larger in particle size and potential exposures to these materials would not be expected to be similar to potential exposures to surrounding soil.

It should be noted that engineering controls, such as the placement of backfill, or future institutional controls are not included in this Post-NTCRA HHERA. As such, the estimated risks are likely overestimated. The EPC calculation methods presented in Section 4 (including treatment of non-detect results [Section 4.2] and backfill [Section 4.0]) are consistent with those used in the 2019 HHERA (Arcadis 2019) and provide a relevant comparison to the 2019 exposure and risk estimates. Furthermore, as stated in the NTCRA Completion Report (Jacobs 2025), DOI-approved clean onsite fill material and imported AB material were used as backfill. The backfill material conformed to the Topock Groundwater Remedy Soil Management Plan reuse criteria approved by DTSC (2022) (including updates to Table 2.4-1 [Reference List of Potentially Applicable Analytes and Associated Screening Levels Management Protocol for Handling and Disposition of Displaced Material]; Jacobs 2022b).

3.1.1 Data Included for Evaluation of Post-NTCRA Conditions

For risk-driving COPCs/COPECs identified in the 2019 HHERA (i.e., dioxin TEQ, hexavalent chromium, total chromium, and copper) (Arcadis 2019), post-NTCRA conditions were evaluated. Samples representing soil that was excavated as part of the NTCRA were excluded from the dataset, and current sample top and bottom depths (reflecting excavation and/or placement of fill material) were used to develop soil datasets for each exposure scenario evaluated in this Post-NTCRA HHERA (see Section 3.3). The post-NTCRA soil data evaluated in each exposure area are presented in the exposure area-specific appendices (e.g., Attachment BCW-A1 for Appendix BCW) and include the following:

- Pre-NTCRA Data: For pre-NTCRA data, the dataset includes results for site risk drivers (i.e., dioxin TEQ, hexavalent chromium, total chromium, and copper) from the 2019 HHERA dataset (Arcadis 2019) where those samples remain in place.
- NTCRA Confirmation Sampling Data: The dataset includes results for site risk drivers (i.e., dioxin TEQ, hexavalent chromium, total chromium, and copper) from confirmation samples that currently remain in place.

Data evaluated in the 2019 HHERA (Arcadis 2019) are summarized in Section 3.1.2. The NTCRA confirmation soil sampling data are presented in the NTCRA Completion Report (Jacobs 2025). Samples were collected and analyzed according to the Quality Assurance Project Plan (included as Appendix L to the NTCRA Work Plan; Jacobs 2022a) and the NTCRA Work Plan. Consistent with the NTCRA Work Plan, samples were analyzed for the following:

- Risk-driving COPCs/COPECs (total chromium, hexavalent chromium, copper, and dioxins/furans); and
- Select metals (lead, mercury, molybdenum, and zinc) in some cases.

The risk-driving COPCs/COPECs were identified in the 2019 HHERA (Arcadis 2019) and are included in the NTCRA to address RAO 1. The additional select metals are not associated with unacceptable risk in the 2019 HHERA but are present at some locations in or adjacent to wash areas that are within, or have the potential to migrate to, HNWR during storm events and where soil concentrations exceed 10 times the numerical RAGs selected in the NTCRA (RAO 2).

The sample locations for the in-place soil data (i.e., current conditions) are presented on Figures 3-1a and 3-1b for areas outside the TCS and Figure 3-2 for areas inside the TCS for exposure areas evaluated in this Post-NTCRA HHERA.

3.1.2 Data Included in the 2019 HHERA

For all remaining constituents evaluated as COPCs in the 2019 HHERA (Arcadis 2019) but not identified as risk drivers, the datasets (and EPCs) are the same as evaluated in the 2019 HHERA and are summarized below.

As discussed in Section 2.2, PG&E's activities in support of the RFI/RI began in 1996 with the signing of the CACA (DTSC 1996). Since 1996, multiple phases of investigation have been conducted at the site to collect data to fulfill the objectives of the RFI/RI. The analytical data collected for inclusion in the Final RFI/RI Report Volume 3 (Jacobs 2024) and the soil and soil gas data evaluated in the 2019 HHERA (Arcadis 2019) representing pre-NTCRA conditions are presented in those documents. The pre-NTCRA soil data for the site consist of the following validated datasets provided to DOI in a soil investigation data package (PG&E 2018):

- Historical data collected prior to 2008. Historical data collected prior to the soil RFI/RI were evaluated in the Final Data Usability Assessment for Soil and Sediment report (CH2M 2008).
- Part A, Phase 1 soil investigation data (2008). These data were collected in 2008 during implementation of the Draft RCRA Facility Investigation/Remedial Investigation Soil Investigation Work Plan Part A (CH2M 2006b). These data were validated as presented in the Soil Investigation Part A Phase 1 Data Gaps Evaluation Report (CH2M 2012).
- RFI/RI and data gap investigation data (2009 to 2017). These data were collected between 2009 and 2017 during the implementation of the Revised Final Soil RFI/RI Work Plan (CH2M 2013) and subsequent data gap work plans (CH2M 2016a, 2016b, 2016c). The results of the validation are presented in the Final RFI/RI Report Volume 3 (Jacobs 2024).

These soil samples were analyzed for one or more of the following chemical analytical suites:

- Metals;
- Contract Laboratory Program inorganics;
- PAHs;
- Semi-volatile organic compounds and volatile organic compounds (VOCs);
- Total petroleum hydrocarbons (TPHs);
- General chemistry parameters;
- Pesticides;

- Polychlorinated biphenyls (PCBs); and
- Dioxins and furans.

The historical sample locations for the soil data evaluated in the 2019 HHERA (Arcadis 2019) are presented on Figures 3-3a and 3-3b for areas outside the TCS.

3.2 Data Usability and Data Management

The data usability criteria used to confirm that the datasets are suitable for risk assessment (USEPA 1992) include the following:

- Data sources;
- Documentation;
- Analytical methods and detection limits;
- Data review; and
- Data quality indicators.

The evaluation of the analytical data with respect to these data usability criteria is discussed in the Final RFI/RI Report Volume 3 (Jacobs 2024). The 2019 HHERA (Arcadis 2019) also includes discussion of the data usability criteria, which is not repeated here. Additionally, the specific approaches for the management of field duplicate samples and multiple analytical methods for a constituent, and calculated total concentrations (e.g., dioxin TEQ) were presented in the 2019 HHERA and are included below for convenience.

3.2.1 Management of Field Duplicate Data and Data from Multiple Analytical Methods

Consistent with the RAWP (Arcadis 2008b) and 2019 HHERA (Arcadis 2019), for cases where a field duplicate sample is present, a single representative concentration for the sample was selected generally consistent with USEPA guidance regarding data verification, data validation, and data quality assessment (USEPA 1992, 2002a). These procedures included the following:

- If there were detections in both samples, the higher concentration was selected.
- If there was a detection in one sample but not the other, the detected concentration was selected.
- If there was not a detection in either sample, the lowest method detection limit was selected and appropriate techniques for handling non-detect (ND) data were applied in calculating statistics.

3.2.2 Calculation of Total Concentrations for Mixtures

Consistent with the 2019 HHERA (Arcadis 2019) and DTSC guidance (DTSC 2015b), some mixtures of constituents with a shared mode of action were evaluated using summed concentrations of constituents in the mixture. For PAHs, individual PAHs designated by the state of California as carcinogenic (carcinogenic polycyclic aromatic hydrocarbons [cPAHs]) were addressed in terms of a benzo(a)pyrene equivalent value, or B(a)PEQ, for each sample using a toxicity equivalency factor (TEF) approach. For dioxins and furans, individual congeners were addressed in terms of a 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) TEQ, or dioxin TEQ, also using a TEF approach. For PCBs, total PCB concentrations were calculated as the sum of all Aroclors. Details related to the approach for the calculations of B(a)PEQ, dioxin TEQ for potential human receptors, and total PCBs for the HHRA are described in Sections 5.3.4 through 5.3.6 of this Post-NTCRA HHERA. Details related to the approach for the calculations of dioxin TEQ for mammal receptors (i.e., desert shrew) are described in Section 6.5.

3.3 Groupings of Data

As described in the RAWP documents (Arcadis 2008b, 2009a, 2015) and based on subsequent direction from DTSC (2017b), areas at the site were identified for independent evaluation in the 2019 HHERA (Arcadis 2019) for potential human and/or ecological exposures. These potential exposure areas are based on investigation areas historically associated with facility use or known releases and incorporate locations where additional sampling has been conducted to define the nature and extent of potential contamination associated with the investigation area. The same exposure areas were evaluated in this Post-NTCRA HHERA if NTCRA TAAs were also included within the exposure area (see Section 2.1).

Data were grouped into datasets for each potential exposure area and evaluated for the relevant potential human and/or ecological receptors, as described in this section. Figure 3-4 presents the potential exposure areas evaluated based on individual AOCs evaluated in this Post-NTCRA HHERA for the three human recreator receptors and desert shrew. Larger areas based on combined potential exposure areas were not evaluated for potential human receptors or large home-range wildlife in this Post-NTCRA HHERA because no unacceptable risk was identified in these scenarios in the 2019 HHERA (Arcadis 2019) prior to completion of the NTCRA. The potential exposure areas evaluated in this Post-NTCRA HHERA are shown in Exhibit 3-1.

Exhibit 3-1 Potential Exposure Areas Based on Individual AOCs Evaluated in the Post-NTCRA HHERA

Potential Exposure Areas Based on Individual AOCs	Sample Locations Representative of this Area	HHRA	ERA
BCW	BCW (AOC 1, AOC 28d, SWMU 1, TCS-4, Tamarisk Thicket)	Yes	Yes
AOC 9	AOC 9 and AOC 10a	Yes	Yes
AOC 10	AOC 10 and Subareas b, c, d	Yes	Yes
AOC 11	AOC 11	Yes	Yes
AOC 14	AOC 14	Yes	Yes
AOC 27	AOC 27	Yes	Yes

AOC 16, located inside the TCS, was also evaluated in this Post-NTCRA HHERA. AOC 16 was not evaluated as an individual exposure area in the 2019 HHERA (Arcadis 2019); it was evaluated for potential human health risk as part of the ICS exposure area (see Section 2.3.2). The post-NTCRA evaluation for AOC 16 is presented in Section 5.4.2.7.

In some cases, sample locations along or just outside the investigation area-specific boundaries were included in the potential exposure area dataset because the samples were collected as part of the nature and extent investigations for that specific investigation area or because there is potential for transport of soil into the exposure area. For example, as part of the 2009 AOC 4 TCRA, soil sampling was conducted at the mouth of AOC 4 where it enters BCW at the south end of BCW. During the installation of the gabions near the mouth of AOC 4, excavation of some soil was conducted. Soil samples collected at four locations (AOC 4-GB10, AOC 4-GB11, AOC 4-GB12, and AOC 4-1) are the only sample locations remaining in that area after the TCRA. In the 2019 HHERA (Arcadis 2019), these samples were evaluated as part of BCW and also as part of AOC 4; the samples were evaluated in the same manner for exposure areas evaluated in this Post-NTCRA HHERA. Details of the exact samples and sampling locations included in each potential exposure area are presented in the Data Evaluation and COPC/COPEC Selection section (Section 2) of each area-specific appendix. For the exposure areas evaluated in this Post-NTCRA HHERA, only one sample (RR-1) was evaluated in more than one exposure area; sample RR-1 was evaluated as part of the BCW and AOC 14 exposure areas.

3.3.1 Potential Human Health Exposure Areas and Depths

As previously summarized in Section 2.3.2, potential human health exposure areas evaluated in the 2019 HHERA (Arcadis 2019) included four main potential exposure areas (BCW, OCS, OCSxBCW, and ICS), BLM land within BCW NORR, 10 additional potential exposure areas associated with individual investigation areas (AOC 4, AOC 9, AOC 10, AOC 11, AOC 12, AOC 14, AOC 27, AOC 28, AOC 31, and UA-2), and two potential exposure areas related to SWMU 1/TSC-4 (SWMU 1 and BCWxSWMU1/TSC-4). For this Post-NTCRA HHERA, potential exposure areas evaluated include BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27. In these areas, potential exposure to surface soil in the 0 to 0.5 foot bgs interval and shallow soil in the 0 to 3 feet bgs interval were evaluated for risk-driving human receptors (i.e., campers, hikers, and OHV riders).

Additionally, for the two potential soil exposure areas encompassing wash areas (BCW and AOC 10), two scouring scenarios were evaluated, consistent with the 2019 HHERA (Arcadis 2019). The 2-foot scouring scenario assumes that the top 2 feet of soil is removed during potential future scouring resulting from surface runoff following heavy rainfalls. In the 2-foot scouring scenario, data in the 2 to 6 feet bgs interval in are evaluated for potential human exposures. Similarly, in the 5-foot scouring scenario, 5 feet of soil is assumed to be removed during scouring and therefore data in the 5 to 10 feet bgs interval are evaluated for potential human exposures. The selection of these exposure depths in the scouring scenarios is described in detail in the RAWP (Arcadis 2008b). As noted in Appendix BCW and Appendix AOC 10, vertical scouring of this nature has not been observed at the bottom of BCW or East Ravine (AOC 10). Lateral scouring has been observed in BCW (Section 5.4.2.1), and AOC 10 is primarily depositional within the ravine (Section 5.4.2.3). Erosion of the hillside above AOC 10, which occurred historically, has now been mitigated through placement of riprap as part of the NTCRA.

Datasets for these potential exposure areas and depth intervals were used to calculate EPCs (Section 4) and estimate risks and hazards for potential human receptors, as summarized in the post-NTCRA HHRAs (Section 5.4).

3.3.2 Potential Ecological Exposure Areas and Depths

As described in the RAWP documents (Arcadis 2008b, 2009a, 2015) and 2019 HHERA (Arcadis 2019), potential exposure of desert shrew to soil was evaluated for potential exposure areas associated with individual investigation areas. For this Post-NTCRA HHERA, these exposure areas include BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27. In these areas, potential exposure to surface soil in the 0 to 0.5 foot bgs interval was evaluated for desert shrew.

Similar to the evaluation for human health, the two soil scouring scenarios were evaluated in the BCW and AOC 10 potential exposure areas. In the 2-foot scouring scenario, data in the 2 to 3 feet bgs interval are evaluated for potential desert shrew exposures to surface soil. In the 5-foot scouring scenario, data in the 5 to 6 feet bgs interval are evaluated for potential desert shrew exposures to surface soil. The selection of these exposure depths in the scouring scenarios is described in detail in the RAWP (Arcadis 2008b).

Datasets for these potential exposure areas and depth intervals were used to estimate risks and hazards for desert shrew in the post-NTCRA ERA (Section 6).

3.4 Identification of Risk-Driving COPCs/COPECs to be Evaluated

In the 2019 HHERA (Arcadis 2019), COPCs and COPECs were selected for each medium that was included in the quantitative risk assessment after reviewing and grouping the data. The process used for identifying those constituents is described in the 2019 HHERA and is not repeated here. Risk characterization in the 2019 HHERA identified four risk-driving COPCs and/or COPECs at one or more site exposure areas: total chromium, hexavalent chromium, copper, and dioxin/furan TEQ. These risk-driving COPCs/COPECs were the target of NTCRA RAO 1: Reduce human and ecological risk related to the COCs in soil up to 10 feet bgs on or adjacent to federal land by removing soil at locations identified as driving risk in the HHERA. Consistent with the approach detailed in the January 30, 2024 Technical Memo (Arcadis 2024a), this Post-NTCRA HHERA evaluates post-NTCRA exposures (i.e., considering NTCRA-related excavation and placement of backfill) to hexavalent chromium, total chromium, copper, and dioxin TEQ. Pre-NTCRA exposures are evaluated for the remaining non-risk-driving COPCs (i.e., EPCs from the 2019 HHERA) to estimate cumulative risk in the Post-NTCRA HHRA.

As noted above, only hexavalent chromium, total chromium, copper, and dioxin TEQ. are evaluated in the post-NTCRA ERA. For the Post-NTCRA HHRA, the COPCs selected for each exposure area and depth scenario are presented in the exposure area-specific appendices. Table 3-1 presents the COPCs/COPECs evaluated in the 2019 HHERA (Arcadis 2019) as well as the risk drivers evaluated in this Post-NTCRA HHERA for each potential exposure area.

4 ESTIMATION OF EXPOSURE POINT CONCENTRATIONS

An EPC is the representative concentration of a constituent in an environmental medium that is potentially contacted by a potential receptor (USEPA 2002b). USEPA (1989) defines the EPC as “the arithmetic average of the concentration that is contacted over the exposure period.” The California Environmental Protection Agency (CalEPA) and DTSC (1996) and USEPA (1989, 1992) recommend using the 95UCL as an estimate for the EPC so that the estimate of the average (or mean) is conservative (i.e., unlikely to be underestimated).

While developing the RAWP (Arcadis 2008b) and in subsequent discussions with the stakeholders, several issues were identified associated with the nature of the available datasets and the proposed methods to calculate EPCs. The stakeholders expressed concern about the representativeness of the data given potential biases in the available data (e.g., non-uniform representation of depth intervals) and oversampling in some areas of interest. These sampling issues, the subsequent treatments of the data, and the statistical methods employed in the calculation of EPCs to address these issues are discussed in the 2019 HHERA (Arcadis 2019) and are not repeated herein. The resolution agreed upon in the 2019 HHERA for addressing the sampling issues was to evaluate three types of EPCs based on the depth-weighted soil datasets: maximum, depth-weighted 95UCL, and depth- and area-weighted 95UCL (referred to as area-weighted EPCs for simplicity).

For this Post-NTCRA HHERA, depth-weighted EPCs and area-weighted EPCs were used to estimate potential risk to recreator receptors and desert shrew. The area-weighting procedure can correct for uneven spatial coverage. In that regard, the area-weighted EPCs (which are both depth- and area-weighted) theoretically provide a better exposure estimate than the depth-weighted EPCs (which are only depth-weighted). However, comparable to the results of the 2019 HHERA (Arcadis 2019), the depth-weighted EPCs and area-weighted EPCs were similar.

Risks were not estimated using maximum depth-weighted concentrations in this Post-NTCRA HHERA because they would be considered overly conservative and are generally used for screening-level purposes. Maximum concentrations were not used for making risk-management decisions in the soil NTCRA and are not considered appropriate to evaluate in this Post-NTCRA HHERA.

Engineering controls, such as the placement of backfill, or future institutional controls are not included in this Post-NTCRA HHERA. The EPC calculation methods are consistent with those used in the 2019 HHERA (Arcadis 2019) and provide a relevant comparison to the 2019 exposure and risk estimates. As stated in the NTCRA Completion Report (Jacobs 2025), DOI-approved clean onsite fill material and imported AB material were used as backfill but the backfill material is not included in the EPC calculations. As a result, the estimated risks are likely overestimated in some areas. Additional information regarding the amount and type of backfill in each NTCRA area and uncertainties related to its potential effects on the EPCs and associated risks calculated in this Post-NTCRA HHERA are presented in Section 5.5.1.4.

4.1 Overview of Statistical Methods

In this Post-NTCRA HHERA, two types of EPCs were calculated for total chromium, hexavalent chromium, copper, and dioxin TEQ based on the depth-weighted soil datasets representing post-NTCRA conditions: depth-weighted 95UCL and depth- and area-weighted 95UCL (referred to as area-weighted EPCs for simplicity). USEPA's ProUCL version 5.2 software (USEPA 2022a) was the basis for, and primary analytical tool used for, the statistical analyses conducted for soil. For a given dataset, ProUCL was used to examine the data distribution to determine the underlying statistical distribution (via goodness-of-fit tests); based on its expert decision process, ProUCL recommends the most appropriate statistic to represent the 95UCL (e.g., based on a normal, lognormal, or gamma distribution or non-parametrically). For area-weighted EPCs, one of the methods in ProUCL, the BCa bootstrap, was applied to the data using different software and data handling to allow for incorporation of area-weighting factors (which cannot be done using ProUCL).

For all remaining non-risking driving COPCs included in the Post-NTCRA HHRA, the depth-weighted EPCs and area-weighed EPCs from the 2019 HHERA (Arcadis 2019) were used (calculated using ProUCL version 5.1 software, the current version available at that time), representing pre-NTCRA exposures to soil.

For all EPCs, an additional criterion of sample size was applied before calculating either depth-weighted or depth- and area-weighted 95UCL. Based on recommendations from ProUCL guidance (USEPA 2015, 2022b) and best professional judgement, two sample size criteria were applied to determine whether a reliable 95UCL EPC calculation can be made for a dataset: if the dataset had fewer than four detected values (i.e., concentrations reported above the detection limit) or fewer than eight total observations, the EPC defaulted to the maximum concentration in that dataset (i.e., maximum depth-weighted concentration for depth-weighted EPCs; maximum area-weighted concentration for area-weighted EPCs). Essentially, the EPC for each dataset is either a 95UCL (UCL method recommended by ProUCL for depth-weighted EPCs, BCa Bootstrap UCL for area-weighted EPCs) or the maximum depth-weighted or area-weighted concentration.

4.2 Calculation of EPCs

When sufficient data were available, depth-weighted and area-weighted EPCs were statistically estimated. Before calculating these EPCs, the soil datasets were depth-weighted to account for unequal sampling at each location. The methodology used to determine weighting factors and calculate EPCs is presented in the 2019 HHERA (Arcadis 2019) and summarized below for convenience.

For ND values, RLs for historical and NTCRA confirmation samples were handled in the same manner as in the DTSC- and DOI-approved RAWP documents (Arcadis 2008b, 2009a, 2015; DOI 2009a, 2009b, 2015; DTSC 2009a, 2015a), DTSC-issued directive letter (DTSC 2017), and DTSC- and DOI-approved 2019 HHERA (Arcadis 2019, 2020; DOI and DTSC 2020). A value of half the RL was used for ND values in the depth-weighting process, and the resulting depth-weighted data for in-place native soil sample locations were used in ProUCL to calculate a representative 95UCL as the EPC.

4.2.1 Depth-Weighting Approach

Before calculating soil EPCs, samples from each unique location in this Post-NTCRA HHERA dataset (as described in Section 3.3) were combined into a single depth-weighted value. The rationale for depth-weighting and methodology used to implement this approach were presented in the RAWP Addendum 2 (Arcadis 2015) and are summarized in this section.

At facilities where extensive sampling programs have been conducted for a variety of purposes, such as at the site, it is not uncommon for the dataset to contain unequal or unbalanced representations of different locations (i.e., samples collected from the same location over multiple core depths and segment thicknesses). The core depths and segment thicknesses vary by sample location. To develop an estimate of the mean concentration of a constituent in soil that is representative of a potential receptor's exposure, some consideration is required in the treatment of unequal datasets.

USEPA (1996a, 1996b) guidance recommends depth-weighting to account for uneven sampling. Specifically, the guidance recommends that the average concentration at a sample location in the representative exposure interval accounts for the different lengths of the sample core segments. This risk assessment uses this approach for calculating the depth-weighted average concentration at each sampling location, as specified in the RAWP and RAWP Addendum 2 (Arcadis 2008b, 2015). The guidance recommends that if samples are collected at equal depth intervals, the arithmetic mean concentration from the surface to the maximum sampled core depth can be used to estimate the average concentration for that location. However, when samples have unequal depth-segment thicknesses (e.g., some are collected over a span of 6 inches while others are collected over a span of 2 feet), the average calculation must account for the different segment lengths.

At the site, soil samples have been collected for multiple objectives over a period of several decades, resulting in unequal sampling depths and segment thicknesses. For most potential exposure areas, soil samples collected from each location have variable depth profiles (i.e., co-located samples). Despite the variability in segment thicknesses, most of the co-located soil samples were collected within the exposure depth intervals defined for the risk assessment, which allows for a straightforward depth-weighting process to be implemented.

The following simple decision tree was used to calculate the average concentration for co-located samples in a manner which reflects USEPA (1996a, 1996b) recommendations:

- For a given relevant exposure depth for the risk assessment, if only a single sample is available at a given location, that value was used to represent the concentration for the entire exposure depth.
- For locations with samples from multiple depths, the samples were weighted to account for the different lengths of the segments in the manner described in USEPA 1996a and 1996b.
- Furthermore, a given segment length is represented by the interval from an individual sample within that segment down to the top of the next available sample.

This approach was described in the RAWP Addendum 2 (Arcadis 2015) to ensure that depth-weighting resulted in conservative EPC estimates based on the assumption that site-related soil constituent concentrations are highest in surface soil. Each sample's weight is the proportional contribution of its length to the overall exposure depth. The depth-weighting approach is illustrated in examples provided in the 2019 HHERA (Arcadis 2019).

In the depth-weighting procedure, ND values were replaced with half the RL for all results except those that were calculated total values. For results that were calculated total values (i.e., result values for B(a)PEQ, dioxin TEQ, total PCBs, and total high molecular weight [HMW] and low molecular weight [LMW] PAHs), the full value of any ND calculated total was used because the calculated total result value already includes half the RL or zero value for individual dioxin/furan, Aroclor, and PAH ND results. (It should be noted that LMW PAHs are PAHs with less than or equal to three benzene rings; parent LMW PAHs include naphthalene, acenaphthylene, acenaphthene, fluorene, anthracene, and phenanthrene. HMW PAHs are defined as PAHs with greater than three benzene rings; parent HMW PAHs include pyrene, fluoranthene, benz(a)anthracene, chrysene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, and dibenz(a,h)anthracene [Arcadis 2008a].)

4.2.2 Soil EPCs

For soil datasets for total chromium, hexavalent chromium, copper, and dioxin TEQ, depth-weighted and area-weighted EPCs were calculated, as described in this section. The maximum EPC was selected to represent the 95UCL EPC when insufficient data existed to reliably calculate a 95UCL. The ProUCL input datasets and 95UCL ProUCL output results for depth-weighted EPCs are presented in Attachment A2 of each exposure area-specific appendix; equivalent input and output data for area-weighted EPCs are presented in Attachment A3 of each exposure area-specific appendix.

For all remaining non-risking driving COPCs included in the Post-NTCRA HHRA, the depth-weighted EPCs and area-weighed EPCs from the 2019 HHERA (Arcadis 2019) were used.

4.2.2.1 Depth-Weighted Soil EPCs

For total chromium, hexavalent chromium, copper, and dioxin TEQ in the post-NTCRA datasets, depth-weighted 95UCL EPCs were calculated from the soil datasets using ProUCL version 5.2 and the recommended UCL method in the ProUCL output was selected as the depth-weighted 95UCL EPC. When ProUCL recommended two or more 95UCL estimates, the relative percent difference (RPD) was used to compare the 95UCL values: if the RPD was less than 5%, the higher UCL was conservatively selected; if the RPD was greater than or equal to 5%, the estimate that, based on the rationales presented in Exhibit 4-1, best represents the dataset was selected as the depth-weighted 95UCL EPC.

Exhibit 4-1 UCL Decision Tree for ProUCL 5.2

ProUCL: Potential UCL(s) to Use	UCL Method Used for Topock EPCs	Rationale
95% KM adjusted gamma UCL 95% GROS adjusted gamma UCL	95% KM adjusted gamma UCL	GROS adjusted gamma is more vulnerable to the effects of outliers.
95% KM approximate gamma UCL 95% GROS approximate gamma UCL	95% KM approximate gamma UCL	GROS approximate gamma is more vulnerable to the effects of outliers.

ProUCL: Potential UCL(s) to Use	UCL Method Used for Topock EPCs	Rationale
95% KM bootstrap t UCL 95% Hall's bootstrap	95% KM bootstrap t UCL	Hall's UCL can be inflated by outliers resulting in an impractically large and unstable value.

Notes:

GROS = gamma regression on order statistics

KM = Kaplan-Meier

t = student's t-statistics

4.2.2.2 Area-Weighted Soil EPCs

Sampling programs often collect more samples in spots known or suspected of higher concentrations or "hot spots." The consequence of this over-representation of the highest concentrations in the distribution of all possible values (concentrations) is that the associated EPC is potentially biased high and, thus, overestimates potential exposure and thus risk. More sophisticated methods can correct for sampling bias and provide a more accurate estimate of the EPC. Spatially explicit EPCs are widely used in risk assessment to account for biased sampling design, as noted by USEPA (2001) and Thayer et al. (2003). CalEPA and DTSC guidance (1996) and the Interstate Technology and Regulatory Council (ITRC) guidance on decision-making for contaminated sites (ITRC 2015) also recommend using spatially weighted (i.e., area-weighted) averages. Area-weighting techniques control for the effects of oversampling in areas of high concentration, such as is typical in site investigations designed to determine the extent of potential contamination. An area-weighted technique was utilized in the 2019 HHERA (Arcadis 2019) and this Post-NTCRA HHERA; details related to area-weighted EPC calculations are repeated here for convenience. Thiessen polygons are the basis for a standard technique to perform an objective area-weighting of sample values, where each sample is associated with a unique location in the field of interest. The appropriateness of its application in this risk assessment is discussed in the RAWP Addendum 2 (Arcadis 2015). In two dimensions, Thiessen polygons are constructed from straight lines, drawn equidistant between adjacent sample locations, such that every point within a given polygon is closer to the sample location contained within that polygon than any other sample location. The area associated with each Thiessen polygon was used to calculate the proportional weight for each sample location in calculating the statistics of a dataset. The potential exposure area boundaries were used to define the outer polygon boundary for sample locations along the boundary. This approach is necessary as the sample locations on the outer edge of a potential exposure area have no adjacent sample locations, beyond the potential exposure area, with which an equidistant line may be drawn to close the Thiessen polygon. The Thiessen polygon maps (figures in Attachment A3 of each exposure area-specific appendix) illustrate this situation and how the potential exposure area boundary closes certain Thiessen polygons.

With the depth-weighted concentration and the associated area represented by the Thiessen polygon for each sample, a bootstrap technique was used to estimate the 95UCL of the mean of area-weighted sample values for the EPC. The method used here, the BCa bootstrap, is one of the non-parametric statistics provided in ProUCL for the calculation of the 95UCL and it is identified in the literature—as well as in ProUCL guidance—as a robust and conservative bootstrap method for confidence interval estimation when the underlying distribution is skewed, as is frequently the case with chemical concentrations measured in samples of physical media.

Area-weighting is necessary to control the effect of potential hot spots and biased sampling on the EPC calculations, but ProUCL cannot accommodate weighting factors such as these, based on the Thiessen polygons, into its BCa bootstrap calculation and so an R subroutine for the BCa bootstrap analyses (Ripley 2017) was used, consistent with the 2019 HHERA (Arcadis 2019).

Maps are provided in Attachment A3 of each exposure area-specific appendix for each area-weighted 95UCL calculation (i.e., for total chromium, hexavalent chromium, copper, and dioxin TEQ and each depth interval and potential exposure area used to calculate an area-weighted 95UCL) as a visual representation of how the spatial distribution of samples and their concentrations might impact the calculation of a given EPC. The maps display the Thiessen polygons used in the area-weighting, and the depth-weighted sample concentrations are represented by colors reflecting ranges of concentrations. The colors represent concentration ranges based on site-specific background threshold values (BTVs) and applicable NTCRA RAGs for each constituent. The RL is used to represent the concentration for ND samples, and ND concentrations are distinguished by hatching on the figures. The maps are provided in Attachment A3 for each exposure area-specific appendix.

5 HUMAN HEALTH RISK ASSESSMENT FOR SOIL

This section describes the quantitative HHRAs for potential exposure areas outside of the TCS fence line following completion of the NTCRA activities (i.e., BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27) to confirm that post-NTCRA soil conditions in these exposure areas do not pose an unacceptable risk to human health or the environment. A qualitative HHRA conducted for AOC 16 is also discussed in this section. This section includes the purpose and objectives, exposure and toxicity assessments, the approach for the HHRA, and a summary of the updated risk characterization for potential human risk-driving receptors (i.e., the camper, hiker, and OHV rider) identified in the 2019 HHERA (Arcadis 2019). The approach used in the HHRAs to evaluate residual risk following the NTCRA activities is consistent with the methodology presented in the agency-approved RAWP documents (Arcadis 2008b, 2009a, 2015) and used to estimate risks and hazards in the 2019 HHERA. The same exposure and risk assumptions (with updates to toxicity values if applicable) will be used in this Post-NTCRA HHERA.

5.1 Purpose and Objectives

As stated in Section 1.2, the purpose of the HHRA included in this Post-NTCRA HHERA is to (1) document that RAO 1 of the NTCRA was achieved, specifically by presenting exposure area-specific EPCs for comparison to the numerical RAGs (e.g., RBRGs) in areas outside of the TCS fence line where NTCRA removals were conducted and (2) provide updated risk estimates for human health and the environment based on potential exposures to current soil conditions in the NTCRA areas. Additionally, the objectives listed below are part of the overall goal of risk assessment at the site and include the following:

- Inform the RCRA corrective action and CERCLA remedy process by providing risk managers with risk characterization results for residual concentrations of risk-driving COPCs targeted during NTCRA and other related investigations;
- Provide estimates of potential site-related risks to potential human receptors;
- Provide spatial context for the risk estimates; and
- Convey the magnitude and direction of uncertainty associated with the risk estimates.

As stated previously, this Post-NTCRA HHERA provides updated risk estimates for human health and the environment based on potential exposures to current soil conditions in the NTCRA areas. Therefore, updated risk estimates were not performed for the OCS potential exposure area in the Post-NTCRA HHERA. It is noted that due to NTCRA soil removal, the potential post-NTCRA OCS soil risks are likely lower than estimated in the 2019 HHERA (Arcadis 2019).

The findings and conclusions of this post-NTCRA HHERA will be used in conjunction with the findings of the 2019 HHERA (Arcadis 2019) to develop risk-management decisions for the site that will be used in the CMS/FS portion of the environmental program to develop and evaluate remedial alternatives protective of potential human receptors. Ultimately, the conclusions reached from conducting the HHRA along with other site information will be used to establish an overall site risk-management strategy. These objectives are consistent with the USEPA's defined functions of an HHRA (USEPA 1989).

Exposure and toxicity assessments, and risk characterization for potential human receptors, are summarized in the following sections for the HHRA.

5.2 Exposure Assessment

Exposure assessment is the process of describing, measuring, or estimating the intensity, frequency, and duration of potential human exposure to COPCs in environmental media (e.g., soil, soil gas, air). This Post-NTCRA HHERA follows the methodology approved in the RAWP documents (Arcadis 2008b, 2009a, 2015) and used in the 2019 HHERA (Arcadis 2019). This section describes the previously agreed mechanisms by which people (receptors) might come in contact with the COPCs present in soil and subsurface soil gas at the site. During the exposure assessment, potentially exposed receptors and potentially complete exposure pathways were identified, and pathway-specific exposures were quantified using EPCs to reflect post-NTCRA conditions and intake assumptions taken from the 2019 HHERA.

An exposure assessment is best conducted within the context of a CSM, which shows the relationships between a chemical source (discussed previously in Section 2.6), potential exposure pathway, and potential receptor. The CSMs were originally prepared in the RAWP (Arcadis 2008b) and were updated and refined in the RAWP Addendum 2 (Arcadis 2015) and presented in the 2019 HHERA (Arcadis 2019) and discussed in Section 2.6. Only those potentially complete source-pathway-receptor relationships for the recreational users in area outside of the TCS fence line are quantitatively evaluated in this Post-NTCRA HHERA and are the same as those evaluated in the 2019 HHERA.

5.2.1 Potentially Exposed Populations and Complete Exposure Pathways

The exposure assessment in the 2019 HHERA (Arcadis 2019) identified plausible human receptors that may be potentially exposed to site-related constituents in contaminated media under current and reasonably anticipated future site-use scenarios and identified the direct and indirect pathways by which they could potentially be exposed to site-related constituents. The appropriateness of including any given receptor scenario is a site-specific determination and depends on the potentially contaminated media, the extent of contamination, and the plausibility that human receptors would be exposed to the contamination.

Risk-driving human receptor identified in the 2019 HHERA (Arcadis 2019), specifically recreational users, the camper, hiker, and OHV rider, are evaluated in this Post-NTCRA HHERA and described below.

As previously described in the 2019 HHERA (Arcadis 2019), the lands managed by the BLM, USFWS, and USBR near the site are largely undeveloped, but there are several recreational opportunities available. DOI (2014a) provided information to PG&E about the types of recreational activities that could occur at the site and the corresponding potential exposure scenarios and exposure assumptions that were incorporated into the HHRA. The recreational user was evaluated in the 2019 HHERA for OCS areas including BCW and other AOCs for potential future land use.

As recommended by DOI, it was assumed that the recreational activities could take place at any location on federal land. However, specific locations may be preferred for certain activities, while other locations may be less attractive or may have limited recreational options (e.g., HNWR). As stated by DOI, the most probable recreational land-use activities on federal land and the associated potential receptors are camper, hiker, hunter, and OHV rider (OHVs are also referred to as ATVs). These potential recreational users were evaluated in the HHRA. This description of the recreational user scenarios is consistent with the DOI memorandum (2014a), the RAWP Addendum 2 (Arcadis 2015), and OSWER Directive No. 9355.7-04, Land Use in the CERCLA Remedy Selection Process (USEPA 1995).

Adults and youth (identified as “child” receptors in the HHRA) recreational users may access areas of the site for sporadic and short periods of time. The potential adult and/or child receptors are evaluated in the 2019 HHERA (Arcadis 2019) and in this Post-NTCRA HHERA for exposure to surface soil (0 to 0.5 foot bgs) and shallow soil (0 to 3 feet bgs) under all recreational site-use scenarios. It is assumed that the recreational user would contact only surface soil (0 to 0.5 foot bgs) and shallow soil (0 to 3 feet bgs) and would not conduct intrusive activity at depths below 3 feet bgs. Potential soil exposure pathways for these receptors include incidental ingestion, dermal contact, and inhalation of dust in ambient air. Another potential exposure pathway is inhalation of VOCs that may volatilize from the soil. As was evaluated in the 2019 HHERA, exposure of recreational receptors to vapors in outdoor air was evaluated in this Post-NTCRA HHERA, although the data indicate only a very minimal presence of VOCs in soil and soil vapor. In the 2019 HHERA, VOCs in soil from the 0 to 10 feet bgs depth interval were assumed to volatize into outdoor air. EPCs for VOCs in soil from the 0 to 10 feet bgs depth interval calculated and used in the 2019 HHERA were conservatively assumed to be the same post-NTCRA and conservatively used as EPCs for the evaluation of the inhalation of VOCs vapors in outdoor air exposure pathway in this Post-NTCRA HHERA.

5.2.2 Potential Exposure Areas

Potential exposure areas outside of the TCS fence line where NTCRA activities were conducted that are quantitatively evaluated in this Post-NTCRA HHERA include BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 to confirm that post-NTCRA soil conditions in these exposure areas do not pose an unacceptable risk to human health or the environment. These exposure area-specific risk evaluations are provided in individual appendices named for each exposure area.

As described in the RAWP Addendum 2 (Arcadis 2015), part of the evaluation of the BCW and AOC 10 potential exposure areas included a scouring evaluation. Both of these wash features at the site channel stormwater runoff flow during heavy storms. It is possible that surface soil may become entrained in the runoff and transported away, resulting in concentrations of chemicals that were previously in the subsurface to the surface. Consistent with the 2019 HHERA (Arcadis 2019), two scouring scenarios were evaluated in this Post-NTCRA HHERA for the BCW and AOC 10 potential exposure areas; one assumes the top 2 feet of soil was removed due to scouring, and the other assumes the top 5 feet of soil was removed due to scouring. Then risks and hazards were estimated for the potential receptors and exposure pathways for the BCW and AOC 10 potential exposure areas, assuming the surface was shifted to the 2-foot or 5-foot depth. Additional details regarding estimation of EPCs are provided in Section 5.2.3. As noted in Appendix BCW and Appendix AOC 10, vertical scouring of this nature has not been observed at the site. Lateral scouring has been observed in BCW (Section 5.4.2.1), and AOC 10 is primarily depositional (Section 5.4.2.3).

NTCRA activities were conducted at AOC 16, located inside the TCS. AOC 16 was evaluated qualitatively in this Post-NTCRA HHERA.

5.2.3 Exposure Point Concentrations

The different potential exposure areas and soil depth intervals used to estimate EPCs and evaluate risks for the risk-driving human receptors, the camper, hiker, and OHV rider, in this Post-NTCRA HHERA are discussed in this section. EPCs are estimated for each of the depth intervals and potential exposure areas associated with each potential human receptor evaluated in this Post-NTCRA HHERA. Exposure depth intervals and areas are discussed for recreational users (campers, hikers, and OHV riders) engaged in activities outside the TCS.

Figure 5-1 shows the areas of the site associated with the various land uses and human receptors evaluated in in the 2019 HHERA (Arcadis 2019). Soil data collected from the potential exposure areas, BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27, are evaluated by depth, based on the CSMs for the soil HHRA (Section 2.6). All potential receptor populations were evaluated with respect to direct and/or indirect contact with surface and shallow soil as described previously in Section 5.2.1. To ensure that the implications of averaging concentrations over one depth zone versus another are clearly understood, this HHRA evaluates representative post-NTCRA EPCs for soil within the following depth categories:

- Surface soil (0 to 0.5 foot bgs); and
- Shallow soil (0 to 3 feet bgs).

For the BCW and AOC 10 potential exposure areas, a 2-foot and 5-foot scouring scenario was assumed. These scouring scenarios, as previously described in Section 5.2.2, were included for consistency with the scenarios evaluated in the 2019 HHERA (Arcadis 2019) and assume that heavy rainfall events can lead to erosion of surface soil.

Under a 2-foot scouring scenario, this Post-NTCRA HHERA evaluated representative EPCs for soil within the following depth categories:

- Surface soil (data collected at 2 to 3 feet bgs); and
- Shallow soil (data collected at 2 to 6 feet bgs).

Under a 5-foot scouring scenario, this Post-NTCRA HHERA evaluated representative EPCs for soil within the following depth categories:

- Surface soil (data collected at 5 to 6 feet bgs); and
- Shallow soil (data collected at 5 to 10 feet bgs).

5.2.3.1 EPC Datasets for Recreational Users Outside TCS

The TCS is owned by PG&E, fenced, and planned for continued use as an industrial site for the foreseeable future. The area inside the TCS fence line is not accessible to recreational users. However, all areas outside the TCS fence line are open and accessible to recreational users, who may use the area for a variety of recreational activities, such as camping, hiking, hunting, and riding an ATV. For this Post-NTCRA HHERA, the risks for soil contact for the potential recreational user were estimated using EPC dataset for the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas to address the complete exposure pathways shown on the CSMs (Figures 2-5 and 2-6).

For direct contact soil pathways (i.e., soil ingestion, dermal contact, and inhalation of particulates), sample data within the top 3 feet of soil were assumed to be available for contact for the potential recreational receptor. To understand the potential implications of averaging concentrations over one depth zone versus another, the risk assessment evaluated representative EPCs for soil within the following depth categories: surface soil (0 to 0.5 foot bgs) and shallow soil (0 to 3 feet bgs). Potential receptors are not likely to contact soil at depth without having to penetrate the soil above that depth. For example, the potential recreational user would not contact soil in the interval from 0.5 to 3 feet bgs without having to go through the material in the 0- to 0.5-foot interval above it. However, depending on their activities, they might only go as far as 0.5 foot and not all the way to 3 feet.

The EPCs for COPCs in surface soil (0 to 0.5 foot bgs) and shallow soil (0 to 3 feet bgs) are presented in Table 3.1 in the exposure area-specific appendices.

5.2.3.2 EPCs for Air

Concentrations of constituents in air were estimated in this Post-NTCRA HHERA as dust and VOCs in ambient air (if data indicate the presence of VOCs). The methodologies employed to model the transport of chemicals from soil to ambient air are described in detail in the 2019 HHERA (Arcadis 2019) and summarized this section.

5.2.3.2.1 Dusts

The estimation of EPCs for compounds present in the particulate form (i.e., adsorbed onto soil particulates) requires the determination of the quantitative relationship between constituent concentrations in the soil (in mg/kg) and the concentration of respirable particulates (particulate matter of 10 micrometers or less in diameter) in the air due to fugitive dust emissions. Particulate emissions are due to wind erosion and, therefore, depend on the erodibility of the surface material. The 2019 HHERA (Arcadis 2019) used the particulate emission factor (PEF) as recommended by DOI for recreational users and by DTSC for residents, as detailed in RAWP Addendum 2 (Arcadis 2015).

Predicted air concentrations of constituents in the particulate phase were estimated by dividing the concentration of each constituent in the soil (in mg/kg) by the PEF in units of cubic meters of air per kilogram of dust).

A primary potential exposure concern associated with recreational users riding OHVs in the area is the generation and subsequent inhalation of airborne particulate matter. With their large wheels, OHVs such as ATVs can release relatively large amounts of surface soil into the ambient air when they are ridden. For the OHV rider population, it was necessary to identify an appropriate PEF that provides an estimate of the airborne level of respirable dust resulting from riding OHVs. USEPA (1991a) has developed a generic PEF for evaluating wind-blown fugitive dust from surface contamination sites, but that scenario does not account for the agitation of the soil as aggressively as the tires of an OHV.

Therefore, DOI reviewed available and relevant studies to recommend a PEF that should be used at the site to represent inhalation exposures for the OHV rider. Based on the studies reviewed, DOI (2014a) recommended the PEF derived for the Standard Mine Site in Colorado for OHV riding because that PEF was based on actual measurements collected during OHV riding. DOI considered the PEF from the Standard Mine Site, 8.47E+05 cubic meters of air per kilogram of dust, to be the most accurate value for estimating airborne respirable dust levels from OHV riding at the site. Accordingly, as presented in the RAWP Addendum 2 (Arcadis 2015), the DOI-recommended value was used as the PEF for estimating air EPCs and associated inhalation risks from OHV riding at the site.

Outdoor air potential exposure concentrations (ECs) in particulates for all population of concern were developed using the EPCs calculated for nonvolatile compounds in soil for each of the NTCRA impacted representative potential exposure areas and the applicable PEF.

5.2.3.2.2 EPCs for Inhalation of VOCs

The method used in this Post-NTCRA HHERA to estimate EPCs for inhalation of VOCs follows that used in 2019 HHERA (Arcadis 2019) as summarized in this section.

The estimation of EPCs for VOCs present in soil requires the determination of the quantitative relationship between chemical concentrations in the soil (in mg/kg) and the concentration of VOCs in air due to VOC emissions from soil. Although only very minimal levels of select VOCs were detected in soil, the volatilization factor equation presented in the USEPA Soil Screening Guidance (1996a, 1996b) was used to estimate <u>outdoor</u> ambient air exposures to VOCs for receptor populations of concern. Transport of volatile constituents from soil to outdoor air was modeled as two distinct processes: the volatilization of chemicals from soil to the ground surface and the dispersion of the chemicals from the ground surface into the ambient air using the approach recommended in the USEPA Soil Screening Guidance (1996a, 1996b). These two processes are accounted for in the calculation of the volatilization factor described in Appendix AM of the 2019 HHERA (Arcadis 2019).

5.2.4 Exposure Assumptions

The exposure assumptions used in this Post-NTCRA HHERA to estimate risks to human health are the same as those used in 2019 HHERA (Arcadis 2019) as summarized in this section.

Constituent intake is the amount of the constituent entering the potential receptor's body. The risk assessment process follows regulatory guidance for both the calculation methods (e.g., equations used) and input terms used to estimate exposure. The calculation equations and input terms used in this HHRA are provided in the following guidance documents:

- Preliminary Endangerment Assessment Guidance Manual (DTSC 2015b);
- Human Health Risk Assessment (HHRA) Note Number 1: Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Hazardous Waste Sites and Permitted Facilities (DTSC 2019b);
- Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A) (USEPA 1989);
- Exposure Factors Handbook, Volume I: General Factors (USEPA 1997c);
- Exposure Factors Handbook, Volume III: Activity Factors (USEPA 1997d); and
- Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E: Supplemental Guidance for Dermal Risk Assessment) (USEPA 2004).

The amount of constituent contacted depends upon activity patterns of the potential receptor and the nature of the environmental media containing the COPC. Key components contributing to intake of site-related compounds include the following:

CR = contact rate, the amount of environmental medium contacted per unit time or event. There are different units depending on whether exposure occurs via ingestion, dermal contact, or inhalation (e.g., milligram per day for soil ingestion).

EF = exposure frequency, accounts for how often exposure occurs (days per year).

ED = exposure duration, describes the length of the exposure (years).

BW = body weight, the average BW of the exposed individual receptor (kilograms [kg]).

AT = averaging time, period over which exposure is averaged (days). This term varies based on whether the compound being evaluated is a carcinogen or noncarcinogen.

The values available for each of the exposure factors can vary according to the type of receptor (e.g., recreational user) and the age and sex, for some components. Site-specific exposure assumptions, as presented in the RAWP and RAWP Addendum 2 (Arcadis 2008b, 2015), are used in this Post-NTCRA HHERA for soil direct and/or indirect contact for the recreational users, as described in this section.

Specific exposure parameters that were selected for each scenario along with the rationale for selection are described in the following sections for the potential receptors. Consistent with regulatory guidance, exposure assumptions were developed using reasonable maximum exposure (RME) assumptions. The intent of the RME approach is to estimate the highest exposure level that could be reasonably expected to occur, but not the worst possible case (USEPA 1989, 1991b). In keeping with USEPA guidance, variables chosen for a baseline RME scenario for intake or contact rate, exposure frequency, and exposure duration were generally upper bounds. All exposure scenarios included an evaluation of both cancer and noncancer (systemic) potential health impacts, depending on the toxicity characteristics for each compound and the relevance for the exposure pathway.

Potential recreational land use and associated potential exposure are expected to occur only in areas outside the TCS. Potential direct contact pathways for exposure to soil for the recreational adult and child include incidental ingestion, dermal contact, and inhalation of dust. The exposure assumptions for this exposure scenario were developed using site-specific input from DOI.

DOI (2014a) has provided information to PG&E about the types of recreational activities that could occur at the site and the corresponding exposure scenarios and exposure assumptions that were incorporated into the 2019 HHERA (Arcadis 2019) and in this Post-NTCRA HHERA. As recommended by DOI, it was assumed that each of the recreational activities could take place at any location on federal land. However, specific locations may be preferred for certain activities, while other locations may be less attractive or may have limited recreational options (e.g., HNWR). As stated by DOI, of the most probable recreational land-use activities on federal land, only the following were found to require additional evaluation, and were included in this HHRA: hiking, camping, and OHV riding.

The exposure parameters proposed by DOI for recreational visitors on federal land near the site are based on site-specific considerations and information provided from nearby sites and relevant sources. To protect human health, it is assumed herein that a participant's entire annual recreational activity is conducted at the site rather than spread out at various recreational locations across the state. A camper is assumed to visit the site 8 days per year while a hiker or OHV rider is assumed to visit the site 16 days per year. The camper and hiker are each assumed to be at the site the entire 24-hour day while the OHV rider is assumed to be onsite for 1.5 hours per day. An exposure duration of 30 years is consistent with those used in the Clear Creek Management Area HHRA (USEPA 2008a) for similar activities.

The recreational user exposure assumptions used in this Post-NTCRA HHERA are summarized in Table 5-1. These exposure assumptions were used in formulas for developing the chronic daily intakes (CDIs) and ECs for estimating health risks for recreational users presented in Tables 5-2a and 5-2b.

5.3 Toxicity Assessment

The methodology and resources for the toxicity assessment used in this Post-NTCRA HHERA follows that used in 2019 HHERA (Arcadis 2019) as summarized in this section and subsections. Some toxicity values have been updated, when applicable per relevant guidance, as indicated below.

The HHRA included a toxicity assessment, which characterized the relationship between the magnitude of exposure to a constituent and the potential for adverse health effects. The toxicity assessment identified agency-promulgated or derived toxicity values that were used to estimate the likelihood of adverse health effects occurring in humans at different exposure levels. The approach for the toxicity assessment was provided in the RAWP (Arcadis 2008b) and RAWP Addendum 2 (Arcadis 2015). Consistent with regulatory risk assessment policy, adverse health effects resulting from potential chemical exposures were evaluated in two categories: carcinogenic effects and noncarcinogenic effects. The hierarchy of sources for the toxicity criteria that was used in this Post-NTCRA HHERA has been updated from the 2019 HHERA (Arcadis 2019) and is compliant with the September 4, 2018, “Toxicity Criteria for Human Health Risk Assessments, Screening Levels, and Remediation Goals” (“Toxicity Criteria Rule”, Title 22, California Code of Regulations, Sections 68400.5, 69020-69022) at the time of preparation of the Post-NTCRA HHERA and is discussed in more detail in this section.

5.3.1 Toxicity Assessment for Carcinogenic Effects

Current HHRA practice for carcinogens assumes that, for most substances, there is a no-threshold dose below which carcinogenic effects do not occur. This current “no-threshold” assumption for carcinogenic effects assumes that the carcinogenic processes are the same at high and low doses. This approach has generally been adopted by regulatory agencies as a conservative practice to protect public health, and the “no-threshold” assumption has been used in the agency-derived cancer slope factors (CSFs) and unit risk factors (URFs) used in the HHRA. Although the magnitude of the risk declines with decreasing exposure, the risk was assumed to be zero only at zero exposure.

The toxicity values used to quantify the response potency of a potential carcinogen are the following:

- The CSF, used to assess the oral and dermal routes of exposure, represents the incremental lifetime cancer risk (ILCR) due to a continuous, constant lifetime exposure to a specified level of a carcinogen generally reported as ILCR per milligram of constituent per kilogram per day ($[mg/kg/day]^{-1}$).
- The URF, used to assess the inhalation route of exposure, represents the ILCR due to a continuous, constant lifetime exposure to a specified level of a carcinogen in the air, generally reported as ILCR

per microgram of chemical per cubic meter of air ([µg/m^3]$^{-1}$); URFs are reported as ILCR per milligram of chemical per cubic meter of air ([mg/m^3]$^{-1}$) in Table 5-3 for risk calculation purposes.

CalEPA and USEPA have published a list of CSFs and URFs recommended for use in risk assessments. In general, the toxicity values for carcinogenic effects used in the HHRA were selected values obtained from the Office of Environmental Health Hazard Assessment (OEHHA) Toxicity Criteria Database (OEHHA 2024) or the USEPA Integrated Risk Information System online database (USEPA 2024a) as included in Appendix I of the Toxicity Criteria Rule or in DTSC's Human and Ecology Office Human Health Risk Assessment (HHRA) Note Number 10 (DTSC 2019a). In the absence of carcinogenic toxicity criteria from these sources, the National Center of Environmental Assessment/Superfund Health Risk Technical Support Center (Office of Superfund Remediation and Technology Innovation [OSRTI] 2024) was used as an additional resource, as recommended by the USEPA (2024b). If CSFs or URFs have not been promulgated by either OEHHA or USEPA, the constituent was not evaluated as a carcinogen.

Neither URFs nor CSFs were available for a few COPCs belonging to carcinogenic classes of compounds. In these cases, surrogate chemicals were chosen based on structural similarity (e.g., chemicals in the same suite of compounds with similar carbon chain structures, such as aromatic carbon rings, and/or group of molecules) to avoid underestimating potential carcinogenic hazards as follows:

- Alpha-chlordane and gamma-chlordane were represented by technical chlordane.
- Dioxin TEQ for the evaluation of human health (TEQ human) was represented by 2,3,7,8-TCDD.

The surrogate chemicals selected in the Post-NTCRA HHERA are the same surrogate chemicals selected in the 2019 HHERA (Arcadis 2019).

The CSFs and/or URFs for six COPCs (i.e., arsenic, methylene chloride, 1-methylnaphthalene, alpha-chlordane, gamma-chlordane, and total PCBs) evaluated in the HHRA were updated from the values used in the 2019 HHERA (Arcadis 2019). Table 5-3 presents the CSFs and URFs used in the HHRA for the COPCs in soil. As indicated, COPCs that are currently regulated as carcinogens include arsenic, cadmium (via inhalation only), hexavalent chromium, cobalt (via inhalation only), nickel (via inhalation only), chloroform, isophorone, methylene chloride, bis (2-ethylhexyl) phthalate, 1-methylnaphthalene, naphthalene, cPAHs as B(a)PEQ, 4,4-dichlorodiphenyldichloroethylene, alpha-chlordane, gamma-chlordane, dieldrin, total PCBs, and TEQ human.

<u>Age-Dependent Adjustments for Mutagens</u>

A few of the COPCs at the site that are currently regulated as carcinogens (B(a)PEQ, hexavalent chromium, and methylene chloride), operate by a mutagenic mode of action, meaning these COPCs may cause irreversible changes to DNA, and therefore may exhibit a greater effect in early-life versus later-life exposure (USEPA 2024b). To account for these life-stage differences in receptor populations that include children (recreational users [camper, hiker, and OHV rider]), separate equations were used to calculate ILCRs for mutagens that include age-dependent adjustment factors (ADAFs) (USEPA 2005b, 2024b). Specifically, for the camper and hiker recreational user and hypothetical future resident receptor populations evaluated in this HHRA, ADAFs of 10, 3, and 1 were used for mutagens for exposure from 0 to 2 years of age, 2 to 16 years of age, and 16 to 26 years of age, respectively (Table 5-2b). For the OHV rider recreational user receptor populations evaluated in the HHRA, ADAFs of 3 and 1 were used for mutagens for exposure from 6 to 16 years of age and 16 to 32 years of age, respectively (Table 5-2b).

Hexavalent chromium, methylene chloride, and B(a)PEQ were evaluated using the carcinogenic toxicity values presented in Table 5-3 and the equations presented in Table 5-2b.

5.3.2 Toxicity Assessment for Noncarcinogenic Effects

The toxicity assessment for noncarcinogenic effects requires the derivation of an exposure level below which no adverse health effects in humans are expected to occur. USEPA refers to these levels as reference doses (RfDs) for oral and dermal exposures and reference concentrations (RfCs) for inhalation exposures (USEPA 1989). In the case of the CalEPA, noncarcinogenic oral and inhalation criteria, as derived by OEHHA, are referred to as reference exposure levels (RELs). The noncancer RfD/REL represents a dose, given in milligrams per kilogram of per day (mg/kg/day), that would not be expected to cause adverse noncancer health effects in potentially exposed populations and is often referred to as the acceptable dose. The noncancer RfC/REL represents the airborne concentration (in units of micrograms per cubic meter; however, reported as milligram per cubic meter [mg/m^3] in Table 5-3 for risk calculation purposes) that would not be expected to cause adverse noncancer health effects in populations exposed through the inhalation pathway.

Consistent with DTSC's recommendation (DTSC 2019a), in general, the RfD/REL and RfC/REL obtained from either the OEHHA Toxicity Criteria Database (2024) or the USEPA sources listed in this section were used in this Post-NTCRA HHERA.

As recommended by USEPA (2003b), the hierarchy of USEPA toxicity values for noncarcinogenic effects for the oral and inhalation exposures (i.e., RfDs and RfCs, respectively) used in the 2019 HHERA (Arcadis 2019) and this Post-NTCRA HHERA is as follows:

1. USEPA-recommended RfDs and RfCs as maintained on the Integrated Risk Information System online database (USEPA 2024a);
2. Provisional peer-reviewed toxicity values recommended by the National Center of Environmental Assessment/Superfund Health Risk Technical Support Center (OSRTI 2024); and
3. USEPA toxicity values as recommended or provided for specific chemicals in the USEPA regional screening-level table (USEPA 2024b) (e.g., Agency for Toxic Substances Disease Registry [ATSDR] minimal risk levels [ATSDR 2024] or Health Effects Assessment Summary Tables toxicity values [USEPA 1997b]).

To evaluate noncancer hazards associated with potential exposures to TPH as diesel and TPH as motor oil, reported in soil at the site, RfDs and RfCs developed by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) were used (2019), consistent with DTSC (2015a) recommendations. (It should be noted that the SFBRWQCB's development of RfDs and RfCs is based on a weighted approach for TPH fractions. Each TPH fraction is weighted based on its relative proportion in the particular fuel mixture [e.g., diesel, motor oil]. For the RfDs, the fraction weighting is based on weight percent composition in the fuel mixture. For the RfCs, the fraction weighting is based on percent vapor composition above the fuel for TPH as diesel, as TPH as motor oil is considered to be nonvolatile. A route-to-route extrapolation based on the RfD was conducted to evaluate the particulate inhalation pathway for TPH as motor oil.)

The RfDs and/or RfCs for 10 COPCs (i.e., antimony, total chromium, manganese, phosphate, acetone, chloroform, toluene, 4,4-dichlorodiphenyldichloroethylene, TPHs as diesel, and TPHs as motor oil) evaluated in this Post-NTCRA HHRA were updated from the values used in the 2019 HHERA (Arcadis 2019). All noncarcinogenic toxicity values used in this Post-NTCRA HHRA for the COPCs in soil are presented in Table 5-3.

Consistent with DTSC (2019a) recommendations, route-to-route extrapolation was used to calculate RfCs from RfDs when RfCs were not available. Similarly, when RfDs were not available for COPCs, RfDs were calculated from RfCs. However, neither RfCs nor RfDs were available for some COPCs. In such cases, surrogate chemicals were chosen based on structural similarity to avoid underestimating potential noncarcinogenic hazards as follows:

- Total chromium was represented by trivalent chromium.
- Phosphate was represented by aluminum metaphosphate.
- Acenaphthylene was represented by acenaphthene.
- Potential noncarcinogenic effects of the cPAHs, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene were represented by pyrene.
- Dibenz(a,h)anthracene was represented by benzo(a)pyrene.
- Benzo(g,h,i)perylene was represented by pyrene.
- Phenanthrene was represented by anthracene.
- Alpha- and gamma-chlordane were represented by technical chlordane.
- Total PCBs were represented by PCB 1254.
- TEQ human was represented by 2,3,7,8-TCDD.

Surrogate chemicals were chosen based on structural similarities such as chemicals in the same suite of compounds with similar carbon chain structures (e.g., aromatic carbon rings) and/or group of molecules attached (e.g., methyl group); however, they may differ in type of carbon bond (e.g., single or double bond) or position of the group of molecules attached. For example, acenaphthene was chosen as a surrogate for acenaphthylene because both compounds are considered semi-volatile organic compounds and PAHs with three carbon rings. Both compounds are peri-fused tricyclic hydrocarbons with two aromatic rings, with the only difference being that acenaphthylene has a double bond between carbons 1 and 8.

The surrogate chemicals selected in the Post-NTCRA HHERA are the same surrogate chemicals selected in the 2019 HHERA (Arcadis 2019).

5.3.3 Toxicity Assessment for Lead

The methodology and resources for the toxicity assessment for lead used in this Post-NTCRA HHERA follows that used in 2019 HHERA (Arcadis 2019) as summarized in this section.

The traditional RfD approach to the evaluation of chemicals was not applied to lead because most human health effects data are based on blood lead concentrations, rather than external dose (DTSC 2011a). Blood lead concentration is an integrated measure of internal dose, reflecting total exposure from site-related and background sources. A clear no-observed effects level has not been established for such lead-related health effects endpoints such as birth weight, gestation period, heme synthesis and neurobehavioral development in children and fetuses, and blood pressure in middle-aged men. OEHHA has developed a 1 microgram per deciliter (µg/dL) benchmark for source-specific incremental change in blood lead levels for the protection of school children and fetuses (OEHHA 2007).

DTSC developed a methodology for evaluating exposure and the potential for adverse health effects resulting from exposure to lead in the environment (DTSC 2011a). The methodology presents an algorithm for estimating blood lead concentrations in children based on a multi-pathway analysis. The agency has provided a spreadsheet (LeadSpread) based on its guidance for evaluating lead toxicity (DTSC 2011a, 2011b).

Per DTSC's current recommendation, the DTSC LeadSpread worksheets were used to evaluate potential exposure to lead in soil for recreational land-users. Impacts were evaluated based on the benchmark change in blood level concentration of 1 µg/dL for a child (based on blood lead concentration at the 90th percentile, estimated using LeadSpread).

5.3.4 Toxicity Equivalency Factors for Polycyclic Aromatic Hydrocarbons

The methodology for identifying TEFs for PAHs used in this Post-NTCRA HHERA follows that used in 2019 HHERA (Arcadis 2019) as summarized in this section.

For human health, PAHs were evaluated for both carcinogenic and noncarcinogenic toxicity endpoints. The compounds with noncancer toxicity values were addressed in the HHRA as individual compounds. The PAHs designated by the state of California as carcinogenic (cPAHs) were addressed in terms of a B(a)PEQ value for each sample. Carcinogenic toxicity values have not been established for each individual cPAH; rather, the carcinogenic potential of each cPAH was determined based upon its toxicity compared to benzo(a)pyrene. As a result, OEHHA has assigned a benzo(a)pyrene TEF for each cPAH, which when multiplied by the site concentration, converts the cPAH concentration into a concentration of B(a)PEQ (DTSC 2015b). For the site, the concentrations of all cPAHs were converted into B(a)PEQs, which were summed for the sample to produce a total B(a)PEQ concentration for that sample. The total B(a)PEQ concentration was included in the final dataset. The B(a)PEQ included all seven cPAH constituents using half the RL for those constituents not reported above the RL.

The TEFs for each cPAH used in this Post-NTCRA HHERA are summarized in Exhibit 5-1.

Exhibit 5-1 Toxicity Equivalency Factors Used in this Post-NTCRA HHERA

cPAH	OEHHA TEF
Benzo(a)pyrene	1.0 (index compound)
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Dibenz(a,h)anthracene	1

cPAH	OEHHA TEF
Chrysene	0.001
Indeno(1,2,3-cd)pyrene	0.1

Note:

1. The information in this table is from DTSC 2015b.

5.3.5 Toxicity Factors for Dioxins and Furans

The methodology used in this Post-NTCRA HHERA for the toxicity factors for dioxins and furans follows that used in 2019 HHERA (Arcadis 2019) as summarized in this section.

The carcinogenic toxicity of dioxins/furans is well established, especially for the most potent congener in the group, TCDD. OEHHA has published carcinogenic toxicity values (an oral CSF of 130,000 $[mg/kg/day]^{-1}$ and inhalation URF of 38 $[\mu g/m^3]^{-1}$) and noncarcinogenic toxicity values (an oral REL of 1×10^{-8} mg/kg/day and inhalation REL of 4×10^{-8} mg/m^3 for liver, reproductive system, development, endocrine system, respiratory system, and hematopoietic system toxicity) for assessing the toxicity of dioxins (OEHHA 2018). Based on these toxicity values, the DTSC has developed risk-based remediation goals for dioxins in soil that also account for the (minimal) contribution of soil and dust to dioxin human body burden, as demonstrated in dioxin exposure studies conducted at the University of Michigan (e.g., the DTSC remedial goal of 50 picograms per gram total TCDD TEQ for residential land use based on a target cancer risk of 1 x 10^{-6} multiplied by a factor of 10 to account for the bioavailability of TCDD TEQ) (DTSC 2017a). USEPA has yet to complete its cancer reassessment of TCDD but has developed an oral RfD for the reproductive system toxicity of TCDD of 7×10^{-10} mg/kg/day (USEPA 2024a).

Although the toxicity of TCDD is best understood among the individual congeners of the group, other TCDD-like compounds within the group are understood to act through the same mechanism of action, a mechanism that depends on chemical structure, specifically the placement of chlorine atoms around the congener molecules. TEFs for human receptors have been developed to express the relative toxicity of individual dioxin-like compounds to that of TCDD. TCDD has a TEF defined as one, and TCDD-like polychlorinated dibenzodioxin (PCDD) and polychlorinated dibenzofuran (PCDF) congeners have TEF values equal to one or less. Individual congeners may have been assigned different TEFs in the ERA due to differences in toxicity to different species.

TCDD TEQ is used to assess the risk of exposure to a mixture of TCDD-like compounds. TCDD TEQ is defined as the product of the concentration, Ci, of an individual dioxin-like compound in a complex environmental mixture and the corresponding TCDD TEF for that compound. The total TCDD TEQ is the sum of the TCDD TEQs for each of the congeners in a given mixture. Equation 5-1 summarizes this approach:

$$\text{Total TCDD TEQ} = \sum_{i=1}^{n}\left(C_i \times TEF_i\right) \qquad \text{Equation 5-1}$$

This approach was applied in this Post-NTCRA HHERA to estimate total TCDD TEQ concentrations for samples analyzed for TCDD and TCDD-like compounds. For the purposes of this report, total TCDD TEQ concentrations estimated specifically for potential human exposures in this HHRA are also referred to as

TEQ human when necessary to differentiate these results from TCDD TEQ concentrations estimated for ecological receptors in the ERA. TCDD TEQ concentrations were estimated from the set of TEFs recommended in DTSC guidance (2017a) to evaluate potential human receptor exposure scenarios in the HHRA. These TEFs are based on the weighting system proposed by the World Health Organization (WHO) in 2005 (Van den Berg et al. 2006). Values equal to half the RLs were used for ND individual congeners in the TCDD TEQ concentration estimations for the HHRA. The TCDD TEFs used in this Post-NTCRA HHERA are summarized in Exhibits 5-2 and 5-3.

Exhibit 5-2 WHO 2005 TEFs Used in this Post-NTCRA HHERA—Chlorinated Dibenzo-p-dioxins

Compound	WHO 2005 TEF
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003

Notes:

1. The information in this table is from DTSC 2017a.

HpCDD = heptachlorodibenzo-p-dioxin

HxCDD = hexachlorodibenzo-p-dioxin

OCDD = octachlorodibenzo-p-dioxin

PeCDD = pentachlorodibenzo-p-dioxin

Exhibit 5-3 WHO 2005 TEFs Used in this Post-NTCRA HHERA—Chlorinated Dibenzofurans

Compound	WHO 2005 TEF
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01

Compound	WHO 2005 TEF
OCDF	0.0003

Notes:

1. The information in this table is from DTSC 2017a.

HpCDF = heptachlorodibenzofuran

HxCDF = hexachlorodibenzofuran

OCDF = octachlorodibenzofuran

PeCDF = pentachlorodibenzofuran

TCDF = tetrachlorodibenzofuran

5.3.6 Toxicity Factors for Polychlorinated Biphenyls

The methodology used in this Post-NTCRA HHERA for the toxicity factors for PCB follows that used in 2019 HHERA (Arcadis 2019) as summarized in this section.

PCB compounds are known carcinogens. Aroclors, which are a mixture of individual PCB congeners, were detected at the site. Currently, toxicity data for carcinogenic and noncarcinogenic endpoints are available for Aroclors rather than for individual PCB congeners. The sum of individual concentrations of Aroclors detected within an investigation area using half the RL for ND values was reported as total PCBs, and this value is used to assess the risks/hazards associated with exposure to PCBs.

OEHHA (2018) has published carcinogenic toxicity values for Aroclor-1016 (an oral CSF of 0.07 $[mg/kg\text{-}day]^{-1}$ and inhalation URF of 0.02 $[\mu g/m^3]^{-1}$) and other Aroclors (Aroclor-1221, 1232, 1242, 1248, 1254,1260,1262, 1268; an oral CSF of 2 $[mg/kg\text{-}day]^{-1}$ and inhalation URF of 0.57 $[\mu g/m^3]^{-1}$). USEPA (2024a) has established noncarcinogenic toxicity values (an RfD of 2×10^{-5} mg/kg-day; RfC of 8×10^{-5} mg/kg-day used is route-to-route extrapolated from RfD) for assessing the toxicity of Aroclor-1254. Conservatively, the toxicity criteria established for Aroclor-1254 is used to evaluate the health risks associated with exposure to total PCBs.

5.3.7 Toxicity Assessment for Other Constituents

The methodology used in this Post-NTCRA HHERA for the toxicity assessment for other compounds follows that used in 2019 HHERA (Arcadis 2019) as summarized in this section.

As per agency request, essential nutrients (calcium, iron, magnesium, manganese, sodium, and potassium) were evaluated for inclusion as COPCs in the 2019 HHERA (Arcadis 2019). Human health toxicity values are available for iron and manganese. Iron was included as a COPC in the HHRA, where concentrations were found to exceed background levels in the 2019 HHERA.

Similarly, no human health toxicity values are available for chloride and sulfate, so these two constituents were excluded as COPCs in the 2019 HHERA (Arcadis 2019). These constituents did not have a background threshold value (BTV) as they were not analyzed for in the background dataset.

5.4 Risk Characterization

The methodologies used in this Post-NTCRA HHERA for risk characterization follow those used in the 2019 HHERA (Arcadis 2019) as summarized in this section.

This section of this Post-NTCRA HHERA presents the quantitative characterization of risks posed by the COPCs identified in soil following completion of NTCRA activities, and a discussion of uncertainties associated with the projected estimated risks. This section is divided into two parts:

- The first part discusses the methodology used in calculating potential cancer risks and noncancer hazards to potentially exposed recreational user populations outside the TCS posed by the presence of COPCs in soil.
- The second part presents the estimated cumulative potential ILCR and noncancer hazard posed by the presence of COPCs in soil. The quantitative estimates of ILCR and noncancer hazard provide the basis for identifying the specific areas and compounds that contribute most significantly to estimated cancer risks and noncancer hazard, and that may warrant some form of mitigation to reduce risks to levels that would be fully protective of human health.

The results of the lead risk assessment are the same as presented in the 2019 HHERA (Arcadis 2019) and summarized in Section 5.4.2 for convenience, along with quantitative estimates of ILCR and noncancer hazard.

5.4.1 Methodology for Estimating Cancer Risks and Noncancer Hazards for Recreational Users

Estimating ILCRs and noncancer hazard indices (HIs) for exposures to constituents in soil requires information regarding constituent concentrations in the soil, the level of potential exposure to each constituent, and the relationship between exposure to the constituent and its toxicity. The methodology used to derive the ILCRs and noncancer HIs for the selected COPCs is the same as that used in the 2019 HHERA (Arcadis 2019) and is based principally on guidance provided in the regulatory documents listed in this section.

- Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part A) (USEPA 1989);
- Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part F: Supplemental Guidance for Inhalation Risk Assessment) (USEPA 2009);
- Human Health Risk Assessment (HHRA) Note Number 1: Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Hazardous Waste Sites and Permitted Facilities (DTSC 2019b); and
- Preliminary Endangerment Assessment Manual (DTSC 2015b).

The following sections present the equations used to derive the ILCRs and noncancer HIs for the COPCs in soil.

5.4.1.1 Carcinogenic Health Effects

The following equations describe the established relationship between exposure, toxicity, and risk for carcinogenic health effects. For exposures occurring via incidental soil ingestion and dermal contact with soil, the relationship for carcinogenic effects is given by Equation 5-2 (USEPA 1989):

$$ILCR = CDI \times CSF \qquad \text{Equation 5-2}$$

where:

ILCR = Incremental lifetime excess cancer risk; the incremental probability of an individual developing cancer as a result of exposure to a particular cumulative dose of a potential carcinogen (unitless);

CDI = Chronic daily intake of a constituent (mg/kg/day); and

CSF = Cancer slope factor; the toxicity value which indicates the upper limit on ILCR per unit of dose of constituent ($[mg/kg/day]^{-1}$).

For the inhalation pathway, the relationship for carcinogenic effects is given by Equation 5-3 (USEPA 2009):

$$ILCR = EC \times URF \qquad \text{Equation 5-3}$$

where:

ILCR = Incremental lifetime excess cancer risk; the incremental probability of an individual developing cancer as a result of exposure to a particular cumulative dose of a potential carcinogen (unitless);

EC = Exposure concentration of a constituent in air (mg/m^3); and

URF = Unit risk factor; the toxicity value that indicates the upper limit on ILCR per unit of concentration of constituent ($(mg/m^3)^{-1}$).

The formulas for developing the CDIs and ECs for the recreational user scenario are presented in Tables 5-2a and 5-2b.

Estimated ILCRs associated with exposure to COPCs in soil for exposure scenarios evaluated in this Post-NTCRA HHERA are presented in the respective exposure area-specific appendices and summarized in Table 5-4.

As a point of reference, it should be noted that the NCP (40 CFR 300) indicates that lifetime incremental cancer risks posed by a site are compared to a range of one in one million (1×10^{-6}) to one hundred in a million (1×10^{-4}). As indicated in the NCP (40 CFR Part 300), cancer risks between one in a million and one hundred in a million probability of occurrence (1×10^{-6} and 1×10^{-4}) fall within a risk-management range. This is generally referred to as the acceptable risk range. Within this estimated cancer risk range, there is flexibility for risk managers in deciding what action, if any, is necessary and appropriate for the protection of human health. CalEPA’s point of departure for excess ILCR for all receptor groups (i.e., residential populations) is 1×10^{-6}. USFWS’s cancer risk threshold level is 10 in a million (1×10^{-5}) for soil deeper than 2 feet bgs (as included in the February 12, 2021 Topock Soil EE/CA Response to Comment Consultation Meeting Agenda).

5.4.1.2 Noncarcinogenic Health Effects

The following equations describe the established relationship between estimated intake, toxicity, and noncarcinogenic hazard. For exposures occurring via incidental soil ingestion and dermal contact with soil, the relationship for noncarcinogenic effects is given by Equations 5-4 and 5-5 (USEPA 1989):

$$HQ = CDI/RfD \quad \text{Equation 5-4}$$

$$HI = \sum HQ \quad \text{Equation 5-5}$$

where:

HQ = Hazard quotient; an expression of the potential for a constituent to cause noncarcinogenic effects, which relates the allowable amount of a constituent (RfD) to the estimated site-specific intake (unitless);

HI = Hazard index; the sum of the constituent-specific HQs, which represents the cumulative potential for predicted exposures to result in noncarcinogenic effects (unitless);

CDI = Chronic daily intake of a constituent (mg/kg/day); and

RfD = Reference dose; the toxicity value indicating the threshold amount of constituent contacted below which no adverse health effects are expected (mg/kg/day).

For noncarcinogenic effects, the relationship for the inhalation pathway is given by Equations 5-6 and 5-7 (USEPA 2009):

$$HQ = EC/RfC \quad \text{Equation 5-6}$$

$$HI = \sum HQ \quad \text{Equation 5-7}$$

where:

HQ = Hazard quotient; an expression of the potential for a constituent to cause noncarcinogenic effects, which relates the allowable concentration of a constituent (RfC) to the estimated site-specific EC (unitless);

HI = Hazard index; the sum of the constituent-specific HQs, which represents the cumulative potential for predicted exposures to result in noncarcinogenic effects (unitless);

EC = Exposure concentration of a constituent in air (mg constituent/m^3 air); and

RfC = Reference concentration; the toxicity value indicating the threshold concentration of constituent contacted below which no adverse health effects are expected (mg constituent/m^3 air).

The formulas for developing the CDIs and ECs for the recreational user scenarios are presented in Tables 5-2a and 5-2b.

Estimated noncancer HIs associated with exposure to COPCs in soil for exposure scenarios evaluated in this Post-NTCRA HHRA are presented in the respective area-specific appendices and summarized in Table 5-5.

For noncancer health effects, a hazard quotient (HQ) of less than or equal to 1 implies that the predicted exposure for a given population and chemical is not expected to result in adverse noncancer health effects; an HI of less than or equal to 1 implies the same for multi-chemical exposures (USEPA 1989).

5.4.2 Results of the Cancer Risk and Noncancer Hazard Assessment

The following section provides the incremental cancer risks and noncancer hazards, estimated using the methods described previously, for each of the potential HHRA exposure areas evaluated in this Post-NTCRA HHERA. A detailed description of the risks/hazards, including the tables that provide the breakdown of risk/hazard by individual chemical and potential exposure pathway, is provided in area-specific appendices (Appendices BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27).

As noted in Section 3.3, this Post-NTCRA HHERA did not evaluate larger exposure areas (e.g., OCS potential exposure area) that were evaluated in the 2019 HHERA (Arcadis 2019). In accordance with the RAWP (Arcadis 2008a), the conclusions and recommendations for the 2019 HHRA are based on the risks estimated for the OCS potential exposure area. The OCS potential exposure area is considered the most representative baseline scenario for potential human exposures and associated risks for soil contact outside TCS. Human populations that could be present at the site would more likely be exposed randomly, over the course of a lifetime, to soil present in all areas located outside the TCS, rather than have a lifetime of contact limited to a single AOC/SWMU/undesignated area. As presented in the sections below, no unacceptable risk to human recreator receptors (camper, hiker, and OHV rider) was identified at the site potential exposure areas evaluated in this Post-NTCRA HHRA. Given the reduction in overall estimated cumulative risks and hazards under post-NTCRA conditions in these potential exposure areas, which were identified with elevated concentrations of risk-driver COPCs in the 2019 HHERA[1] (Arcadis 2019), estimated cumulative risks and hazards for recreational users, camper, hikers, and OHV riders for the OCS potential exposure area under post-NTCRA conditions are likely lower than estimated in the 2019 HHERA (Arcadis 2019) and likely at or slightly above 1×10^{-6} and well within the risk-management range of 1×10^{-6} and 1×10^{-4}.

5.4.2.1 Bat Cave Wash

The cumulative ILCRs and HIs associated with potential exposure to COPCs in post-NTCRA soil at the BCW potential exposure area using depth-weighted EPCs under baseline (non-scouring), 2-foot scouring (where 2 feet of soil are assumed to be transported away due to heavy storm runoff), and 5-foot scouring (where 5 feet of soil are assumed to be transported away due to heavy storm runoff) scenarios were estimated. Assuming lifetime soil contact is limited to the BCW potential exposure area for the receptors evaluated, the estimated potential ILCR and HI results are summarized in this section and in Exhibits BCW-5.1 through BCW-5.3. As noted in Section 1.1 of Appendix BCW, vertical scouring within BCW has been infrequently observed only to a few inches below the wash bottom. The scouring that typically

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[1] As presented in the 2019 HHERA (Arcadis 2019), the pre- NTCRA estimated cumulative risks and hazards for recreational users (i.e., campers, hikers, and OHV riders) for the OCS potential exposure area, were above 1×10^{-6} (up to 1×10^{-5}) and above 1, respectively; attributed primarily to risk-driver COPCs (i.e. dioxin TEQ and/or hexavalent chromium) in individual exposure areas, SWMU1 within BCW, AOC 9, and AOC 10.

occurs is mainly lateral, along the edges of the wash walls, in narrower areas of the wash during high flow events when ban-to-bank flows occur. However, consistent with the approach in the RAWP documents (Arcadis 2008b, 2009a, and 2015) and scenarios evaluated for AOC 1 in the 2019 HHERA (Arcadis 2019), scouring scenarios are evaluated in this Post-NTCRA HHERA.

Baseline Scenario

Exhibit 5-4 provides the results from the baseline scenario.

Exhibit 5-4 Baseline Scenario Estimated Cumulative Incremental Lifetime Cancer Risk and Hazard Index for the BCW Potential Exposure Area

Potential Receptor	Exposure Depth	Cumulative ILCR Depth-Weighted	Cumulative ILCR Area-Weighted	HI Depth-Weighted	HI Area-Weighted
Camper	Surface	Less than or equal to 1 x 10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Camper	Shallow	Less than or equal to 1 x 10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Hiker	Surface	Less than or equal to 1 x 10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Hiker	Shallow	Less than or equal to 1 x 10^{-6}	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Surface	Less than or equal to 1 x 10^{-6}	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Shallow	Less than or equal to 1 x 10^{-6}	Not calculated	Less than or equal to 1	Not calculated

Note:
not calculated = area-weighted estimate not calculated because depth-weighted estimates for the receptor were below de minimis levels

Depth-weighted potential exposures that are at or below the de minimis levels include the following:

- **HI less than or equal to 1 for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders; and
- **ILCR less than or equal to 1 x 10^{-6} for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders.
- **2-FOOT SCOURING SCENARIO**

Two potential scouring scenarios due to heavy storm runoff were evaluated for the BCW potential exposure area—2-foot scouring and 5-foot scouring. Exhibit 5-5 provides the results from the 2-foot scouring scenario.

Exhibit 5-5 2-Foot Scouring Scenario Estimated Cumulative Incremental Lifetime Cancer Risk and Hazard Index for the BCW Potential Exposure Area

Potential Receptor	Exposure Depth	Cumulative ILCR Depth-Weighted	Cumulative ILCR Area-Weighted	HI Depth-Weighted	HI Area-Weighted
Camper	Surface	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Camper	Shallow	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Hiker	Surface	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Hiker	Shallow	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Surface	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Shallow	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated

Note:
not calculated = area-weighted estimate not calculated because depth-weighted estimates for the receptor were below de minimis levels

Depth-weighted potential exposures that are below or at de minimis levels include the following:

- **HI less than or equal to 1 for all soil depths**—All potential receptors evaluated, i.e., campers, hikers, and OHV riders; and
- **ILCR less than or equal to 1×10^{-6} for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders.

5-FOOT SCOURING SCENARIO

Exhibit 5-6 provides the results from the 5-foot scouring scenario.

Exhibit 5-6 5-Foot Scouring Scenario Estimated Cumulative Incremental Lifetime Cancer Risk and Hazard Index for the BCW Potential Exposure Area

Potential Receptor	Exposure Depth	Cumulative ILCR Depth-Weighted	Cumulative ILCR Area-Weighted	HI Depth-Weighted	HI Area-Weighted
Camper	Surface	Less than or equal to 1 x 10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Camper	Shallow	Less than or equal to 1 x 10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Hiker	Surface	Less than or equal to 1 x 10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Hiker	Shallow	Less than or equal to 1 x 10^{-6}	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Surface	Less than or equal to 1 x 10^{-6}	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Shallow	Less than or equal to 1 x 10^{-6}	Not calculated	Less than or equal to 1	Not calculated

Note:
not calculated = area-weighted estimate not calculated because depth-weighted estimates for the receptor were below de minimis levels

Depth-weighted potential exposures that are below or at de minimis levels include the following:

- **HI less than or equal to 1 for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders; and
- **ILCR less than or equal to 1 x 10^{-6} for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders.

OVERALL SUMMARY FOR BCW

Assuming lifetime soil contact is limited to the BCW potential exposure area, the estimated cumulative ILCRs and HIs associated with potential exposure to COPCs in post-NTCRA soil using depth-weighted EPCs for the camper, hiker, and OHV rider under the baseline and scouring exposure scenarios are below 1 x 10^{-6} and 1, respectively. The depth-weighted EPCs for lead in the BCW potential exposure area soil at all exposure depths under the baseline, 2-foot scouring, and 5-foot scouring scenarios are not expected to result in an increase in blood lead levels above the OEHHA benchmark value of 1 µg/dL in the child recreational user.

5.4.2.2 AOC 9

The cumulative ILCRs and HIs associated with potential exposure to COPCs in post-NTCRA soil at the AOC 9 potential exposure area using depth- and area-weighted EPCs under the baseline scenario were estimated. Assuming lifetime soil contact is limited to the AOC 9 potential exposure area for the potential receptors evaluated, the estimated potential ILCR and HI results are summarized in this section and in Exhibit 5-7.

Exhibit 5-7 Baseline Scenario Estimated Cumulative Incremental Lifetime Cancer Risk and Hazard Index for the AOC 9 Potential Exposure Area

Potential Receptor	Exposure Depth	Cumulative ILCR Depth-Weighted	Cumulative ILCR Area-Weighted	HI Depth-Weighted	HI Area-Weighted
Camper	Surface	3×10^{-6} (Arsenic, hexavalent chromium, B(a)PEQ, and dioxin TEQ)	2×10^{-6} (Arsenic, hexavalent chromium, B(a)PEQ, and dioxin TEQ)	Less than or equal to 1	Less than or equal to 1
Camper	Shallow	3×10^{-6} (Arsenic, hexavalent chromium, B(a)PEQ, and dioxin TEQ)	2×10^{-6} (Arsenic, hexavalent chromium, B(a)PEQ, and dioxin TEQ)	Less than or equal to 1	Less than or equal to 1
Hiker	Surface	6×10^{-6} (Arsenic, hexavalent chromium, B(a)PEQ, and dioxin TEQ)	5×10^{-6} (Arsenic, hexavalent chromium, B(a)PEQ, and dioxin TEQ)	Less than or equal to 1	Less than or equal to 1
Hiker	Shallow	5×10^{-6} (Arsenic, hexavalent chromium, B(a)PEQ, and dioxin TEQ)	4×10^{-6} (Arsenic, hexavalent chromium, B(a)PEQ, and dioxin TEQ)	Less than or equal to 1	Less than or equal to 1
OHV Rider	Surface	4×10^{-6} (Arsenic, hexavalent chromium, B(a)PEQ, and dioxin TEQ)	3×10^{-6} (Arsenic, hexavalent chromium,	Less than or equal to 1	Less than or equal to 1

Potential Receptor	Exposure Depth	Cumulative ILCR Depth-Weighted	Cumulative ILCR Area-Weighted	HI Depth-Weighted	HI Area-Weighted
			B(a)PEQ, and dioxin TEQ)		
OHV Rider	Shallow	3 x 10^{-6} (Arsenic, hexavalent chromium, B(a)PEQ, and dioxin TEQ)	3 x 10^{-6} (Arsenic, hexavalent chromium, B(a)PEQ, and dioxin TEQ)	Less than or equal to 1	Less than or equal to 1

Depth-Weighted Potential Exposures

Potential exposures that are at or below de minimis levels include the following:

- **HI less than or equal to 1 for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders; and
- **ILCR less than or equal to 1 x 10^{-6}**—none.

Potential exposures that are above de minimis levels of HI greater than 1 and/or within the risk-management range of 1×10^{-6} and 1×10^{-4} include the following:

- **ILCR greater than 1 x 10^{-6} and less than or equal to 5 x 10^{-6}**—camper (surface and shallow), hiker (shallow), and OHV rider (surface and shallow);
- **ILCR greater than 5 x 10^{-6} and less than or equal to 1 x 10^{-5}**—hiker (surface); and
- **ILCR greater than 1 x 10^{-5} and less than or equal to 1 x 10^{-4}**—none.

Assuming lifetime soil contact is limited to the AOC 9 potential exposure area, the depth-weighted estimated risks and hazards above de minimis levels for the camper, hiker, and OHV rider were due to arsenic, hexavalent chromium, B(a)PEQ, and dioxin TEQ. Therefore, potential risks and hazards for these three potential receptors were estimated using area-weighted EPCs and are provided in this section.

Area-Weighted Potential Exposures

Potential exposures that are at or below de minimis levels include the following:

- **HI less than or equal to 1 for all soil depths—**camper, hiker, and OHV rider; and
- **ILCR less than or equal to 1 x 10^{-6} for all soil depths—**none.

Potential exposures that are above de minimis levels of HI greater than 1 and/or within the risk-management range of 1 x 10^{-6} to 1 x 10^{-4} include the following:

- **ILCR greater than 1 x 10^{-6} and less than or equal to 5 x 10^{-6}—**camper (surface and shallow), hiker (surface and shallow), and OHV rider (surface and shallow);

- **ILCR greater than 5 x 10^{-6} and less than or equal to 1 x 10^{-5}—**none; and
- **ILCR greater than 1 x 10^{-5} and less than or equal to 1 x 10^{-4}—**none.

OVERALL SUMMARY FOR AOC 9

Assuming lifetime soil contact is limited to the AOC 9 potential exposure area, the estimated cumulative ILCRs associated with potential exposure to COPCs in post-NTCRA soil using depth-weighted EPCs for the camper, hiker, and OHV rider are above 1 x 10^{-6}. Therefore, the camper, hiker, and OHV rider receptors were carried forward in the area-weighted evaluation. The estimated cumulative ILCRs using the depth- and area-weighted EPCs for the camper, hiker, and OHV rider were above the point of departure for risk-management decisions of 1 x 10^{-6} but well within the risk-management range of 1 x 10^{-6} and 1 x 10^{-4}. The estimated cumulative ILCRs are also below the USFWS's cancer risk threshold level of 1 x 10^{-5} for soil deeper than 2 feet bgs (as included in the February 12, 2021 Topock Soil EE/CA Response to Comment Consultation Meeting Agenda).

In general, the area-weighted approach resulted in a reduction in the risk or hazard estimates, which ranged from 1.2 to 1.3 times lower than the depth-weighted estimates. However, use of the area-weighted approach does not change the overall conclusions of the HHRA for the AOC 9 potential exposure area evaluation. Approximately 78 to 85% of the estimated ILCRs for arsenic are attributed to background concentrations of arsenic in soil. Considering the substantial contribution of background arsenic in soil to the estimated cumulative ILCRs for all the receptors potentially exposed to AOC 9 potential exposure area soil, it is likely that incremental risks for site-related COPCs in soil are at or only slightly above 1 x 10^{-6} but below 5 x 10^{-6}, which is well within the risk-management range of 1 x 10^{-6} and 1 x 10^{-4}. The estimated cumulative ILCRs are also below the USFWS's cancer risk threshold level of 1 x 10^{-5} for soil deeper than 2 feet bgs (as include in the February 12, 2021 Topock Soil EE/CA Response to Comment Consultation Meeting Agenda).

The cumulative HIs estimated using the depth-weighted and area-weighted EPCs for the camper, hiker, and OHV rider were below 1. The depth- and area-weighted EPCs for lead in the AOC 9 potential exposure area soil at all exposure depths are not expected to result in an increase in blood lead levels above OEHHA benchmark value of 1 µg/dL in the child recreational user.

5.4.2.3 AOC 10

The cumulative ILCRs and HIs associated with potential exposure to COPCs in post-NTCRA soil at the AOC 10 potential exposure area using depth- and area-weighted EPCs under baseline (non-scouring), 2-foot scouring, and 5-foot scouring scenarios were estimated. Assuming lifetime soil contact is limited to the AOC 10 potential exposure area for the camper, hiker, and OVH rider evaluated, the estimated potential ILCR and HI results under the baseline, 2-foot scouring, and 5-foot scouring scenarios are summarized in this section and in Exhibits AOC 10-5.1 through AOC 10-5.3. As noted in Section 1.1 of Appendix AOC 10, the subareas of concern are primarily depositional. During recent high runoff conditions that occurred with rainstorm events on August 24 and September 11, 2022, and March 15, 2023, flooding and sediment deposition were observed in the subareas rather than scouring. However, consistent with the approach in the RAWP documents (Arcadis 2008b, 2009a, and 2015) and scenarios evaluated for AOC 10 in the 2019 HHERA (Arcadis 2019), scouring scenarios are evaluated in this Post-NTCRA HHERA.

BASELINE SCENARIO

Exhibit 5-8 provides the results from the baseline scenario.

Exhibit 5-8 Baseline Scenario Estimated Cumulative Incremental Lifetime Cancer Risk and Hazard Index for the AOC 10 Potential Exposure Area

Potential Receptor	Exposure Depth	Cumulative ILCR Depth-Weighted	Cumulative ILCR Area-Weighted	HI Depth-Weighted	HI Area-Weighted
Camper	Surface	2×10^{-6} (Arsenic)	Not calculated	Less than or equal to 1	Not calculated
Camper	Shallow	2×10^{-6} (Arsenic)	Not calculated	Less than or equal to 1	Not calculated
Hiker	Surface	5×10^{-6} (Arsenic)	Not calculated	Less than or equal to 1	Not calculated
Hiker	Shallow	4×10^{-6} (Arsenic)	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Surface	3×10^{-6} (Arsenic)	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Shallow	3×10^{-6} (Arsenic)	Not calculated	Less than or equal to 1	Not calculated

Note:
not calculated = area-weighted estimate not calculated because although the depth-weighted estimate for the receptor was above de minimis levels, a substantial portion of estimate is attributed to background arsenic concentrations in soil

Depth-weighted potential exposures that are below or at de minimis levels include the following:

- **HI less than or equal to 1 for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders; and
- **ILCR less than or equal to 1 x 10^{-6}**—none.

Potential exposures above de minimis levels of HI greater than 1 and/or within the risk-management range of 1 x 10^{-6} and 1 x 10^{-4} include the following:

- **ILCR greater than 1 x 10^{-6} and less than or equal to 5 x 10^{-6}**—camper (surface and shallow), hiker (surface and shallow), and OHV rider (surface and shallow);
- **ILCR greater than 5 x 10^{-6} and less than or equal to 1 x 10^{-5}**—none; and
- **ILCR greater than 1 x 10^{-5} and less than or equal to 1 x 10^{-4}**—none.

Assuming lifetime soil contact is limited to the AOC 10 potential exposure area for the baseline scenario, the depth-weighted estimated risks and hazards above de minimis levels for the camper, hiker, and OHV rider are due to contribution from background arsenic concentrations in soil. The cumulative ILCRs for the camper (surface and shallow soil), hiker (shallow soil) and OHV rider (surface and shallow soil), excluding contribution from background arsenic concentrations, would be at or below the point of departure for risk-management decisions of 1 x 10^{-6}. As presented in the 2019 HHERA (Arcadis 2019), estimated ILCRs for arsenic for the camper, hiker, and OHV rider using the area-weighted EPCs for arsenic in surface and shallow soils are the same using the depth-weighted EPCs. Therefore, an area-weighted EPC baseline scenario risk evaluation is not presented in this Post-NTCRA HHERA, as the risk conclusions for the camper, hiker, and OHV rider would not be changed using area-weighted EPCs for arsenic.

2-FOOT SCOURING SCENARIO

Two potential scouring scenarios due to heavy storm runoff were evaluated for the AOC 10 potential exposure area—2-foot scouring and 5-foot scouring. Exhibit 5-9 provides the results from the 2-foot scouring scenario.

Exhibit 5-9 2-Foot Scouring Scenario Estimated Cumulative Incremental Lifetime Cancer Risk and Hazard Index for the AOC 10 Potential Exposure Area

Potential Receptor	Exposure Depth	Cumulative ILCR Depth-Weighted	Cumulative ILCR Area-Weighted	HI Depth-Weighted	HI Area-Weighted
Camper	Surface	2 x 10^{-6} (Arsenic)	2 x 10^{-6} (Arsenic)	Less than or equal to 1	Less than or equal to 1
Camper	Shallow	3 x 10^{-6} (Arsenic and dioxin TEQ)	2 x 10^{-6} (Arsenic)	Less than or equal to 1	Less than or equal to 1
Hiker	Surface	5 x 10^{-6} (Arsenic and dioxin TEQ)	5 x 10^{-6} (Arsenic, dioxin TEQ, and hexavalent chromium)	Less than or equal to 1	Less than or equal to 1
Hiker	Shallow	6 x 10^{-6} (Arsenic and dioxin TEQ)	5 x 10^{-6} (Arsenic, dioxin TEQ, and hexavalent chromium)	2 (Arsenic)	Less than or equal to 1
OHV rider	Surface	3 x 10^{-6} (Arsenic)	3 x 10^{-6} (Arsenic, dioxin TEQ, and hexavalent chromium)	Less than or equal to 1	Less than or equal to 1
OHV rider	Shallow	4 x 10^{-6} (Arsenic and dioxin TEQ)	3 x 10^{-6} (Arsenic, dioxin TEQ, and hexavalent chromium)	Less than or equal to 1	Less than or equal to 1

Depth-Weighted 2-Foot Scouring Scenario

Potential exposures that are below or at de minimis levels include the following:

- **HI less than or equal to 1—**camper (surface and shallow), hiker (surface), and OHV rider (surface and shallow); and
- **ILCR less than or equal to 1 x 10^{-6}**—none.

Potential exposures that are above de minimis levels of HI greater than 1 and/or within the risk-management range of 1 x 10^{-6} to 1 x 10^{-4} include the following:

- **HI greater than 1 and less than or equal to 3**—hiker (shallow);
- **ILCR greater than** 1 x 10^{-6} **and less than or equal to 5 x 10^{-6}**—camper (surface and shallow), hiker (surface), and OHV rider (surface and shallow);
- **ILCR greater than 5 x 10^{-6} and less than or equal to 1 x 10^{-5}**—hiker (shallow); and
- **ILCR greater than 1 x 10^{-5} and less than or equal to 1 x 10^{-4}**—none.

Assuming lifetime soil contact is limited to the AOC 10 potential exposure area for the 2-foot scouring scenario, the depth-weighted estimated risks and hazards above de minimis levels for the camper, hiker, and OHV rider are due to arsenic and dioxin TEQ. Therefore, potential risks and hazards for these receptors were evaluated using area-weighted EPCs and are provided in this section.

Area-Weighted 2-Foot Scouring Scenario

Potential exposures that are below or at de minimis levels include the following:

- **HI less than or equal to 1 for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders; and
- **ILCR less than or equal to 1 x 10^{-6} for all soil depths**—none.

Potential exposures that are above de minimis levels of HI greater than 1 and/or within the risk-management range of 1 x 10^{-6} to 1 x 10^{-4} include the following:

- **ILCR greater than 1 x 10^{-6} and less than or equal to 5 x 10^{-6}**—camper (surface and shallow), hiker (surface and shallow), and OHV rider (surface and shallow);
- **ILCR greater than 5 x 10^{-6} and less than or equal to 1 x 10^{-5}**—none; and
- **ILCR greater than 1 x 10^{-5} and less than or equal to 1 x 10^{-4}**—none.

5-FOOT SCOURING SCENARIO

Exhibit 5-10 provides the results for the 5-foot scouring scenario.

Exhibit 5-10 5-Foot Scouring Scenario Estimated Cumulative Incremental Lifetime Cancer Risk and Hazard Index for the AOC 10 Potential Exposure Area

Potential Receptor	Exposure Depth	Cumulative ILCR Depth-Weighted	Cumulative ILCR Area-Weighted	HI Depth-Weighted	HI Area-Weighted
Camper	Surface	3×10^{-6} (Arsenic and dioxin TEQ)	Not calculated	Less than or equal to 1	Not calculated
Camper	Shallow	2×10^{-6} (Arsenic)	Not calculated	Less than or equal to 1	Not calculated
Hiker	Surface	5×10^{-6} (Arsenic and dioxin TEQ)	Not calculated	Less than or equal to 1	Not calculated
Hiker	Shallow	5×10^{-6} (Arsenic and dioxin TEQ)	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Surface	3×10^{-6} (Arsenic, dioxin TEQ, and hexavalent chromium)	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Shallow	3×10^{-6} (Arsenic, dioxin TEQ, and hexavalent chromium)	Not calculated	Less than or equal to 1	Not calculated

Note:
not calculated = area-weighted estimate not calculated because, although the depth-weighted estimate for the receptor was above de minimis levels, a substantial portion of estimate is attributed to background arsenic concentrations in soil

Depth-weighted potential exposures that are below or at de minimis levels include the following:

- **HI less than or equal to 1 for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders; and
- **ILCR less than or equal to 1×10^{-6}**—none.

Potential exposures that are above de minimis levels of HI greater than 1 and/or within the risk-management range of 1×10^{-6} and 1×10^{-4} include the following:

- **ILCR greater than 1 x 10^{-6} and less than or equal to 5 x 10^{-6}**—camper (surface and shallow), hiker (surface and shallow), and OHV rider (surface and shallow);
- **ILCR greater than 5 x 10^{-6} and less than or equal to 1 x 10^{-5}**—none; and
- **ILCR greater than 1 x 10^{-5} and less than or equal to 1 x 10^{-4}**—none.

Under the 5-foot scouring scenario, the depth-weighted estimated risks and hazards above de minimis levels for the camper, hiker, and OHV rider are due to arsenic, hexavalent chromium, and/or dioxin TEQ.

The cumulative ILCRs for the camper (surface and shallow soil) and OHV rider (surface and shallow soil) excluding contribution from background arsenic concentrations would be at or below the point of departure for a risk-management decision of 1 x 10^{-6}. As presented in the 2019 HHERA (Arcadis 2019), estimated ILCRs for arsenic for the camper, hiker, and OHV rider using the area-weighted EPCs for arsenic in surface and shallow soils are the same as those using the depth-weighted EPCs. Therefore, an area-weighted EPC risk evaluation for the 5-foot scouring scenario is not presented in this Post-NTCRA HHERA because the risk conclusions for the camper, hiker, and OHV rider would not be changed using area-weighted EPCs for arsenic.

OVERALL SUMMARY FOR AOC 10

Assuming lifetime contact with post-NTCRA soil is limited to the AOC 10 potential exposure area, the depth- and/or area-weighted estimated cumulative HIs for the camper, hiker, and OHV rider under the baseline and scouring exposure scenarios are at or below 1, except for the hiker for shallow soil under 2-foot scouring scenario. The depth-weighted estimated HI for the hiker exposed to shallow soil under 2-foot scouring scenario is slightly above 1. The majority of the estimated HI for the hiker (0.82 of 1 or approximately 82%) is attributed to background concentrations of arsenic in soil. In addition, the area-weighted estimated HI for the hiker exposed to shallow soil under the 2-foot scouring scenario is equal to 1. Considering the substantial contribution of background arsenic in soil to the estimated cumulative HI for the receptors potentially exposed to AOC 10 potential exposure area soil under 2-foot scouring scenario, it is likely that incremental hazards for site-related COPCs in soil are well below an HI of 1. In general, the area-weighted approach resulted in a reduction in the hazard estimates ranging from 1.1 to 2 times lower than the depth-weighted estimates.

The depth- and/or area-weighted estimated cumulative ILCRs for the camper, hiker, and OHV rider under the baseline, 2-foot scouring, and 5-foot scouring scenarios are above the point of departure for risk-management decisions of 1 x 10^{-6} but are at or below 5 x 10^{-6}, except for the depth-weighted estimated cumulative ILCR for the hiker under the 2-foot scouring scenario for shallow soil. The depth-weighted estimated cumulative ILCR for the hiker under the 2-foot scouring scenario is above the point of departure for a risk-management decision of 1 x 10^{-6} but is below 1 x 10^{-5}. For the 2-foot scouring scenario, the area-weighted approach resulted in a reduction in the risk estimate ranging from 1.2 to 1.5 times lower than that of the depth-weighted estimate.

Under the baseline and 5-foot scouring scenarios, the depth-weighted estimated risks and hazards above de minimis levels for the camper, hiker, and OHV rider are due to arsenic (i.e., primarily from background concentrations in soil), hexavalent chromium, and/or dioxin TEQ. For the baseline and 5-foot scouring scenarios, the cumulative ILCRs for the camper (surface and shallow soil) and OHV rider (surface and shallow soil), excluding contribution from background arsenic concentrations, would be at or below the point of departure for risk-management decisions of 1 x 10^{-6}. As presented in the 2019 HHERA (Arcadis 2019), estimated ILCRs for arsenic for the camper, hiker, and OHV rider using the area-weighted EPCs for arsenic in surface and shallow soils are the same as those using the depth-weighted EPCs. Therefore, an area-weighted EPC risk evaluations for the baseline and 5-foot scouring scenarios are not presented in this Post-NTCRA HHERA because the risk conclusions for the camper, hiker, and OHV rider would not be changed using area-weighted EPCs for arsenic.

As summarized above, the depth-weighted 2-foot scouring and 5-foot scouring ILCRs for the camper, hiker, and OHV rider are slightly higher for shallow soil than the depth-weighted baseline ILCRs for surface soil, which suggests that the impacts for the risk drivers (arsenic, hexavalent chromium, and dioxin TEQ) are primarily within the 2 to 5 feet bgs interval for the AOC 10 potential exposure area. As summarized in Section 1.1 of Appendix AOC 10, although AOC 10 includes steep slopes along the ravine, scouring has not been observed. As noted in Section 1.1 of Appendix AOC 10, the subareas of concern are primarily depositional. During recent high runoff conditions that occurred with rainstorm events on August 24 and September 11, 2022, and March 15, 2023, flooding and sediment deposition were observed in the subareas rather than scouring. Therefore, risk estimates presented in the HHRA for the hypothetical 2-foot scouring and 5-foot scouring scenarios are not believed to be representative scenarios of actual exposure to soil in AOC 10 for the camper, hiker, and OHV rider.

The depth- and/or area-weighted EPCs for lead in AOC 10 potential exposure area soil at all exposure depths under the baseline, 2-foot scouring, and 5-foot scouring scenarios are not expected to result in an increase in blood lead levels above the OEHHA benchmark value of 1 µg/dL in the child recreational user.

5.4.2.4 AOC 11

The cumulative ILCRs and HIs associated with potential exposure to COPCs in post-NTCRA soil at the AOC 11 potential exposure area using depth- and area-weighted EPCs under the baseline scenario were estimated. Assuming lifetime soil contact is limited to the AOC 11 potential exposure area for the potential receptors evaluated, the estimated potential ILCR and HI results are summarized in this section and in Exhibit 5-11.

Exhibit 5-11 Baseline Scenario Estimated Cumulative Incremental Lifetime Cancer Risk and Hazard Index for the AOC 11 Potential Exposure Area

Potential Receptor	Exposure Depth	Cumulative ILCR Depth-Weighted	Cumulative ILCR Area-Weighted	HI Depth-Weighted	HI Area-Weighted
Camper	Surface	2×10^{-6} (Arsenic and dioxin TEQ)	2×10^{-6} (Arsenic, dioxin TEQ), and Hexavalent chromium)	Less than or equal to 1	Less than or equal to 1
Camper	Shallow	3×10^{-6} (Arsenic and dioxin TEQ)	2×10^{-6} (Arsenic, dioxin TEQ, and Hexavalent chromium)	Less than or equal to 1	Less than or equal to 1
Hiker	Surface	5×10^{-6} (Arsenic, dioxin TEQ, and Hexavalent chromium)	5×10^{-6} (Arsenic, dioxin TEQ, and Hexavalent chromium)	Less than or equal to 1	Less than or equal to 1

Potential Receptor	Exposure Depth	Cumulative ILCR Depth-Weighted	Cumulative ILCR Area-Weighted	HI Depth-Weighted	HI Area-Weighted
Hiker	Shallow	6×10^{-6} (Arsenic and dioxin TEQ)	5×10^{-6} (Arsenic, dioxin TEQ, and Hexavalent chromium)	Less than or equal to 1	Less than or equal to 1
OHV rider	Surface	3×10^{-6} (Arsenic, dioxin TEQ, and Hexavalent chromium)	3×10^{-6} (Arsenic, Hexavalent chromium, and dioxin TEQ)	Less than or equal to 1	Less than or equal to 1
OHV rider	Shallow	4×10^{-6} (Arsenic, dioxin TEQ, and Hexavalent chromium)	3×10^{-6} (Arsenic, Hexavalent chromium, and dioxin TEQ)	Less than or equal to 1	Less than or equal to 1

Depth-Weighted Scenario

Potential exposures that are at or below de minimis levels include the following:

- **HI less than or equal to 1 for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders; and
- **ILCR less than or equal to 1×10^{-6}**—none.

Potential exposures that are within the risk-management range of 1×10^{-6} and 1×10^{-4} include the following:

- **ILCR greater than 1×10^{-6} and less than or equal to 5×10^{-6}**—camper (surface and shallow soil), hiker (surface), and OHV rider (surface and shallow soil);
- **ILCR greater than 5×10^{-6} and less than or equal to 1×10^{-5}—**hiker (shallow soil); and
- **ILCR greater than 1×10^{-5} and less than or equal to 1×10^{-4}**—none.

Assuming lifetime soil contact is limited to the AOC 11 potential exposure area, the depth-weighted estimated risks and hazards above de minimis levels for the camper, hiker, and OHV rider were due to arsenic, hexavalent chromium, and/or dioxin TEQ. Therefore, potential risks and hazards for these potential receptors were evaluated using area-weighted EPCs and are provided in this section. It should be noted that a substantial portion of the ILCRs for arsenic can be attributed to background levels of arsenic in soil.

Area-Weighted

Potential exposures that are at or below the de minimis levels include the following:

- **HI less than or equal to 1 for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders; and
- **ILCR less than or equal to 1 x 10^{-6} for all soil depths**—none.

Potential exposures that are a within the risk-management range of 1 x 10^{-6} and 1 x 10^{-4} include the following:

- **ILCR greater than 1 × 10^{-6} and less than or equal to 5 x 10^{-6}—**camper (surface and shallow soil), hiker (surface and shallow soil), and OHV rider (surface and shallow soil);
- **ILCR greater than 5 x 10^{-6} and less than or equal to 1 × 10^{-5}**—none; and
- **ILCR greater than 1 × 10^{-5} and less than or equal to 1 x 10^{-4}**—none.

OVERALL SUMMARY FOR AOC 11

Assuming lifetime soil contact is limited to the AOC 11 potential exposure area, the estimated cumulative ILCRs associated with potential exposure to COPCs in post-NTCRA soil conditions using depth-weighted EPCs for the camper, hiker, and OHV rider are above 1 × 10^{-6}. Therefore, the camper, hiker, and OHV rider were carried forward in the area-weighted evaluation. The estimated cumulative ILCRs using the depth- and area-weighted EPCs for the camper, hiker, and OHV rider were above the point of departure for risk-management decisions of 1 x 10^{-6} but well within the risk-management range of 1 x 10^{-6} and 1 x 10^{-4}.

As demonstrated by comparing the values, the area-weighted estimated cumulative ILCRs for the camper, hiker, and OHV rider are not materially different than the depth-weighted cumulative ILCRs for all exposure depths. Approximately 78 to 85% of the estimated ILCRs for arsenic are attributed to background concentrations of arsenic in soil. Considering the substantial contribution of background arsenic in soil to the estimated cumulative ILCRs for all the receptors potentially exposed to AOC 11 potential exposure area soil, it is likely that incremental risks for site-related COPCs in soil are at or only slightly above 1 x 10^{-6}, but below 5 x 10^{-6}, which is well within the risk-management range of 1 x 10^{-6} and 1 x 10^{-4}. The estimated cumulative ILCRs are also below the USFWS's cancer risk threshold level of 1 x 10^{-5} for soil deeper than 2 feet bgs (as included in the February 12, 2021 Topock Soil EE/CA Response to Comment Consultation Meeting Agenda).

The cumulative HIs estimated using the depth- and area-weighted EPCs for campers, hikers, and OHV riders were at or below HI of 1. The depth- and area-weighted EPCs for lead in the AOC 11 potential exposure area soil at all exposure depths are not expected to result in an increase in blood lead levels above OEHHA's benchmark value of 1 µg/dL in child recreational user.

5.4.2.5 AOC 14

The cumulative ILCRs and HIs associated with potential exposure to COPCs in post-NTCRA soil at the AOC 14 potential exposure area using depth-weighted EPCs under the baseline scenario were estimated. Assuming that lifetime soil contact is limited to the AOC 14 potential exposure area for the receptors evaluated, the estimated potential ILCR and HI results are summarized in this section and in Exhibit 5-12.

Exhibit 5-12 Baseline Scenario Estimated Cumulative Incremental Lifetime Cancer Risk and Hazard Index for the AOC 14 Potential Exposure Area

Potential Receptor	Exposure Depth	Cumulative ILCR Depth-Weighted	Cumulative ILCR Area-Weighted	HI Depth-Weighted	HI Area-Weighted
Camper	Surface	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Camper	Shallow	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Hiker	Surface	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Hiker	Shallow	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Surface	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Shallow	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated

Note:
not calculated = area-weighted estimate was not calculated because the depth-weighted estimates for the receptor were below de minimis levels

Depth-weighted potential exposures that are at or below de minimis levels include the following:

- **HI less than or equal to 1 for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders; and
- **ILCR less than or equal to 1×10^{-6} for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders.

OVERALL SUMMARY FOR AOC 14

Assuming that lifetime soil contact is limited to the AOC 14 potential exposure area, the estimated cumulative ILCRs and HIs are all below 1×10^{-6} and 1, respectively, for potential exposure to COPCs in post-NTCRA soil at the AOC 14 potential exposure area using depth-weighted EPCs for the camper, hiker, and OHV rider.

The depth-weighted EPCs for lead in AOC 14 potential exposure area soil at all exposure depths are not expected to result in an increase in blood lead levels above the OEHHA benchmark value of 1 µg/dL in the child recreational user.

5.4.2.6 AOC 27

The cumulative ILCRs and HIs associated with potential exposure to COPCs in post-NTCRA soil at the AOC 27 potential exposure area using depth-weighted EPCs under the baseline scenario were estimated. Assuming that lifetime soil contact is limited to the AOC 27 potential exposure area for the receptors evaluated, the estimated potential ILCR and HI results are summarized in this section and in Exhibit 5-13.

Exhibit 5-13 Baseline Scenario Estimated Cumulative Incremental Lifetime Cancer Risk and Hazard Index for the AOC 27 Potential Exposure Area

Potential Receptor	Exposure Depth	Cumulative ILCR Depth-Weighted	Cumulative ILCR Area-Weighted	HI Depth-Weighted	HI Area-Weighted
Camper	Surface	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Camper	Shallow	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Hiker	Surface	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
Hiker	Shallow	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Surface	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated
OHV rider	Shallow	Less than or equal to 1×10^{-6}	Not calculated	Less than or equal to 1	Not calculated

Note:
not calculated = area-weighted estimate was not calculated because the depth-weighted estimates for the receptor were below de minimis levels

Depth-weighted potential exposures that are at or below de minimis levels include the following:

- **HI less than or equal to 1 for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders; and
- **ILCR less than or equal to 1 x 10^{-6} for all soil depths**—All potential recreational receptors evaluated, i.e., campers, hikers, and OHV riders.

OVERALL SUMMARY FOR AOC 27

Assuming that lifetime soil contact is limited to the AOC 27 potential exposure area, the estimated cumulative ILCRs and HIs are all below 1 x 10^{-6} and 1, respectively, for potential exposure to COPCs in post-NTCRA soil at the AOC 14 potential exposure area using depth-weighted EPCs for the camper, hiker, and OHV rider .

The depth-weighted EPCs for lead in AOC 27 potential exposure area soil at all exposure depths are not expected to result in an increase in blood lead levels above the OEHHA benchmark value of 1 µg/dL in the child recreational user.

5.4.2.7 AOC 16 Inside the Compressor Station

The HHRA results for the ICS potential exposure area presented in the 2019 HHERA (Arcadis 2019) inclusive of AOC 16 support that the levels of COPCs in ICS post-NTCRA soil and/or soil gas are safe and protective of commercial and short- and long-term maintenance workers for current and anticipated future operational conditions and practices.

During the NTCRA, removal of a small volume of material occurred in AOC 16, which included removal of approximately 10 cubic yards of sandblast grit contaminated soil to a depth of 1 foot bgs. Confirmation sample results indicate that risk-driver and non-risk-driver COPCs/COPECs were below RAGs protective of recreational users and ecological receptors, which are also protective of workers inside the TCS. As such, given the limited removal in AOC 16 and levels of COPCs/COPECs in the confirmation samples, the levels of COPCs in ICS soils under post-NTCRA conditions remain safe and protective of commercial and short- and long-term maintenance workers for current and anticipated future operational conditions and practices.

It should be noted that much of the ICS potential exposure area is covered by buildings, pavement, and gravel, and the assumption that workers are exposed to all soil in the ICS potential exposure area is overly conservative. Furthermore, Occupational Safety and Health Administration standards and work practices are currently in place that limit the amount of exposure to dusts and soil and provide an added level of protection to all workers, above and beyond what is necessary to ensure full protection of the health of all PG&E workers at the TCS. Therefore, the estimated ILCRs and HIs associated with current potential exposure to COPCs in post-NTCRA soil at the ICS potential exposure area presented in the 2019 HHERA (Arcadis 2019) are overestimated and are likely well below 1 × 10^{-5} and HI of 1, respectively. PG&E follows all relevant and appropriate worker health and safety protocols and is in compliance with worker health and safety measures set forth by the Occupational Safety and Health Administration, as required by state and federal law. The results of the HHRA at the ICS exposure area in the 2019 HHERA are intended to provide additional information useful in identifying chemical hazards and appropriate controls, where necessary.

5.5 Uncertainty Analysis

Many of the assumptions used in the 2019 HHERA (Arcadis 2019) and in this Post-NTCRA HHERA, regarding the representativeness of the sampling data, human exposures, fate and transport modeling, and chemical toxicity are conservative, following agency guidance, and reflect a 90th or 95th percentile value, rather than a typical or average value. The use of several conservative exposure and toxicity assumptions can introduce considerable uncertainty into the risk assessment. By using conservative exposure assumptions or toxicity estimates, the assessment can develop a significant conservative bias that may result in the calculation of significantly higher cancer risks or noncancer hazards than are actually posed by the chemicals present in soil and soil gas.

Many of the generic and site-specific uncertainties discussed in the 2019 HHERA (Arcadis 2019) also apply to this Post-NTCRA HHERA. Uncertainties that have been previously discussed in the 2019 HHERA and applicable to this Post-NTCRA HHERA are included in this Post-NTCRA HHERA for completeness. Additional uncertainties applicable to this Post-NTCRA HHERA, which evaluates post-NTCRA conditions at the site, are also discussed in this section. The generic and site-specific uncertainties discussed in this section with respect to the post-NTCRA HHRA also apply to the ERA where noted. Additional uncertainties applicable only to the ERA are discussed in Section 6.7. Uncertainties applicable only to certain potential exposure areas are discussed in detail in the relevant potential area-specific HHERA appendices.

5.5.1 Uncertainty in the Data

5.5.1.1 Data Quality

Data used in this Post-NTCRA HHERA were analyzed by approved USEPA methods, and appropriate quality assurance/quality control procedures were followed. Errors in chemical analyses may result from several sources, including errors inherent in the sampling and analytical procedures. Analytical accuracy or sampling errors can result in the rejection of data, which decreases the available data for use in this Post-NTCRA HHERA, or in the qualification of data, which increases the uncertainty in the detected chemical concentrations. Data used in this Post-NTCRA HHERA were validated, and the overall quality of the data was assessed. Only those data classified as Category 1 were used in this Post-NTCRA HHERA. A few analytical results were excluded from this Post-NTCRA HHERA because they were rejected during the data validation process. These cases are discussed specifically in each exposure area-specific appendix, and exclusion of these rejected data do not significantly impact the risk assessment datasets. Additionally, some sample results were qualified as estimated (J) due to a high RPD reported in a laboratory duplicate analysis. However, the data validation results indicate that the data are suitable for their intended use.

5.5.1.2 Analytical Methods and Reporting Limits

The analytical methods and RLs for data used in this Post-NTCRA HHERA were evaluated in Section 3.2.3 of the 2019 HHERA (Arcadis 2019). Certain COPCs/COPECs may be excluded from the risk assessment if they were detected at the site at concentrations consistent with background values. COPCs/COPECs with a maximum detected concentration less than the applicable BTV were excluded from the risk assessment. Elevated RLs may lead to a non-conservative decision to exclude a constituent from the HHERA (i.e., not selected as a COPC/COPEC) if the maximum detected concentration is lower than the BTV, and the BTV is, in turn, lower than the maximum RL. If elevated RLs at the site are greater than the maximum detected concentration, uncertainty in the ability to assess whether COPCs/COPECs are present at concentrations equivalent to background increases with the number of ND sample results with RLs greater than the BTV. A detailed discussion of the potential implications of RLs that exceed the BTVs on the COPC/COPEC selection process is provided here.

In the 2019 HHERA (Arcadis 2019), for the OCS potential exposure area (which represents the combined individual AOC/SWMU/UA potential exposure areas outside the TCS), beryllium, cadmium, hexavalent chromium, copper, molybdenum, selenium, and B(a)PEQ were the only COPCs/COPECs for which at least one sample had an RL greater than the BTV. RLs were above the BTV in ND results in 99.8% (beryllium), 4% (cadmium), less than 1% (hexavalent chromium), less than 1% (copper), 16% (molybdenum), 2% (selenium), and 2% (B(a)PEQ) of the soil samples collected within exposure areas outside the TCS. Based on the frequency of RLs above the BTV in ND results, beryllium is the only COPEC where significant uncertainty exists regarding the ability to assess whether it is present at concentrations equivalent to the background value.

The BTV for beryllium (0.672 mg/kg) is equivalent to the maximum detected concentration in the background dataset that contains RLs for beryllium ranging from 1 to 5.4 mg/kg. RLs in the ICS potential exposure area dataset exceed the BTV by a factor of two or less (maximum RL = 1.4 mg/kg; BTV = 0.672 mg/kg) and are well within the range of RLs in the background dataset. RLs in the OCS potential exposure area dataset exceed the maximum BTV by up to 16 times (maximum RL = 11 mg/kg) and exceed the maximum RL in the background dataset by a factor of two or less (maximum RL = 11 mg/kg). The majority of the RLs for beryllium in the OCS exposure area dataset are within the range of those in background dataset with only 3 of 1,181 results exceeding the maximum RL in the background dataset of 5.4 mg/kg. To more fully understand the extent to which the exclusion of beryllium from this Post-NTCRA HHERA may materially underestimate risk and/or hazard, it is necessary to understand whether the RLs are greater than risk-based screening levels. The risk-based screening level for beryllium is 210 mg/kg, which is greater than the maximum RL of 11 mg/kg for the OCS exposure area datasets. In addition, beryllium is not known to be associated with historical site activities, and beryllium was never detected in the OCS potential exposure area. For these reasons, although beryllium RLs frequently exceed the BTV, the overall effect on this Post-NTCRA HHERA is expected to be negligible.

Based the information presented above, RLs for the Post-NTCRA HHERA dataset did not result in material underestimation of exposure or risk for human health or ecological receptors.

Analytical methods for metals only included analysis for total metals except for hexavalent chromium. The toxicity of many metals depends strongly on the oxidation state, presence of methylation, and other site-specific factors (such as presence of iron sulfide or co-occurring metals) that influence uptake and effects. Thus, measurement of total metal concentration may overestimate actual risk from some metals to specific receptors because the form and toxicity of these metals at the site is not accounted for in the exposure estimations.

5.5.1.3 Calculated Total Concentrations for Soil

Exposure to dioxin/furan congeners, PCBs (as Aroclors), and PAHs was evaluated in this Post-NTCRA HHERA using calculated total concentrations for these mixtures. There are uncertainties associated with these calculated total concentrations, as described in this section.

5.5.1.3.1 Dioxin TEQ

Uncertainty associated with calculated total dioxin concentrations is related to the treatment of ND congeners in the TEQ estimates. Because several congeners routinely were not detected in soil samples, a potential area of uncertainty is the evaluation of ND values in calculating TEQ concentrations. In this Post-NTCRA HHERA, ND congeners were evaluated at half the RL. TEQs calculated assuming ND concentrations are equal to zero would result in lower TEQ concentrations and associated exposure and risk. When ND congeners are evaluated at zero in the TEQ calculation, the TEQ contribution of individual congeners with elevated RLs may be underestimated. When ND congeners are evaluated at half the RL or the full RL, the TEQ contributions of individual congeners are unlikely to be underestimated but may be overestimated, especially for congeners with elevated RLs.

5.5.1.3.2 Total PCBs

As described in Section 5.3.6, the calculation of total PCBs was conducted based on the specific Aroclors detected in each exposure area. For example, if two Aroclors were detected in the exposure area, the total PCB concentration in each sample would be calculated as the sum of the detected concentrations and/or half the RL for ND samples for those two Aroclors only. Measured Aroclors that were not detected in the exposure area were not included in the total PCB concentration for that exposure area. Use of half the RL or the full RL for calculation of total PCBs based on all Aroclors, including those not detected within a given exposure area, would result in overestimation of the total PCB concentrations present in soil.

5.5.1.3.3 B(a)P Equivalent Concentrations

Similar to the uncertainty associated with calculated total dioxin concentrations, uncertainty in the B(a)PEQ estimates is related to the treatment of ND cPAHs in the HHRA.

Because several cPAHs routinely were not detected in soil samples, a potential area of uncertainty is the evaluation of ND values in calculating B(a)PEQ concentrations. In the HHRA, ND cPAHs were evaluated at half the RL. B(a)PEQ values calculated assuming ND concentrations are equal to zero would result in lower B(a)PEQ concentrations and associated exposure and risk. When ND cPAHs are evaluated at zero in the B(a)PEQ calculation, the B(a)PEQ contribution of individual cPAHs with elevated RLs may be underestimated. When ND cPAHs are evaluated at half the RL, the B(a)PEQ contributions of individual cPAHs are unlikely to be underestimated but may be overestimated, especially for cPAHs with elevated RLs.

5.5.1.4 Soil Datasets

5.5.1.4.1 Biased Sampling Design

Soil data for each NTCRA impacted potential exposure area were collected according to approved sampling work plans (CH2M 2006b, 2013; DTSC 2007b, 2015c) and the soil NTCRA Work Plan (Jacobs 2022a, DOI 2022) to define the nature and extent of site-related constituents in areas outside the TCS potentially impacted by historical site use, to refine the understanding of fate and transport of COPCs/COPECs, and to confirm removal of risk-driving and non-risk-driving COPCs/COPECs identified under RAO 1 and RAO 2 of the soil NTCRA Work Plan (Jacobs 2022a). As such, soil samples were collected in a biased manner around known or suspected sources of release as well as at excavation boundaries around known or suspected sources of release. Human and ecological receptors potentially using the site are assumed to use areas of the site as described in Sections 5.2.2 and 3.3.2, respectively. They would not be expected to preferentially use more contaminated areas (and ecological receptors may even avoid highly developed or disturbed areas related to current or historical site operations). Human and ecological receptors would also be expected to have equal access to and utilization of unsampled areas distant from the historical sources of release. These unsampled areas are expected to contain lower or undetectable concentrations of site-related COPCs/COPECs. Therefore, use of the site soil data can potentially overestimate receptor exposure to COPCs/COPECs. In the 2019 HHERA (Arcadis 2019) and this Post-NTCRA HHERA, area-weighting was used to reduce the impact of biased sampling on the EPCs. Overestimation of exposure and associated risk is more likely for EPCs calculated without area-weighting (i.e., the depth-weighted EPCs) and especially when the EPC is based on the maximum depth-weighted concentration. The maximum depth-weighted concentration was frequently selected as the EPC for some COPCs/COPECs that were rarely detected in the soil datasets outside and inside the TCS, such as antimony, cadmium, silver, thallium, and/or PCBs. The effect of biased sampling on the risk estimates and conclusions are minimized, to the extent feasible, using area-weighted EPCs (except in cases when area-weighted EPCs were not warranted due to lack of risk using depth-weighted EPCs). The area-weighting, however, did not take into account the unsampled areas between the source areas, and thus, although the effect of biased sampling on the risk conclusions was minimized, to the extent feasible, area-weighted EPCs for the combined exposure areas (e.g., OCS potential exposure area) still likely represent an overestimate of exposure and risk for the receptors potentially exposed to the combined exposure areas, as presented in the 2019 HHERA. For the six potential exposure areas evaluated in this Post-NTCRA HHERA, the effect of biased sampling is less apparent because the risk estimates calculated using depth- or area-weighted EPCs produce similar results and, thus, use of either depth- or area-weighted EPCs would not materially change the conclusions of this Post-NTCRA HHERA that there is no unacceptable risk to human or ecological receptors in the NTCRA areas. These EPC calculation methods are consistent with those used in the 2019 HHERA (Arcadis 2019) and as presented in the DTSC-approved RAWP (Arcadis 2008b) and related documents (Arcadis 2009a, 2015).

5.5.1.4.2 Data Grouping

Consistent with the 2019 HHERA (Arcadis 2019), a few individual sample locations were evaluated in more than one potential exposure area. In some cases, sample locations along or just outside the investigation area-specific boundaries were included in the potential exposure area dataset because the samples were collected as part of the nature and extent investigations for that specific investigation area or because there is potential for transport of soil into the exposure area. Details of the exact samples and sampling locations included in each potential exposure area are presented in the Data Evaluation and COPC/COPEC Selection section (Section 2) of each exposure area-specific appendix. A comprehensive list of the sample locations that were analyzed in more than one AOC-based exposure area evaluated in this Post-NTCRA HHERA are included in Exhibit 5-14.

Exhibit 5-14. Sample Locations Included in Multiple Post-NTCRA HHERA Exposure Areas

Sample Location	AOC1	AOC11	AOC14	AOC27
RR-1	Yes		Yes	
AOC16-5	Yes	Yes		Yes
PA-01	Yes	Yes		Yes
PA-07	Yes	Yes		Yes
PA-13	Yes	Yes		Yes
PA-14	Yes	Yes		Yes
PA-15	Yes	Yes		Yes
PA-16	Yes	Yes		Yes
PA-17	Yes	Yes		Yes

The number of sample locations evaluated in more than one potential exposure area is small relative to the risk assessment datasets for each potential exposure area, and elevated COPC/COPEC concentrations are not present at these locations. As a result, the effect on the calculated EPCs and resulting risk estimates is expected to be negligible.

5.5.1.4.3 Effect of Backfill

As noted in Sections 3.1 and 4, clean backfill placed in some excavated areas associated with the NTCRA was not included in the soil datasets used to calculate EPCs and estimate risk in this Post-NTCRA HHERA. As a result, potential soil exposures in the NTCRA areas are likely overestimated, although the magnitude of this effect varies for each NTCRA exposure area depending on the spatial extent of the exposure area relative to the excavated areas, the amount and type of clean backfill placed, and the surface area currently represented by backfill. As noted in the Soil Non-Time-Critical Removal Action Completion Report (Jacobs 2025), several types of clean backfill were used during construction, including offsite soil (i.e., Campbell’s AB), onsite materials (i.e., soil, screened onsite rock, gravel), and rip-rap. The NTCRA excavation areas and the types and amount of backfill placed in each NTCRA area are presented on Figure 5-2 and Table 5-6.

Gravel, rock, and rip-rap do not have the same exposure routes as soil, as these materials are too large to be inhaled, ingested, or adhere to skin. Thus, in areas where these larger aggregate materials were placed, exposure to this material is considered to be negligible. In areas where clean soil was placed as backfill, potential exposures are expected to be the same as for on-site native soils evaluated in this Post-NTCRA HHERA. Additionally, material present at the ground surface is mostly likely to be contacted by both human and ecological receptors. Shotcrete was applied for slope stabilization in some areas (i.e., AOC 9 and AOC 10 on the steep slopes near the TCS boundary). In areas where clean fill was covered by rip-rap and or shotcrete, exposure to underlying soil is considered to be negligible.

In areas where clean soil was placed as backfill at the ground surface, the EPCs presented in this Post-NTCRA HHERA may overestimate actual exposure to native soil in these areas. While inclusion of the backfill would be likely to result in lower EPCs for some constituents (i.e., those that have both significantly lower concentrations in the backfill and have a significant volume of backfill within the AOC-based exposure area), the magnitude of this effect is uncertain. As noted above, the surface area of the backfill relative to the entire exposure area is an important factor determining the magnitude of this effect. Exposure areas with a greater relative backfill area could be expected to have higher degree of EPC overestimation based on consideration of surface area alone. Additionally, the COPC concentrations in backfill relative to residual concentrations in native soil will also determine the magnitude of by which EPCs could be overestimated. While EPCs for some of the AOC-specific exposure areas with backfill evaluated in this Post- NTCRA HHERA have uncertainty, it is important to note that the NTCRA excavation and backfill areas represent a small overall proportion of area outside the TCS to which potential human and ecological receptors are more likely to be exposed.

For the key risk-driving COPCs/COPECs evaluated in this Post- NTCRA HHERA, the remedial actions reduced COPC/COPEC concentrations to below the RAGs in most areas and the Post- NTCRA HHERA risk estimates (not including backfill) indicate that no unacceptable risk remains in the NTCRA areas for human or ecological receptors. Inclusion of backfill in the EPC estimates may further reduce the quantitative risk estimates; however, the overall conclusions of the report (i.e., that there is no unacceptable risk to potential human or ecological receptors in the NTCRA areas) will not change.

5.5.1.5 Background Datasets

Soil samples for the background datasets were collected from areas representative of background conditions near the TCS and analyzed for inorganic constituents, PAHs, and dioxin/furans (CH2M 2009c, 2017a). Sample locations for inorganic compounds and PAHs are shown on Figure 1 from the Background Tech Memo (CH2M 2009c). Sample locations for dioxins/furans and PAHs are presented on Figure 1 from the soil background investigation (CH2M 2017a). As shown on the figures, the samples collected represent a range of geologic soil types that broadly represent soil at the site and AOCs outside the TCS. However, some soil sample locations represented in the risk assessment datasets are in locations that may represent soil types not included in the background dataset. For example, soils in the UA-2 exposure area are known to be representative of bedrock, whereas background datasets were taken primarily from alluvial soil. Therefore, the background soil datasets may not be representative of UA-2 bedrock-related soil in this area. Soils in some parts of the Tamarisk Thicket area appear to be representative of Quaternary river gravels, which are not well represented in soil samples analyzed for inorganic compounds, PAHs, and dioxin/furans included in the background datasets. Additionally, soil types and associated background concentrations can be patchy at small spatial scales. Although the soil background datasets and resulting BTVs are generally appropriate for identifying the range of background concentrations at the TCS exposure area, it is possible that some sample concentrations exceeding the BTVs and/or range of background concentrations may be representative of concentrations in a different background population (i.e., different soil type). Similarly, some concentrations below the BTVs and/or range of background concentrations may be representative of a different background population (i.e., different soil type). Overall, constituents determined to be above background levels using the agency-approved site background dataset were conservatively included as COPCs/COPECs in this Post-NTCRA HHERA.

5.5.2 Uncertainties in the Selection of Chemicals of Potential Concern

Selecting the COPCs/COPECs to be included in the risk assessments is a sequential process where a compound detected in site media may be eliminated from further consideration based on either the concentration being consistent with ambient background conditions or its status as an essential nutrient. Current DTSC guidance (1997) allows inorganic compounds to be eliminated from a risk assessment if it can be demonstrated that they do not exceed local background levels. Methods comparable to the DTSC guidance (1997, 2009d) are also commonly used in the risk assessment process to evaluate whether ubiquitous anthropogenic compounds such as dioxins/furans and PAHs are present at a site at levels that exceed background concentrations. As described in Section 3.4 of the 2019 HHERA (Arcadis 2019), soil datasets from each exposure area were compared to background datasets for inorganic compounds, dioxins/furans, and PAHs. Background conditions were not evaluated for the inorganic compounds phosphate and orthophosphate; therefore, these COPCs were included in the risk assessment in exposure areas where detected. For some exposure areas where a small number of soil samples were collected (e.g., AOC 28 and AOC 31), a statistical comparison to background soil datasets was not possible because of small sample size.

With the exception of chemicals determined to be consistent with ambient background conditions, all detected chemicals were included in the risk assessment regardless of detection frequency. This could have resulted in inclusion of chemicals in the quantitative risk assessment that are limited to small areas of the site and which may not be site-related. Inclusion of these infrequently detected chemicals could have resulted in an overestimation of site-related risks from exposure to these COPCs.

5.5.3 Uncertainties in the Exposure Assessment

5.5.3.1 Exposure Assumptions and Pathways

In general, the HHRA has quantified potentially complete exposure pathways through which individuals could become exposed to COPCs present in site soil and indoor/outdoor air. Accordingly, the exposure pathways quantified in the HHRA are believed to capture the range of theoretical potential current and reasonably foreseeable future exposures for potential recreational receptors evaluated in the HHRA and thus provide a conservative estimate of long-term exposures that could occur at the site.

This baseline risk assessment assumes that contact with soil is not limited by the presence of engineering or institutional controls in the future. The potential health risks estimated for recreational users do not account for potential vegetative covering, unsuitable topography (e.g. steep slopes), or backfill material cover placed during or after completion of NTCRA activities outside the TCS that would reduce exposure below that assumed in this analysis. As such, the estimated risks are likely overestimated. However, the EPC calculation methods are consistent with those used in the 2019 HHERA (Arcadis 2019) and provide a relevant comparison to the 2019 exposure and risk estimates. Furthermore, as stated in the NTCRA Completion Report (Jacobs 2025), DOI-approved clean onsite fill material and imported AB material were used as backfill. The backfill material conformed to the Topock Groundwater Remedy Soil Management Plan reuse criteria (Jacobs 2022b) approved by DTSC (2022) (including updates to Table 2.4-1 [Reference List of Potentially Applicable Analytes and Associated Screening Levels Management Protocol for Handling and Disposition of Displaced Material]). Additionally, arsenic concentrations in the fill material are below site-specific background thresholds. Inclusion of backfill material in the EPC calculations would not materially change the conclusions of this Post-NTCRA HHERA that there is no unacceptable risk to human or ecological receptors in the NTCRA areas.

The specific exposure assumptions for the recreational user were provided by DOI and included in RAWP Addendum 2 (Arcadis 2015). As summarized by DOI, generic, or default, exposure factors are generally not available for recreational land use (except for some specific scenarios, such as fishing and fish ingestion rates). USEPA’s 2011 Exposure Factors Handbook update does not present exposure factors for any recreational scenarios other than fishermen (USEPA 2011). Rather, informed professional judgment is necessary to select factors that best represent the types of recreational activities that may be conducted at the site of interest.

Recreational use of federal land at the site is expected to vary during the course of a year due to a variety of factors, including weather (especially hot, cold, or rainy periods) and time of year. In general, recreational activities at the site are expected to be limited in frequency and duration during the hottest summer months. The exposure parameters recommended by DOI and used in the HHRA for recreational users are based on site-specific considerations and information provided from nearby sites and relevant sources. The exposure frequency parameters have been informed by information presented in the California Natural Resources Agency’s (CNRA’s) document “Summary Findings: Survey on Public Opinions and Attitudes on Outdoor Recreation in California” (CNRA 2009). The use rates provided by CNRA are mean values; for risk assessment purposes, an upper bound measure of exposure (e.g., the 95UCL) is generally preferred. To be protective of human health, it is conservatively assumed herein that a participant’s entire annual recreational activity is conducted at the site rather than spread out at various recreational locations across the state. Exposure duration values (in years) are consistent with those used in the Clear Creek Management Area HHRA (USEPA 2008a) for similar activities. The exposure time, frequency, and duration for the recreational user provided by DOI and used in the HHRA erred on the side of conservatism to be protective of human health and may not represent “reasonably anticipated use” of the site. Therefore, the health risks estimated for recreational users are likely overestimated and lower than presented in the HHRA. The exposure calculation methods are consistent with those used in the 2019 HHERA (Arcadis 2019) and provide a relevant comparison to the 2019 exposure estimates.

In addition, as recommended by DOI (Arcadis 2015), it is assumed that each of the recreational activities could take place at any location on federal land. However, specific locations may be preferred for certain activities, while other locations may be less attractive or may have limited recreational options. No physical barrier (such as fencing) is present that would stop an individual recreational user from accessing any and all areas of the AOCs outside the TCS. Therefore, potential receptor populations would more likely be exposed randomly, over the course of a lifetime, to soils present across the OCS potential exposure area, rather than have a lifetime of contact limited to a potential exposure area based on an individual AOC (as evaluated in the area-specific appendices at the request of DTSC).

As noted in Section 5.4.2, the OCS potential exposure area is considered the most representative baseline scenario for potential human exposures and associated risks for soil contact outside TCS. No unacceptable risk to human recreator receptors (camper, hiker, and OHV rider) was identified at the site potential exposure areas evaluated in this Post-NTCRA HHRA. Given the reduction in overall estimated cumulative risks and hazards under post-NTCRA conditions in these potential exposure areas, which were identified with elevated concentrations of risk-driver COPCs in the 2019 HHERA (Arcadis 2019), estimated cumulative risks and hazards for recreational users, camper, hikers, and OHV riders for the OCS potential exposure area under post-NTCRA conditions are likely lower than estimated in the 2019 HHERA (Arcadis 2019).

In sum, the risk assessment meets the regulatory requirement to address an upper bound for potential exposures for current and reasonably foreseeable future receptor populations; the actual exposures to soil at the site that could be incurred by recreators use would probably be much lower than has been estimated in this Post-NTCRA HHRA.

5.5.3.2 Effect of Scouring Assumptions

As described in Appendix BCW and Appendix AOC 10, vertical scouring within the ravine bottoms of BCW and AOC 10 has not been observed over many years of site observations that include several high flow events. The vertical scouring scenarios evaluated in this Post-NTCRA HHERA are considered highly unlikely to occur at the site.

Although vertical scouring of the ravine bottoms does not occur, erosion has been occurring on the steep hillside where AOC 9 and AOC 10 TAA1 are located, just below the TCS. The catchment area for East Ravine is small, so the ravine does not get large amounts of stormwater runoff. As a result, and consistent with observations, scouring is not expected in the ravine bottom. Prior to removal of the berm adjacent to AOC 10c (i.e., AOC 10 TAA2), flow within ravine stopped there, and any transported sediment was deposited. The berm was removed as part of the NTCRA. Following berm removal, flow within ravine is now continuous to AOC 10d, where the next berm (SoCal Gas pipeline berm) is located. Additionally, NTCRA activities included placement of riprap on the slope at AOC 9 TAA1 and AOC 10 TAA1 after backfilling to prevent further erosion from occurring in those locations.

The risk estimates in the HHRA based on scouring scenarios for recreational users (i.e., camper, hiker, and OHV rider) are calculated to be consistent with the 2019 HHRA exposure scenarios, but are overly conservative estimates given the observed conditions in BCW and AOC 10 and do not meaningfully inform risk-management decision-making at the site.

5.5.3.3 Bioavailability of Constituents in Soil

Exposure estimates calculated herein assume that measured concentrations of COPCs/COPECs in soil are 100% bioavailable. For many COPCs/COPECs, this assumption overestimates exposure. The chemical extraction methods used in laboratory procedures to measure COPC/COPEC concentrations in soil samples result in complete or nearly complete extraction of bound and insoluble COPC/COPEC fractions in soil, whereas chemical extraction in the gut of ecological and human receptors can be far less efficient. Uncertainties associated with bioavailability of COPECs in soil for ecological receptors are discussed in detail in Section 6.7.3.1.

Studies support that certain organic compounds, particularly highly lipophilic compounds such as PAHs, tend to be tightly bound to soil (Kelsey et al. 1997). This phenomenon can substantially reduce the bioavailability of chemicals to people exposed to chemicals in soil. A reduction in the bioavailability of the chemicals adsorbed to soil would reduce the projected health risk associated with exposure to soil. Low bioavailability could substantially reduce estimated risks below levels calculated using the default assumption that all chemicals are 100% bioavailable. Therefore, risk is likely overestimated for lipophilic chemicals assumed to be 100% bioavailable in this HHERA. For the key risk-driving COPCs, this assumption applies only to dioxin TEQ.

5.5.3.4 Soil Exposure Point Concentrations

For the HHRA, EPCs were updated for only risk-driver COPCs (i.e., hexavalent chromium, TEQ, total chromium, and copper) identified in the 2019 HHERA (Arcadis 2019). Pre-NTCRA depth-weighted and area-weighted EPCs calculated and used in the 2019 HHERA for non-risk-driver COPC are conservatively assumed to represent an upper bound EC for non-risk-driver COPCs in post-NTCRA soil in potential exposure areas BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 and are conservatively used to estimate cumulative human health risks and hazards inclusive of all COPCs because analytical concentrations for all COPCs were not measured in the NTCRA confirmation samples. Post-NTCRA EPCs for non-risk-driver COPCs are likely lower than pre-NTCRA EPCs as removal of risk-driver COPC-impacted soil would also remove soils with concentrations of non-risk-driver COPCs. Also, EPCs for non-risk-driver COPCs and risk-driver COPCs/COPECs do not account for the unimpacted backfill material placed in the NTCRA TAAs to restore the surface grade in certain areas, which will mitigate and reduce overall exposure to residual impacted soils in these areas. Therefore, estimated cumulative human health risk and hazards for the potential recreational receptors (i.e., campers, hikers, and OHV riders) in potential exposure areas BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 are likely overestimated. Hazards estimated for the desert shrew discussed in Section 6.6 are likely overestimated as EPC for COPECs do not account for the unimpacted backfill material placed in the NTCRA TAAs. As noted previously, the EPC calculation methods are consistent with those used in the 2019 HHERA (Arcadis 2019) and provide a relevant comparison to the 2019 exposure and risk estimates.

Additionally, both depth-weighted EPCs and area-weighted EPCs were used to estimate potential risk in this Post-NTCRA HHERA. As noted in Section 4, the area-weighting procedure can correct for uneven spatial coverage. In that regard, the area-weighted EPCs (which are both depth- and area-weighted) theoretically provide a better exposure estimate than the depth-weighted EPCs (which are only depth-weighted). However, comparable to the results of the 2019 HHERA (Arcadis 2019), the depth-weighted EPCs and area-weighted EPCs were similar indicating that uncertainty associated with the specific EPC calculation method is low.

5.5.4 Uncertainties in the Toxicity Assessment

Uncertainty in the toxicity assessment arises for those chemicals which rely on animal studies as the basis for determining the appropriate toxicity value. All risk assessments assume that adverse effects observed in animal toxicity experiments would also be observed in humans (animal-to-human extrapolation) and that the toxic effect observed after exposure by one route would occur following exposure by a different route (route-to-route extrapolation).

To adjust for uncertainties that arise from the use of animal data, regulatory agencies often base the RfD for noncarcinogenic effects on the most sensitive animal species (i.e., the species that experiences adverse effects at the lowest dose) and adjust the dose via the use of safety or uncertainty factors. The adjustment compensates for the lack of knowledge regarding interspecies extrapolation and the possibility that humans are more sensitive than the most sensitive experimental animal species tested. The use of uncertainty factors is considered to be health protective.

Additionally, when route-specific toxicity data are unavailable, data are often derived by route-to-route extrapolation, and equal absorption rates for both routes are assumed (i.e., oral to inhalation and inhalation to oral). This may or may not reflect the actual differences in toxicity that can be associated with the route of exposure but is considered to be a conservative and health-protective assumption. For dermal exposure to soil, chemical-specific absorption data generally are not available. Instead, dermal absorption rates, which are based on the default assumptions provided by the DTSC (2015b), are assumed.

As stated in Section 5.3, the hierarchy of sources for the toxicity criteria that is used in this Post-NTCRA HHERA has been updated from the 2019 HHERA (Arcadis 2019) and is compliant with the September 4, 2018, "Toxicity Criteria for Human Health Risk Assessments, Screening Levels, and Remediation Goals" ("Toxicity Criteria Rule", Title 22, California Code of Regulations, Sections 68400.5, 69020-69022) at the time of the preparation of the Post-NTCRA HHERA.

As summarized in Section 5.3.1, the CSFs and/or URFs for six COPCs (i.e., arsenic, methylene chloride, 1-methylnaphthalene, alpha-chlordane, gamma-chlordane, and total PCBs) evaluated in the HHRA are updated from the values used in the 2019 HHERA (Arcadis 2019). The 2019 HHERA and updated CSFs and/or URFs at the time of the preparation of the Post-NTCRA HHERA and 2019 HHERA and updated maximum cancer risk results for the six COPCs are summarized in Exhibit 5-14.

Exhibit 5-15. COPCs with Cancer Toxicity Values Updates

COPC	2019 HHERA Toxicity Value	2025 Post-NTCRA HHERA Updated Toxicity Value	2019 HHERA Maximum Cancer Risk Results	2025 Post-NTCRA HHERA Maximum Cancer Risk Results
Arsenic	URF - 3.3 $(mg/m^3)^{-1}$ (DTSC Note 3)	URF - 4.3 $(mg/m^3)^{-1}$ (IRIS)	4.1E-06	4.1E-06
Methylene chloride	CSF - 0.014 $(mg/kg\text{-}day)^{-1}$ (OEHHA)	CSF - 0.002 $(mg/kg\text{-}day)^{-1}$ (IRIS)	Not a COPC in the 6 Post-NTCRA Soil HHERA Exposure Areas	
1-Methyl naphthalene	URF - 0.00725 $(mg/m^3)^{-1}$ (route) CSF - 0.029 $(mg/kg\text{-}day)^{-1}$ (PPTRV)	URF - 0.01275 $(mg/m^3)^{-1}$ (route) CSF - 0.051 $(mg/kg\text{-}day)^{-1}$ (PPTRV)	5.0E-10	8.8E-10

COPC	2019 HHERA Toxicity Value	2025 Post-NTCRA HHERA Updated Toxicity Value	2019 HHERA Maximum Cancer Risk Results	2025 Post-NTCRA HHERA Maximum Cancer Risk Results
alpha-Chlordane	URF - 0.34 $(mg/m^3)^{-1}$ (surrogate) CSF - 1.3 (mg/kg-day)-1 (surrogate)	URF - 0.1 $(mg/m^3)^{-1}$ (surrogate) CSF - 0.35 (mg/kg-day)-1 (surrogate)	1.2E-09	3.2E-10
gamma-Chlordane	URF - 0.34 $(mg/m^3)^{-1}$ (surrogate) CSF - 1.3 $(mg/kg\text{-}day)^{-1}$ (surrogate)	URF - 0.1 $(mg/m^3)^{-1}$ (surrogate) CSF - 0.35 $(mg/kg\text{-}day)^{-1}$ (surrogate)	1.3E-09	3.5E-10
Total PCBs	URF - 0.57 $(mg/m^3)^{-1}$ (OEHHA)	URF - 0.1 $(mg/m^3)^{-1}$ (IRIS)	1.4E-07	1.4E-07

As summarized in Section 5.3.2, the RfDs and/or RfCs for 10 COPCs (i.e., antimony, total chromium, manganese, phosphate, acetone, chloroform, toluene, 4,4-dichlorodiphenyldichloroethylene, TPHs as diesel, and TPHs as motor oil) evaluated in the HHRA are updated from the values used in the 2019 HHERA (Arcadis 2019). The 2019 HHERA and updated RfDs and/or RfCs at the time of the preparation of the Post-NTCRA HHERA and 2019 HHERA and updated maximum hazard index results for the ten COPCs are summarized in Exhibit 5-15.

Exhibit 5-16. COPCs with Non-Cancer Toxicity Values Updates

COPC	2019 HHERA Toxicity Value	2025 Post-NTCRA HHERA Updated Toxicity Value	2019 HHERA Maximum Hazard Index Results	2025 Post-NTCRA HHERA Maximum Hazard Index Results
Antimony	RfC - 0.0016 mg/m^3 (route)	RfC - 0.0003 mg/m^3 (ATSDR)	2.7E-02	2.7E-02
Chromium, total	RfC - 6 mg/m^3 (surrogate)	RfC - 0.00006 mg/m^3 (OEHHA)	2.9E-04	2.7E-03
Manganese	RfC - 0.00009 mg/m^3 (OEHHA)	RfC - 0.00005 mg/m^3 (IRIS)	2.4E-02	4.2E-02

COPC	2019 HHERA Toxicity Value	2025 Post-NTCRA HHERA Updated Toxicity Value	2019 HHERA Maximum Hazard Index Results	2025 Post-NTCRA HHERA Maximum Hazard Index Results
Phosphate	RfC - 196 mg/m^3 (surrogate) RfD - 49 mg/kg-day (surrogate)	RfC - 11.7 mg/m^3 (surrogate) RfD - 2.93 mg/kg-day (surrogate)	4.4E-06	7.3E-05
Acetone	RfC - 31 mg/m^3 (ATSDR)	RfC - 3.6 mg/m^3 (route)	Not a COPC in the 6 Post-NTCRA Soil HHERA Exposure Areas	
Chloroform	RfC - 0.098 mg/m^3 (ATSDR)	RfC - 0.00195 mg/m^3 (ATSDR)	Not a COPC in the 6 Post-NTCRA Soil HHERA Exposure Areas	
Toluene	RfC - 0.3 mg/m^3 (OEHHA)	RfC - 0.42 mg/m^3 (OEHHA)	Not a COPC in the 6 Post-NTCRA Soil HHERA Exposure Areas	
4,4-DDE	RfC - 0.0012 mg/m^3 (route) RfD - 0.0003 mg/kg-day (PPRTV-Screen)	RfC - 0.002 mg/m^3 (route) RfD - 0.0005 mg/kg-day (ATSDR)	1.4E-05	8.2E-06
TPH as diesel	RfC - 0.13 mg/m^3 (ESL) RfD - 0.02 mg/kg-day (ESL)	RfC - 0.26 mg/m^3 (ESL) RfD - 0.019 mg/kg-day (ESL)	5.7E-02	4.6E-02
TPH as motor oil	RfC - 0.68 mg/m^3 (route) RfD - 0.17 mg/kg-day (ESL)	RfC - 0.6 mg/m^3 (route) RfD - 0.15 mg/kg-day (ESL)	8.3E-03	9.4E-03

The toxicity values for COPCs updated in this Post-NTCRA HHERA are consistent with the DTSC Human Health Risk Assessment (HHRA) Note 10 recommended toxicity values (DTSC 2019a) at the time the Draft Post-NTCRA HHERA was submitted to DTSC on December 14, 2024. Since the submittal, the toxicity values for arsenic, Total PCBs, hexavalent chromium, molybdenum, acetone, 1-methylnaphthalene, and 4-methylphenol have been updated as referenced in the most recent DTSC April 2025 Note 10 (DTSC 2025) or the November 2024 USEPA Regional Screening Level tables (USEPA 2024), Molybdenum and acetone are not COPCs in the six Post-NTCRA Soil HHERA exposure areas.

The oral CSF for arsenic was updated in January 2025 and is approximately three times higher than the values used in this Post-NTCRA HHERA (i.e., updated from 9.5 (mg/kg-day)$^{-1}$ to 32 (mg/kg-day)$^{-1}$). The updated toxicity values did not result in additional risk drivers to be identified in the six exposure areas evaluated in this Post-NTCRA HHERA. Cancer risk estimates associated with arsenic in soil in AOC 9, AOC 10, and AOC 11 would increase for the camper, hiker, and OHV rider approximately threefold as would the cancer estimate associated with background levels of arsenic in soil under these recreational user scenarios. As such, the incremental cancer risks from arsenic would be marginally higher but likely between 3 x 10^{-7} and 4 x 10^{-6}, which is above 1 x 10^{-6} but below 5 x 10^{-6} and well within the risk-management range of 1 x 10^{-6} and 1 x 10^{-4}. The incremental cancer risks from arsenic are also below the USFWS's cancer risk threshold level of 1 x 10^{-5} for soil deeper than 2 feet bgs (as included in the February 12, 2021 Topock Soil EE/CA Response to Comment Consultation Meeting Agenda).

The current URF for Total PCBs is 0.57 (mg/m^3)$^{-1}$ with is the same values as used in the 2019 HHERA and as shown in Exhibit 5-14, the maximum cancer risk for Total PCBs presented in the 2019 HHERA is the same as presented in this Post-NTCRA HHERA.

The current inhalation RfC of 0.00003 mg/m^3 and oral RfD of 0.0009 mg/kg-day for hexavalent chromium is approximately 3.3-times lower than the inhalation RfC of 0.0001 mg/m^3 and oral RfD of 0.003 mg/kg-day used in this Post-NCTRA HHRA HQ calculations, however, all HIs associated with hexavalent chromium in soils in the six exposure areas are 0.0001 or lower. Therefore, the use of the current inhalation RfC and oral RfD for hexavalent chromium would result in a maximum HI of 0.001 for hexavalent chromium, which is well below an HI of 1.

The current inhalation RfC of 0.00003 mg/m^3 for 1-methynaphthalene is approximately 93,000-times lower than inhalation RfC of 0.28 mg/m^3 used in this Post-NCTRA HHRA HQ calculations, however, all total HIs associated with 1-methynaphthalene in soil in AOC9, AOC10, and AOC11 exposure areas (i.e., only a COPC in these NTCRA exposure area) are 0.000002 or lower and 0.00000006 or lower for the inhalation route. Therefore, the use of the current inhalation RfC for 1-methynaphthalene would result in a maximum total HI of 0.006 for 1-methynaphthalene, which is well below an HI of 1.

The current oral RfD of 0.02 mg/kg-day for 4-methyphenol is 5-times lower than the oral RfD of 0.1 mg/kg-day used in the this Post-NCTRA HHRA HQ calculations, however, all HIs associated with 4-methylphenol in soil in AOC14 exposure area (i.e., only a COPC in this NTCRA exposure area) are 0.00007 or lower. Therefore, the use of the current oral RfD for 4-methylphenol would result in a maximum HI of 0.0004 for 4-methylphenol, which is well below an HI of 1.

Therefore, the updates in the toxicity values for COPCs used in the estimate of potential cancer risk and noncancer hazard indices in this Post-NTCRA HHERA and updates after time of the preparation of the this Post-NTCRA HHERA do not materially affect the conclusion of the HHRA (i.e., that there is no unacceptable risk to potential human receptors in the NTCRA areas).

5.5.5 Uncertainties in the Risk Characterization

5.5.5.1 Summing Cancer Risk and Noncancer Hazard Indices

One source of uncertainty that is unique to risk characterization is the assumption that the total risk associated with exposure to multiple chemicals is equal to the sum of the individual risks for each chemical (i.e., the risks are additive). Other possible interactions include synergism, where the total risk is higher than the sum of the individual risks, and antagonism, where the total risk is lower than the sum of the individual risks. Relatively little data are available regarding potential chemical interactions following environmental exposure to chemical mixtures. Some studies have been carried out in rodents given simultaneous doses of multiple chemicals. The results of these studies indicated that no interactive effects were observed for mixtures of chemicals affecting different target organs (i.e., each chemical acted independently), whereas antagonism was observed for mixtures of chemicals affecting the same target organ but by different mechanisms (Presidential/Congressional Commission on Risk Assessment and Risk Management 1997).

Although there are no data on interactions in humans with chemical mixtures at the dose levels typically observed in environmental exposures, animal studies suggest that synergistic effects will not occur at levels of exposure below their individual effect levels (Seed et al. 1995). As exposure levels approach the individual effect levels, a variety of interactions may occur, including those that are additive, synergistic, and antagonistic (Seed et al. 1995).

Current USEPA guidance for risk assessment of chemical mixtures (USEPA 1989) recommends assuming an additive effect following exposure to multiple chemicals. Subsequent recommendations by other parties, such as the National Research Council (1988) and the Presidential/Congressional Commission on Risk Assessment and Risk Management (1997) have also advocated for a default assumption of additivity. As currently practiced, risk assessments of chemical mixtures generally sum cancer risks regardless of tumor type and sum noncancer HIs regardless of toxic endpoint or mode of action. Given the available experimental data, this approach likely overestimates potential risks associated with simultaneous exposure to multiple chemicals in AOCs that were evaluated in this Post-NTCRA HHERA.

5.5.5.2 Carcinogenic Polycyclic Aromatic Hydrocarbon Risk

Consistent with the 2019 HHERA (Arcadis 2019) and DTSC guidance (DTSC 2015b), individual PAHs designated by the state of California as cPAH were addressed in terms of a B(a)PEQ, for each sample using a TEF approach. An alternative approach of evaluating risk for cPAHs is to estimate cancer risks for each cPAH separately using CSFs and URFs promulgated by OEHHA or USEPA for the individual cPAHs. Given that B(a)PEQ for the total mixture of cPAHs for each sample is likely biased high due to the inclusion of ND cPAHs in the sample at half the RL, the EPCs for B(a)PEQ are also likely biased high. Therefore, evaluating cPAH cancer risks using the alternative method likely results in a lower overall estimated cumulative risks for cPAHs and would not materially change the conclusions in the HHRA that there is no unacceptable risk to human or ecological receptors in the NTCRA areas.

5.5.5.3 Potential Exposure Area OCS Risk

The OCS potential exposure area is considered the most representative baseline scenario for potential human exposures and associated risks for soil contact outside the TCS. As stated in the 2019 HHERA (Arcadis 2019), risks/hazards estimated for an individual AOC, SWMU, or UA potential exposure area, such as BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27, evaluated in this Post-NTCRA HHERA are not considered representative of the realistic or likely potential exposures for the human populations that could be present in the areas outside the TCS (such as recreational users). Risks/hazards calculated separately for individual AOCs are conservative and likely overestimate site risks/hazards. As described in the RAWP documents (Arcadis 2008b, 2009a, 2015), these human populations would more likely be exposed randomly, over the course of a lifetime, to soil present in all individual AOC/SWMU/UA potential exposure areas located outside the TCS, rather than have a lifetime of contact limited to the area of a single potential exposure area. Therefore, estimated risks/hazards presented for individual AOC/SWMU/UA potential exposure areas are not believed to be representative of the potential health risks to humans potentially contacting the soil outside the TCS. Rather, the HHRA results for all AOC/SWMU/UA potential exposure areas located outside the TCS represents the more realistic or likely potential exposures to and risks from COPCs in soil for the human populations.

The estimated cumulative risks and hazards for recreational users, camper, hikers, and OHV riders for the OCS potential exposure area, as presented in the 2019 HHERA (Arcadis 2019) were above 1×10^{-6} (up to 1×10^{-5}) and above 1, respectively, and attributed primarily to risk-driver COPCs (i.e. dioxin TEQ and/or hexavalent chromium) in individual exposure areas SWMU 1 within BCW, AOC 9, and AOC 10. Post-NTCRA estimated cumulative risks/hazards for recreational users, camper, hikers, and OHV riders for the BCW, AOC 9, and AOC 10 potential exposure areas are at 1×10^{-6} or slightly above 1×10^{-6} when the contribution of background arsenic risk is excluded, which is well within the within the risk-management range of 1×10^{-6} and 1×10^{-4}. Given the reduction in overall estimated cumulative risks and hazards under post-NTCRA conditions in these potential exposure areas, which were identified with elevated concentrations of risk-driver COPCs in the 2019 HHERA, estimated cumulative risks and hazards for recreational users, camper, hikers, and OHV riders for the OCS potential exposure area under post-NTCRA conditions are likely lower than estimated in the 2019 HHERA and likely at or slightly above at 1×10^{-6} and well within the within the risk-management range of 1×10^{-6} and 1×10^{-4}. The estimated cumulative ILCRs are also below the USFWS's cancer risk threshold level of 1×10^{-5} for soil deeper than 2 feet bgs (as included in the February 12, 2021 Topock Soil EE/CA Response to Comment Consultation Meeting Agenda).

6 ECOLOGICAL RISK ASSESSMENT FOR SOIL

This section describes the ERA conducted to evaluate post-NTCRA conditions at the TCS and includes the purpose and objectives, applicable guidance, the approach used to estimate risks to ecological receptors, and the ecological risk characterization. The approach and methodology used to evaluate post-NTCRA conditions in this Post-NTCRA HHERA utilizes the methodology from the 2019 HHERA (Arcadis 2019), as presented in the Agencies-approved Risk Assessment Work Plan documents (Arcadis 2008b, 2009a, 2015, DOI 2009a,b, DOI 2015, DTSC 2009a, DTSC 2015a), DTSC-issued directive letter (DTSC 2017b, and Agencies-approved 2019 HHERA (Arcadis 2019, 2020; DOI and DTSC 2020). Consistent with the January 30, 2024 Technical Memo (Arcadis 2024a), updated ecological risk characterization included in this Post-NTCRA HHERA is presented only for risk-driving ecological receptors (desert shrew) identified in the 2019 HHERA.

In the 2019 HHERA (Arcadis 2019), risks were estimated for potentially complete and significant exposure pathways identified for a suite of ecological receptors exposed to COPECs in soil at the site potential exposure areas. These included plants, invertebrates, and small home-range receptors (Merriam’s kangaroo rat, desert shrew, cactus wren, and Gambel’s quail). Potential large home-range receptors (desert kit fox, red-tailed hawk, and Nelson’s desert bighorn sheep) were evaluated for larger potential exposure areas (combined AOCs/investigation areas). Semi-quantitative and qualitative evaluations for special-status species were also conducted, as described in the 2019 HHERA.

The 2019 HHERA (Arcadis 2019) concluded that potential risk to ecological receptors, including special-status species, at the site was limited to desert shrew potentially exposed to a few risk-driving COPECs (i.e., total chromium, copper, and dioxin TEQ) in surface soil in one or more potential exposure areas. Therefore, this Post-NTCRA HHERA presents risk estimates for desert shrew and the risk-driving COPECs in surface soil that reflect current conditions following soil remediation associated with the NTCRA. For consistency, risk estimates for hexavalent chromium (a risk-driving COPC for some recreational human receptors; see Section 6.3.3), total chromium, copper, and dioxin TEQ are provided for each exposure area even if the constituents were not considered to be risk drivers (i.e., no unacceptable risk) in a specific exposure area.

6.1 Purpose and Objectives

As stated in Section 1.2, the purpose of the ERA included in this Post-NTCRA HHERA is to (1) document that RAO 1 of the NTCRA was achieved, specifically by presenting exposure area-specific EPCs for comparison to the numerical RAGs (e.g. RBRGs) in areas outside of the TCS fence line where NTCRA removals were conducted and (2) provide updated risk estimates for human health and the environment based on potential exposures to current soil conditions in the NTCRA areas. Additionally, the objectives listed below are part of the overall goal of risk assessment at the site and include the following:

- Inform the RCRA corrective action and CERCLA remedy process by providing risk managers with risk characterization results for residual concentrations of risk-driving COPECs targeted during NTCRA and other related investigations;
- Provide estimates of potential site-related risks to potential ecological receptors;

- Provide spatial context for the risk estimates; and
- Convey the magnitude and direction of uncertainty associated with the risk estimates.

The findings and conclusions of the post-NTCRA ERA will be used in conjunction with the findings of the 2019 HHERA (Arcadis 2019) to develop risk-management decisions for the site that will be used in the CMS/FS portion of the environmental program to develop and evaluate remedial alternatives protective of potential ecological receptors. Ultimately, the conclusions reached from conducting the ERA along with other site information will be used to establish an overall site risk-management strategy. These objectives are consistent with the USEPA's defined functions of an ERA (USEPA 1997a).

6.2 Applicable Guidance

The ERA is consistent with the Agencies-approved RAWP documents (Arcadis 2008b, 2009a, 2015, DOI 2009a,b, DOI 2015, DTSC 2009a, DTSC 2015a), DTSC-issued directive letter (DTSC 2017b), 2019 HHERA (Arcadis 2019, 2020, DOI and DTSC 2020), and Technical Memo (Arcadis 2024a) and follows regulatory guidance including the following:

- Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities, Parts A and B (CalEPA and DTSC 1996);
- HERD ERA Note Number: 1 (DTSC 1998);
- HERO Ecological Risk Assessment Note Number 2 (DTSC 1999);
- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA 1997a);
- Guidelines for Ecological Risk Assessment (USEPA 1998);
- Guidance for Developing Ecological Soil Screening Levels (USEPA 2005a);
- ECO Update Bulletin Series (available from USEPA 2025); and
- Generic Ecological Assessment Endpoints (GEAE) for Ecological Risk Assessment (USEPA 2003a).

6.3 Problem Formulation

The problem formulation step of the ERA includes identifying societal or regulatory goals and assessment endpoints, preparing a CSM, and developing an analysis plan using available and relevant site data. The problem formulation consists of the ecological setting (described in Section 2.4), the CSM (discussed in Sections 2.6 and 6.3.1 and depicted on Figure 2-7), and the selection of assessment and measurement endpoints (Section 6.3.2). The analysis plan relies on chemical and spatial data collected during the site investigations and is discussed in Section 6.4. These elements are consistent with the problem formulation presented in the 2019 HHERA (Arcadis 2019) and are summarized below as relevant for this Post-NTCRA HHERA.

6.3.1 Conceptual Site Model

The CSM is the framework for relating potential receptors to chemically affected media and evaluating the degree of completion of potential exposure pathways. The components of a CSM include potential sources, release mechanisms, and retention and transport media; these constitute the fate and transport portions of the CSM and apply to both the post-NTCRA HHRA and post-NTCRA ERA as described in Section 2.6 and in the 2019 HHERA (Arcadis 2019). The CSM also includes potential exposure routes and receptors. Consistent with the approach detailed in the January 30, 2024 Technical Memo (Arcadis 2024a), the ERA evaluated post-NTCRA exposures (i.e., considering NTCRA-related excavation and placement of backfill) to hexavalent chromium, total chromium, copper, and dioxin TEQ for the only risk-driving ecological receptor (i.e., desert shrew) identified in the 2019 HHERA and exposure areas where NTCRA removal activities were conducted.

Figure 2-7 presents the ecological CSM from the 2019 HHERA (Arcadis 2019) and shows the relationship between the constituent sources, potential exposure pathways, and potential receptors at the site.

Only the complete and significant potential source-pathway-receptor relationships for desert shrew are evaluated quantitatively in this ERA. which include incidental ingestion of surface soil (0 to 0.5 foot bgs) and ingestion of soil invertebrate prey exposed to surface soil (0 to 0.5 foot bgs).

6.3.2 Assessment and Measurement Endpoints

Identification of assessment and measurement endpoints for this ERA follows approaches used in the 2019 HHERA (Arcadis 2019), repeated here for convenience.

An assessment endpoint is an explicit expression of the environmental value (species, ecological resource, or habitat type) that is to be protected (USEPA 1997a). Assessment endpoints relate to statutory mandates (protection of the environment) but must be specific enough to guide the development of the risk assessment study design at a particular site (USEPA 1997a, 1998). Generally, assessment endpoints cannot be directly measured; rather, a measurement endpoint related to the assessment endpoint is evaluated. Measurement endpoints are measurable ecological characteristics that are related to the valued characteristic chosen as the assessment endpoint (USEPA 1997a). Assessment and measurement endpoints for desert shrew, as selected in the RAWP documents (Arcadis 2008b, 2009a, 2015) and 2019 HHERA (Arcadis 2019), are presented in Exhibit 6-1.

Exhibit 6-1 Assessment Endpoints and Measurement Endpoints for Invertivorous Small Mammals

Assessment Endpoint	Corresponding Measurement Endpoint	Representative Receptor
Sufficient rates of survival, growth, and reproduction to sustain mammalian populations	Calculated HQs for selected indicator receptors; HQs will be based on estimated exposure doses compared with TRVs	Desert shrew (invertivorous small mammals)

Measurement endpoints such as estimates of HQs only account for a single line of evidence (LOE). A weight-of-evidence (WOE) approach using multiple LOEs provides a more robust approach for interpreting the risk results and evaluating assessment endpoints. LOEs could include but are not limited to the following: supporting statistical and site-use information (e.g., frequency of detection), basis of the EPCs (maximum vs 95UCL), confidence in the toxicity values, the direction of uncertainty in the risk estimates, and spatial extent of any remaining elevated concentrations.

6.3.3 Risk-Driving COPECs To Be Evaluated

As described in Section 2.2, risk characterization in the 2019 HHERA (Arcadis 2019) identified four risk-driving COPCs and/or COPECs at one or more site exposure areas: total chromium, hexavalent chromium, copper, and dioxin/furan TEQ. These constituents were the target of RAO 1 of the NTCRA: Reduce human and ecological risk related to the COCs in soil up to 10 feet bgs on or adjacent to federal land by removing soil at locations identified as driving risk in the HHERA. Consistent with the approach detailed in the January 30, 2024 Technical Memo (Arcadis 2024a), this Post-NTCRA HHERA evaluates post-NTCRA exposures (i.e., considering NTCRA-related excavation and placement of backfill) to hexavalent chromium, total chromium, copper, and dioxin TEQ, and only these constituents are evaluated in this associated ERA.

As presented in Section 2.3.2, total chromium, copper, and dioxin TEQ were identified as risk drivers in the 2019 HHERA (Arcadis 2019) for desert shrew in the exposure areas identified in Exhibit 6-2. Unacceptable risk associated with some potential human exposures was identified for hexavalent chromium 2019 HHERA, but hexavalent chromium was not identified as a risk driver for desert shrew in the 2019 HHERA.

Exhibit 6-2 Exposure Areas and Ecological Risk Driver Summary

Potential Exposure Area	Scenario	Dioxin TEQ	Copper	Total Chromium	Hexavalent Chromium
AOC 1	Baseline	✓	None	None	None
AOC 1	2-foot scouring	✓	None	None	None
AOC 1	5-foot scouring	None	None	None	None
AOC 9	Baseline	✓	✓	✓	None
AOC 10	Baseline	✓	None	None	None
AOC 10	2-foot scouring	✓	None	✓	None
AOC 10	5-foot scouring	✓	None	None	None
AOC 11	Baseline	✓	None	None	None
AOC 14	Baseline	None	None	None	None
AOC 16	Baseline	None	None	None	None
AOC 27	Baseline	None	None	None	None

Note:
✓ = Identified as a risk driver in the 2019 HHERA (Arcadis 2019)

6.4 Exposure Assessment

The exposure assessment describes the potential or actual contact of receptors with constituents in site media. The objective of the exposure assessment is to estimate exposure doses based on receptor contact with COPECs in the soil of the post-NTCRA potential exposure areas for the complete and significant exposure pathways described in the CSM. Thus, the exposure analysis identifies the assumptions necessary to estimate direct exposure EPCs (i.e., soil concentrations) and EPCs used as the basis for estimating bioaccumulation and subsequent exposure of upper trophic-level receptors (i.e., soil and biota tissue EPCs). Except where noted below, these methods and assumptions are consistent with the 2019 HHERA (Arcadis 2019), as described in the following sections.

6.4.1 Exposure Point Concentrations

As described in Section 4, the EPC is the representative concentration of a constituent in an environmental medium that is potentially contacted by the receptor (USEPA 1997a). The EPC is constituent-specific and is estimated for each individual potential exposure area impacted by NTCRA soil removal actions. The potential exposure areas evaluated in the ERA for small home-range receptors, including desert shrew, are those impacted by NTCRA actions (i.e., BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27). For soil, EPCs were calculated based on depth-weighted data. In most cases, area-weighted data were also used to develop EPCs. The soil EPC calculation methodology is described in detail in Section 4.2. Summary statistics for the depth-weighted datasets used in this Post-NTCRA HHERA and the resulting depth-weighted and area-weighted EPCs are presented in Section 3 of each exposure area-specific appendix.

For dioxins/furans, concentrations were calculated as totals as described in Section 6.5.2. For dioxin/furans, TEQ concentrations are calculated for mammals using the mammalian TEFs from Van den Berg et al. (1998, 2006). TEFs for wildlife are discussed in Section 6.5.2; mammalian TEFs were evaluated for desert shrew.

Biota tissue EPCs were calculated for soil invertebrate prey from soil EPCs using soil-to-invertebrate uptake relationships, as described in Section 6.4.3.2. The depth intervals selected to represent exposure to soil and calculate biota tissue EPCs for the risk calculations for desert shrew are presented in Section 6.4.2.

6.4.2 Exposure Depths

As described in the CSM (Section 6.3.1), potential receptor exposure to post-NTCRA soil varies by functional group (e.g., habitat requirements, feeding strategies). In coordination with the DOI and DTSC, exposure depths for desert shrew were selected in the RAWP documents (Arcadis 2008b, 2009a, 2015, DOI 2009a,b, DOI 2015, DTSC 2009a, DTSC 2015a) and were used in this Post-NTCRA HHERA.

The soil exposure depths evaluated for desert shrew include the following:

- Direct Contact/Incidental Ingestion—soil EPCs from surface soil (0 to 0.5 foot bgs; and
- Biota Uptake—soil uptake to invertebrate prey based on surface soil (0 to 0.5 foot bgs) EPCs.

The exposure depths presented previously are relevant from the ground surface (i.e., baseline scenario). In addition to the baseline scenario described previously, two scouring scenarios were evaluated to address potential for extensive soil loss assumed to occur via scouring due to surface runoff during high flow events. Consistent with the 2019 HHERA (Arcadis 2019), a 2-foot scouring scenario and a 5-foot scouring scenario were evaluated for the BCW and AOC 10 potential exposure areas, as described in Section 3.3. In the two scouring scenarios, the exposure depths for surface soil relevant to desert shrew exposures described previously for the baseline (no scouring) scenario were modified, as shown in Exhibit 6-3.

Exhibit 6-3 Exposure Depths for Baseline, 2-Foot Scouring, and 5-Foot Scouring Scenarios

Baseline Scenario	2-Foot Scouring	5-Foot Scouring
Surface soil (0 to 0.5 foot bgs)	Surface soil (2 to 3 feet bgs)	Surface soil (5 to 6 feet bgs)

Rationale for the selection of the exposure depth intervals for the scouring scenarios is presented and discussed in detail in the Agencies-approved Revised Addendum to the Revised Human Health and Ecological Risk Assessment Work Plan (Arcadis 2009a, DOI 2009b, DTSC 2009a). As noted in Appendix BCW and Appendix AOC 10, scouring of this nature has not been observed (see also Sections 5.4.2.1 and 5.4.2.3).

6.4.3 Exposure Dose Models

Exposure does models used in this Post-NTCRA ERA follow the approach and methods used in the 2019 HHERA (Arcadis 2019) and are presented below for convenience.

For the potential receptors (i.e., desert shrew), route-specific and food-web or dietary exposure models were used to estimate doses in milligram per kilogram of body weight per day (mg/kg-bw/day). To calculate exposure doses for desert shrew, soil data and receptor-specific parameters were used in Equation 6-1:

$$ADD\ t = ADD\ f + ADD\ s \qquad \text{Equation 6-1}$$

where:

ADD t = total average daily dose in mg/kg-bw/day;

ADD f = average daily dose resulting from food (mg/kg-bw/day); and

ADD s = average daily dose resulting from soil (mg/kg-bw/day).

Modeled exposure doses were estimated using depth-weighted 95UCL concentrations for each COPEC in soil. In most cases, an area-weighted 95UCL was also used to refine exposure doses.

The total average daily dose presented in Equation 6-1 is estimated using Equation 6-2 and exposure parameters.

$$ADD\ t\ (mg/kg\text{-}day) = [(EPC_{soil} \times SIR) + (C_{plants} \times FIR \times F_{plants}) + (C_{ins/inv} \times FIR \times F_{ins/inv}) + (C_{mammals} \times FIR \times F_{mammals})] \times SUF$$

Equation 6-2

where:

ADD t = total average daily dose per day (mg/kg-bw/day);

EPC_{soil} = exposure point concentration in soil (milligram per kilogram dry weight [mg/kg dw]);

EPC_{plants} = exposure point concentration in plants (mg/kg dw);

$EPC_{ins/inv}$ = exposure point concentration in insects/invertebrates (mg/kg dw);

$EPC_{mammals}$ = exposure point concentration in mammals (mg/kg dw);

F_{plants} = fraction of plants in diet;

$F_{ins/inv}$ = fraction of insects/invertebrates in diet;

$F_{mammals}$ = fraction of mammals in diet;

FIR = food ingestion rate (kilogram dry weight per kilogram body weight per day);

SIR = soil ingestion rate (kilogram dry weight per kilogram body weight per day); and

SUF = site use factor (fraction).

6.4.3.1 Exposure Parameters for Desert Shrew

For dietary dose modeling, species-specific values used for the potential terrestrial receptors were selected in the RAWP (Arcadis 2008b) and are presented in Table 6-1 for desert shrew. These values are consistent with exposure parameters evaluated in the 2019 HHERA (Arcadis 2019) and more detail is presented in that report.

The site use factor (SUF) represents the area used by an individual relative to the size of the exposure area. If the home range of a receptor species is larger than the potential exposure area, Equation 6-3 can be applied:

SUF = exposure area acreage/home range of species   Equation 6-3

The desert shrew home range is small relative to the potential exposure areas, and therefore only a generic SUF of 1 was evaluated.

6.4.3.2 Prey Uptake Assumptions (Bioaccumulation Factors)

Bioaccumulation in animal tissue or uptake into plants is the process where COPECs in the surrounding media accumulate within the tissues of ecological receptors, especially to concentrations higher than in the surrounding media. Any COPEC that is excreted or metabolized at a slower rate than its uptake through absorption and ingestion will increase in tissues over time, resulting in bioaccumulation. COPECs that bioaccumulate have the potential to be passed up the food chain.

Soil-to-biota uptake factors for plants, invertebrates, and mammals were developed as either regression equations or BAFs for COPECs evaluated in the 2019 HHERA (Arcadis 2019), although for this Post-NTCRA HHERA, only soil-to-invertebrate uptake factors were necessary. Uptake regression equations express a significant and predictive relationship between COPEC concentrations in soil and biota tissues and are typically expressed in a form similar to Equation 6-4.

$$ln(Cb) = M*ln(Cs) + I \qquad \text{Equation 6-4}$$

where:

Cb = constituent concentration in biota tissue (mg of constituent/kg of tissue);

M = slope of regression line;

Cs = constituent concentration in soil (mg constituent/kg soil); and

I = y-intercept of regression line (unitless).

When a significant and predictive uptake regression is unavailable, a simple uptake ratio can be used to estimate concentrations of constituents that can accumulate in tissues through any route of exposure (USEPA 2000). A BAF is the ratio of biota constituent concentration to soil concentration and is expressed as follows in Equation 6-5.

$$BAF = Cb/Cs \qquad \text{Equation 6-5}$$

where:

BAF = soil-to-biota bioaccumulation factor (kg soil/kg tissue);

Cb = constituent concentration in biota tissue (mg constituent/kg tissue); and

Cs = constituent concentration in soil (mg constituent/kg soil).

Uptake regressions and BAFs were selected in the Agencies-approved RAWP (Arcadis 2008b) and technical memoranda (BBL 2007; Arcadis 2008a, 2009b, DOI 2009a,b, DTSC 2009a) and were used to estimate concentrations of COPECs in biota and food item tissue (i.e., prey) from post-NTCRA soil. Table 6-2 presents the uptake regressions/BAFs for total chromium, hexavalent chromium, copper, and dioxin TEQ used in the 2019 HHERA (Arcadis 2019) and in this Post-NTCRA HHERA. All uptake regressions/BAFs presented in Table 6-2 are on a dry-weight basis and are consistent with the RAWP and technical memoranda.

It should be noted that the BAFs and uptake regressions presented in the RAWP documents (Arcadis 2008b, 2009a, 2015) were used in developing soil ecological comparison values for use in the RFI/RI site characterization to determine nature and extent and, therefore, were based on conservative and readily available literature/published values. These BAFs and uptake regressions are generally considered very conservative and, therefore, tend to overestimate risk. The selected BAFs and uptake regressions (i.e., those present in the RAWP documents) were used in characterizing potential risk to wildlife (through their diet) at the site. However, the quality of the selected BAFs and uptake regressions with respect to confidence in predicting risks are discussed as part of the risk characterization. Where risks are believed to be significantly overestimated because of these selected BAFs and uptake regressions (e.g., for dioxin TEQ), alternate and more robust values were developed and evaluated, consistent with the 2019 HHERA (Arcadis 2019).

Although the selected BAFs and uptake regressions were used to estimate risk to potential ecological receptors at the site (i.e., forward risk calculations), the alternate and more robust values for dioxin TEQ (Section 6.4.3.2.1) were used for risk-management decisions (e.g., when developing RBRGs that were selected as numerical RAGs for the NTCRA). The alternate dioxin TEQ BAFs were also used for drawing risk conclusions for the ERA to evaluate post-NTCRA conditions.

6.4.3.2.1 Alternate Dioxin TEQ BAFs

For dioxin TEQ, the BAFs selected in the RAWP (Arcadis 2008b) are based on uptake of a single congener: 2,3,7,8-TCDD. There are some published uptake factors (derived as the ratio of concentrations in earthworms to those in soil as for a BAF) for a few common dioxin congeners in the literature, notably 2,3,7,8-TCDD (Sample et al. 1998). However, available uptake factors cannot be extrapolated across all dioxin and furan congeners to estimate invertebrate tissue concentrations for all of the individual congeners. This approach ignores differences in congener uptake due to differences in their structure and physico-chemical properties. Uptake data available in the literature for earthworms (Fagervold et al. 2010) and published soil-to-invertebrate BAFs (USEPA 1999) indicate that 2,3,7,8-TCDD has among the highest uptake rates for the 2,3,7,8-substituted congeners included in TEQ concentrations. As a result, uptake of dioxin TEQ is likely overestimated for some ecological receptors, especially for invertivorous wildlife receptors like the desert shrew. As reported in the 2019 HHERA (Arcadis 2019), the overestimation of dioxin TEQ uptake was demonstrated in the Tittabawassee River risk assessment when use of simplified uptake factors from the literature of 5 for 2,3,7,8-TCDD and 0.1 for 2,3,7,8-TCDF led to a tenfold overprediction of dioxin and furan concentrations in soil invertebrates relative to measured values (Galbraith Environmental Sciences LLC [Galbraith] 2004; Kay et al. 2005). The uncertainty associated with the selected dioxin TEQ BAFs for the ERA was discussed in the 2019 HHERA and is also summarized in Section 6.7.4.

Because of the uncertainty associated with use of a single congener-based BAF, similar to the approach used in the 2019 HHERA (Arcadis 2019), dioxin TEQ uptake was also estimated using two congener-specific approaches: congener-specific BAFs for soil invertebrates from USEPA (1999) and congener-specific BAFs for soil invertebrates from Fagervold et al. (2010). For dioxin TEQ, the alternate congener-specific BAFs are presented in Table 6-3 and are consistent with the values used in the 2019 HHERA. Details of the congener-specific BAFs are presented in Section 6.7.4 of the 2019 HHERA.

In summary, using the USEPA (1999) or Fagervold et al. (2010) congener-specific BAFs, uptake by invertebrates and subsequent ingestion by mammals using the congener-specific approach results in lower uptake than predicted using the BAF based on 2,3,7,8-TCDD alone. For example, in the BCW potential exposure area following completion of the NTCRA, the invertebrate tissue EPC for the baseline scenario is approximately 26 times lower for mammals compared to invertebrate tissue EPCs estimated using the selected uptake models for 2,3,7,8-TCDD from the RAWP (Arcadis 2008b, Table 6-2). Similarly, congener-specific soil BAFs from Fagervold et al. (2010) result in uptake by invertebrates approximately 33 times below that estimated using the selected BAF for the post-NTCRA BCW baseline exposure scenario evaluated in this Post-NTCRA HHERA. Uptake and risk calculations using the alternate congener-specific BAFs were conducted for each exposure area and presented in each of the area-specific appendices.

The invertebrate tissue EPCs estimated using congener-specific BAFs are still considered to be conservative. As the congener-specific BAFs are used with 95UCL EPCs for the individual dioxin congener concentrations in soil, the resulting invertebrate tissue EPCs are likely to overestimate prey tissue concentrations due to the use of 95UCL soil concentrations for each congener. Since the relative congener distribution is unlikely to be the same in each soil sample, it is likely that individual soil samples will have congener concentrations that represent various points in the distribution (e.g., in a single sample, some congener concentrations would fall at the low end of the distribution for a soil dataset and some congeners would fall at the high end of the distribution for a soil dataset). All congeners are unlikely to be present at the 95 UCL concentration.

6.5 Effects Assessment

The effects assessment identifies exposure levels considered to represent thresholds (e.g., dose-based TRVs) associated with potential for adverse effects. For the post-NTCRA ERA, TRVs for wildlife (i.e., desert shrew) were selected from previously approved values used in the 2019 HHERA (Arcadis 2019). TEFs for dioxin/furan congeners are also discussed.

6.5.1 Toxicity Reference Values

A range of risks to desert shrew was estimated using the TRVs based on a NOAEL and based on a LOAEL. For hexavalent chromium, total chromium, and copper, the NOAEL- and LOAEL-based TRVs used in this Post-NTCRA HHERA are the selected TRVs from the RAWP documents (Arcadis 2008b, 2009a, 2015).

For dioxin TEQ, the selected mammalian TRVs in the RAWP documents (Arcadis 2008b, 2009a, 2015) are from Toxicological Benchmarks for Wildlife from Oak Ridge National Laboratory (Sample et al. 1996). However, an alternate set of mammalian TRVs were also evaluated in the 2019 HHERA (Arcadis 2019). The alternate TRVs for dioxin TEQ presented in the 2019 HHERA were used to estimate potential risk to desert shrew in this Post-NTCRA HHERA. Details related to the derivation of the alternate dioxin TRVs for mammals are repeated below for convenience.

The LOAEL-based TRVs used in this Post-NTCRA HHERA are the same as the TRVs used to develop ecological RBRGs in the 2019 HHERA (Arcadis 2019); RBRGs were then used to define the extent of NTCRA soil removals.

Although other additional sets of TRVs (i.e., Biological Technical Assistance Group [BTAG] TRVs [DTSC 2002]) were also evaluated in the 2019 HHERA (Arcadis 2019) for mammals, BTAG TRVs are not available for hexavalent chromium, total chromium, or dioxin TEQ, and they were ultimately not used for making remedial decisions. BTAG TRVs were not evaluated in this Post-NTCRA HHERA.

Wildlife TRVs used in this Post-NTCRA HHERA are presented in Table 6-4.

Following DTSC guidance (CalEPA and DTSC 1996; DTSC 2000), TRVs were adjusted when the differences in body weight between the site-specific wildlife receptor and the laboratory animals used in the studies to develop the TRVs were significant (i.e., greater than two orders of magnitude). For the constituents evaluated in this post-NTCRA ERA, allometric adjustments were made only for copper. Thus, literature-derived mammalian TRVs for copper presented in Table 6-4 were allometrically adjusted using Equation 6-6 from Sample and Arenal (1999):

$$Aw = At * (BWt/BWw)^{1-b} \quad \text{Equation 6-6}$$

where:

Aw = TRV of wildlife species (mg/kg-bw/day);

At = TRV of test species (mg/kg-bw/day);

BWt = body weight of test species (kg);

BWw = body weight of wildlife species (kg); and

b = allometric scaling factor (0.94 for mammals).

Although no longer typically conducted, allometric conversions were used in line with the approved RAWP (Arcadis 2008b) and are consistent with TRVs evaluated in the 2019 HHERA (Arcadis 2019). Allometric conversions may increase uncertainty associated with the TRVs. However, no substantial changes to risk conclusions as a result of allometric conversions are expected (discussed further in Section 6.7.5.3).

6.5.1.1 Alternate Dioxin TRVs

The alternate TRVs for dioxin TEQ derived in the 2019 HHERA (Arcadis 2019) were used to estimate potential risk to desert shrew in this Post-NTCRA HHERA. As stated above, details related to the derivation of the alternate dioxin TRVs for mammals are repeated below for convenience.

Toxicity of dioxins in mammals is mediated through aryl hydrocarbon receptor (AHR). Exposure of mammals to dioxins is associated with adverse effects on reproduction and development, and the sensitivity of mammals to TCDD toxicity is highly variable. Acute toxicity studies with 2,3,7,8-TCDD have shown marked differences among species, up to a factor of 8,400 between the single oral LD50 dose for the guinea pig (the most sensitive mammal) and the hamster (Eisler 1985). The exposure levels at which adverse effects are observed span a large range across avian taxa, from low ng/kg to low micrograms per kilogram in tissue. There are also clear differences among bird species in susceptibility to dioxin-like toxicity, which have been attributed to biochemical differences in AHRs among species (Karchner et al. 2006; Head et al. 2008). The range of sensitivity of various species to dioxins and furans results in significant uncertainty associated with the selected dioxin TEQ TRVs, as discussed in detail in Section 6.7.5 of the 2019 HHERA (Arcadis 2019).

For dioxin TEQ, the selected mammalian TRVs for the 2019 HHERA (Arcadis 2019) were based on TRVs presented in the RAWP documents (Arcadis 2008b, 2009a, 2015) and are based on the lowest available TRVs (NOAEL-based TRV and LOAEL-based TRV of 1 and 10 mg/kg-bw/day, respectively). Additional relevant toxicity data suggest that adverse effects would not be observed until higher doses. As a result, the risk estimates for dioxin TEQ are likely overestimated when these TRVs are used.

Because of the uncertainty associated with use of highly conservative dioxin TRVs, alternate TRVs were calculated for the site. Details of the studies included as the basis for the alternate TRVs are discussed in Section 6.7.5 of the 2019 HHERA (Arcadis 2019). In summary, rat studies report NOAEL-based doses that are 7 to 70 times and LOAEL-based doses that are 1.6 to 22 times greater than the selected mammalian TRVs. Additionally, as discussed in Section 6.7.5.1, sensitive wildlife receptors, such as mink, have been shown to tolerate exposure doses 25 times greater than the NOAEL-based TRV from the RAWP (Arcadis 2008b) without adverse effect (Moore et al. 2012).

As mentioned in Section 6.5, selected TRVs presented in the RAWP (Arcadis 2008b) are generally conservative. Where risks are believed to be significantly overestimated because of these selected TRVs, alternate and more robust values were developed (e.g., dioxin TEQ).

Following the approach used by USEPA in developing TRVs for the ecological soil screening levels (EcoSSLs; USEPA 2005a), alternate dioxin TEQ TRVs were developed for mammals based the geometric mean of the reproduction and growth endpoints for the NOAEL and LOAEL effect levels, respectively. The alternate TRVs are presented in this section.

Alternate mammal TRVs for dioxin TEQ are presented below:

- NOAEL-based TRV = 4.9 nanogram per kilogram of body weight per day (ng/kg-bw/day); and
- LOAEL-based TRV = 30 ng/kg-bw/day.

More detail related to the derivation of the alternate dioxin TEQ TRVs is provided in Section 6.7.5 of the 2019 HHERA (Arcadis 2019).

The alternate mammalian LOAEL TRV for dioxin TEQ was used for RBRG development in the 2019 HHERA (Arcadis 2019). The RBRGs were then used to define the extent of NTCRA soil removals. The alternate mammalian TRVs were therefore used in this Post-NTCRA HHERA.

6.5.2 Dioxin TEFs

The toxicity of PCDD/PCDFs, collectively known as dioxins, is highly variable. Only 17 congeners are considered to be of interest for evaluating environmental exposure and risk. These are the PCDD/PCDF congeners that have chlorines attached in at least the 2, 3, 7, and 8 positions. The 2,3,7,8-substituted congeners are believed to exhibit similar toxicity and act through the same toxic mechanism.

The ability of the 2,3,7,8-substituted congeners to cause toxic effects is mediated by their ability to bind the AHR in vertebrates (ATSDR 1998; Safe 1986). Each congener has a different relative binding affinity, and thus a different relative toxicity. The most toxic congener to mammals is 2,3,7,8-TCDD. The other congeners are assigned a TEF, which is relative to 2,3,7,8-TCDD (thus, the TEF for 2,3,7,8-TCDD is equal to one.). The WHO provides published and peer-reviewed TEF values, shown in Exhibit 6-4 for polychlorinated dibenzo-p-dioxins and Exhibit 6-5 for PCDFs at the end of this section (Van den Berg et al. 1998, 2006). These TEFs are currently endorsed by the USEPA. Individual congeners are assigned different TEFs for mammalian species and avian species, due to differences in toxicity to these species. Concentrations of the individual 2,3,7,8-substituted congeners in environmental samples are then multiplied by their respective TEF, resulting in a congener concentration normalized to the toxicity of 2,3,7,8-TCDD for each species (TEQ; see Section 3.2.2 for calculation of dioxin TEQ). Because the congeners all share the same mode of toxicity, the TEF-adjusted concentrations are summed for all 17 congeners. The resulting value is a total dioxin TEQ concentration, given in terms of the toxicity of 2,3,7,8-TCDD. The total mammalian dioxin TEQ concentrations are used to assess exposure to desert shrew at the site, consistent with evaluation of dioxin TEQ in the 2019 HHERA (Arcadis 2019).

Exhibit 6-4 Mammal TEFs for Polychlorinated Dibenzo-p-dioxins

Compound	Mammal TEF[a]
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003

Note:
[a] Van den Berg et al. 2006.

Exhibit 6-5 Mammal TEFs for Polychlorinated Dibenzofurans

Compound	Mammal TEF[a]
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3

Compound	Mammal TEF[a]
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.0003

Note:
[a] Van den Berg et al. 2006.

6.6 Risk Characterization

The risk characterization integrates the results of the exposure assessment and toxicity assessment, which are subject to uncertainties in both those efforts, as well as uncertainties in the problem formulation step. Risk characterization includes two major components: risk estimation and risk description. Risks were estimated using HQs, following the approach described in the RAWP documents (Arcadis 2008b, 2009a, 2015) and summarized in this section. HQs only account for a single LOE. Following USEPA guidance (1998) guidance, risk estimates for each receptor and COPEC within a potential exposure area were interpreted based on a semi-quantitative WOE approach using multiple LOEs. The WOE assessment, including the HQs and supporting LOEs, was used to evaluate the assessment endpoints (Section 6.3.2), reduce uncertainty, and ultimately draw risk conclusions. These components comprise the risk description. This risk characterization approach is consistent with the 2019 HHERA (Arcadis 2019). In this Post-NTCRA HHERA, the additional LOEs were evaluated and discussed when LOAEL-based HQs greater than 1 were estimated.

6.6.1 Approach

The 2019 HHERA (Arcadis 2019) concluded that potential risk to ecological receptors, including special-status species, at the site was limited to desert shrew potentially exposed to a few risk-driving COPECs (i.e., total chromium, copper, and dioxin TEQ) in surface soil in one or more potential exposure areas. Therefore, this Post-NTCRA HHERA presents risk estimates for desert shrew and the risk-driving COPECs in surface soil that reflect current conditions following soil remediation associated with the NTCRA. For consistency across exposure areas evaluated in this Post- Post-NTCRA HHERA, risk estimates for hexavalent chromium, total chromium, copper, and dioxin TEQ are provided for each exposure area even if the constituents were not considered to be risk drivers (i.e., no unacceptable risk) in a specific exposure area impacted by NTCRA soil removal activities (e.g., hexavalent chromium is not an ecological risk-driving COPEC but was identified as a human health risk-driving COPC).

Risks to desert shrew from total chromium, hexavalent chromium, copper, and dioxin TEQ (i.e., risk-driving COPCs and/or COPECs in one or more exposure area) in soil were estimated for six potential ecological exposure areas where NTCRA removals were conducted by calculating HQs. Consistent with the Technical Memo (Arcadis 2024a), updated ecological risk characterization included in this Post-NTCRA HHERA is presented only for risk-driving ecological receptors (desert shrew) identified in the 2019 HHERA (Arcadis 2019). Risks were estimated by calculating HQs. HQs are an expression of the ratio of an exposure estimated dose (ADD t) to an effects dose (i.e., TRV).

For wildlife such as desert shrew, the exposure models estimate exposure to an individual, and TRVs are derived from individual-level effects data. Therefore, HQs represent potential risk to individual receptors, and population-level risk must be extrapolated from these HQ values. Equation 6-7, the standard HQ equation (USEPA 1997a), was used to estimate risks to desert shrew:

$$HQ=\frac{Dose}{TRV}=\frac{(C_{soil}\ x\ SIR)+(C_{biota}\ x\ FIR)\ x\ SUF}{TRV\ x\ BW}=\frac{(C_{soil}\ x\ SIR)+(C_{soil}\ x\ BAF\ x\ FIR)\ x\ SUF}{TRV\ x\ BW}$$

Equation 6-7

where:

HQ = hazard quotient (unitless);

Dose = exposure dose (mg/kg-bw/day);

TRV = toxicity reference value (mg/kg-bw/day]);

C_{soil} = concentration of constituent in soil (mg/kg soil);

SIR = soil ingestion rate (kg soil/day);

C_{biota} = concentration of constituent in biota or tissue (mg/kg tissue), represented by the EPC;

FIR = food or biota ingestion rate (kg tissue/day);

SUF = site-use factor (unitless); an adjustment factor used when the foraging range of a potential receptor is larger than the potentially contaminated area; calculated by dividing the potentially contaminated area by the home or foraging range of the potential receptor;

BW = body weight of receptor (kg-bw); and

BAF = bioaccumulation factor or regression for media-to-biota uptake (kg soil/kg tissue).

The exposure parameters used to calculate risks are discussed in Section 6.4, and the effects levels (TRVs) are discussed in Section 6.5. As mentioned in Section 6.4.3, selected BAFs/uptake regressions presented in the RAWP documents (Arcadis 2008b, 2009a, 2015) were used to estimate risk to potential ecological receptors at the site. However, where risks are believed to be significantly overestimated because of these selected values, alternate and more robust values were developed. For dioxins, alternate congener-specific BAFs are summarized in Section 6.4.3.2.1 (and presented in Table 6-3). Alternate and more robust TRVs for dioxin TEQ are summarized in Section 6.5.1.1 and were used to estimate risks in this Post-NTCRA HHERA. These alternate and more robust values (congener-specific BAFs and alternate TRVs) are considered the most refined assumptions for dioxin TEQ and were used to evaluate dioxin TEQ.

For desert shrew, a range of HQs was calculated using NOAEL- and LOAEL-based TRVs in this Post-NTCRA HHERA. HQs based on LOAEL-based TRVs are referred to as LOAEL-based HQs. HQs based on NOAEL-based TRVs are referred as NOAEL-based HQs. As noted above, the 2019 HHERA (Arcadis 2019) did not identify a potential for unacceptable risk to sensitive species, and therefore protection of individual invertivorous small mammals is not warranted. This Post-NTCRA HHERA presents NOAEL-based HQs for completeness; however, LOAEL-based HQs were used to evaluate populations of invertivorous small mammals like desert shrew.

For each area-specific ERA, potential risks to desert shrew were estimated using depth-weighted EPCs and area-weighted EPCs based on the 95UCL for the potential exposure area of interest. Using this approach, an EPC that is less than the RBRG will result in an HQ less than 1[2]. Because the shrew home range is smaller than the exposure areas, a generic SUF of 1 was evaluated. Depth- and area-weighted EPCs are discussed in Section 4.2.

Risks were not estimated using maximum depth-weighted concentrations in this Post-NTCRA HHERA because they would be considered overly conservative and are generally used for screening-level purposes. Maximum concentrations were not used for making risk-management decisions in the soil NTCRA and were not evaluated in this Post-NTCRA HHERA.

The ERAs for each potential ecological exposure area are presented in detail in the area-specific appendices, including risk calculations based on depth-weighted and area-weighted EPCs (when calculated) for total chromium, hexavalent chromium, copper, and dioxin TEQ regardless if those constituents were identified as risk drivers at the specific exposure area. Risk estimates (HQs) for each potential exposure area calculated using depth-weighted EPCs and area-weighted EPCs are presented in in this section (reference to specific tables are included in the discussions in this section).

For the risk description part of the risk characterization process, a semi-quantitative WOE approach was used incorporating multiple LOEs, consistent with the WOE approach utilized in the 2019 HHERA (Arcadis 2019). For interpreting the risk results and identifying potential adverse effects to ecological receptors, in addition to the HQ results, other LOEs included supporting statistical information (e.g., frequency of detection), confidence in the screening values, the direction of uncertainty in the risk estimates, and spatial extent of elevated concentrations. In this Post-NTCRA HHERA, the additional LOEs were evaluated and discussed when LOAEL-based HQs greater than 1 were estimated.

Uncertainties specific to a potential exposure area are discussed in context with the risk characterization results in the area-specific appendices. Uncertainties common between the 2019 HHERA (Arcadis 2019) and this Post-NTCRA HHERA are summarized in Section 6.7; more detail is presented in the 2019 HHERA. Additionally, uncertainties specific to this Post-NTCRA HHERA evaluation of post-NTCRA conditions at the site are discussed in Section 6.7.

For each potential exposure scenario with LOAEL-based HQs greater than 1, the results of individual LOE evaluations were evaluated collectively to derive an overall WOE conclusion. Key uncertainties were considered along with the strength, relevance, and other qualities of the LOE in reaching the WOE conclusions.

Risk conclusions for desert shrew used the following criteria:

- COPECs with NOAEL-based HQs less than or equal to 1 pose de minimis risk to individual and populations of potential wildlife receptors.

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[2] Consistent with the 2019 HHERA approach, RBRGs are applied based on the potential exposure area of interest (i.e., the 95UCL for the potential exposure area should be less than or equal to the RBRG).

- COPECs with a NOAEL-based HQ greater than 1 but LOAEL-based HQ less than or equal to 1 pose no unacceptable risks to potential wildlife populations. However, as described in the RAWP (Arcadis 2008b), adverse effects to potential individual receptors are uncertain because the NOAEL-based TRVs are thresholds with an interval that is an artifact of the dosing study. The nature and magnitude of the effects, if any, that may occur at exposures between these values are unknown. Because protection at the individual level is not warranted for desert shrew, COPECs with NOAEL-based HQs greater than 1 and LOAEL-based HQs less than 1 were not further evaluated using a WOE approach.
- COPECs with LOAEL-based HQs greater than 1 indicate unacceptable risk is possible for populations of potential wildlife receptors. However, these LOAEL-based HQs are based on individual-level effects thresholds and only account for a single LOE. In such cases, a WOE approach was used in reducing uncertainty for characterizing potential risk to desert shrew populations.

Ultimately three risk outcomes are possible for desert shrew based on the LOAEL-based HQs greater than 1 and WOE: (1) unacceptable risk to wildlife populations is possible (i.e., indicated by sufficient and strong supporting LOEs), (2) unacceptable risk to wildlife populations is unlikely (i.e., indicated by sufficient and strong LOEs supporting a conclusion of no unacceptable risk), or (3) unacceptable risk to wildlife populations is uncertain (i.e., indicated by insufficient LOEs). For the post-NTCRA ERA, the results of individual LOE evaluations were evaluated collectively to derive an overall WOE conclusion when LOAEL-based HQs greater than 1 were estimated. Key uncertainties were considered along with the strength, relevance, and other qualities of the LOEs in reaching the WOE conclusions.

Risks characterized for each potential NTCRA impacted exposure area are presented in detail in the area-specific appendices and summarized in Section 6.6.2. Using an approach consistent with the 2019 HHERA (Arcadis 2019), the initial risk estimates for each potential exposure scenario were calculated using depth-weighted EPCs, selected BAFs, TRVs used to develop ecological RBRGs in the 2019 HHERA, and an SUF equal to 1. When LOAEL-based HQs greater than 1 were estimated using these initial assumptions, additional exposure refinements were also evaluated including the following:

- Area-weighted EPCs, selected BAFs, TRVs used to develop ecological RBRGs in the 2019 HHERA, and an SUF equal to 1; and
- Depth-weighted EPCs, congener-specific BAFs, TRVs used to develop ecological RBRGs in the 2019 HHERA, and an SUF equal to 1. Depth-weighted EPCs were used in this evaluation to be consistent with the 2019 HHERA.

At the conclusion of each scenario evaluation, risk conclusions were based on whether COPECs remain for which unacceptable population-level risk was predicted using LOAEL-based HQs calculated from the most refined exposure and effects assumptions and LOEs supporting the conclusion of unacceptable risk.

6.6.2 Results

Risks characterized for each potential exposure area evaluated in this Post-NTCRA HHERA are summarized in this section. As described above, this Post-NTCRA HHERA evaluated potential risk to desert shrew from exposure to total chromium, hexavalent chromium, copper, and dioxin TEQ in post-NTCRA soil using multiple sets of exposure assumptions (i.e., depth-weighted and area-weighted EPCs, select BAFs, and congener-specific BAFs for dioxin TEQ) and effects assumptions (i.e., NOAEL-based HQs and LOAEL-based HQs) for the baseline and scouring scenarios identified for each exposure area. Risk estimates based on LOAEL TRVs (i.e., LOAEL-based HQs) calculated using refined exposure and effects assumptions associated with a higher level of confidence in predicting risks and the supporting LOEs are discussed below. More detail, including the NOAEL-based HQs and LOAEL-based HQs for all exposure and effects assumptions evaluated in this Post-NTCRA HHERA, is provided in the exposure area-specific appendices.

Notably for dioxin TEQ, multiple LOEs were evaluated that support the conclusions outlined below for each exposure area. These LOEs include the following:

- Evaluation of multiple sets of congener-specific BAFs from USEPA (1999) and Fagervold et al. (2010) as described in Section 6.4.3.2 that result in LOAEL HQs less than 1 (Sections 5.6.3 of the exposure area-specific appendices).
- Site-specific evaluations presented in Section 6.7.4.1 that predict lower dioxin/furan uptake relative to uptake predicted using a generic TCDD BAF.
- Shrew dietary assumption (100% earthworm diet as described in Section 6.4.3.1) that is likely to overestimate dioxin exposure because earthworms are unlikely to be present at the site. As discussed in Section 6.7.3.3, other terrestrial invertebrates likely to be present at the site have lower potential dioxin uptake due to feeding habits and external structures, such as hard cuticles, that limit dermal absorption of soil constituents.
- Infrequent and spatially dispersed nature of remaining dioxin TEQ concentrations significantly (10 times) above background values (i.e., BTV), indicating that few individual shrews would be substantially exposed to concentrations significantly above the BTV. These locations and concentrations are discussed and presented in the exposure-area-specific appendices (Section 5.6.1.1 and Attachment A3 of each appendix).
- Conclusion that there is no unacceptable risk in the 2019 HHERA (pre-NTCRA conditions) for all ecological receptors except desert shrew.
- Lack of shrew observations at the site. As noted in the 2019 HHERA (Arcadis 2019), shrew have not been observed at the site and are unlikely to be present.

6.6.2.1 Bat Cave Wash

For the BCW potential exposure area, the 2019 HHERA (Arcadis 2019) concluded that potential risk to ecological receptors, including special-status species, in BCW and the larger exposure areas relevant to large home-range receptors was limited to desert shrew potentially exposed to dioxin TEQ in surface soil. Therefore, this Post-NTCRA HHERA presents risk estimates for desert shrew and dioxin TEQ in surface soil that reflect current conditions in the BCW potential exposure area following soil remediation associated with the NTCRA. Risk estimates for hexavalent chromium, total chromium, and copper as well as risk estimates for all three scouring scenarios (baseline, 2-foot scouring, and 5-foot scouring) evaluated in the 2019 HHERA are also included to evaluate post-NTCRA conditions.

The post-NTCRA ERA for the BCW potential exposure area is presented in detail in Appendix BCW, including risk calculations based on depth-weighted and area-weighted EPCs for the baseline and scouring scenarios. The HQs were calculated for the BCW potential exposure area using depth-weighted and area-weighted EPCs, selected and refined TRVs, and selected BAFs for metals or congener-specific BAFs for dioxin congeners are presented in Table 6-5 for the baseline, 2-foot scouring, and 5-foot scouring scenarios. For COPECs with LOAEL-based HQs greater than 1 using the most refined exposure and effects assumptions, a WOE assessment was used to draw risk conclusions and identify potential risk drivers for the BCW potential exposure area. Although LOAEL-based HQs greater than 1 were estimated for dioxin TEQ in some of the less refined exposure scenarios (i.e., the baseline scenario using depth-weighted and area-weighted EPCs and a generic BAF based on a single congener; see Appendix BCW), all LOAEL-based HQs were less than 1 in the most refined scenario evaluated for each constituent. Therefore, the WOE assessment was not presented below. The various LOE and WOE conclusions for all scenarios are presented in detail in Appendix BCW.

Risk conclusions for potential desert shrew populations in BCW are presented in the following list.

- For dioxin TEQ, risk conclusions are based on LOAEL-based HQs estimated in the most refined exposure scenario evaluated for this constituent (Section 5.6.3 of Appendix BCW) using the assumptions used for RBRG development (i.e., an SUF of 1, congener-specific BAFs, and alternate TRVs) and depth-weighted EPCs. Using these assumptions, the LOAEL-based HQs are less than 1 for the baseline, 2-foot scouring, and 5-foot scouring scenarios using both sets of congener-specific BAFs (USEPA 1999; Fagervold et al. 2010). These HQs indicate that no unacceptable risk is expected for populations of invertivorous small mammals in the BCW potential exposure area.
- For total chromium, risk conclusions are based on LOAEL-based HQs estimated in the most refined scenario evaluated for this constituent (Section 5.6.2 of Appendix BCW) using the assumptions used for RBRG development (i.e., an SUF of 1, selected BAFs, and selected TRVs) and area-weighted EPCs. Using these assumptions, the NOAEL- and LOAEL-based HQs are less than or equal to 1 for the baseline and 5-foot scouring scenarios, indicating de minimis risk to individuals and populations of invertivorous small mammals at the BCW potential exposure area. Although a NOAEL-based HQ of 2 is estimated in the 2-foot scouring scenario, the LOAEL-based HQ is less than 1, indicating that no unacceptable risk expected for populations of invertivorous small mammals.
- For hexavalent chromium and copper, all NOAEL- and LOAEL-based HQs are less than 1 for the baseline, 2-foot scouring, and 5-foot scouring scenarios, indicating de minimis risk to individuals and populations of invertivorous small mammals at the BCW potential exposure area.

In conclusion, no unacceptable risk to potential small mammal populations represented by the desert shrew is identified at the BCW potential exposure area for post-NTCRA conditions as evaluated in this Post-NTCRA HHERA.

6.6.2.2 AOC 9

For the AOC 9 potential exposure area, the 2019 HHERA (Arcadis 2019) concluded that potential risk to ecological receptors, including special-status species, in AOC 9 and the larger exposure areas relevant to large home-range receptors was limited to desert shrew potentially exposed to total chromium, copper, and dioxin TEQ in surface soil. Therefore, this Post-NTCRA HHERA presents risk estimates for desert shrew and total chromium, copper, and dioxin TEQ in surface soil that reflect current conditions in the

AOC 9 potential exposure area following soil remediation associated with the NTCRA. Risk estimates for hexavalent chromium are also included to evaluate post-NTCRA conditions.

The post-NTCRA ERA for the AOC 9 potential exposure area is presented in detail in Appendix AOC 9, including risk calculations based on depth-weighted and area-weighted EPCs for the baseline scenario. Scouring scenarios were not evaluated, consistent with the 2019 HHERA (Arcadis 2019). The HQs were calculated for the AOC 9 potential exposure area using depth-weighted and area-weighted EPCs, selected and refined TRVs, and selected BAFs for metals or congener-specific BAFs for dioxin congeners and are presented in Table 6-6 for the baseline scenario. For COPECs with LOAEL-based HQs greater than 1 using the most refined exposure and effects assumptions, a WOE assessment was used to draw risk conclusions and identify potential risk drivers for the AOC 9 potential exposure area. Although LOAEL-based HQs greater than 1 were estimated for dioxin TEQ in some of the less refined exposure scenarios (i.e., the baseline scenario using depth-weighted and area-weighted EPCs and a generic BAF based on a single congener; see Appendix AOC 9), all LOAEL-based HQs were less than 1 in the most refined scenario evaluated for each constituent. Therefore, the WOE assessment was not presented below. The various LOE and WOE conclusions for all scenarios are presented in detail in Appendix AOC 9.

Risk conclusions for potential desert shrew populations in AOC 9 are presented in the following list.

- For dioxin TEQ, risk conclusions are based on LOAEL-based HQs estimated in the most refined exposure scenario evaluated for this constituent (Section 5.6.3 of Appendix AOC 9) using the assumptions used for RBRG development (i.e., an SUF of 1, congener-specific BAFs, and alternate TRVs) and depth-weighted EPCs. Using these assumptions, the LOAEL-based HQs are less than 1 for the baseline scenario using both sets of congener-specific BAFs (USEPA 1999; Fagervold et al. 2010). These HQs indicate that no unacceptable risk is expected for populations of invertivorous small mammals in the AOC 9 potential exposure area.
- For total chromium, hexavalent chromium, and copper, all NOAEL- and LOAEL-based HQs are less than 1 for the baseline scenario, indicating de minimis risk to individuals and populations of invertivorous small mammals at the AOC 9 potential exposure area.

In conclusion, no unacceptable risk to potential small mammal populations represented by the desert shrew is identified at the AOC 9 potential exposure area for post-NTCRA conditions as evaluated in this Post-NTCRA HHERA.

6.6.2.3 AOC 10

For the AOC 10 potential exposure area, the 2019 HHERA (Arcadis 2019) concluded that potential risk to ecological receptors, including special-status species, in AOC 10 and the larger exposure areas relevant to large home-range receptors was limited to desert shrew potentially exposed to total chromium and dioxin TEQ in surface soil. Therefore, this Post-NTCRA HHERA presents risk estimates for desert shrew and total chromium and dioxin TEQ in surface soil that reflect current conditions in the AOC 10 potential exposure area following soil remediation associated with the NTCRA. Risk estimates for hexavalent chromium and copper as well as risk estimates for all three scouring scenarios evaluated in the 2019 HHERA (baseline, 2-foot scouring, and 5-foot scouring) are also included to evaluate post-NTCRA conditions.

The post-NTCRA ERA for the AOC 10 potential exposure area is presented in detail in Appendix AOC 10, including risk calculations based on depth-weighted and area-weighted EPCs for the baseline and scouring scenarios. The HQs were calculated using depth-weighted and area-weighted EPCs, selected and refined TRVs, and selected BAFs for metals or congener-specific BAFs for dioxin congeners and are presented in Table 6-7 for the baseline, 2-foot scouring, and 5-foot scouring scenarios. For COPECs with LOAEL-based HQs greater than 1 using the most refined exposure and effects assumptions, a WOE assessment was used to draw risk conclusions and identify potential risk drivers for the AOC 10 potential exposure area. Although LOAEL-based HQs greater than 1 were estimated for dioxin TEQ in some of the less refined exposure scenarios (i.e., the 2-foot and 5-foot scouring scenarios using depth-weighted and area-weighted EPCs and a generic BAF based on a single congener; see Appendix AOC 10), all LOAEL-based HQs were less than 1 in the most refined scenario evaluated for each constituent. Therefore, the WOE assessment was not presented below. The various LOE and WOE conclusions for all scenarios are presented in detail in Appendix AOC 10.

Risk conclusions for potential desert shrew populations in AOC 10 are presented in the following list.

- For dioxin TEQ, risk conclusions are based on LOAEL-based HQs estimated in the most refined exposure scenario evaluated for this constituent (Section 5.6.3 of Appendix AOC 10) using the assumptions used for RBRG development (i.e., an SUF of 1, congener-specific BAFs, and alternate TRVs) and depth-weighted EPCs. Using these assumptions, the LOAEL-based HQs are less than 1 for the baseline, 2-foot scouring, and 5-foot scouring scenarios using both sets of congener-specific BAFs (USEPA 1999; Fagervold et al. 2010). These HQs indicate that no unacceptable risk is expected for populations of invertivorous small mammals in the AOC 10 potential exposure area.
- For hexavalent chromium, total chromium, and copper, risk conclusions are based on LOAEL-based HQs estimated in the most refined scenario evaluated for these constituents (Section 5.6.2 of Appendix AOC 10) using the assumptions used for RBRG development (i.e., an SUF of 1, selected BAFs, and selected TRVs) and area-weighted EPCs. The NOAEL- and LOAEL-based HQs are less than 1 for the baseline, 2-foot scouring, and 5-foot scouring scenarios indicating de minimis risk to individuals and populations of invertivorous small mammals at the AOC 10 potential exposure area. The HQs calculated using depth-weighted EPCs and resulting risk conclusions are the same.

In conclusion, no unacceptable risk to potential small mammal populations represented by the desert shrew is identified at the AOC 10 potential exposure area for post-NTCRA conditions as evaluated in this Post-NTCRA HHERA.

6.6.2.4 AOC 11

For the AOC 11 potential exposure area, the 2019 HHERA (Arcadis 2019) did not identify potential risk to ecological receptors, including special-status species, in AOC 11 and the larger exposure areas relevant to large home-range receptors in surface soil. However, the 2024 NTCRA targeted soil removal in areas where dioxin TEQ and hexavalent chromium exceeded RAGs (Jacobs 2025). Therefore, this Post-NTCRA HHERA presents risk estimates for desert shrew and hexavalent chromium and dioxin TEQ in surface soil that reflect current conditions in the AOC 11 potential exposure area following soil remediation associated with the NTCRA. Risk estimates for total chromium and copper are also included to evaluate post-NTCRA conditions.

The post-NTCRA ERA for the AOC 11 potential exposure area is presented in detail in Appendix AOC 11, including risk calculations based on depth-weighted and area-weighted EPCs the baseline scenario. Scouring scenarios were not evaluated, consistent with the 2019 HHERA (Arcadis 2019). The HQs were calculated using depth-weighted and area-weighted EPCs, selected and refined TRVs, and selected BAFs for metals or congener-specific BAFs for dioxin congeners are presented in Table 6-8. For COPECs with LOAEL-based HQs greater than 1 using the most refined exposure and effects assumptions, a WOE assessment was used to draw risk conclusions and identify potential risk drivers for the AOC 11 potential exposure area.

Although LOAEL-based HQs greater than 1 were estimated for dioxin TEQ in some of the less refined exposure scenarios (i.e., the baseline scenario using depth-weighted and area-weighted EPCs and a generic BAF based on a single congener; see Appendix AOC 11), all LOAEL-based HQs were less than 1 in the most refined scenario evaluated for each constituent. Therefore, the WOE assessment was not presented below. The various LOE and WOE conclusions for all scenarios are presented in detail in Appendix AOC 11.

Risk conclusions for potential desert shrew populations in BCW are presented in the following list.

- For dioxin TEQ, risk conclusions are based on LOAEL-based HQs estimated in the most refined exposure scenario evaluated for this constituent (Section 5.6.3 of Appendix AOC 11) using assumptions used for RBRG development (i.e., an SUF of 1, congener-specific BAFs, and alternate TRVs) and depth-weighted EPCs. Using these assumptions, LOAEL-based HQs are less than 1 using both sets of congener-specific B A Fs (i.e., USEPA 1999, Fagervold et al. 2010) indicating that no unacceptable risk is expected for populations of invertivorous small mammals in AOC 11 potential exposure area.
- For hexavalent chromium, total chromium, and copper, the NOAEL- and LOAEL-based HQs are less than 1 for the baseline scenario indicating de minimis risk to individuals and populations of invertivorous small mammals like desert shrew at the AOC 11 potential exposure area.

In conclusion, no unacceptable risk to potential small mammal populations represented by the desert shrew is identified at the AOC 11 potential exposure area for post-NTCRA conditions as evaluated in this Post-NTCRA HHERA.

6.6.2.5 AOC 14

For the AOC 14 potential exposure area, the 2019 HHERA (Arcadis 2019) did not identify potential risk to ecological receptors, including special-status species, in AOC 14 and the larger exposure areas relevant to large home-range receptors in surface soil. However, the 2024 NTCRA targeted soil removal in areas where metals (i.e., total chromium, hexavalent chromium, copper, lead, mercury, and zinc) and TEQ exceeded RAGs (Jacobs 2025). Therefore, this Post-NTCRA HHERA presents risk estimates for desert shrew and total chromium, hexavalent chromium, copper and dioxin TEQ in surface soil that reflect current conditions in the AOC 14 potential exposure area following soil remediation associated with the NTCRA.

The post-NTCRA ERA for the AOC 14 potential exposure area is presented in detail in Appendix AOC 14, including risk calculations based on depth-weighted and area-weighted EPCs for the baseline scenario. Consistent with the 2019 HHERA (Arcadis 2019), scouring scenarios were not evaluated. The

HQs were calculated using depth-weighted and area-weighted EPCs and selected and refined TRVs, and selected BAFs are presented in Table 6-9. Evaluation of congener-specific BAFs for dioxin congeners was not warranted. For COPECs with LOAEL-based HQs greater than 1 using the most refined exposure and effects assumptions, a WOE assessment was used to draw risk conclusions and identify potential risk drivers for the AOC 14 potential exposure area.

LOAEL-based HQs were less than 1 in all potential exposure scenarios. Therefore, a WOE assessment was not presented below. The various LOE and WOE conclusions for all scenarios are presented in detail in Appendix AOC 14.

Risk conclusions are based on LOAEL-based HQs estimated in the most refined exposure scenario applicable to this AOC (Section 5.6.2 of Appendix AOC 14) using the assumptions used for RBRG development (i.e., an SUF of 1, selected BAFs, and selected TRVs) and area-weighted EPCs. NOAEL-based HQs and LOAEL-based HQs for desert shrew are less than 1 for hexavalent chromium, total chromium, copper, and dioxin TEQ indicating de minimis risk to individuals and populations of invertivorous small mammals at the AOC 14 potential exposure area.

In conclusion, no unacceptable risk to potential desert shrew populations is identified at the AOC 14 potential exposure area for post-NTCRA conditions as evaluated in this Post-NTCRA HHERA.

6.6.2.6 AOC 27

For the AOC 27 potential exposure area, the 2019 HHERA (Arcadis 2019) did not identify potential risk to ecological receptors, including special-status species, in AOC 27 and the larger exposure areas relevant to large home-range receptors in surface soil. However, the 2024 NTCRA targeted soil removal in areas where metals (i.e., total chromium, hexavalent chromium, copper, lead, molybdenum, and zinc) and TEQ exceeded RAGs (Jacobs 2025). Therefore, this Post-NTCRA HHERA presents risk estimates for desert shrew and total chromium, hexavalent chromium, copper, and dioxin TEQ in surface soil that reflect current conditions in the AOC 27 potential exposure area following soil remediation associated with the NTCRA. The post-NTCRA ERA for the AOC 27 potential exposure area is presented in detail in Appendix AOC 27, including risk calculations based on depth-weighted and area-weighted EPCs for the baseline scenario. Consistent with the 2019 HHERA, scouring scenarios were not evaluated. The HQs were calculated using depth-weighted and area-weighted EPCs and selected and refined TRVs, and selected BAFs for metals or congener-specific BAFs for dioxin congeners are presented in Table 6-10. For COPECs with LOAEL-based HQs greater than 1 using the most refined exposure and effects assumptions, a WOE assessment was used to draw risk conclusions and identify potential risk drivers for the AOC 27 potential exposure area. LOAEL-based HQs were less than 1 were for all exposure scenarios. Therefore, a WOE assessment was not presented below. The various LOE and WOE conclusions for all scenarios are presented in detail in Appendix AOC 27.

Risk conclusions for potential desert shrew populations in AOC 27 are presented in the following list.

- For dioxin TEQ, risk conclusions are based on HQs estimated in the most refined exposure scenario evaluated for this constituent (Section 5.6.3 of Appendix AOC 27) using assumptions used for RBRG development (i.e., an SUF of 1, congener-specific BAFs, and alternate TRVs) and depth-weighted EPCs. Using these assumptions, NOAEL- and LOAEL-based HQs are less than 1 using both sets of congener-specific BAFs (i.e., USEPA 1999; Fagervold et al. 2010) indicating de minimis risk to individuals and populations of invertivorous small mammals from exposure to dioxin TEQ at the AOC 27 potential exposure area.

- For hexavalent chromium, total chromium, and copper, all NOAEL- and LOAEL-based HQs are less than 1 for the baseline scenario indicating de minimis risk to individuals and populations of invertivorous small mammals like desert shrew at the AOC 27 potential exposure area. Risk conclusions are based on HQs estimated in the most refined exposure scenario applicable to these constituents (Section 5.6.2 of Appendix AOC 27) using an SUF of 1, selected BAFs, and TRVs used for RBRG development and area-weighted EPCs.

In conclusion, no unacceptable risk to potential small mammal populations represented by the desert shrew is identified at the AOC 27 potential exposure area for post-NTCRA conditions as evaluated in this Post-NTCRA HHERA.

6.7 Uncertainty Analysis

Understanding the underlying uncertainties inherent in the data and models used in the risk assessment is a critical aspect of a risk-based decision-making process. The uncertainty analysis presented in this section includes qualitative discussions and, in some cases, quantitative evaluations intended to convey the magnitude and direction of uncertainty in the risk estimates. Sources of uncertainty that influenced risk characterization included uncertainties in the analytical results, data evaluation, CSM, exposure assessment, effects assessment, and interpretation of the risk estimates. Many of these sources of uncertainty are generic in nature and inherent in the risk assessment process. Additionally, many of the site-specific uncertainties discussed in the 2019 HHERA (Arcadis 2019) also apply for this Post-NTCRA HHERA. In many cases, the generic and site-specific uncertainties discussed in Section 5.5 with respect to the HHRA also apply to the ERA. Uncertainties that have been previously discussed in the 2019 HHERA or in Section 5.5 are not repeated here. Additional uncertainties applicable to the ERA, which evaluates post-NTCRA conditions at the site, are discussed in this section.

In general, conservative practices and assumptions were made to minimize underestimation of risk in the ERA, including the following:

- Estimates of COPEC concentrations in media were based on samples collected from known or suspected impacted locations within each exposure area and, thus, are likely to overestimate actual exposures to ecological receptors that might use the site.
- Wildlife representative receptor species were intentionally selected based on attributes (e.g., small foraging areas) that provide conservative estimates of exposure for other members of the feeding guild. Exposure parameters for the selected representative species from approved sources (e.g., USEPA Wildlife Exposure Factors Handbook [USEPA 1993]) were preferred sources of wildlife exposure information to reduce the uncertainty for the species living at this specific site.
- Estimates of exposure assume that wildlife do not avoid contaminated areas or foods, and do not actively avoid areas of the site in close proximity to industrial development and/or uses.

- Reproductive, developmental, and mortality effects, among the most sensitive of test endpoints for evaluating effects at the individual and population level, were the preferred endpoints when identifying toxicity studies used in the selection of TRVs.
- The exposure assumptions and toxicity values used in the ERA were based on values selected in the various agency-approved tech memos (BBL 2007; Arcadis 2008a, 2009b) and values approved in the 2019 HHERA (Arcadis 2019) for RBRG development. These assumptions are often based on conservative and readily available literature/published values. Literature-based TRVs are generally considered very conservative and, therefore, tend to overestimate risk as discussed in the risk characterization for ecological receptors. For dioxin TEQ, alternate and more robust BAFs and TRVs were developed in the 2019 HHERA based on more current literature and approaches (as summarized earlier in Section 6.5). These alternate and more robust values were used to develop RBRGs to guide the NTCRA removals and are were used in this Post-NTCRA HHERA.

Because of these approaches and other protective assumptions made throughout the ERAs, risk estimates are expected to be overestimated rather than underestimated, an intentional feature of risk assessments to ensure adequate protection of relevant receptors.

Topics included in this analysis address uncertainties inherent in each phase of the ERAs. Specifically, uncertainties associated with the problem formulation, the data evaluation, the exposure assessment, the effects assessment, and the risk characterization are described in detail in this section.

6.7.1 Uncertainty in the Problem Formulation

In the 2019 HHERA (Arcadis 2019), the primary uncertainties associated with the problem formulation included lack of site-specific information for the CSM, including omission of potentially complete but insignificant exposure pathways (e.g., dermal and inhalation exposure to soil, exposure to sediment). For this Post-NTCRA HHERA, uncertainties related to potential dermal and inhalation exposures to soil are the same as discussed in the 2019 HHERA, and these factors were not considered major sources of uncertainty in either case. The NTCRA removal areas did not include sediment and, therefore, this uncertainty for the 2019 HHERA is not relevant to this Post-NTCRA HHERA. A more detailed discussion for soil pathways taken from the 2019 HHERA is included in Section 6.7.1.1.

Additional uncertainties related to problem formulation in this evaluation of post-NTCRA conditions were not identified.

6.7.1.1 Omission of Potentially Complete but Insignificant Exposure Pathways

According to USEPA guidance (USEPA 1998), an exposure pathway must consist of four elements to be considered complete: (1) sources and release mechanisms, (2) retention and transport mechanisms, (3) exposure points, and (4) exposure routes. A pathway is considered incomplete if any of these elements are missing. Additionally, complete or potentially complete pathways may be considered insignificant due to the following: (1) low levels of contaminants, (2) low exposure frequency, or (3) the fact that they are insignificant compared to other risk-driving pathways. Complete or potentially complete pathways considered less significant may not warrant quantitative evaluation in an ERA as discussed in USEPA guidance (USEPA 1989, 1997a). Additionally, exposure and toxicity information necessary for quantitative evaluation of some pathways (e.g., dermal exposure) are limited or lacking. Therefore, these less significant or unquantifiable pathways should be qualitatively evaluated and identified as a source of uncertainty. Potential exposures due to dermal contact, inhalation of volatiles in burrow air and ambient air, and exposure to sediment were considered unquantifiable and/or insignificant for wildlife and were not quantitatively evaluated in this ERA.

Potential exposures via dermal contact were considered insignificant for wildlife receptors. For ecological communities, dermal contact was evaluated via direct contact with site media. For wildlife, dermal exposure through direct contact with site media can be considered a complete exposure pathway; however, this pathway was considered incidental due to low frequency and/or duration of exposure. Dermal exposure was also expected to minimally contribute to risk compared to oral routes of exposure (USEPA 2007). Additionally, data necessary to estimate dermal exposure are generally not available for wildlife (USEPA 1993). Thus, dermal exposure to wildlife was not quantitatively evaluated in this ERA.

Inhalation of VOCs in ambient and burrow air was considered complete but insignificant exposure pathway because VOCs were infrequently detected outside the TCS, and detected concentrations were low. VOCs are expected to disperse rapidly in air following volatilization from soil or groundwater and are generally not highly toxic to birds or mammals (USEPA 2007). Additionally, VOCs have log Kow values less than 2.0 and are unlikely to bioaccumulate in plant and animal tissues at significant levels (USEPA 2000).

Consistent with USEPA guidance (1989, 2008a), dermal exposure to soil and inhalation of VOCs in ambient air and burrow air are not expected to be significant routes of exposure and were not considered a major source of uncertainty for this ERA.

6.7.2 Uncertainty in the Data

In the 2019 HHERA (Arcadis 2019), the primary uncertainties associated with the data applied to both the HHRA and the ERA, and the same is true for this Post-NTCRA HHERA. Relevant to this Post-NTCRA HHERA are uncertainties related to data quality, analytical methods and RLs, calculated total concentrations for mixtures (e.g., dioxin TEQ), biased sampling design, and data grouping. These uncertainties are summarized in Section 5.5.1. For the ERA, there is also uncertainty in the application of TEFs for dioxin congeners, which is the same as discussed in the 2019 HHERA and which is repeated below as it was found to be a significant source of uncertainty in both risk assessments. Additional uncertainties related to data in this evaluation of post-NTCRA conditions, including depth adjustments necessary to account for excavation and backfill associated with NTCRA removals, are discussed in Section 5.5.

6.7.2.1 Use of Mammalian TEFs for Calculation of Dioxin TEQ Concentrations for Soil

Dioxin TEQs calculated for post-NTCRA soil using mammalian TEFs are based on prey tissue ingestion (i.e., primarily from oral uptake studies through dietary exposure). Direct calculation of dioxin TEQ concentrations in soil does not account for reductions in bioavailability or uptake that occur differentially for the individual congeners during ingestion, and for differences in the environmental fate of these compounds in abiotic media (Van den Berg et al. 2006). (It should be noted that concern was expressed [by the WHO committee] about direct application of the TEF/total TEQ approach to abiotic matrices, such as soil, sediment, etc., for direct application in human risk assessment. This is problematic as the present

TEF scheme and TEQ methodology are primarily intended for estimating exposure and risks via oral ingestion [e.g., by dietary intake].) There is significant uncertainty in the application of mammal TEFs to soil data in the dietary models, and dioxin TEQ HQs for these receptors are likely to overestimate risk.

6.7.3 Uncertainty in Exposure Estimates

In the 2019 HHERA (Arcadis 2019), the key uncertainties associated with the exposure estimates include uncertainties related to bioavailability of COPECs in soil, EPC estimation, and receptor exposure assumptions (including dietary composition); relevant uncertainties are repeated below from the 2019 HHERA. While the soil bioavailability and receptor exposure assumptions are likely to substantially overestimate potential exposure and risk, these assumptions are consistent with those used in the 2019 HHERA and the DTSC-approved RAWP (Arcadis 2008b) and associated RAWP documents (Arcadis 2009a, 2015). . The 2019 HHERA concluded that uncertainties related to the calculation of depth-weighted concentrations and estimation of EPCs had a minimal impact on the risk estimates and these uncertainties are the same for this Post-NTCRA HHERA. Additional uncertainties related to exposure estimates specific to this evaluation of post-NTCRA conditions include the unlikely nature of the scouring scenarios, as summarized below and discussed in Appendix BCW and Appendix AOC 10.

6.7.3.1 Assumption of Bioavailability in Soil

Exposure estimates calculated herein assume that measured concentrations of COPECs in soil are 100% bioaccessible via dietary uptake (dermal gut absorption) and direct contact. For many COPECs, this assumption overestimates exposure. The chemical extraction methods used to measure COPEC concentrations in soil result in complete or nearly complete extraction of bound and insoluble COPEC fractions in soil, whereas chemical extraction in the gut of ecological (and human, previously discussed in Section 5.5.3.3 of the 2019 HHERA [Arcadis 2019]) receptors can be far less efficient. Relative bioaccessibility data are available for arsenic, lead, and zinc, and the data demonstrate that bioaccessibility in soil is well below 100% for dietary uptake in mammals (USEPA 2012; DTSC 2000). Details of arsenic and lead bioavailability, including recent studies and methodologies, are discussed in the ITRC guidance (2017).

Specific to the risk-driving COPECs evaluated in this Post-NTCRA HHERA, literature bioaccessibility factors are also available for dioxins:

- TCDD: In a study by Fries and Marrow (1975), rats were given TCDD in a laboratory prepared diet continuously for 42 days. Fries and Marrow (1975) reported the absorption of TCDD into the tissue to be 50 to 60%, with an average of 55%.
- Dioxins: Swine and rats have been used most frequently in studies to assess the relative bioavailability of dioxin from soil (Budinsky et al. 2008; Wittsiepe et al. 2007; Finley et al. 2009; Lucier et al. 1986; Shu et al. 1988). In the swine studies, the total TEQ relative bioavailability average was 28%. In the rat studies, the total TEQ relative percent bioavailability average was 41%. The mean of these is 35% (USEPA 2010).

In addition, TRVs are typically based on laboratory dosing studies in which highly soluble forms of the COPECs were used. As a result, these toxicity estimates can overestimate the bioavailability, uptake, and ultimate toxicity of COPECs in the receptor's gut.

To account for the absorbed fraction across the gut wall, DTSC (2015b) recommends reducing dermal uptake estimates for several COPECs (metals, PAHs, PCBs, chlorinated pesticides, dioxins/furans, and other organic compounds). The absorbed fractions range from 0.001 for cadmium to 0.15 for PAHs and PCBs (DTSC 2015b).

While these relative bioaccessibility and dermal absorption values have been calculated for use in HHERAs, they likely also apply to many other mammalian species to varying degrees. Based on the magnitude of the bioaccessible fractions in soil, the assumption that 100% of measured COPEC concentrations are bioavailable can result in substantial overestimation of exposure and risk.

6.7.3.2 Exposure Point Concentration Estimation

Uncertainties associated with estimation of EPCs that are applicable to both the HHRAs and the ERAs are discussed in Section 5.5.3. Uncertainties applicable only to the ERAs are provided here. In the ERA, depth-weighted soil datasets were used to calculate EPCs. Two sets of EPCs were used to estimate risk, including the upper bound on the mean of the depth-weighted concentrations (i.e., depth-weighted 95UCL) and the upper bound on the mean of depth- and area-weighted concentrations (i.e., area-weighted 95UCL). When the available dataset for a depth interval and exposure area was composed of less than eight total samples and four detected results, the maximum depth-weighted concentration was selected as the EPC for both EPC scenarios. In these cases, such as for constituents that were rarely detected or exposure areas where few samples were collected because detected concentrations did not warrant further step-out sampling, use of the maximum may not appropriately characterize site risk.

Use of half the RL to calculate the depth-weighted soil concentrations for each boring location also introduces uncertainty in the EPCs. As discussed in Section 5.5.3, the magnitude of this uncertainty is relatively small because most EPCs are the same or differ by a factor of two or less. For example, depth-weighted EPCs for the BCW exposure area (0 to 6 feet bgs interval; Table BCW-3.1 of Appendix BCW) were recalculated using the full RL in the depth-weighting procedure. For most COPECs, the same UCL method was recommended by ProUCL, and the resulting EPCs (using full RL) were less than 20% greater than estimated using half the RL in the depth-weighting procedure. For those COPECs with a frequency of detection at or near 100%, the resulting EPCs using full RLs were the same as using half the RLs because there are few or no ND values in the dataset. Similarly, for those COPCs with fewer than four detected concentrations, the resulting EPCs using the full RLs were the same as using half the RLs because the EPC is based on the maximum detected concentration. The remaining COPCs with EPCs that differed by more than 20% included antimony (41% or 1.4 times greater), mercury (86% or 1.86 times greater), and TPH as diesel (84% or 1.84 times greater). For TPH as diesel, risk to ecological receptors was evaluated using individual constituents of the TPH mixture for which EPCs differed by less than 20%. For antimony and mercury, use of the full RL resulted in no changes or minor changes to the estimated HQs. Ecological receptors potentially exposed to the 0- to 6-foot-bgs interval include plants, Gambel's quail, Merriam's kangaroo rat, desert kit fox, and Nelson's desert bighorn sheep. In the BCW exposure area, antimony and mercury LOAEL-based HQs for these receptors are below 1 using half the RL or the full RL in the depth-weighting scenario, except for antimony and plants. The antimony HQ for plants equals 4 in both scenarios (half the RL and full RL) because the HQs are based on an EPC of 18 mg/kg, the maximum detected value for surface soil and the highest EPC for all depths intervals.

In most cases (as described in the preceding paragraph), use of the full RL in the depth-weighting procedure resulted in the selection of the same UCL method; therefore, the resulting difference in EPCs can be attributed to the use of the full RL value. However, in a small number of cases, a different UCL method was recommended by ProUCL when the full RL was used, which may contribute to the observed change in EPC value. For the example for the BCW 0- to 6-foot-bgs dataset, this occurred for antimony and TPH as diesel. For antimony, use of the full RL resulted in a 95UCL of 2.339 mg/kg based on the ProUCL-recommended method (95% KM [BcA] UCL), whereas use of half the RL yielded a 95UCL of 1.658 mg/kg based on the ProUCL-recommended method (95% KM Chebyshev UCL).

For shallower depth intervals (e.g., 0 to 3 feet bgs), the effect of using the full RL is similar in that it produces higher EPCs for those COPCs with relatively low frequencies of detection. For the 0- to 3-foot-bgs BCW dataset, the only COPCs with EPCs that differed by more than 20% included mercury (84% or 1.84 times greater) and TPH as diesel (59% or 1.59 times greater). EPCs for antimony and bis(2-ethylhexyl)phthalate at this depth were based on the maximum detected concentration due to there being fewer than four detected concentrations for this depth interval.

Overall, the use of half the RL in the depth-weighting procedure had a minimal effect on the risk estimates and did not impact the risk conclusions for ecological receptors potentially exposed to soil at the site.

6.7.3.3 Receptor Exposure Assumptions

For desert shrew, potential exposure was estimated using a dietary exposure model. This model uses generic assumptions for food ingestion rates, body weight, and dietary composition that were derived from literature sources or estimated from allometric relationships and not actually measured using site-specific data. Variations from natural stresses may result in one or multiple parameter changes (e.g., mean value body weight or dietary consumption). It should also be noted that wildlife exposure factors for these representative species can vary by location, quality of habitat, and season. Conservative values, identified as the published values resulting in the highest exposure estimate, were often selected when conflicting information was presented.

The selected exposure parameters are likely to accurately represent or overestimate, but not underestimate, potential exposure to actual wildlife present at the site, as the exposure parameters were selected to be more protective (i.e., high IRs, low body weights, exposure to the upper bound of concentrations, and diet consisting of a single prey item). Specifically, shrew have not been observed at the site. The selection of shrew as a representative receptor for other small invertivorous mammals that may be present at the site is likely to overestimate exposure and risk due to the high metabolic rate, food ingestion rate, and small body weight for this species.

6.7.3.3.1 Dietary Composition

The assumption that each wildlife receptor consumes one type of diet (e.g., desert shrew eating 100% invertebrates), instead of a mixed diet, is also conservative for most receptors. The assumption that 100% of the receptor’s diet is contaminated with site chemicals is also conservative. These assumptions tend to overestimate risk estimated for ecological receptors, especially for wildlife that are omnivorous. Generally, uptake of organics (lipophilic compounds) tends to be higher in prey items such as invertebrates and small mammals than uptake by plants. Risk estimates based on invertivorous and carnivorous receptors likely overestimate risk for omnivorous species with more variable diets.

An additional uncertainty is related to the soil-to-invertebrates BAFs selected in these ERAs, which are based on uptake data or theoretical models for bioaccumulation from soil to earthworm tissue. Use of the earthworm-based BAFs assumes that invertivorous species consume only earthworms. Earthworms ingest soil, are in direct contact with soil, and have few external features that would limit dermal absorption through the skin. As a result, uptake estimates for earthworms are typically higher than observed for many other soil invertebrate species, including terrestrial insects that live along the soil surface or on plants/organic material at or above ground level. Additionally, many of these species' feeding habits and external structures, such as hard cuticles, limit dermal absorption of soil constituents. Because of the arid environment at the site, invertebrates that are likely present onsite are spiders, beetles, scorpions, etc., and not earthworms. As a result, the assumption that invertivorous receptors feed solely on earthworms likely overestimates exposure and risk for most invertivorous/insectivorous receptors that consume species other than earthworms as part of their diet. Additional uncertainty related to the earthworm BAFs is discussed in Section 6.7.4.

6.7.3.4 Effect of Scouring Assumptions

As described in Appendix BCW and Appendix AOC 10, vertical scouring within the ravine bottoms of BCW and AOC 10 has not been observed over the many years of site observations, which have included several high flow events. The vertical scouring scenarios evaluated in this Post-NTCRA HHERA are considered highly unlikely to occur at the site. For shrew, which are assumed to be exposed only to surface soil, the potential for contact with soils currently present below 2 feet bgs and/or 5 feet bgs is also considered highly unlikely. As a result, the risk estimates in the ERA based on scouring scenarios do not meaningfully inform risk-management decision-making at the site.

Although vertical scouring of the ravine bottoms does not occur, erosion has been occurring on the steep hillside where AOC 9 and AOC 10 TAA1 are located, just below the TCS. The catchment area for East Ravine is small, so the ravine does not get large amounts of stormwater runoff. As a result, and consistent with observations, scouring is not expected in the ravine bottom. Prior to removal of the berm adjacent to AOC 10c (i.e., AOC 10 TAA2), flow within ravine stopped there, and any transported sediment was deposited. The berm was removed as part of the NTCRA. Following berm removal, flow within ravine is now continuous to AOC 10d, where the next berm (SoCal Gas pipeline berm) is located. Additionally, NTCRA activities have included placement of riprap on the slope at AOC 9 TAA1 and AOC 10 TAA1 after backfilling to prevent further erosion from occurring in those locations.

6.7.4 Uncertainty in Uptake Assumptions

Bioaccumulation assumptions represent a large source of uncertainty in the ERAs due to the use of literature-derived BAFs. Site-specific tissue residue data, which provide a direct measure of prey tissue concentrations, are unavailable at the site. Prey concentrations estimated using literature-derived BAFs do not account for assimilation, metabolism, or depuration of constituents, or site-specific factors that may influence uptake. Site-specific factors may include species-specific characteristics (e.g., feeding strategy, age, gender) as well as abiotic factors (e.g., soil organic carbon and mineral content, COPEC weathering, climate). The sandy soil near the sites may not be representative of soils typically used to derive BAFs in the published literature. However, published BAFs are generally thought to be conservative because they are recommended by the USEPA for use in screening-level risk assessments. When USEPA-recommended BAFs were not available, BAFs were developed based on suitable data and/or models available in literature. In general, the use of the generic literature-based BAFs is assumed to overestimate uptake, exposure, and risk at the sites. However, the magnitude of this effect cannot be estimated without site-specific tissue residue data.

Uncertainties related to bioaccumulation of dioxins in prey tissues are presented below as stated in the 2019 HHERA (Arcadis 2019).

6.7.4.1 Uncertainty in Uptake of Dioxins/Furans

In the ERA, potential dietary exposure for desert shrew to dioxin TEQ was estimated by estimating dioxin TEQ concentrations in their prey tissue (conservatively assumed to be earthworms). Uptake from soil-to-prey tissue was estimated using an uptake regression for a single congener (2,3,7,8-TCDD) published by Sample et al. (1998) to represent uptake of all 17 dioxin/furan congeners included in dioxin TEQ. This is a critical uncertainty for dioxins/furans, one of the potential risk drivers for the sites, as this approach ignores differential uptake of congeners based on differences in their structure and physico-chemical properties leading to potential and significant overestimation of risks to ecological receptors, especially wildlife receptors. Uptake data available in the literature for earthworms (Fagervold et al. 2010) and published soil-to-invertebrate BAFs (USEPA 1999) indicate that 2,3,7,8-TCDD has among the highest uptake rates for the dioxin/furan congeners included in TEQ concentrations. Several sites impacted by dioxin/furan sites (e.g., Tittabawassee River [Galbraith 2004; Kay et al. 2005] and Centredale Manor in Rhode Island [Mactec 2004] have demonstrated the overestimation of dioxin TEQ risk resulting from use of a single BAF compared with measured concentrations). Because TEQ uptake was estimated in less refined scenarios using uptake data for only 2,3,7,8-TCDD, TEQ uptake is likely overestimated in the ERAs in these scenarios.

The magnitude of this uptake overestimation was evaluated in the 2019 HHERA (Arcadis 2019) using congener-specific BAFs to predict individual congener concentrations in prey tissue, which were then used to calculate tissue TEQ concentrations for use in the dietary food-web models used in the ERA. Congener-specific BAFs are readily available from USEPA (1999) for soil-to-plant uptake and soil-to-terrestrial invertebrate uptake and congener-specific soil-to-invertebrate BAFs are also available from Fagervold et al. (2010). Table 6-11 presents the example provided in the 2019 HHERA. As shown in Table 6-11, the dioxin TEQ EPCs for invertebrate tissue based on congener-specific BAFs are about 10 to 19 times lower compared to the tissue TEQ EPCs used in the ERA for the BCW potential exposure area. Details of this analysis from the 2019 HHERA are provided below:

Table 6-11 presents individual congener concentrations in soil for the BCW potential exposure area (depth-weighted EPCs from the 2019 ERA), the plant and invertebrate congener-specific BAFs from USEPA (1999) and Fagervold et al. (2010), and resulting tissue EPCs for dioxin TEQ. To calculate the dioxin TEQ tissue EPCs, the soil concentrations were first multiplied by the congener-specific BAFs to estimate plant and invertebrate tissue EPCs for each congener. The congener-specific tissue EPCs were then multiplied by the mammalian and avian TEFs (Section 6.5.2). Dioxin tissue TEQ concentrations were estimated by summing the TEF-adjusted individual congener concentrations, resulting in plant tissue TEQ EPCs and invertebrate tissue TEQ EPCs for use in food-web models for mammals and birds.

The tissue TEQ EPCs based on congener-specific BAFs were compared to the plant and invertebrate tissue TEQ EPCs used in the ERA estimated using only the 2,3,7,8-TCDD uptake regressions from Sample et al. (1998) (i.e., not congener specific), presented at the bottom of Table 6-11. For plants, the congener-specific approach using the USEPA (1999) plant BAFs resulted in plant tissue TEQ EPCs of 0.5 ng/kg (for mammals) and 1.3 ng/kg (for birds), which are similar (within a factor of two) to the TEQ EPCs used in the ERA (1.1 ng/kg for mammals and 0.61 ng/kg for birds). For invertebrates, however, the congener-specific approaches resulted in dioxin TEQ tissue EPCs of 153 ng/kg for mammals and 371 ng/kg for birds using the USEPA (1999) invertebrate BAFs, and dioxin TEQ tissue EPCs of 80 ng/kg for mammals and 105 ng/kg for birds, using the Fagervold et al. (2010) invertebrate BAFs. The dioxin TEQ tissue EPCs based on congener-specific BAFs are about 10 to 19 times lower compared to the mammalian TEQ and about two to seven times lower than the avian TEQ compared to the tissue TEQ EPCs used in the ERA for the BCW potential exposure area (0 to 0.5 foot bgs; 1,491 ng/kg for mammals and 703 ng/kg for birds).

The following two sets of congener-specific BAFs for invertebrates were evaluated in Table 6-11:

- Congener-specific BAFs calculated by USEPA (1999); and
- Congener-specific BAFs calculated from data presented in Fagervold et al. (2010).

The second set of congener-specific BAFs from Fagervold et al. (2010) were developed using the Fagervold et al. (2010) data, bioaccumulation equivalency factors (BEFs, Table 6-12) and the 2,3,7,8-TCDD BAF based on a floodplain soil sample (SW-20 containing 0.38% organic carbon; Fagervold et al. 2010). The data from this location are considered the most representative of the site based on the low organic carbon content. However, invertebrate BAFs were not available for some congeners as they were not detected in the SW-20 soil sample. Therefore, invertebrate BEFs for a wetland location (SW-265 containing 5.6% organic carbon; Fagervold et al. 2010) were also included in the development of the overall congener-specific BAFs by the calculation of BEFs for each soil location. The BEFs assume that the uptake of each congener relative to 2,3,7,8-TCDD in a particular soil sample is dependent on physical/chemical characteristics of the individual congeners and not related to the geochemical characteristics of the soil. BEFs were estimated as a ratio of the congener-specific BAF to the TCDD BAF (e.g., BEF for TCDD is 1.65/1.65 =1; BEF for 1,2,3,4,7,8-HxCDF is 0.584/1.65 = 0.35). BEFs were calculated for the SW-20 and SW-265 samples, and the average of the two were calculated for each congener (e.g., BEF for 1,2,3,4,7,8-HxCDF of 0.29 is the average of the BEF from SW-20 of 0.35 and 0.22 from SW-265). These BEFs were then used to estimate congener-specific invertebrate BAFs by multiplying the invertebrate BAF of 1.65 for 2,3,7,8-TCDD for SW-20 (the most representative of the site) by the average BEF (e.g., the invertebrate BAF for 1,2,3,4,7,8-HxCDF is 1.65 * 0.29 = 0.48). The BEFs and overall congener-specific BAFs developed from Fagervold et al. (2010) are presented in Table 6-12. As shown in Table 6-12, the BEFs for sample SW-20 are similar to the BEFs for sample SW-265 in most cases. As a result, average BEFs calculated from both samples and used in the ERA are similar to SW-20 BEFs, indicating that including wetland sample (SW-265) results does not significantly impact uptake predictions relative to the soil sample with low organic carbon considered to be most representative of site conditions. Although the sample size is small, the similarity of the BEFs between the two soil types suggests that congener-specific uptake relative to TCDD is similar across soil types (i.e., soil type may influence TCDD BAF but does not appear to significantly influence the BEFs). These refined and robust congener-specific invertebrate BAFs were used to estimate congener tissue concentrations in Table 6-11.

Concentrations of dioxin/furan congeners in tissue were multiplied by mammalian and avian TEFs to calculate dioxin TEQ concentrations in tissue, consistent with the approach used in the ERAs. Tissue dioxin TEQ EPCs and potential wildlife risks were calculated for surface soil (0 to 0.5 foot bgs) in the BCW potential exposure area (2019 ERA) using the congener-specific BAFs and compared to the HQs for the BCW potential exposure area (2019 ERA) calculated using the 2,3,7,8-TCDD uptake regression selected for the ERA (Table 6-13).

Table 6-13 compares wildlife HQs estimated using the congener-specific approaches (i.e., USEPA 1999 and Fagervold et al. 2010) and the approach used in the 2019 ERA using the 2,3,7,8-TCDD uptake regression. The HQs based on the congener-specific approach were estimated using the tissue TEQ concentrations presented in Table 6-11. For herbivorous receptors, HQs estimated using congener-specific BAFs are similar to those estimated for the ERA. For invertivorous mammals (i.e., shrew), however, HQs estimated using the congener-specific approach are about 10 times lower than those estimated in the ERA.

The magnitude of the differences between the congener-specific and 2,3,7,8-TCDD-only uptake approaches will vary somewhat between potential exposure areas depending on the relative concentrations of the individual congeners in each potential exposure area, but these calculations and the HQs estimated in each area-specific appendix using congener-specific uptake and uptake based on 2,3,7,8-TCDD only demonstrate that the overall dioxin TEQ concentrations for invertivorous/insectivorous receptors like desert shrew are likely substantially overestimated in the ERA when the generic BAF based on uptake of a single congener is used. The congener-specific BAFs are considered robust and are based on current science and were considered the most relevant uptake assumptions for calculating potential risk associated with current post-NTCRA conditions at the site.

In the 2019 HHERA (Arcadis 2019), DTSC (2019c) concurred with these conclusions, stating that “ERAS [Ecological Risk Assessment Section] therefore believes the earthworm model, if anything, over-estimates dioxin uptake by invertebrates. ERAS accepts the PG&E description of the uncertainties regarding the uptake of dioxins and supports the RBRG of 360 ng/kg” which was calculated using the congener-specific BAF approach.

6.7.5 Uncertainty in Effects Assumptions

As also described in the 2019 HHERA (Arcadis 2019), there is uncertainty in the effects data because most of the toxicity data used to derive screening levels and TRVs were based on laboratory studies conducted in settings that do not mimic true field conditions. Laboratory studies typically control various factors in order to isolate one parameter in particular. Although such controlled experiments result in a more valid interpretation of the isolated parameters or relationship, uncertainty is associated with assuming that laboratory exposure conditions are equivalent to in-field exposure conditions. Exposure duration and toxicity characterization are two parameters that exemplify the difficulty in translating literature-derived data to data representing the exposure conditions for receptors.

Uncertainties are also associated with the quantity and variable quality of literature-derived toxicity data. In order to reduce the uncertainties in the toxicity dataset, most TRVs were taken from widely accepted sources such as USEPA EcoSSL documents (USEPA 2005a).

Additional uncertainties related to the effects assumptions for this Post-NTCRA HHERA include uncertainty in the selected TRVs, derivation of alternate dioxin TEQ TRVs, chromium speciation in biota tissue, and species-to-species extrapolations. These uncertainties are discussed in this section and are also stated in the 2019 HHERA (Arcadis 2019).

6.7.5.1 Uncertainty in the Selected TRVs

A general lack of wildlife toxicity data with the low probability of new data forthcoming leads to uncertainties in the development of wildlife TRVs (Allard et al. 2009). The potential for adverse effects to desert shrew was evaluated for total chromium, hexavalent chromium, and copper using NOAEL- and LOAEL-based TRVs selected in the RAWP (Arcadis 2008b) and supporting documents (Arcadis 2009a, 2015). Conservative TRVs were selected from published sources, namely the USEPA (2005a) EcoSSLs. By design, these published TRVs provide lower-bound toxicity threshold estimates for use in baseline risk assessments. The USEPA EcoSSLs have been extensively vetted, and the listed published sources are widely used to evaluate potential risk to wildlife. As such, the TRVs are not expected to underestimate risk; however, there is potential for overestimation of risk.

For dioxin TEQ, the TRVs for dioxin TEQ selected in the RAWP documents (Arcadis 2008b, 2009a, 2015) warrant additional discussion, as risk for dioxin TEQ is predicted at low ng/kg concentrations associated with typical background levels. Additional information related to the toxicity of dioxin TEQ in mammals is provided in this section.

As mentioned earlier in Section 6.5, alternate and more robust TRV values were developed for small mammals and presented in this section. These alternate values were used to develop RBRGs in the 2019 HHERA (Arcadis 2019), guide the extent of NTCRA soil removals (Jacobs 2025), and in this Post-NTCRA HHERA. Details related to the alternate mammalian TRVs for dioxin TEQ are repeated below from the 2019 HHERA for convenience.

Mammalian TRVs

The mammalian TRVs for dioxin TEQ are based on a three-generation rat study with 2,3,7,8-TCDD conducted by Murray et al. (1979). This study was selected by Sample et al. (1996) to represent mammalian toxicity of 2,3,7,8-TCDD. Rats were fed diets containing 2,3,7,8-TCDD at three dose levels, and reproductive endpoints were measured in this multigenerational chronic study. The LOAEL of 10 ng/kg-bw/day was based on reduced fertility and neonatal survival, whereas no adverse effects were measured after three generations at 1 ng/kg-bw/day (selected NOAEL-based TRV) based on a study by Murray et al. (1979). The NOAEL- and LOAEL-based TRVs derived by Sample et al. (1996) represent a conservative estimate of 2,3,7,8-TCDD toxicity to mammals.

Additional studies conducted in mink, a species known to be particularly sensitive to 2,3,7,8-TCDD and other AHR receptor antagonists, suggest that adverse effects would not be observed until higher exposure doses.

Previous studies of individual PCDD and PCDF congeners or their mixtures have demonstrated that mink are among the more sensitive mammalian species tested, with effects reported on reproduction, development, and morphological lesions of the jaw (Bursian et al. 2006; Heaton et al. 1995; Restum et al. 1998). Studies on mink jaw lesions suggest that this endpoint is considered a sentinel for adverse effects in mink populations (Ellick et al. 2012; Zwiernik et al. 2009). However, from a population impact perspective, adverse effects on reproduction and development are considered more relevant assessment endpoints. While mink are unlikely to be present at the sites, studies with this wild species are more environmentally relevant than those conducted on laboratory species such as mice or rats (e.g., Murray et al. 1979; DeVito et al. 1997), especially with compounds such as PCDDs/PCDFs, which exhibit a high degree of variability in sensitivity among mammalian species. For example, Moore et al. (2012) investigated the effect of TCDD, 2,3,4,7,8-PeCDF, and 2,3,7,8-TCDF on mink reproductive success, and offspring viability and growth. Nine adult female mink were assigned randomly to one of 13 dietary treatments: one control and four doses each of TCDD, PeCDF, and TCDF (2.1 to 8.4, 4 to 15, and 5.2 to 25 nanograms of toxicity equivalent per kilogram of body weight per day [ng TEQ/kg-bw/day], respectively). The mink were dosed from 2 months prior to breeding through weaning of offspring at 6 weeks of age. At least nine kits per treatment group were maintained on these diets through 27 weeks of age. No effects on litter size or viability of offspring were observed at any treatment level. In addition, no consistent effects on body mass or relative organ masses were observed. This recent study by Moore et al. (2012) provides an unbounded NOAEL of 25 ng TEQ/kg-bw/day, the highest dose at which no effects were observed (i.e., 25 times greater [less conservative] than the selected NOAEL-based TRV used in the ERA).

Similarly, Zwiernik et al. (2009) exposed mink to TCDF in diet up to 240 nanograms of TEQ per kilogram of wet weight. These authors reported that doses as high as 30 ng TEQ/kg-bw/day did not affect reproduction and kit viability; although, body masses of offspring through 36 weeks of age were decreased compared to controls at various time points in the experiment. (It should be noted that the dose was calculated using the mink food ingestion rate of 0.125 kilogram per kilogram of body weight per day from Moore et al. [2012].) The results of this study are supported by a review by Blankenship et al. (2008), which indicated 242 nanograms of TEQ per kilogram of wet weight as the highest diet-based LOAEL for offspring weight.

Toxicity studies that have assessed the effects of TCDD on growth, reproduction, and survival endpoints on mammalian species other than mink are limited. These studies and the NOAEL- and LOAEL-based doses derived from them are presented in Table 6-14. Kociba et al. (1976) conducted growth studies on rats resulting in reduced body weights and NOAEL- and LOAEL-based doses of 7.1 and 71 ng/kg-bw/day, respectively. Croutch et al. (2005) conducted growth studies on rats resulting in reduced body weights and NOAEL- and LOAEL-based doses of 54.3 and 217 ng/kg-bw/day, respectively. Walker et al. (2006) conducted mortality studies on rats resulting in a unbounded NOAEL-based dose of 71 ng/kg-bw/day and reduced body weights at bounded NOAEL- and LOAEL-based doses of 7.1 and 15.7 ng/kg-bw/day, respectively.

In summary, rat studies report NOAEL-based doses that are 7 to 70 times and LOAEL-based doses that are 1.5 to 22 times greater than the selected mammalian TRVs. Additionally, sensitive wildlife receptors, such as mink, have been shown to tolerate exposure doses 25 times greater than the selected NOAEL-based TRV without adverse effect. The mammalian TRVs selected to evaluate potential risk associated with dioxin TEQ at the sites are considered to overestimate toxicity for many mammal species potentially present at the sites.

Following the approach used by USEPA in developing TRVs for EcoSSLs, the geometric mean of growth and reproductive endpoints based on the data from the small mammal studies were calculated as shown in Table 6-14. The alternate NOAEL- and LOAEL-based TRVs are 4.9 and 30 ng/kg-bw/day, respectively. The alternate LOAEL-based TRV of 30 ng/kg-bw/day is considered more robust than the value based on a single study (basis for the selected TRVs) and was used in the development of RBRGs.

6.7.5.2 Chromium Speciation

Total chromium (assumed to be trivalent chromium) was evaluated as a potential risk-driving COPEC in this Post-NTCRA HHERA. Potential risks to desert shrew were estimated for both hexavalent chromium and total chromium. Hexavalent chromium TRVs were developed based on dietary hexavalent chromium exposure, and total chromium TRVs are based on dietary exposure to trivalent chromium. Available wildlife toxicity data for hexavalent chromium are quite limited. Toxicity endpoints for wildlife considered in the ERAs generally include population-level effects (i.e., survival, growth, and reproduction), and these data indicate that dietary exposure to trivalent chromium is more toxic than dietary exposure to hexavalent chromium (NOAEL- and LOAEL-based TRVs are generally lower for trivalent chromium). Cancer endpoints are not evaluated for population-level impacts to wildlife.

The EPCs for total chromium are based on the measured concentrations in soil, which include background and site-related inputs. Background total chromium was not removed from the exposure estimates used in the risk calculations (i.e., incremental risks were not estimated).

In the ERA, chromium exposure was assumed to occur as the state/valence measured in soil (i.e., dietary exposure to wildlife receptors for hexavalent chromium is via incidental ingestion of hexavalent chromium in soil and ingestion of prey tissues containing hexavalent chromium). This assumption ignores the potential for hexavalent chromium reduction to trivalent chromium in vivo, which is known to occur in many plant and animal tissues (USEPA 2008b). Chromium is an essential nutrient for humans and animals, and trivalent chromium has been shown to have antioxidative properties in vivo that are critical for activating enzymes and maintaining stability of proteins and nucleic acids (USEPA 2008b). Hexavalent chromium is absorbed better than trivalent chromium and some studies suggest that when ingested orally, most of the hexavalent chromium is reduced to trivalent chromium before reaching the sites of adsorption in the small intestine. However, as noted previously, available wildlife toxicity data suggest that trivalent chromium is more toxic than hexavalent chromium. Thus, risk estimates for hexavalent chromium for mammals may be underestimated by not accounting for this biological reduction in prey tissues. Due to the lack of data for relative proportion of each chromium species present in soil invertebrates, the magnitude of this uncertainty cannot be readily assessed.

6.7.5.3 Species-to-Species Toxicity Extrapolations

One source of uncertainty in the 2019 HHERA (Arcadis 2019) and the post-NTCRA ERA is the lack of applicable species-specific toxicity data. Because of this data limitation, TRVs were developed using available toxicity data for laboratory test species. For example, TRVs for all mammalian receptors were developed primarily from toxicity data for mice and rats. Species vary with respect to sensitivity to specific constituents (USEPA 1998; Calabrese and Baldwin 1993; Venugopal and Luckey 1978). Based on a review of the toxicological data, the sensitivity for members within a class of vertebrates may typically range up to one hundredfold. This range of uncertainty is substantiated by Calabrese and Baldwin (1993).

CalEPA does not recommend allometric adjustment of TRVs unless the body weights of the test species and receptor species differ by two orders of magnitude (DTSC 1999). Based on this, TRVs were adjusted for differences in body weights only for copper.

Although no longer typically conducted, allometric conversions were used as discussed in the approved RAWP (Arcadis 2008b) and 2019 HHERA (Arcadis 2019) and may increase uncertainty associated with the TRVs. However, no substantial changes to risk conclusions as a result of allometric conversions are expected. For small mammals (including desert shrew), allometric TRVs were applied for copper, resulting in higher TRVs and lower HQs for these COPECs than using unadjusted TRVs. The magnitude of the change in TRVs and HQs is relatively small and does not affect risk conclusions based on a target LOAEL-based HQ of 1.

6.7.6 Uncertainty in the Risk Characterization

In the 2019 HHERA (Arcadis 2019), the key sources of uncertainty related to the risk characterization included the use of individual effects data points to extrapolate to population-level effects, uncertainty in the HQ approach, uncertainty in use of the more refined scenario for drawing conclusions, uncertainty due to exposure to chemical mixtures, and uncertainty in the risk characterization for dioxin TEQ. Except for dioxin TEQ, the remaining uncertainties are the same as discussed in the 2019 HHERA and are repeated in this section. Uncertainties related to risk characterization for dioxin TEQ discussed in the 2019 HHERA were largely mitigated through use of the alternate TRVs and congener-specific BAFs in this Post-NTCRA HHERA.

6.7.6.1 Uncertainty Related to Use of Individual Effects Data to Extrapolate to Population-Level Effects

The toxicity studies used to derive TRVs for this Post-NTCRA ERA did not directly evaluate population-level effects (e.g., reduced density, change in age/size class structure, extinction). The available toxicity data describe reproductive and developmental effects on small groups of individuals. Effects on these individuals were then used to infer effects at the population level. Accordingly, these population-level effect extrapolations include uncertainty associated with the extrapolation between a study endpoint (e.g., number of offspring, reduced litter size) to a population-level effect (e.g., abundance, density, persistence, extinction). It should be noted that any adverse effect on reproduction does not necessarily lead to a decrease in population stability or extinction; the reproductive effect must be sufficient in magnitude to result in such a population-level effect.

6.7.6.2 Uncertainty in the HQ Approach

In the ERA, the primary method to estimate potential risks to ecological receptors was by calculating HQs, with an HQ less than 1 associated with no unacceptable risk to individuals (for NOAEL-based HQs) or populations (for LOAEL-based HQs). Conservative assumptions are used in the risk models to avoid type 2 error (i.e., to conclude no unacceptable risks when in fact there is), and consequently, there is a high level of confidence that COPECs with HQ less than 1 do not pose unacceptable risk. Due to the conservative assumptions used, probability of a type 1 error (i.e., to conclude unacceptable risk when in fact there are none) based on an HQ greater than 1 is more likely and typically requires further evaluation to address uncertainties (Allard et al. 2009). Because there are inherent uncertainties in the exposure and effects assumptions (discussed previously), the resulting HQs are also uncertain and could over- or underestimate unacceptable risk. In the ERAs, HQs were used as a single LOE to characterize risks; a WOE approach using multiple independent LOE provides a more robust prediction of potential risk to ecological receptors.

6.7.6.3 Uncertainty based on Use of the Most Refined Risk Estimates

A range of potential risks were estimated in the ERAs, based on multiple assumptions used for the various input factors. Multiple assumptions were evaluated for EPCs (depth-weighted and area-weighted), site use (SUF equal to 1 or site-specific SUF), and TRVs. Uncertainties related to these assumptions and alternate values are discussed in Section 6.7.3 for EPCs, Section 6.7.4 for SUFs, and Section 6.7.5 for TRVs. The overall risk conclusions were based on a semi-quantitative WOE approach based on the HQs and supporting LOE, incorporating the most realistic and refined assumptions to minimize overall uncertainty in the ERA. Although less refined evaluations often provided higher risk estimates and indicated greater potential for unacceptable risk at the sites, the likelihood of risk overestimation and overall uncertainty in these conclusions has been reduced by using refined assumptions. Risk conclusions and risk-management decisions at the sites are supported by the best available assumptions, as presented in the ERAs.

6.7.6.4 Uncertainty Due to Exposure to Chemical Mixtures

Some constituents, such as some metals, are known to have synergistic, antagonistic, or neutral influence on the toxicities of other metals (Calabrese 1991). The degree to which metals influence each other’s toxicities depends not only on the mixture but also on relative concentrations. However, there is a lack of studies describing the degree to which toxicity may be affected due to exposures to the multiple COPEC compositions present at the sites. The lack of knowledge with regard to specific multiple COPEC interactions does not support the assumption of additive effects. Accordingly, HQs for metals were not added to evaluate cumulative exposures and potential risks to metals. In the 2019 ERA, the HQs for chemicals with similar toxicological effects, known to affect the same target organ in an additive matter, were added to estimate HIs including LMW PAHs, HMW PAHs, total DDT, and total TEQ (only TEQ is relevant in this Post-NTCRA HHERA). The effects due to exposure to multiple COPECs are unknown; however, based on the limited number of risk-driving chemicals identified at the sites, the effect of chemical mixtures on the overall toxicity and risk estimates is expected to be small.

7 CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the conclusions of the HHRA and ERA conducted in this Post-NTCRA HHERA. As described in this section based on the results presented herein, no additional remedial actions are warranted for the exposure areas evaluated in this Post-NTCRA HHERA. The forthcoming CMS/FS will evaluate the need for and feasibility of corrective measure(s) based on the 2019 HHERA, this Post-NTCRA HHERA, and potential future risk calculations as needed to document potential for unacceptable risk to human and ecological receptors based on current soil conditions at and around the TCS.

This Post-NTCRA HHERA presents updated risk characterization using methodology from the 2019 HHERA (Arcadis 2019) and DTSC-approved RAWP documents (Arcadis 2008b, 2009a, 2015). Consistent with the Technical Memo (Arcadis 2024a), updated risk characterization included in this Post-NTCRA HHERA is presented only for risk-driving human receptors (camper, hiker, and OHV rider) and ecological receptors (desert shrew) identified in the 2019 HHERA and exposure areas where NTCRA removal activities were conducted. For each potential exposure area evaluated in this Post-NTCRA HHERA, potential exposure to surface (0 to 0.5 foot bgs) and shallow (0 to 3 feet bgs) was evaluated for risk-driving receptors according to the exposure scenarios for these potential receptors as evaluated in the 2019 HHERA. In addition to the baseline scenario (i.e., no scouring) evaluated for each exposure area, risk evaluations were also conducted for potential 2-foot and 5-foot scouring scenarios for the BCW and AOC 10 potential exposure areas, consistent with the scenarios evaluated in the 2019 HHERA. Post-NTCRA exposures were evaluated for risk-driving COPCs and COPECs identified in the 2019 HHERA (i.e., total chromium, hexavalent chromium, copper, and dioxin TEQ). For all remaining non-risk-driving COPCs evaluated in the 2019 HHERA, pre-NTCRA exposures were evaluated in order to generate cumulative risk estimates for human receptors.

In general, and consistent with regulatory guidance and the 2019 HHERA (Arcadis 2019), conservative approaches and assumptions were used to minimize the underestimation of potential risk in this Post-NTCRA HHERA. For the post-NTCRA HHRA included in this Post-NTCRA HHERA, assumptions regarding the amount of exposure and the toxicity of the compounds were intentionally conservative and were selected to represent upper bound estimates. For the post-NTCRA ERA included in this Post-NTCRA HHERA, EPCs and parameters were selected to provide a conservative approach for the following: upper bound estimates of exposure, toxicity values based on sensitive endpoints for individual-level effects, and assumptions that each potential exposure area is sufficiently large to support a population of ecological receptors. Additionally, the post-NTCRA HHERA risk estimates were based on exposure to remaining native soil samples (not accounting for backfill). Because of these conservative approaches and other protective assumptions made throughout this Post-NTCRA HHERA, risk estimates likely overstate the potential for unacceptable risk to human and ecological receptors at the site. Use of the same methods as in the 2019 HHERA and as presented in the DTSC-approved RAWP (Arcadis 2008b) and related documents (Arcadis 2009a, 2015) allows for a relevant comparison between previous and current risk estimates.

7.1 Human Health Risk Assessment

This HHRA evaluates the likelihood that COPCs detected in post-NTCRA soil in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas of the site could adversely impact potential recreational receptor’s health under the assumed set of current and reasonable future land-use scenarios described in the 2019 HHERA (Arcadis 2019) for the areas outside the TCS fence line. The estimated cumulative ILCRs and HIs associated with potential exposure to COPCs in post-NTCRA soil for the camper, hiker, and OHV rider were calculated using depth- and area-weighted EPCs (where applicable) for surface and shallow soils under a baseline scenario for potential recreational receptors evaluated in this HHRA.

It should be noted that the 2-foot and 5-foot potential scouring scenarios were evaluated for both BCW and AOC 10. In Appendix BCW, the estimated receptor-specific risks for the baseline and both scouring scenarios are generally similar. Likewise, in Appendix AOC 10, the estimated receptor-specific risks were similar for the baseline and both scouring scenarios. The similarity in risk estimates for the baseline and scouring scenarios is an appropriately conservative representation of potential risks, including potential for post-scouring exposures, for the potential exposure area.

As requested by DTSC (DTSC 2017b) and consistent with the approach in the 2019 HHERA (Arcadis 2019), the risks/hazards estimated in this Post-NTCRA HHERA for individual AOCs/SWMU/UA potential exposure areas outside the fence line where NTCRA removal activities were conducted are based on the assumption that lifetime soil contact for these potential receptors would be limited to that single specific area. It is highly unlikely that activities of the recreational users would be limited to such a small area. Therefore, the risks/hazards presented in this Post-NTCRA HHERA for the camper, hiker, and OHV rider potentially exposed to COPCs detected in post-NTCRA soil in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas of the site are likely overestimated. In the 2019 HHERA, the risks/hazards estimated for the OCS potential exposure area are believed to provide a more appropriate representation of the potential exposures for the human populations that could be present in the areas outside the TCS. As stated previously, this Post-NTCRA HHERA provides updated risk estimates for human health and the environment based on potential exposures to current soil conditions in the NTCRA areas. Therefore, updated risk estimates were not performed for the OCS potential exposure area in this Post-NTCRA HHERA. It should be noted that, due to NTCRA soil removal, the potential post-NTCRA soil COPC concentrations and associated risks for the OCS exposure area are likely lower than estimated in the 2019 HHERA.

The OCS potential exposure area is considered the most representative baseline scenario for potential human exposures and associated risks for soil contact outside TCS. No unacceptable risk to human recreator receptors (camper, hiker, and OHV rider) was identified at the site potential exposure areas evaluated in this Post-NTCRA HHRA. Given the reduction in overall estimated cumulative risks and hazards under post-NTCRA conditions in these potential exposure areas, which were identified with elevated concentrations of risk-driver COPCs in the 2019 HHERA (Arcadis 2019), estimated cumulative risks and hazards for recreational users, camper, hikers, and OHV riders for the OCS potential exposure area under post-NTCRA conditions are likely lower than estimated in the 2019 HHERA (Arcadis 2019).

7.1.1 AOC-Specific Potential Exposure Area Risk

The estimated cumulative ILCRs and HIs associated with potential exposure to COPCs in post-NTCRA soil in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas were calculated using depth- and area-weighted EPCs (where applicable) under a baseline scenario for potential recreational users (camper, hiker, and OHV rider). As indicated, the area-weighted estimated cumulative ILCRs are marginally lower than the depth-weighted estimated cumulative ILCRs, but the marginal reduction in estimated risk does not materially affect the overall conclusions for the potential receptors in these potential exposure areas. The estimated cumulative ILCR and HI results and conclusions for the camper, hiker, and OHV rider for the OCS potential exposure area are summarized by receptor in the following sections.

7.1.1.1 Recreational User—Camper

The camper was evaluated for potential contact with COPCs in post-NTCRA soil for surface and shallow potential exposure depths at the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas. The depth-weighted estimated cumulative ILCRs for the camper in the BCW, AOC 14, and AOC 27 potential exposure areas are at or below 1×10^{-6}, the point of departure for risk-management decisions. The depth- and/or area-weighted estimated cumulative ILCRs for the camper in the AOC 9, AOC 10, and AOC 11 potential exposure areas are slightly above 1×10^{-6}, the point of departure for risk-management decisions primarily due to the contribution from background arsenic risks. The ILCRs are well within the risk-management range of 1×10^{-6} and 1×10^{-4}. Excluding background arsenic risks would result in ILCRs at or below 1×10^{-6}.

The depth- and/or area-weighted estimated cumulative HIs for campers in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas are at or below an HI of 1. Furthermore, the depth- and/or area-weighted EPCs for lead in soil in these potential exposure areas are not expected to result in an increase in blood lead levels above the OEHHA benchmark value of 1 µg/dL for the child camper.

Consistent with the NCP and based on the results of the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure area HHRAs for campers, risks are slightly above 1 × 10-6, the point of departure for risk-management decisions, primarily due to the contribution from background arsenic risks. Excluding background arsenic risks would result in ILCRs at or below 1 × 10-6. The camper risks are below the USFWS's cancer risk threshold level of 10 in a million (1×10^{-5}) for soil deeper than 2 feet bgs (as included in the February 12, 2021 Topock Soil EE/CA Response to Comment Consultation Meeting Agenda). All cumulative HIs for campers are at or below 1, and lead in soil in these potential exposure areas are not expected to result in an increase in blood lead levels above the OEHHA benchmark value of 1 µg/dL for the child camper. Accordingly, the levels of COPCs in BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure area soils under post-NTCRA conditions are safe and protective for campers.

7.1.1.2 Recreational User—Hiker

The hiker was evaluated for potential contact with COPCs in post-NTCRA soil for surface and shallow potential exposure depths at the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas. The depth-weighted estimated cumulative ILCRs for the hiker in the BCW, AOC 14, and AOC 27 potential exposure areas are at or below 1×10^{-6}, the point of departure for risk-management decisions. The depth- and/or area-weighted estimated cumulative ILCRs for the hiker in the AOC 9, AOC 10, and AOC 11 potential exposure areas are slightly above 5×10^{-6}, well within the risk-management range of 1×10^{-6} and 1×10^{-4}, primarily due to the contribution from background arsenic risks. Excluding background arsenic risks would result in ILCRs at slightly above 1×10^{-6}, the point of departure for risk-management decisions.

The depth- and/or area-weighted estimated cumulative HIs for hikers in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas are at or below an HI of 1 with the exception of the HI for AOC 10 in shallow soil under the 2-foot scouring scenario using depth-weighted EPCs and attributed primarily to background arsenic HQ. Excluding background arsenic HQ would result in an estimated cumulative HI of 1. Furthermore, the depth- and/or area-weighted EPCs for lead in soil in these potential exposure areas are not expected to result in an increase in blood lead levels above the OEHHA benchmark value of 1 µg/dL for the child hiker.

Consistent with the NCP and based on the results of the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure area HHRAs for hikers, risks are slightly above 5×10^{-6}, well within the risk-management range of 1×10^{-6} and 1×10^{-4}, primarily due to the contribution from background arsenic risks. Excluding background arsenic risks would result in ILCRs slightly above 1×10^{-6}. The hiker risks are below the USFWS's cancer risk threshold level of 10 in a million (1×10^{-5}) for soil deeper than 2 feet bgs (as included in the February 12, 2021 Topock Soil EE/CA Response to Comment Consultation Meeting Agenda). All cumulative HIs for campers are at or below an HI of 1 (excluding contribution from background arsenic), and lead concentrations in soil in these potential exposure areas are not expected to result in an increase in blood lead levels above the OEHHA benchmark value of 1 µg/dL for the child camper. Accordingly, the levels of COPCs in BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure area soils under post-NTCRA conditions are safe and protective for hikers.

7.1.1.3 Recreational User—OHV Rider

The OHV rider was evaluated for potential contact with COPCs in post-NTCRA soil for surface and shallow potential exposure depths at the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas. The depth-weighted estimated cumulative ILCRs for the OHV rider in the BCW, AOC 14, and AOC 27 potential exposure areas are at or below 1×10^{-6}, the point of departure for risk-management decisions. The depth- and/or area-weighted estimated cumulative ILCRs for the OHV rider in the AOC 9, AOC 10, and AOC 11 potential exposure areas are slightly above 1×10^{-6}, the point of departure for risk-management decisions, primarily due to the contribution from background arsenic risks. Excluding background arsenic risks would result in ILCRs at or slightly above 1×10^{-6}.

The depth- and/or area-weighted estimated cumulative HIs for OHV riders in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas are at or below an HI of 1. Furthermore, the depth- and/or area-weighted EPCs for lead in soil in these potential exposure areas are not expected to result in an increase in blood lead levels above the OEHHA benchmark value of 1 µg/dL for the child OHV rider.

Consistent with the NCP and based on the results of the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure area HHRAs for OHV riders, risks are slightly above 1×10^{-6}, the point of departure for risk-management decisions, primarily due to the contribution from background arsenic risks. Excluding background arsenic risks would result in ILCRs at or below 1×10^{-6}. The OHV rider risks are below the USFWS's cancer risk threshold level of 10 in a million (1×10^{-5}) for soil deeper than 2 feet bgs (as included in the February 12, 2021 Topock Soil EE/CA Response to Comment Consultation Meeting Agenda). All cumulative HIs for campers are at or below an HI of 1, and lead concentrations in soil in these potential exposure areas are not expected to result in an increase in blood lead levels above the OEHHA benchmark value of 1 µg/dL for the child OHV riders. Accordingly, the levels of COPCs in BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure area soils under post-NTCRA conditions are safe and protective for OHV riders.

7.1.2 AOC 16 Inside the Compressor Station

The HHRA results for the ICS potential exposure area presented in the 2019 HHERA (Arcadis 2019) support that the levels of COPCs in ICS soil and/or soil gas are safe and protective of commercial and short- and long-term maintenance workers for current and anticipated future operational conditions and practices.

AOC 16 was included in the ICS potential exposure area evaluation in the 2019 HHERA (Arcadis 2019). During the NTCRA, removal of a small volume of material occurred in AOC 16, which included removal of approximately 10 cubic yards of sandblast grit contaminated soil to a depth of 1 foot bgs. Confirmation sample results indicate that risk-driver and non-risk-driver COPCs/COPECs were below RAGs, which are lower and protective of workers inside the TCS. As such, given the limited removal in AOC 16 and levels of COPCs/COPECs in the confirmation samples, the levels of COPCs in ICS soils under post-NTCRA conditions remain safe and protective of commercial and short- and long-term maintenance workers for current and anticipated future operational conditions and practices.

7.1.3 Summary and Overall Conclusions and Recommendations for the HHRA

Below is a summary of the conclusions and recommendations for the HHRA evaluation.

- The depth- and area-weighted EPCs for lead in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas evaluated under post-NTCRA conditions are not expected to result in an increase in blood lead levels above the OEHHA benchmark value of 1 µg/dL for the child camper, hiker, or OHV rider evaluated. **Based on the results of this HHRA, the levels of lead in post-NTCRA soil in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas are safe and protective for all potential recreational receptors evaluated.**
- ILCRs and HIs for the campers, hikers, and OHV riders were at or slightly above 1 x 10^{-6} and 1, respectively, for both depth- and/or area-weighted EPCs for the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas evaluated under post-NTCRA conditions when contribution of background arsenic risks were excluded. **Based on the results of the HHRA, the levels of COPCs in post-NTCRA soil in the BCW, AOC 9, AOC 10, AOC 11, AOC 14, and AOC 27 potential exposure areas are safe and protective all potential recreational receptors evaluated.**
- The OCS potential exposure area is considered the most representative baseline scenario for potential human exposures and associated risks for soil contact outside TCS. Human populations that could be present at the site would more likely be exposed randomly, over the course of a lifetime, to soil present in all areas located outside the TCS, rather than have a lifetime of contact limited to a single AOC/SWMU/U A. For the post-NTCRA HHRA, no unacceptable risk to human recreator receptors (camper, hiker, OHV rider) was identified at the site potential exposure areas evaluated in this Post- NTCRA HHERA. Given the reduction in overall estimated cumulative risks and hazards under post- NTCRA conditions in these potential exposure areas which were identified with elevated concentrations of risk-driver COPCs in the 2019 HHERA (Arcadis 2019), estimated cumulative risks and hazards for recreational users, camper, hikers, and OHV riders for the OCS potential exposure

area under post- NTCRA conditions are likely lower than estimated in the 2019 HHERA (Arcadis 2019) and likely at or slightly above at 1 x 10^{-6} and well within the within the risk-management range of 1 x 10^{-6} and 1 x 10^{-4}. Accordingly, **the levels of COPCs in the OCS potential exposure area soil under post-NTCRA conditions are safe and protective for campers, hikers, and OHV riders.**

- Given the limited removal in AOC 16, which is inside the TCS fence line, and levels of COPCs/COPECs in the confirmation samples, **the levels of COPCs in ICS soils under post-NTCRA conditions remain safe and protective of commercial and short- and long-term maintenance workers for current and anticipated future operational conditions and practices as concluded in the 2019 HHERA (Arcadis 2019).**

In conclusion, no unacceptable risk to human receptors was identified at the site potential exposure areas evaluated in this Post-NTCRA HHERA. For recreator receptors, the conclusions are based on post-NTCRA conditions for key COPCs, as evaluated in this Post-NTCRA HHERA. For the remaining human receptors, the conclusions are based on pre-NTCRA conditions as evaluated in the 2019 HHERA (Arcadis 2019). Based on these results, no further remediation is warranted for protection of human health in the areas evaluated in this Post-NTCRA HHERA based on current post-NTCRA conditions.

7.2 Ecological Risk Assessment

In the 2019 HHERA (Arcadis 2019), risks were estimated for potentially complete and significant exposure pathways identified for a suite of ecological receptors exposed to COPECs in soil at the site potential exposure areas. These included plants, invertebrates, and small home-range receptors (Merriam’s kangaroo rat, desert shrew, cactus wren, and Gambel’s quail). Potential large home-range receptors (desert kit fox, red-tailed hawk, and Nelson’s desert bighorn sheep) were evaluated for larger potential exposure areas (combined AOCs/investigation areas). Semi-quantitative and qualitative evaluations for special-status species were also conducted, as described in the 2019 HHERA.

The ERA presented in this Post-NTCRA HHERA evaluates the likelihood that assumed exposure to residual concentrations of total chromium, hexavalent chromium, copper, and dioxin TEQ present in soil following completion of the NTCRA could result in unacceptable potential risk to small mammal populations represented by the desert shrew. The 2019 HHERA (Arcadis 2019) did not identify a potential for unacceptable risk to sensitive species, and therefore protection of individual invertivorous small mammals is not warranted. The methodology used to conduct the ERAs for each potential exposure area evaluated in this Post-NTCRA HHERA was presented and approved in the RAWP documents (Arcadis 2008b, 2009a, 2015) and DTSC-approved 2019 HHERA. The assumptions, input values, and risk characterization methodology were presented previously in Section 6.

Estimated terrestrial exposures (soil) for desert shrew were evaluated for the following potential exposure areas where NTCRA removals were conducted:

- BCW;
- AOC 9;
- AOC 10;
- AOC 11;

- AOC 14; and
- AOC 27.

Risk estimates (HQs) were calculated for multiple sets of exposure and effects assumptions, as described in Section 6.6.1. For interpreting the risk results and identifying potential adverse effects to desert shrew, a semi-quantitative WOE approach was also used incorporating multiple LOEs, consistent with the WOE approach utilized in the 2019 HHERA (Arcadis 2019). In this Post-NTCRA HHERA, additional LOEs were evaluated and discussed when LOAEL-based HQs greater than 1 were estimated. This Post-NTCRA HHERA presents NOAEL-based HQs for completeness; however, only the LOAEL-based HQs were used to draw conclusions regarding population-level protection of invertivorous small mammals.

Risk conclusions for this Post-NTCRA HHERA were drawn based on whether COPECs remain for which unacceptable population-level risk was predicted using LOAEL-based HQs calculated from the most refined exposure and effects assumptions and LOEs supporting the conclusion of unacceptable risk.

7.2.1 Risk Conclusions for Desert Shrew

For total chromium, hexavalent chromium, copper, and dioxin TEQ, no unacceptable risk was identified for invertivorous small mammal populations, represented by desert shrew, in any potential exposure area where NTCRA removals were conducted. The risk conclusions were similar for all the exposure areas as summarized below:

- For dioxin TEQ, LOAEL-based HQs are less than 1 for all evaluated exposure areas and scouring scenarios when calculated using the most refined exposure and effects assumptions for this constituent (i.e., using an SUF of 1, congener-specific BAFs, and alternate TRVs) and depth-weighted EPCs. The LOAEL-based HQs less than 1 indicate no unacceptable risk to populations of invertivorous small mammals potentially exposed to soil in these areas following completion of the NTCRA. Multiple sets of congener-specific BAFs indicate lower uptake of dioxin/furan congeners than predicted using a TCDD-specific BAF. Shrew have not been observed at the site and are not expected to be present. Supporting LOEs, evaluated in some of the less refined scenarios (see related area-specific appendices), include conservative dietary and uptake assumptions, the dispersed nature of the remaining highest dioxin TEQ concentrations, and small home range of the shrew, and also support this conclusion. The LOEs supporting this risk conclusion are described in more detail in Section 6.6.2 and the exposure area-specific appendices.
- For total chromium, LOAEL-based HQs are less than 1 for all evaluated exposure areas and scouring scenarios when calculated using the most refined exposure and effects assumptions for this constituent (i.e., using an SUF of 1, selected BAFs, and selected TRVs) and area-weighted EPCs. The LOAEL-based HQs less than 1 indicate no unacceptable risk to populations of invertivorous small mammals potentially exposed to soil in these areas following completion of the NTCRA. Except for the 2-foot scouring scenario in BCW, NOAEL-based HQs were less than 1 in all evaluated exposure areas and scouring scenarios indicating de minimis risk to individuals and populations of desert shrew in these areas.
- For hexavalent chromium and copper, NOAEL-based and LOAEL-based HQs are less than 1 in all evaluated exposure areas and scouring scenarios, indicating de minimis risk to individuals and populations of invertivorous small mammals potentially exposed to soil in these areas following

completion of the NTCRA. Risk conclusions are based on HQs estimated in the most refined exposure and effects assumptions applicable to these constituents (i.e., using an SUF of 1, selected BAFs, and selected TRVs) and area-weighted EPCs.

7.2.2 Overall Conclusions of the Post-NTCRA ERA

The 2019 HHERA (Arcadis 2019) concluded that potential risk to ecological receptors, including special-status species, at the site was limited to desert shrew potentially exposed to a few risk-driving COPECs (i.e., total chromium, copper, and dioxin TEQ) in surface soil in one or more potential exposure areas.

In this Post-NTCRA HHERA, potentially unacceptable risk was not identified for populations of invertivorous small mammals, as represented by desert shrew, for any exposure area or scouring scenario evaluated for post-NTCRA conditions. Unacceptable risk was not expected based on LOAEL-based HQs less than 1 estimated using the conservative assumptions incorporated herein.

In the 2019 HHERA (Arcadis 2019), pre-NTCRA soil exposures resulted in desert shrew LOAEL-based HQs greater than 10 estimated for dioxin TEQ in BCW, AOC 9, and AOC 10 and desert shrew LOAEL-based HQs greater than 1 for dioxin TEQ in AOC 11, total chromium in AOC 9 and 10, and copper in AOC 9. Following NTCRA removals, the LOAEL-based HQs were less than 1 in all exposure areas and scouring scenarios evaluated in this Post-NTCRA HHERA. The updated risk estimates confirm that the NTCRA was effective at reducing potential risk to invertivorous small mammal populations to acceptable levels at the site.

In conclusion, no unacceptable risk to wildlife receptor populations was identified at the site potential exposure areas. For desert shrew, the conclusions are based on post-NTCRA conditions as evaluated in this Post-NTCRA HHERA. For the remaining ecological receptors, the conclusions are based on pre-NTCRA conditions as evaluated in the 2019 HHERA (Arcadis 2019). Based on these results, no further remediation is warranted for protection of ecological receptors in the areas evaluated in this Post-NTCRA HHERA based on current post-NTCRA conditions.

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TABLES

Table 2-1
Depth-Weighted Soil Sample Locations Exceeding Removal Action Goals

Post-Soil NTCRA Human Health and Ecological Risk Assessment
PG&E Topock Compressor Station
Needles, California

A O C	Sample Location[a,b]	Chromium, Hexavalent Off-Highway Vehicle Rider ($1x10^{-6}$) Removal Action Goal = 3.1 mg/kg	Chromium, Total Desert Shrew Removal Action Goal = 145 mg/kg	Copper Desert Shrew Removal Action Goal = 145 mg/kg	Dioxin TEQ Hiker ($1x10^{-6}$) Removal Action Goal = 100 ng/kg	Dioxin TEQ Desert Shrew Removal Action Goal = 190 ng/kg
BCW	AOC1-BCW10	--	--	--	110	--
BCW	AOC1-BCW28	--	--	--	180	--
BCW	AOC1-BCW30	--	--	--	140	--
BCW	AOC4-BCW3	--	--	--	190	--
BCW	AOC4-GB11	--	--	--	110	--
BCW	PA-15	--	170	--		--
BCW	SD-14	--	--	--	190	--
BCW	SWMU1-18	--	--	--	140	--
BCW	SWMU1TAA1-CW23	7.8	--	--		--
A O C 9	AOC10a-1	8.3	--	270		--
A O C 9	AOC10a-3	5.3	--	--	130	--
A O C 9	AOC9-16	4.4	--	--	190	--
A O C 9	AOC9-21		--	--	110	--
A O C 9	AOC9-7	4.4	--	--		--
A O C 10	AOC10-11		--	--	200	--
A O C 10	AOC10-12	5	--	--		--
A O C 10	AOC10-15		--	--	110	--
A O C 10	AOC10b-1		--	--	150	--
A O C 10	AOC10c-1	4.8	220	--		--
A O C 10	AOC10TAA2-CW10a	7.3	--	--		--
A O C 10	AOC10TAA4-CW13		--	--	210	--
A O C 10	DTSC-AOC10d-2	6	243	--		--
A O C 10	DTSC-AOC10d-3	4.4	224	--		--
A O C 11	AOC11e-1	3.2	--	--		--
A O C 11	AOC11e-6	16	320	--		--
A O C 11	AOC11TAA1-CF4		--	--	130	--
A O C 11	AOC11TAA1-CW6a		--	--	210	210
A O C 11	PA-10		--	--	140	--
A O C 11	PA-11		--	--	120	--
A O C 11	PA-12		--	--	520	520
A O C 11	SD-11A		--	--	140	--
A O C 14	S2-6	12	--	--	--	--

Notes:

[a] Depth-weighted concentrations are presented for soil exposure depths evaluated in the no scouring scenario of the Post-Soil NTCRA Human Health and Ecological Risk Assessment. These include 0 to 0.5 ft bgs and 0 to 3 ft bgs for recreator receptors and 0 to 0.5 ft bgs for shrew.

[b] If a location has more than one depth-weighted concentration exceeding the removal action goal for a constituent (i.e., in multiple depth intervals), the maximum of the concentrations is presented in this table.

Acronyms and Abbreviations:

"--" = not applicable
A O C = area of concern
ft bgs = feet below ground surface
mg/kg = milligrams per kilogram
ng/kg = nanograms per kilogram
TEQ = toxic equivalency

Table 3-1
C O P C / C O P E C Summary for Potential Exposure Areas

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Constituent Category	C O P C / C O P E C	C O P C / C O P E C Note	Bat Cave Wash (BCW)	A O C 9	A O C 10	A O C 11	A O C 14	A O C 27
Inorganicss	Antimony	None	x	x	x		x	x
Inorganics	Arsenic	None		x	x	x		
Inorganics	Barium	None						
Inorganics	Cadmium	None						x
Inorganics	Chromium, Hexavalent	Note 1	x	x	x	x	x	x
Inorganics	Chromium, total	Note 1	x	x	x	x		
Inorganics	Cobalt	None	x					
Inorganics	Copper	Note 1	x	x	x	x	x	x
Inorganics	Cyanide	None			x			
Inorganics	Lead	None	x	x	x	x	x	x
Inorganics	Manganese	None			x			
Inorganics	Mercury (inorganic)	None	x	x	x	x	x	x
Inorganics	Molybdenum	None						
Inorganics	Nickel	None		x				
Inorganics	Nitrate	None	x				x	
Inorganics	Orthophosphate	None	x					
Inorganics	Phosphate	None	x				x	
Inorganics	Silver	None						
Inorganics	Thallium	None	x	x	x		x	
Inorganics	Vanadium	None						
Inorganics	Zinc	None	x	x	x	x		x
Volatile Organic Compounds	Acetone	None						
Volatile Organic Compounds	Bromomethane	None						x
Volatile Organic Compounds	Chloro methane	None						x
Volatile Organic Compounds	Chloroform	None						
Volatile Organic Compounds	Isophorone	None		x				
Volatile Organic Compounds	Methyl acetate	None	x			x		
Volatile Organic Compounds	Methylene chloride	None						
Volatile Organic Compounds	Toluene	None						
Volatile Organic Compounds	Xylenes, total	None						

Table 3-1
C O P C / C O P E C Summary for Potential Exposure Areas

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Constituent Category	C O P C / C O P E C	C O P C / C O P E C Note	Bat Cave Wash (BCW)	A O C 9	A O C 10	A O C 11	A O C 14	A O C 27
Semi-Volatile Organic Compounds	4-Methylphenol	None					x	
Semi-Volatile Organic Compounds	bis (2-ethylhexyl) phthalate	None	x				x	
Semi-Volatile Organic Compounds	Butylbenzylphthalate	None					x	
Polycyclic Aromatic Hydrocarbons	P A H High molecular weight	None	x	x	x	x	x	x
Polycyclic Aromatic Hydrocarbons	P A H Low molecular weight	None	x	x	x	x	x	x
Polycyclic Aromatic Hydrocarbons	1-Methyl naphthalene	None		x	x	x		
Polycyclic Aromatic Hydrocarbons	2-Methyl naphthalene	None	x	x	x	x		
Polycyclic Aromatic Hydrocarbons	Acenaphthene	None		x		x		x
Polycyclic Aromatic Hydrocarbons	Acenaphthylene	None		x		x	x	x
Polycyclic Aromatic Hydrocarbons	Anthracene	None	x	x	x	x	x	x
Polycyclic Aromatic Hydrocarbons	Benzo (a) anthracene	None		x	x	x		x
Polycyclic Aromatic Hydrocarbons	Benzo (a) pyrene	None		x	x	x		x
Polycyclic Aromatic Hydrocarbons	Benzo (b) fluoranthene	None		x	x	x		x
Polycyclic Aromatic Hydrocarbons	Benzo (ghi) perylene	None	x	x	x	x	x	x
Polycyclic Aromatic Hydrocarbons	Benzo (k) fluoranthene	None		x	x	x		x
Polycyclic Aromatic Hydrocarbons	Chrysene	None		x	x	x		x
Polycyclic Aromatic Hydrocarbons	Dibenzo (a,h) anthracene	None		x	x	x		x
Polycyclic Aromatic Hydrocarbons	Fluoranthene	None	x	x	x	x	x	x
Polycyclic Aromatic Hydrocarbons	Fluorene	None	x	x		x		x
Polycyclic Aromatic Hydrocarbons	Indeno (1,2,3-cd) pyrene	None		x	x	x		x
Polycyclic Aromatic Hydrocarbons	Naphthalene	None	x	x	x	x		x
Polycyclic Aromatic Hydrocarbons	Phenanthrene	None	x	x	x	x	x	x
Polycyclic Aromatic Hydrocarbons	Pyrene	None	x	x	x	x	x	x
Polycyclic Aromatic Hydrocarbons	B (a) P Equivalent	None		x	x	x		x
Pesticides	4,4-DDE	None		x		x	x	
Pesticides	4,4-DDT	None					x	
Pesticides	alpha-Chlordane	None				x		
Pesticides	Dieldrin	None				x		
Pesticides	gamma-Chlordane	None				x		
Polychlorinated Biphenyls	Total PCBs	None	x	x	x	x	x	x

Table 3-1
C O P C / C O P E C Summary for Potential Exposure Areas

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Constituent Category	C O P C / C O P E C	C O P C / C O P E C Note	Bat Cave Wash (BCW)	A O C 9	A O C 10	A O C 11	A O C 14	A O C 27
Total Petroleum Hydrocarbons	TPH as diesel	None	x	x	x	x	x	x
Total Petroleum Hydrocarbons	TPH as motor oil	None	x	x	x	x	x	x
Dioxins/Furans	TEQ Avian	None	x	x	x	x	x	x
Dioxins/Furans	TEQ Human	Note 1	x	x	x	x	x	x
Dioxins/Furans	TEQ Mammals	Note 1	x	x	x	x	x	x

Note:
Note 1. Risk drivers (copper, total chromium, hexavalent chromium, TEQ Human, and TEQ Mammal) were evaluated in the HHERA Addendum for the relevant exposure areas (i.e., Bat Cave Wash, A O C 9, A O C 10, A O C 11, A O C 14, and A O C 27).

Abbreviations:
A O C = area of concern.
B (a) P equivalent = benzo(a)pyrene equivalent.
BCW = Bat Cave Wash.
C O P C = constituent of potential concern.
C O P E C = constituent of potential ecological concern.
x = Chemical included as COPC or COPEC in the 2019 human health and ecological risk assessment (H H E R A). Blank cells indicate that chemical is either: (1) not analyzed for, (2) not detected if analyzed for, (3) detected within background levels, or (4) detected, but with no toxicity value available.
DDE = dichlorodiphenyldichloroethylene.
DDT = dichlorodiphenyltrichloroethane.
P A H = polycyclic aromatic hydrocarbon.
PCB = polychlorinated biphenyl.
TEQ = toxic equivalent.
TPH = total petroleum hydrocarbon.

Table 5-1
Human Health Exposure Parameters

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Exposure Parameter	Symbol	Potential Receptor Scenario: Child Camper	Potential Receptor Scenario: Adult Camper	Potential Receptor Scenario: Age-Adjusted Adult Camper	Potential Receptor Scenario: Child Hiker	Potential Receptor Scenario: Adult Hiker	Potential Receptor Scenario: Age-Adjusted Adult Hiker	Potential Receptor Scenario: Child OHV Rider	Potential Receptor Scenario: Adult OHV Rider	Potential Receptor Scenario: Adult OHV Rider	Units
Inhalation of Soil Particulates											
Particulate Emission Factor [a]	PEF	1.4E+09	1.4E+09	1.4E+09	1.4E+09	1.4E+09	1.4E+09	8.5E+05	8.5E+05	8.5E+05	m^3/kg
Dermal Contact with Soil											
Surface Area [b]	SA	2900	6032	6032	2900	6032	6032	2900	6032	6032	cm^2/day
Adherence Factor [c]	AF	0.2	0.07	0.07	0.2	0.07	0.07	0.8	0.8	0.8	mg/cm^2
Absorption Factor-P A Hs/PCBs [d]	ABS-PAH	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	unitless
Absorption Factor-Metals [d]	ABS-Met	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	unitless
Absorption Factor-Arsenic [d]	ABS-As	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	unitless
Absorption Factor-Cadmium [d]	ABS-Cd	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	unitless
Absorption Factor-Chromium VI [d]	ABS-CrVI	NA	NA	NA	NA	NA	NA	NA	NA	NA	unitless
Absorption Factor-Cyanide [d]	ABS-CN	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	unitless
Absorption Factor-Mercury [d]	ABS-Hg	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	unitless
Absorption Factor-Organochlorine Pesticides [d]	ABS-Pest	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	unitless
Absorption Factor-Organics [d]	ABS-Org	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	unitless
Conversion Factor	CF	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	kg/mg
Ingestion of Soil											
Ingestion Rate [e]	IR	200	100	100	200	100	100	330	330	330	mg/day
Conversion Factor	CF	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	kg/mg
Population-Specific Intake Parameters											
Exposure Time (ingestion) [f]	ET_{ing}	16	16	16	16	16	16	1.5	1.5	1.5	hrs/day
Exposure Time (inhalation) [g]	ET_{inh}	24	24	24	24	24	24	1.5	1.5	1.5	hrs/day
Time Conversion Factor (ingestion)	TCF_{ing}	16	16	16	16	16	16	16	16	16	hrs/day
Time Conversion Factor (inhalation)	TCF_{inh}	24	24	24	24	24	24	24	24	24	hrs/day
Exposure Frequency [h]	E F	8	8	8	16	16	16	16	16	16	days/yr
Exposure Duration [i]	E D	6	26	20	6	26	20	6	26[j]	20[j]	yrs
Body Weight [k]	BW	15	80	80	15	80	80	33	80	80	kg
Averaging Time-Carcinogens [l]	A T_c	25550	25550	25550	25550	25550	25550	25550	25550	25550	days
Averaging Time-Noncarcinogens [l]	A T_{nc}	2190	9490	7300	2190	9490	7300	2190	9490	7300	days

Table 5-1
Human Health Exposure Parameters

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Notes:

[a] A default particulate emission factor (PEF) of 1.4×10^9 m^3/kg as recommended by Department of Toxic Substances Control (DTSC 2014) was used for recreational users (campers and hikers). A PEF of 8.5×10^5 m^3/kg was used for recreational users (off-highway vehicle rider) as calculated in United States Environmental Protection Agency (2008, 2009) and recommended in "Revised Technical Memorandum, Recreational Visitor Exposure Scenario for Federal Land, PG&E Topock Compressor Station Remediation Project, California," prepared by the Department of the Interior (DOI).

[b] The default area of exposed skin as recommended by DTSC (2019) was used for recreational users (campers, hikers, and OHV riders).

[c] Soil adherence factors as recommended by DTSC (2019) was used for recreational users (campers, hikers, and OHV riders).

[d] Dermal absorption factors for specific compound classes from DTSC (2015).

[e] Default incidental soil ingestion rates as recommended by DTSC (2019) used for recreational users (campers, hikers, and OHV riders).

[f] Exposure time for ingestion for all potential receptor scenarios consistent with that defined in the "Final Human Health and Ecological Risk Assessment Work Plan Addendum 2" ([RAWP Addendum 2] Arcadis 2015). For campers and hikers 16 hours is assumed to be awake hours where ingestion will occur.

[g] Exposure time for inhalation for all potential receptor scenarios consistent with that defined in the "Final Human Health and Ecological Risk Assessment Work Plan Addendum 2" ([RAWP Addendum 2] Arcadis 2015). For child hikers, an assumed 24 hour per day exposure time is provided to generate a 10 m^3 daily inhalation volume, based on an assumed elevated activity rate for hiking. The actual expected exposure time is more likely between 8 to 12 hours per day (e.g., daylight hours). For adult hikers, an assumed 24 hour per day exposure time is provided to generate a 20 m^3 daily inhalation volume, based on an assumed elevated activity rate for hiking and hunting. The actual expected exposure time is more likely between 8 to 12 hours per day (e.g., daylight hours).

[h] Exposure frequency for all potential receptor scenarios consistent with that defined in the RAWP Addendum 2 (Arcadis 2015).

[i] Exposure duration for all potential receptor scenarios consistent with that defined in the RAWP Addendum 2 (Arcadis 2015).

[j] Per U S E P A guidance (2002), cancer risks for receptors potentially exposed during childhood and adult years are calculated using an age-adjusted approach to account for the higher exposures per body weight that occur during the childhood years. Accordingly, for carcinogenic effects, recreational users (campers, hikers, and OHV riders) are evaluated as children for the first 6 years of potential exposure and adults for the remaining 20 years (for a total exposure duration of 26 years). For noncarcinogenic hazards, potential child and adult recreactional user receptors are evaluated separately (6 year exposure duration for child, 26 year exposure duration for adult).

[k] Body weight values correspond to Cal/E P A default values for potential adult and child receptors (DTSC 2019).

[l] Averaging times correspond to Cal/E P A default values (70 year lifetime × 365 days/year for carcinogens; exposure duration × 365 days/year for noncarcinogens) (DTSC 2019).

Abbreviations:

cm^2/day = centimeters squared per day
days/yr = days per year
hrs/day = hours per day
kg/mg = kilograms per milligram
m^3/kg = meters cubed per kilogram
mg/cm^2 = milligrams per centimeters squared
mg/day = milligrams per day
NA = Not applicable; parameter not applicable to exposure scenario for potential exposure pathways evaluated in the Human Health Risk Assessment (HHRA). Hexavalent chromium is not absorbed via dermal contact.

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Table 5-2a
Equations Used to Calculate Exposure Concentrations and Chronic Daily Intakes: Recreational Users, Tribal Users, and Hypothetical Future Residential Scenarios

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Exposure Concentration: Vapor Inhalation

Noncancer Equation:

$$EC_{inhv,\ nc} = \frac{C_a \times ET \times (1/TCF_{inh}) \times EF \times ED_{adult}}{AT_{nc,\ adult}}$$

where $C_a = C_s \times 1/VF$ for soil to outdoor air pathway

Exposure Concentration: Vapor Inhalation

Cancer Equation:

$$EC_{inhv,\ c} = \frac{C_a \times ET \times (1/TCF_{inh}) \times EF \times ED_{adult}}{AT_c}$$

where $C_a = C_s \times 1/VF$ for soil to outdoor air pathway

Exposure Concentration: Soil Particulate Inhalation

Noncancer Equation:

$$EC_{inhp,\ nc} = \frac{C_s \times (1/TCF_{inh}) \times (1/PEF) \times EF \times ED_{adult}}{AT_{nc,\ adult}}$$

Exposure Concentration: Soil Particulate Inhalation

Cancer Equation:

$$EC_{inhp,\ c} = \frac{C_s \times (1/TCF_{inh}) \times (1/PEF) \times EF \times ED_{adult}}{AT_c}$$

Table 5-2a
Equations Used to Calculate Exposure Concentrations and Chronic Daily Intakes: Recreational Users, Tribal Users, and Hypothetical Future Residential Scenarios

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Chronic Daily Intake: Dermal Contact

Noncancer Equation:

$$CDI_{derm,\ child,\ nc} = \frac{C_s \times SA_{child} \times AF_{child} \times ABS \times EF \times ED_{child} \times CF}{BW_{child} \times AT_{nc,\ child}} \qquad CDI_{derm,\ adult} = \frac{C_s \times SA_{adult} \times AF_{adult} \times ABS \times EF \times ED_{adult} \times CF}{BW_{adult} \times AT_{nc,\ adult}}$$

Chronic Daily Intake: Dermal Contact

Cancer Equation:

$$CDI_{derm,\ age\ adjusted,\ c} = \frac{C_s \times SA_{child} \times AF_{child} \times ABS \times EF \times ED_{child} \times CF}{BW_{child} \times AT_c} + \frac{C_s \times SA_{adult} \times AF_{adult} \times ABS \times EF \times ED_{adult,\ age\ adjusted} \times CF}{BW_{adult} \times AT_c}$$

Chronic Daily Intake: Soil Ingestion

Noncancer Equation:

$$CDI_{ing,\ child,\ nc} = \frac{C_s \times IR_{child} \times CF \times ET \times (1/TCF_{ing}) \times EF \times ED_{child}}{BW_{child} \times AT_{nc,\ child}} \qquad CDI_{ing,\ adult} = \frac{C_s \times IR_{adult} \times CF \times ET \times (1/TCF_{ing}) \times EF \times ED_{adult}}{BW_{adult} \times AT_{nc,\ adult}}$$

Chronic Daily Intake: Soil Ingestion

Cancer Equation:

$$CDI_{ing,\ age\ adjusted,\ c} = \frac{C_s \times IR_{child} \times CF \times ET \times (1/TCF_{ing}) \times EF \times ED_{child}}{BW_{child} \times AT_c} + \frac{C_s \times IR_{adult} \times CF \times ET \times (1/TCF_{ing}) \times EF \times ED_{adult,\ age\ adjusted}}{BW_{adult} \times AT_c}$$

Table 5-2a
Equations Used to Calculate Exposure Concentrations and Chronic Daily Intakes: Recreational Users, Tribal Users, and Hypothetical Future Residential Scenarios

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Equation Notes:

where ABS = Absorption Factor [unitless]
where AF = Soil to Skin Adherence Factor [milligrams per square centimeter]
where AT_c = Averaging Time for Carcinogenic Compounds [days]
where AT_{nc} = Averaging Time for Noncarcinogenic Compounds [days]
where BW = Body Weight [kilograms]
where C_a = Concentration of Chemical in Air [milligrams per cubic meter]
where C_s = Concentration of Chemical in Soil [milligrams per kilogram]
where CDI_{derm} = Chronic Daily Intake: Dermal Contact [milligrams of the chemical per kilogram of body weight per day]
where CDI_{ing} = Chronic Daily Intake: Ingestion [milligrams of the chemical per kilogram of body weight per day]
where CF = Conversion Factor [kilograms per milligram]
where EC_{inhp} = Exposure Concentration: Soil Particulate Inhalation [milligrams of the chemical per cubic meter of air]
where EC_{inhv} = Exposure Concentration: Vapor Inhalation [milligrams of the chemical per cubic meter of air]
where ED = Exposure Duration [years]
where EF = Exposure Frequency [days per year]
where ET = Exposure Time [hours per day]
where IR = Soil Ingestion Rate [milligrams per day]
where PEF = Soil-to-Air Particulate Emission Factor [cubic meters per kilogram]
where SA = Surface Area of Exposed Skin [square centimeters per day]
where TCF_{ing} = Time Conversion Factor: Ingestion [hours per day]
where TCF_{inh} = Time Conversion Factor: Inhalation [hours per day]
where VF = Soil-to-Air Volatilization Factor [cubic meters per kilogram]

Table 5-2b
Equations Used to Calculate Exposure Concentrations and Chronic Daily Intakes for Mutagens: Recreational Users and Hypothetical Future Residential Scenarios

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Needles, California

Exposure Concentration: Vapor Inhalation

Mutagenic Equation:

$$EC_{inhv,mut} = C_a \times ET \times \frac{1}{TCF_{inh}} \times \frac{1}{AT_c} \times \begin{pmatrix} (EF_{0-2} \times ED_{0-2} \times 10) + \\ (EF_{2-6} \times ED_{2-6} \times 3) + \\ (EF_{6-16} \times ED_{6-16} \times 3) + \\ (EF_{16-26} \times ED_{16-26} \times 1) \end{pmatrix}$$

where C_a = C_s x 1/Volatilization Factor for soil to outdoor air pathway

Exposure Concentration: Soil Particulate Inhalation

Mutagenic Equation:

$$EC_{inhp,mut} = C_s \times ET \times \frac{1}{TCF_{inh}} \times \frac{1}{PEF} \times \frac{1}{AT_c} \times \begin{pmatrix} (EF_{0-2} \times ED_{0-2} \times 10) + \\ (EF_{2-6} \times ED_{2-6} \times 3) + \\ (EF_{6-16} \times ED_{6-16} \times 3) + \\ (EF_{16-26} \times ED_{16-26} \times 1) \end{pmatrix}$$

Chronic Daily Intake: Dermal Contact

Mutagenic Equation:

$$CDI_{derm,mut} = C_s \times ABS \times CF \times \frac{1}{AT_c} \times$$
$$\begin{pmatrix} \frac{SA_{0-2} \times AF_{0-2} \times EF_{0-2} \times ED_{0-2} \times 10}{BW_{0-2}} + \\ \frac{SA_{2-6} \times AF_{2-6} \times EF_{2-6} \times ED_{2-6} \times 3}{BW_{2-6}} + \\ \frac{SA_{6-16} \times AF_{6-16} \times EF_{6-16} \times ED_{6-16} \times 3}{BW_{6-16}} + \\ \frac{SA_{16-26} \times AF_{16-26} \times EF_{16-26} \times ED_{16-26} \times 1}{BW_{16-26}} \end{pmatrix}$$

Table 5-2b
Equations Used to Calculate Exposure Concentrations and Chronic Daily Intakes for Mutagens: Recreational Users and Hypothetical Future Residential Scenarios

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Chronic Daily Intake: Soil Ingestion

Mutagenic Equation:

$$\mathrm{CDI_{ing,mut}} = \mathrm{C_s} \times \mathrm{CF} \times \mathrm{ET} \times \frac{1}{\mathrm{TCF_{ing}}} \times \frac{1}{\mathrm{AT_c}} \times \left(\frac{\mathrm{IR_{0-2}} \times \mathrm{EF_{0-2}} \times \mathrm{ED_{0-2}} \times 10}{\mathrm{BW_{0-2}}} + \frac{\mathrm{IR_{2-6}} \times \mathrm{EF_{2-6}} \times \mathrm{ED_{2-6}} \times 3}{\mathrm{BW_{2-6}}} + \frac{\mathrm{IR_{6-16}} \times \mathrm{EF_{6-16}} \times \mathrm{ED_{6-16}} \times 3}{\mathrm{BW_{6-16}}} + \frac{\mathrm{IR_{16-26}} \times \mathrm{EF_{16-26}} \times \mathrm{ED_{16-26}} \times 1}{\mathrm{BW_{16-26}}} \right)$$

Equation Notes:
where ABS = Absorption Factor [unitless]
where AF = Soil to Skin Adherence Factor [milligrams per square centimeter]
where AT_c = Averaging Time for Carcinogenic Compounds [days]
where BW = Body Weight [kilograms]
where C_a = Concentration of Chemical in Air [milligrams per cubic meter]
where C_s = Concentration of Chemical in Soil [milligrams per kilogram]
where CDI_{derm} = Chronic Daily Intake: Dermal Contact [milligrams of the chemical per kilogram of body weight per day]
where CDI_{ing} = Chronic Daily Intake: Ingestion [milligrams of the chemical per kilogram of body weight per day]
where CF =Conversion Factor [kilograms per milligram]
where EC_{inhp} = Exposure Concentration: Soil Particulate Inhalation [milligrams of the chemical per cubic meter of air]
where EC_{inhv} = Exposure Concentration: Vapor Inhalation [milligrams of the chemical per cubic meter of air]
where ED = Exposure Duration [years]
where EF = Exposure Frequency [days per year]
where ET = Exposure Time [hours per day]
where IR = Soil Ingestion Rate [milligrams per day]
where PEF = Soil-to-Air Particulate Emission Factor [cubic meters per kilogram]
where SA = Surface Area of Exposed Skin [square centimeters per day]
where TCF_{ing} = Time Conversion Factor: Ingestion [hours per day]
where TCF_{inh} = Time Conversion Factor: Inhalation [hours per day]
where VF = Soil-to-Air Volatilization Factor [cubic meters per kilogram]

Table 5-3
Carcinogenic and Noncarcinogenic Toxicity Values for C O P Cs in Soil

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C O P C	Unit Risk Factor, URF $(mg/m^3)^{-1}$ Value	Unit Risk Factor, URF Source	Cancer Slope Factor, CSF $(mg/kg\text{-}day)^{-1}$ Value	Cancer Slope Factor, CSF Source	Reference Concentration, RfC (mg/m^3) Value	Reference Concentration, RfC Source	Reference Dose, RfD (mg/kg-day) Value	Reference Dose, RfD Source
Inorganics								
Antimony	NL	NL	NC	NC	0.0003	ATSDR	0.0004	IRIS
Arsenic	4.3	IRIS	9.5	OEHHA PHG	0.000015	OEHHA	0.0000035	OEHHA
Barium	NL	NL	NC	NC	0.0005	HEAST	0.2	IRIS
Cadmium	4.2	OEHHA	NC	NC	0.00001	ATSDR	0.0000063 / 0.0005	DTSC / IRIS (a)
Chromium, Hexavalent	150	OEHHA	0.5	OEHHA PHG	0.0001	IRIS	0.003	IRIS
Chromium, total	NL	NL	NC	NC	0.00006	OEHHA	1.5	IRIS
Cobalt	9	PPRTV	NC	NC	0.000006	PPRTV	0.0003	PPRTV
Copper	NL	NL	NC	NC	0.16	Route	0.04	HEAST (b)
Cyanide	NL	NL	NC	NC	0.0008	RSL User's Guide	0.00063	IRIS
Lead	na	na	na	na	na	na	na	na
Manganese	NL	NL	NC	NC	0.00005	IRIS	0.024	RSL User's Guide
Mercury (inorganic)	NC	NC	NC	NC	0.00003	OEHHA	0.00016	OEHHA
Molybdenum	NL	NL	NC	NC	0.02	Route	0.005	IRIS
Nickel	0.26	OEHHA	NC	NC	0.000014	OEHHA	0.011	OEHHA
Nitrate	NL	NL	NC	NC	6.4	Route	1.6	IRIS
Phosphate	NL	NL	NC	NC	11.7	Surrogate	2.93	Surrogate
Silver	NL	NL	NC	NC	0.02	Route	0.005	IRIS
Thallium	NL	NL	NC	NC	0.00004	Route	0.00001	PPRTV
Vanadium	NL	NL	NC	NC	0.0001	ATSDR	0.005	RSL User's Guide
Zinc	NL	NL	NC	NC	1.2	Route	0.3	IRIS
Volatile Organic Compounds								
Acetone	NL	NL	NC	NC	3.6	Route	0.9	IRIS
Bromomethane	NL	NL	NC	NC	0.005	IRIS	0.0014	IRIS
Chloro methane	NL	NL	NC	NC	0.09	IRIS	0.0225	Route
Chloroform	0.023	IRIS	0.031	OEHHA	0.00195	ATSDR	0.01	IRIS
Isophorone	NL	NL	0.00095	IRIS	2	OEHHA	0.2	IRIS
Methyl acetate	NL	NL	NC	NC	4	Route	1	PPRTV
Methylene chloride	0.001	OEHHA	0.002	IRIS	0.4	OEHHA	0.006	IRIS
Toluene	NL	NL	NC	NC	0.42	OEHHA	0.08	IRIS
Xylenes, total	NL	NL	NC	NC	0.1	IRIS	0.2	IRIS
Semi-Volatile Organic Compounds								
4-Methylphenol	NL	NL	NC	NC	0.6	OEHHA	0.1	ATSDR
bis (2-ethylhexyl) phthalate	0.0024	OEHHA	0.014	IRIS	0.08	Route	0.02	IRIS
Butylbenzylphthalate	NL	NL	0.0019	PPRTV	0.8	Route	0.2	IRIS

Table 5-3
Carcinogenic and Noncarcinogenic Toxicity Values for C O P Cs in Soil

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C O P C	Unit Risk Factor, URF $(mg/m^3)^{-1}$ Value	Unit Risk Factor, URF Source	Cancer Slope Factor, CSF $(mg/kg\text{-}day)^{-1}$ Value	Cancer Slope Factor, CSF Source	Reference Concentration, RfC (mg/m^3) Value	Reference Concentration, RfC Source	Reference Dose, RfD (mg/kg-day) Value	Reference Dose, RfD Source
Polycyclic Aromatic Hydrocarbons								
1-Methyl naphthalene	0.0128	Route	0.051	PPRTV	0.28	Route	0.07	ATSDR
2-Methyl naphthalene	NL	NL	NC	NC	0.016	Route	0.004	IRIS
Acenaphthene	NL	NL	NC	NC	0.24	Route	0.06	IRIS
Acenaphthylene	NL	NL	NC	NC	0.24	Surrogate	0.06	Surrogate
Anthracene	NL	NL	NC	NC	1.2	Route	0.3	IRIS
Benzo (a) anthracene (c)	0.11	OEHHA	0.1	ECAO	0.12	Surrogate	0.03	Surrogate
Benzo (a) pyrene (c)	1.1	OEHHA	1	IRIS	0.000002	IRIS	0.0003	IRIS
Benzo (b) fluoranthene (c)	0.11	OEHHA	0.1	ECAO	0.12	Surrogate	0.03	Surrogate
Benzo (ghi) perylene	NL	NL	NC	NC	0.12	Surrogate	0.03	Surrogate
Benzo (k) fluoranthene (c)	0.11	OEHHA	0.01	ECAO	0.12	Surrogate	0.03	Surrogate
Chrysene (c)	0.011	OEHHA	0.001	ECAO	0.12	Surrogate	0.03	Surrogate
Dibenzo (a,h) anthracene (c)	1.2	OEHHA	4.1	OEHHA ECP	0.000002	Surrogate	0.0003	Surrogate
Fluoranthene	NL	NL	NC	NC	0.16	Route	0.04	IRIS
Fluorene	NL	NL	NC	NC	0.16	Route	0.04	IRIS
Indeno (1,2,3-cd) pyrene (c)	0.11	OEHHA	0.1	ECAO	0.12	Surrogate	0.03	Surrogate
Naphthalene	0.034	OEHHA	0.12	OEHHA	0.003	IRIS	0.02	IRIS
Phenanthrene	NL	NL	NC	NC	1.2	Surrogate	0.3	Surrogate
Pyrene	NL	NL	NC	NC	0.12	Route	0.03	IRIS
B(a)P Equivalent	1.1	OEHHA	1	IRIS	NA	NA	NA	NA
Pesticides								
4,4-DDE	0.097	OEHHA	0.34	IRIS	0.002	Route	0.0005	ATSDR
4,4-DDT	0.097	IRIS	0.34	IRIS	0.002	Route	0.0005	IRIS
alpha-Chlordane	0.1	Surrogate	0.35	Surrogate	0.0007	Surrogate	0.0005	RSL User's Guide
Dieldrin	4.6	IRIS	16	IRIS	0.0002	Route	0.00005	IRIS
gamma-Chlordane	0.1	Surrogate	0.35	Surrogate	0.0007	Surrogate	0.0005	RSL User's Guide
Polychlorinated Biphenyls								
Total PCBs	0.1	IRIS	2	IRIS	0.00008	Surrogate	0.00002	Surrogate
Total Petroleum Hydrocarbons								
TPH as diesel	NC	NC	NC	NC	0.26	ESL	0.019	ESL
TPH as motor oil	NC	NC	NC	NC	0.6	Route	0.15	ESL
Dioxins/Furans								
TEQ Human	38000	Surrogate	130000	Surrogate	0.00000004	Surrogate	0.0000000007	Surrogate

Table 5-3
Carcinogenic and Noncarcinogenic Toxicity Values for C O P Cs in Soil

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Notes:

(a) For cadmium, the RfD of 6.3×10^{-6} mg/kg-day is recommended for adult exposures, while the IRIS RfD of 5.0×10^{-4} mg/kg-day is used for potential child exposures, per Note 3.

(b) The RfD for copper is based on a drinking water standard of 1.3 mg/L.

(c) Potential carcinogenic effects of carcinogenic polycyclic aromatic hydrocarbons (C P A Hs) are evaluated using benzo(a)pyrene equivalents consistent with the approach presented in the Soil Human Health and Ecological Risk Assessment for the Site (Arcadis, 2019). Potential noncarcinogenic effects of C P A Hs are evaluated for each of the C P A Hs individually.

Abbreviations:

C O P C = Constituent of Potential Concern.

na = Not applicable. Potential exposure to lead is evaluated using the United States Environmental Protection Agency's (U S E P A) Adult Lead Methodology (ALM) or California Environmental Protection Agency (Cal/E P A) Department of Toxic Substances Control's (DTSC) LeadSpread model. Please see text for discussion.

NC = Not considered to be a carcinogen by either U S E P A or Cal/E P A.

Surrogate = In the absence of available toxicity values for chemicals of potential concern, surrogate chemicals were chosen based on structural similarity to avoid underestimating potential carcinogenic risks/noncarcinogenic hazards:

- Total chromium was represented by chromium (III).
- Phosphate was represented by aluminum metaphosphate.
- Acenaphthylene was represented by acenaphthene.
- Potential noncarcinogenic effects of benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene, were represented by pyrene.
- Potential noncarcinogenic effects of dibenz(a,h)anthracene was represented by benzo(a)pyrene.
- Benzo(g,h,i)perylene was represented by pyrene.
- Phenanthrene was represented by anthracene.
- Alpha- and gamma-chlordane was represented by technical chlordane.
- Potential noncarcinogenic effects of Total PCBs was represented by Aroclor 1254.
- TEQ human was represented by 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD).

Surrogate chemicals were chosen as stated and are based on structural similarities such as chemicals in the same suite of compounds with similar carbon chain structures (e.g., aromatic carbon rings) and/or group of molecules attached (e.g., methyl group), however may differ in type of carbon bond (e.g., single or double bond) or position of the group of molecules attached. For example, acenaphthene was chosen as a surrogate for acenaphthylene. Both compounds are considered semi-volatile organic compounds and PAHs with three carbon rings. Acenaphthene (C12H10) has two aromatic rings (i.e., carbon ring with double bonds) and one non-aromatic ring (i.e., single bonds only carbon ring) and acenaphthylene (C12H8) has three aromatic rings. The surrogate chemicals selected in the Post-NTCRA HHERA are the same surrogate chemicals selected in the 2019 Soil HHERA.

Route = Route-to-route extrapolation from reference dose (RfDo) or reference concentration (RfC) using the following equations:

RfC = RfDo / (InhR / BW) or RfDo = RfC / (BW / Inhr), where:
Adult daily inhalation rate (InhR) = 20 m^3/day (DTSC 2019), and
Adult body weight (BW) = 80 kg (DTSC 2019).

Table 5-3
Carcinogenic and Noncarcinogenic Toxicity Values for C O P Cs in Soil

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Sources:

A T S D R	Agency for Toxic Substances and Disease Registry (A T S D R). 2024. Minimal Risk Levels (MRLs) for Hazardous Substances. Available at: http://www.atsdr.cdc.gov/mrls/mrllist.asp
E C A O	Environmental Criteria and Assessment Office. Per the U S E P A RSL User's Guide (2024), a relative potency factor (RPF) is applied to calculate the oral slope factor based on relative potency to benzo(a)pyrene.
ESL	San Francisco Bay Regional Water Quality Control Board (RWQCB). 2019. Environmental Screening Levels. Interim Final (Rev. 2). February. Available at: http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/esl.shtml
H E A S T	United States Environmental Protection Agency (U S E P A). 1997. Health Effects Assessment (HEAST) Summary Tables. FY 1997 Update. July. Office of Solid Waste and Emergency Response (OSWER).
IRIS	United States Environmental Protection Agency (U S E P A). 2024. Integrated Risk Information System Database. Maintained online at http://www.epa.gov/iris/index.html.
O E H H A	Office of Environmental Health Hazard Assessment (O E H H A). 2024. Toxicity Criteria Database. Table of cancer slope factors maintained at http://www.oehha.ca.gov/risk/ChemicalDB/index.asp; table of chronic RELs maintained online at http://www.oehha.ca.gov/air/allrels.html.
O E H H A E C P	O E H H A Expedited Cancer Potency Factors (E C P). 2024. Toxicity Criteria Database. Table of cancer slope factors maintained online at https://oehha.ca.gov/chemicals
O E H H A PHG	O E H H A California Public Health Goals (PHG). 2024. Toxicity Criteria Database. Table of cancer slope factors maintained online at https://oehha.ca.gov/chemicals.
PPRTV	Superfund Health Risk Technical Support Center (STSC). 2018. Provisional Peer Reviewed Toxicity Values (PPRTV). Maintained online at: http://hhpprtv.ornl.gov/index.html.
RSL	United States Environmental Protection Agency (U S E P A). 2024. Regional Screening Levels (RSLs). May. Available at: https://www.epa.gov/risk/regional-screening-levels-rsls.

Table 5-4
HHRA Cancer Risk Estimate Summary

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Exposure Area	Scenario	Camper - Surface Soil	Camper - Shallow Soil	Hiker - Surface Soil	Hiker - Shallow Soil	OHV Rider - Surface Soil	OHV Rider - Shallow Soil
Background As Estimated LCR [a]	Footnote a	**2E-06**	**2E-06**	**3E-06**	**3E-06**	**2E-06**	**2E-06**
BCW	Baseline (depth-wt)	3E-07	3E-07	7E-07	5E-07	5E-07	5E-07
BCW	Baseline (depth-wt) Risk Drivers	NA	NA	NA	NA	NA	NA
BCW	2-ft Scouring (depth-wt)	2E-07	2E-07	4E-07	4E-07	4E-07	5E-07
BCW	2-ft Scouring (depth-wt) Risk Drivers	NA	NA	NA	NA	NA	NA
BCW	5-ft Scouring (depth-wt)	2E-07	2E-07	4E-07	5E-07	4E-07	5E-07
BCW	5-ft Scouring (depth-wt) Risk Drivers	NA	NA	NA	NA	NA	NA
A O C 9	Baseline (depth-wt)	**3E-06**	**3E-06**	**6E-06**	**5E-06**	**4E-06**	**3E-06**
A O C 9	Baseline (depth-wt) Risk Drivers	Arsenic (2E-06) T E Q for humans (5E-07) B (a) P E Q (3E-07) Hexavalent chromium (2E-07)	Arsenic (2E-06) T E Q for humans (4E-07) B (a) P E Q (2E-07) Hexavalent chromium (1E-07)	Arsenic (4E-06) T E Q for humans (1E-06) B (a) P E Q (6E-07) Hexavalent chromium (5E-07)	Arsenic (4E-06) T E Q for humans (8E-07) B (a) P E Q (4E-07) Hexavalent chromium (3E-07)	Arsenic (2E-06) Hexavalent chromium (1E-06) T E Q for humans (5E-07) B (a) P E Q (4E-07)	Arsenic (2E-06) Hexavalent chromium (5E-07) T E Q for humans (4E-07) B (a) P E Q (3E-07)
A O C 9	Baseline Excluding Background As (depth-wt)	1E-06	1E-06	**3E-06**	**2E-06**	**2E-06**	1E-06
A O C 9	Baseline (area-wt)	**2E-06**	**2E-06**	**5E-06**	**4E-06**	**3E-06**	**3E-06**
A O C 9	Baseline (area-wt) Risk Drivers	Arsenic (2E-06) T E Q for humans (5E-07) B (a) P E Q (1E-07) Hexavalent chromium (2E-07)	Arsenic (2E-06) T E Q for humans (4E-07) B (a) P E Q (1E-07) Hexavalent chromium (1E-07)	Arsenic (3E-06) T E Q for humans (1E-06) B (a) P E Q (3E-07) Hexavalent chromium (3E-07)	Arsenic (3E-06) T E Q for humans (7E-07) B (a) P E Q (2E-07) Hexavalent chromium (2E-07)	Arsenic (2E-06) Hexavalent chromium (7E-07) T E Q for humans (5E-07) B (a) P E Q (2E-07)	Arsenic (2E-06) Hexavalent chromium (5E-07) T E Q for humans (4E-07) B (a) P E Q (1E-07)
A O C 9	Baseline Excluding Background As (area-wt)	5E-07	5E-07	**2E-06**	1E-06	**2E-06**	1E-06
A O C 10	Baseline (depth-wt)	**2E-06**	**2E-06**	**5E-06**	**4E-06**	**3E-06**	**3E-06**
A O C 10	Baseline (depth-wt) Risk Drivers	Arsenic (2E-06)	Arsenic (2E-06)	Arsenic (4E-06)	Arsenic (4E-06)	Arsenic (2E-06)	Arsenic (2E-06)
A O C 10	Baseline Excluding Background As (depth-wt)	4E-07	4E-07	**2E-06**	9E-07	1E-06	1E-06
A O C 10	2-ft Scouring (depth-wt)	**2E-06**	**3E-06**	**5E-06**	**6E-06**	**3E-06**	**4E-06**
A O C 10	2-ft Scouring (depth-wt) Risk Drivers	Arsenic (2E-06)	Arsenic (2E-06) T E Q for humans (1E-06)	Arsenic (3E-06) T E Q for humans (1E-06)	Arsenic (3E-06) T E Q for humans (2E-06)	Arsenic (2E-06)	Arsenic (2E-06) T E Q for humans (1E-06)
A O C 10	2-ft Scouring Excluding Background As (depth-wt)	**4E-07**	**1E-06**	**2E-06**	**3E-06**	**1E-06**	**2E-06**
A O C 10	2-ft Scouring (area-wt)	**2E-06**	**2E-06**	**5E-06**	**5E-06**	**3E-06**	**3E-06**
A O C 10	2-ft Scouring (area-wt) Risk Drivers	Arsenic (2E-06)	Arsenic (2E-06)	Arsenic (3E-06) T E Q for humans (1E-06)	Arsenic (3E-06) T E Q for humans (1E-06)	Arsenic (2E-06) T E Q for humans (6E-07) Hexavalent chromium (6E-07)	Arsenic (2E-06) T E Q for humans (6E-07) Hexavalent chromium (4E-07)
A O C 10	2-ft Scouring Excluding Background As (area-wt)	4E-07	4E-07	**2E-06**	**2E-06**	1E-06	1E-06
A O C 10	5-ft Scouring (depth-wt)	**3E-06**	**2E-06**	**5E-06**	**5E-06**	**3E-06**	**3E-06**
A O C 10	5-ft Scouring (depth-wt) Risk Drivers	Arsenic (2E-06) T E Q for humans (5E-07)	Arsenic (2E-06)	Arsenic (4E-06) T E Q for humans (1E-06)	Arsenic (4E-06) T E Q for humans (1E-06)	Arsenic (2E-06) T E Q for humans (5E-07) Hexavalent chromium (2E-07)	Arsenic (2E-06) T E Q for humans (2E-07) Hexavalent chromium (1E-07)
A O C 10	5-ft Scouring Excluding Background As (depth-wt)	1E-06	4E-07	**2E-06**	**2E-06**	1E-06	1E-06
A O C 11	Baseline (depth-wt)	**2E-06**	**3E-06**	**5E-06**	**6E-06**	**3E-06**	**4E-06**
A O C 11	Baseline (depth-wt) Risk Drivers	Arsenic (2E-06) T E Q human (4E-07)	Arsenic (2E-06) T E Q human (1E-06))	Arsenic (4E-06) T E Q human (8E-07) Hexavalent chromium (2E-07)	Arsenic (4E-06) T E Q human (2E-06)	Arsenic (2E-06) T E Q human (4E-07) Hexavalent chromium (4E-07)	Arsenic (2E-06) T E Q human (1E-06) Hexavalent chromium (4E-07)

Table 5-4
HHRA Cancer Risk Estimate Summary

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Exposure Area	Scenario	Camper - Surface Soil	Camper - Shallow Soil	Hiker - Surface Soil	Hiker - Shallow Soil	OHV Rider - Surface Soil	OHV Rider - Shallow Soil
Background As Estimated LCR [a]	Footnote a	**2E-06**	**2E-06**	**3E-06**	**3E-06**	**2E-06**	**2E-06**
A O C 11	Baseline Excluding Background As (depth-wt)	4E-07	1E-06	**2E-06**	**3E-06**	**1E-06**	**2E-06**
A O C 11	Baseline (area-wt)	**2E-06**	**2E-06**	**5E-06**	**5E-06**	**3E-06**	**3E-06**
A O C 11	Baseline (area-wt) Risk Drivers	Arsenic (2E-06) T E Q human (3E-07) Hexavalent chromium (1E-07)	Arsenic (2E-06) T E Q human (3E-07) Hexavalent chromium (1E-07)	Arsenic (4E-06) T E Q human (6E-07) Hexavalent chromium (2E-07)	Arsenic (4E-06) T E Q human (6E-07) Hexavalent chromium (2E-07)	Arsenic (2E-06) Hexavalent chromium (5E-07) T E Q human (3E-07)	Arsenic (2E-06) Hexavalent chromium (5E-07) T E Q human (3E-07)
A O C 11	Baseline Excluding Background As (area-wt)	4E-07	4E-07	**2E-06**	**2E-06**	**1E-06**	**1E-06**
A O C 14	Baseline (depth-wt)	2E-07	2E-07	4E-07	4E-07	9E-07	7E-07
A O C 14	Baseline (depth-wt) Risk Drivers	NA	NA	NA	NA	NA	NA
A O C 27	Baseline (depth-wt)	7E-07	4E-07	1E-06	9E-07	9E-07	6E-07
A O C 27	Baseline (depth-wt) Risk Drivers	NA	NA	NA	NA	NA	NA

Notes:
a. Estimated lifetime cancer risk (LCR) for exposure to arsenic background concentrations in soil was calculated using the 95% upper confidence limit (UCL) on the mean background arsenic concentration as an estimate of the exposure point concentration (EPC).

Abbreviations:
--- = Scenario not evaluated for this exposure area.
- Area-weighted exposure point concentrations (EPC) are evaluated only for receptors and exposure areas where depth-weighted EPCs result in estimated incremental lifetime cancer risks (ILCRs) and hazard indices above 1 × 10-6 and 1, respectively, per the Risk Assessment Work Plan (RAWP, Arcadis 2008).
- Subsurface II soil is not evaluated for the 5-ft scouring scenarios.

A O C = area of concern.
Area-wt = results presented are for area-weighted EPCs.
BCW = bat cave wash.
C O P C = constituent of potential concern.
Depth-wt = results presented are for depth-weighted EPCs.
EPC = exposure point concentration.
NA = Not applicable. ILCR and HI drivers are presented only for the scenarios included in the exposure area-specfic evaluation and only for estimated ILCRs above 1×10^{-6} and estimated HIs above 1 which are represented by **bolded** values.
ND = Not detected. No carcinogenic COPCs were detected in this depth interval.
RAWP = Risk Assessment Work Plan.
T E Q human = dioxin toxicity equivalents for humans.

References:
Arcadis. 2008. Human Health and Ecological Risk Assessment Work Plan (RAWP), Topock Compressor Station, Needles, California. August.

Table 5-5
HHRA Noncancer Hazard Index Estimate Summary

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Exposure Area	Scenario	Camper - Surface Soil	Camper - Shallow Soil	Hiker - Surface Soil	Hiker - Shallow Soil	OHV Rider - Surface Soil	OHV Rider - Shallow Soil
Background As Estimated HI [a]	Footnote a	0.4	0.4	0.8	0.8	0.2	0.2
BCW	Baseline (depth-wt)	0.1	0.1	0.2	0.2	0.04	0.03
BCW	Baseline (depth-wt) Hazard Drivers	NA	NA	NA	NA	NA	NA
BCW	2-ft Scouring (depth-wt)	0.03	0.07	0.07	0.1	0.02	0.03
BCW	2-ft Scouring (depth-wt) Hazard Drivers	NA	NA	NA	NA	NA	NA
BCW	5-ft Scouring (depth-wt)	0.1	0.1	0.2	0.2	0.04	0.04
BCW	5-ft Scouring (depth-wt) Hazard Drivers	NA	NA	NA	NA	NA	NA
A O C 9	Baseline (depth-wt)	0.6	0.6	1	1	0.3	0.3
A O C 9	Baseline (depth-wt) Hazard Drivers	NA	NA	NA	NA	NA	NA
A O C 9	Baseline Excluding Background As (depth-wt)	0.2	0.2	0.2	0.2	0.1	0.1
A O C 9	Baseline (area-wt)	0.5	0.5	1.0	1.0	0.2	0.2
A O C 9	Baseline (area-wt) Hazard Drivers	NA	NA	NA	NA	NA	NA
A O C 9	Baseline Excluding Background As (area-wt)	0.1	0.1	0.2	0.2	0.03	0.03
A O C 10	Baseline (depth-wt)	0.6	0.7	1	1	0.3	0.3
A O C 10	Baseline (depth-wt) Hazard Drivers	NA	NA	NA	NA	NA	NA
A O C 10	Baseline Excluding Background As (depth-wt)	0.2	0.3	0.2	0.2	0.2	0.2
A O C 10	2-ft Scouring (depth-wt)	0.7	0.8	1	**2**	0.3	0.3
A O C 10	2-ft Scouring (depth-wt) Hazard Drivers	NA	NA	NA	Arsenic (0.9)	NA	NA
A O C 10	2-ft Scouring Excluding Background As (depth-wt)	0.3	0.4	0.6	1	0.1	0.1
A O C 10	2-ft Scouring (area-wt)	0.7	0.7	1	1	0.3	0.3
A O C 10	2-ft Scouring (area-wt) Hazard Drivers	NA	NA	NA	NA	NA	NA
A O C 10	2-ft Scouring Excluding Background As (area-wt)	0.3	0.3	0.2	0.2	0.1	0.1
A O C 10	5-ft Scouring (depth-wt)	0.6	0.6	1	1	0.3	0.3
A O C 10	5-ft Scouring (depth-wt) Hazard Drivers	NA	NA	NA	NA	NA	NA
A O C 10	5-ft Scouring Excluding Background As (depth-wt)	0.2	0.2	0.2	0.2	0.1	0.1

Table 5-5
HHRA Noncancer Hazard Index Estimate Summary

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Exposure Area	Scenario	Camper - Surface Soil	Camper - Shallow Soil	Hiker - Surface Soil	Hiker - Shallow Soil	OHV Rider - Surface Soil	OHV Rider - Shallow Soil
Background As Estimated HI [a]	Footnote a	0.4	0.4	0.8	0.8	0.2	0.2
A O C 11	Baseline (depth-wt)	0.5	0.6	1	1	0.2	0.3
A O C 11	Baseline (depth-wt) Hazard Drivers	NA	NA	NA	NA	NA	NA
A O C 11	Baseline Excluding Background As (depth-wt)	0.09	0.2	0.2	0.2	0.03	0.1
A O C 11	Baseline (area-wt)	0.6	0.6	1	1	0.2	0.2
A O C 11	Baseline (area-wt) Hazard Drivers	NA	NA	NA	NA	NA	NA
A O C 11	Baseline Excluding Background As (area-wt)	0.2	0.2	0.2	0.2	0.03	0.03
A O C 14	Baseline (depth-wt)	0.003	0.2	0.005	0.4	0.001	0.05
A O C 14	Baseline (depth-wt) Hazard Drivers	NA	NA	NA	NA	NA	NA
A O C 27	Baseline (depth-wt)	0.002	0.01	0.04	0.03	0.01	0.008
A O C 27	Baseline (depth-wt) Hazard Drivers	NA	NA	NA	NA	NA	NA

Notes:

a. Estimated hazard index (HI) for exposure to arsenic background concentrations in soil was calculated using the 95% upper confidence limit (95UCL) on the mean background arsenic concentration as an estimate of the exposure point concentration (EPC).

Abbreviations:

--- = Scenario not evaluated for this exposure area.
- Area-weighted exposure point concentrations (EPC) are evaluated only for receptors and exposure areas where depth-weighted EPCs result in estimated incremental lifetime cancer risks (ILCRs) and hazard indices above 1 × 10-6 and 1, respectively, per the Risk Assessment Work Plan (RAWP, Arcadis 2008).
- Subsurface II soil is not evaluated for the 5-ft scouring scenarios.

A O C = area of concern.
Area-wt = results presented are for area-weighted EPCs.
BCW = bat cave wash.
C O P C = constituent of potential concern.
Depth-wt = results presented are for depth-weighted EPCs.
EPC = exposure point concentration.
NA = Not applicable. ILCR and HI drivers are presented only for the scenarios included in the exposure area-specfic evaluation and only for estimated ILCRs above 1×10^{-6} and estimated HIs above 1 which are represented by **bolded** values.
RAWP = Risk Assessment Work Plan.
T E Q human = dioxin toxicity equivalents for humans.

References:

Arcadis. 2008. Human Health and Ecological Risk Assessment Work Plan (RAWP), Topock Compressor Station, Needles, California. August.

Table 5-6
Excavation and Backfill Information for NTCRA areas

Post-Soil NTCRA Human Health and Ecological Risk Assessment
PG&E Topock Compressor Station
Needles, California

TAA	Excavated Area (Sq Ft.)	Maximum Excavation Depth (Feet)	Backfill Volume (Bank Cyds)	Percentage of Excavation Area Backfilled	Backfill Description
AOC 01 TAA 1	1182	7	339	100	Backfilled area to grade with Campbells AB, compacted to 90%.
AOC 01 TAA 2	6321	10	2029	100	Backfilled with 3/4-inch plus screened rock to within 2 to 3 ft of surface. Campbells AB placed on top 2-3 ft. In areas where the BCW access road was removed and within 10 feet of the Transwestern gas pipeline, AB material was used from the excavation bottom to ground surface. Compaction testing of the AB material was conducted to confirm placement of the soil to 90% of the maximum dry density.
AOC 01 TAA 3	Part of SMWU1-1	4	18	100	Backfilled to grade with Campbells AB
AOC 09 TAA 1	336	3	140	100	Backfilled to grade with geofabric and 18-inches of riprap. Entire slope subsequently covered with shot-crete concrete by TCS Operations, not related to NTCRA Activities.
AOC 10 TAA 1	8417	5	2407	100	Backfilled select areas (top of Slope, bottom of slope near access road) to grade with geofabric and Campbells AB, compacted to 90%. 18-inches of riprap on slope, on top of geotextile fabric. Gravel and riprap on flat area at top of slope, large boulders at toe of slope. Entire slope subsequently covered with shot-crete concrete by TCS Operations, not related to NTCRA Activities.
AOC 10 TAA 2	28141	7	1827	~20	Limited backfill around existing monitoring wells, check dam, and at the base of steep slopes. Backfilled with reused onsite soil
AOC 10 TAA 3	824	2		0	Not backfilled. Area graded, and surface covered with gravel
AOC 10 TAA 4	6897	5	640	100	Backfilled with re-used onsite soil; compacted to 90%
AOC 11 TAA 1	3187	10	0	0	Not backfilled
AOC 14 TAA 1	8540	13	2428	100	Backfilled. Grade changed slightly. Campbells AB used to 90% compaction.
AOC 16 TAA 1	393	1	6	100	Backfilled to grade with Campbells AB
AOC 27 TAA 1	2071	7	674	100	Backfilled. Grade changed slightly. Campbells AB used to 90% compaction
SWMU 1 TAA 1	36354	10	10528	100	Backfilled to grade with 3/4-inch plus screened rock to within 2-3 feet of surface, then Campbells AB to surface. In the area where remedy pipeline crosses ravine, A 20 foot wide corridor of Campbells AB used for entire backfill depth (10 feet).
SWMU 1 TAA 2	11168	4	1839	20	Steep slope not backfilled. Excavation at bottom of slope backfiiled with Campbells AB and rip rap. Rip rip then covered with Campbell's AB. Approximately 420 CY of material were placed on top of the SWMU1 TAA2 riprap.
SWMU 1 TAA 3	Part of SMWU1-2	3	0	0	Not backfilled
Total Volume			**22875**		

Table 5-6
Excavation and Backfill Information for NTCRA areas

Post-Soil NTCRA Human Health and Ecological Risk Assessment
PG&E Topock Compressor Station
Needles, California

Notes:
Information summarized by Jacobs as presented in the Soil Non-Time-Critical Removal Action Completion Report (Jacobs 2025).
The Targeted Action Areas, excavation extent, and backfill volumes are also presented on Figure 5-2.

Acronyms and Abbreviations:
A O C = area of concern
Cyds = cubic yards
NTCRA = Non-Time Critical Removal Action
sq. ft = square feet
SWMU = Solid Waste Management Unit
T A A = targeted action area
TCS = Topock Compressor Station

Sources:
Jacobs 2025. Soil Non-Time-Critical Removal Action Completion Report. Topock Compressor Station, Needles, California. February.

Table 6-1
Exposure Parameters for Terrestrial Wildlife Receptor (Desert Shrew)

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Category	Parameter	Units	Desert Shrew	Source
Diet Composition	Plants	fraction	NA	NA
Diet Composition	Invertebrates	fraction	1	CDFG (CalEPA 2005)
Diet Composition	Mammals	fraction	NA	NA
Body Weight	Body Weight	kg	0.005	Based on average weight for M/F adults for desert shrew (Silva and Downing 1995)
Media Uptake	Water ingestion rate	L/kg bw-day	0.168	WIR (L/day) = 0.099 $BW(kg)^{0.90}$ Calder and Braun (1983)
Media Uptake	Food ingestion rate	kg/day	0.001	Nagy (2001); ingestion equation for insectivores
Media Uptake	Food ingestion rate units	kg/day	(dry weight)	Nagy (2001); ingestion equation for insectivores
Media Uptake	Percent soil in diet	%	2	Based on white-footed mouse (Beyer et al., 1994)
Media Uptake	Soil ingestion rate	kg/day	2.03E-05	Calculated: % soil * F I R
	AUF - conservative	unitless	1	NA
Home Range	Receptor home range	acres	0.1	Based on dusky shrew; Hawes (1977); cited in CDFG (CalEPA 2005)

Notes:
Exposure parameters presented are consistent with the RAWP and Technical Memorandums for the site (Arcadis 2008a, 2008b, and 2009).

Acronyms and Abbreviations:
NA = not applicable
% = percent
BW = body weight
CalEPA = California Environmental Protection Agency
CDFG = California Department of Fish and Game
F I R = food ingestion rate
FS = fraction soil
HR = home range
kg = kilogram
L = liter
M/F = male/female
S I R = soil ingestion rate
WIR = water ingestion rate

References:

Arcadis. 2008a. Final Human Health and Ecological Risk Assessment Work Plan. PG&E Topock Compressor Station, Needles, California. August.
Arcadis. 2008b. Technical Memorandum 3: Ecological Comparison Values for Metals and Polycyclic Aromatic Hydrocarbons in Soil. May 23.
Arcadis. 2009. Topock Compressor Station – Final Technical Memorandum 4: Ecological Comparison Values for Additional Detected Chemicals in Soil. July 1.
Beyer, W. N., E. Connor, and S. Gerould. 1994. Estimates of Soil Ingestion by Wildlife. Journal of Wildlife Management 58:375-382.
CalEPA. 2005. Biogeographic Data Branch: Wildlife Notes. California Environmental Protection Agency. Available at: http://www.dfg.ca.gov/bdb/html/cawildlife.html
Calder, W. A.; Braun, E. J. 1983. Scaling of osmotic regulation in mammals and birds. Am. J. Physiol. 244: R601-R606.
Hawes, M.L. 1977. Home range, territoriality, and ecological separation in sympatric shrews, *Sorex vagrans and Sorex obscurus* . J. Mammal. 58:354-367.
Nagy, K.A. 2001. Food requirements of wild animals: predictive equations for free-living mammals, reptiles, and birds. Nutrition Abstracts and Reviews, Series B71, 21R-31R.
Silva M. and J.A. Downing. 1995. CRC Handbook of Mammalian Body Masses.

Table 6-2
Bioaccumulation Factors for Estimating Tissue Concentrations from Soil

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Category	Constituent	Soil-to-Biota Bioaccumulation Factors BAF_{invert} (dw) (kg soil/kg tissue)	Soil-to-Biota Bioaccumulation Factor Source
Inorganics	Chromium, total	0.306	USEPA (2007)
Inorganics	Chromium, hexavalent	0.306	USEPA (2007)
Inorganics	Copper	0.515	USEPA (2007)
Dioxins	TEQ Mammals	$\ln(Ci) = 1.182 * \ln(Cs) + 3.533$	Sample et al. (1998)

Notes:
Bioaccumulation factors presented are consistent with the RAWP and Technical Memorandums for the site (Arcadis 2008a, 2008b, and 2009).

Acronyms and Abbreviations:
BAF = bioaccumulation factor
BAF_{invert} = soil-to-invertebrate uptake bioaccumulation factor (kilogram soil/kilogram tissue)
C_i = constituent concentration in invertebrates
C_s = constituent concentration in soil
dw = dry weight
kg = kilogram
U S E P A = United States Environmental Protection Agency

References:

Arcadis. 2008a. Final Human Health and Ecological Risk Assessment Work Plan. PG&E Topock Compressor Station, Needles, California. August.
Arcadis. 2008b. Technical Memorandum 3: Ecological Comparison Values for Metals and Polycyclic Aromatic Hydrocarbons in Soil. May 23.
Arcadis. 2009. Topock Compressor Station – Final Technical Memorandum 4: Ecological Comparison Values for Additional Detected Chemicals in Soil. July 1.
Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter, II, and T.L. Ashwood. 1998. Development and Validation of Bioaccumulation Models for Earthworms. ES/ER/TM-220. Oak Ridge National Laboratory, Oak Ridge TN. 93 pp.
U S E P A. 2007. Updated Attachment 4-1 to U S E P A's 2005 Guidance for Developing Ecological soil screening Levels (EcoSSLs): Exposure Factors and Bioaccumulation Models for Derivation of Wildlife Eco-SSLs Office of Solid Waste and Emergency Response, Washington D.C. February. 113 pp.

Table 6-3
Congener-Specific Bioaccumulation Factors for Dioxin TEQ

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Category	Constituent	Bioaccumulation Factors - Terrestrial Invertebrates
Congener-Specific Approach (U S E P A 1999)	1,2,3,4,6,7,8-hpcdd	0.081
Congener-Specific Approach (U S E P A 1999)	1,2,3,4,6,7,8-hpcdf	0.017
Congener-Specific Approach (U S E P A 1999)	1,2,3,4,7,8,9-hpcdf	0.62
Congener-Specific Approach (U S E P A 1999)	1,2,3,4,7,8-hxcdd	0.49
Congener-Specific Approach (U S E P A 1999)	1,2,3,4,7,8-hxcdf	0.121
Congener-Specific Approach (U S E P A 1999)	1,2,3,6,7,8-hxcdd	0.19
Congener-Specific Approach (U S E P A 1999)	1,2,3,6,7,8-hxcdf	0.3
Congener-Specific Approach (U S E P A 1999)	1,2,3,7,8,9-hxcdd	0.22
Congener-Specific Approach (U S E P A 1999)	1,2,3,7,8,9-hxcdf	1
Congener-Specific Approach (U S E P A 1999)	1,2,3,7,8-pecdd	1.46
Congener-Specific Approach (U S E P A 1999)	1,2,3,7,8-pecdf	0.32
Congener-Specific Approach (U S E P A 1999)	2,3,4,6,7,8-hxcdf	1.07
Congener-Specific Approach (U S E P A 1999)	2,3,4,7,8-pecdf	2.54
Congener-Specific Approach (U S E P A 1999)	2,3,7,8-tcdd	1.59
Congener-Specific Approach (U S E P A 1999)	2,3,7,8-tcdf	1.27
Congener-Specific Approach (U S E P A 1999)	ocdd	0.019
Congener-Specific Approach (U S E P A 1999)	ocdf	0.025
Congener-Specific Approach (Fagervold et al. 2010)[a]	1,2,3,4,6,7,8-hpcdd	0.20
Congener-Specific Approach (Fagervold et al. 2010)[a]	1,2,3,4,6,7,8-hpcdf	0.36
Congener-Specific Approach (Fagervold et al. 2010)[a]	1,2,3,4,7,8,9-hpcdf	0.34
Congener-Specific Approach (Fagervold et al. 2010)[a]	1,2,3,4,7,8-hxcdd	0.23
Congener-Specific Approach (Fagervold et al. 2010)[a]	1,2,3,4,7,8-hxcdf	0.48
Congener-Specific Approach (Fagervold et al. 2010)[a]	1,2,3,6,7,8-hxcdd	0.19
Congener-Specific Approach (Fagervold et al. 2010)[a]	1,2,3,6,7,8-hxcdf	0.59
Congener-Specific Approach (Fagervold et al. 2010)[a]	1,2,3,7,8,9-hxcdd	0.13
Congener-Specific Approach (Fagervold et al. 2010)[a]	1,2,3,7,8,9-hxcdf	1.22
Congener-Specific Approach (Fagervold et al. 2010)[a]	1,2,3,7,8-pecdd	0.18
Congener-Specific Approach (Fagervold et al. 2010)[a]	1,2,3,7,8-pecdf	0.79
Congener-Specific Approach (Fagervold et al. 2010)[a]	2,3,4,6,7,8-hxcdf	0.33
Congener-Specific Approach (Fagervold et al. 2010)[a]	2,3,4,7,8-pecdf	0.56
Congener-Specific Approach (Fagervold et al. 2010)[a]	2,3,7,8-tcdd	1.65
Congener-Specific Approach (Fagervold et al. 2010)[a]	2,3,7,8-tcdf	1.21
Congener-Specific Approach (Fagervold et al. 2010)[a]	ocdd	0.25
Congener-Specific Approach (Fagervold et al. 2010)[a]	ocdf	0.27

Notes:
a. Fagervold et al. (2010) bioaccumulation factors calculated using soil-to-earthworm 2,3,7,8-TCDD BAF for soil at location SW-20 (BAF = 1.65) and congener-specific earthworm bioaccumulation equivalency factors. See Table 6-34 of the 2019 H H E R A (Arcadis 2019).

Acronyms and Abbreviations:
BAF = bioaccumulation factor
NA = not available
U S E P A = United States Environmental Protection Agency

References:

Arcadis. 2019. Final Soil Human Health and Ecological Risk Assessment Report, Topock Compressor Station, Needles, California.
Fagervold, SK, Y Chai, JW Davis, M Wilken, G Cornelissen, and U Ghosh. 2010. Bioaccumulation of polychlorinated dibenzo-p-dioxins/dibenzofurans in E. fetida from floodplain soils and the effect of activated carbon amendment. Environ Sci Technol. 44(14):5546-52.
U S E P A. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. U.S. Environmental Protection Agency Peer Review Draft. August.

U S E P A. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. U.S. Environmental Protection Agency Peer Review Draft. August.

Table 6-4
Toxicity Reference Values for Wildlife

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Category	Constituent	Wildlife TRVs (mg/kg-bw/day)[a,b] Mammals - Low TRV (N O A E L)	Mammals Low TRV (N O A E L) TRV Test Species	Mammals Low TRV (N O A E L) Test Species Body Weight (kg)	Wildlife TRVs (mg/kg-bw/day)[a,b] Mammals - Source	Wildlife TRVs (mg/kg-bw/day)[a,b] Mammals - High TRV (L O A E L)	Mammals High TRV (L O A E L) TRV Test Species	Mammals High TRV (L O A E L) Test Species Body Weight (kg)	Wildlife TRVs (mg/kg-bw/day)[a,b] Mammals - Source	Allometrically Converted Wildlife TRVs (mg/kg-bw/day)[c] Mammals - Low TRV (N O A E L)	Allometrically Converted Wildlife TRVs (mg/kg-bw/day)[c] Mammals - Low TRV (L O A E L)
Inorganics	Chromium, total	2.40	NA (Geometric Mean)	NA (Geometric Mean)	U S E P A (2008)	9.62	Mouse	0.025	U S E P A (2008)	NA	NA
Inorganics	Chromium, hexavalent	9.24	NA (Geometric Mean)	NA (Geometric Mean)	U S E P A (2008)	38.4	NA (Geometric Mean)	NA (Geometric Mean)	U S E P A (2008)	NA	NA
Inorganics	Copper	5.60	Pig	100	U S E P A (2008)	9.34	Pig	100	U S E P A (2008)	9.43	15.7
Dioxins (presented in ng/kg-bw/day)	TEQ Mammals	4.9 (Note 1)			Geometric mean	30 (Note 1)			Geometric mean	NA	NA

Notes:
Note 1 Blue Note 1 indicates new or updated values from those presented in the RAWP and Technical Memorandums. Dioxin TRVs are discussed in Section 6.7.5 of the 2019 HHERA (Arcadis 2019).

a. EcoSSLs (U S E P A 2008) were preferentially selected.
b. Some sources provide only N O A E L-based TRVs. Therefore, L O A E L-based TRVs were developed for mammals as follows:
(a) If a bounded N O A E L-based TRV was recommended, the L O A E L from the same study and endpoint was selected.
(b) If the recommended N O A E L-based TRV was unbounded, the lowest reproduction, growth, and survival L O A E L greater than the N O A E L-based TRV was selected.
(c) If the recommended N O A E L-based TRV was a geometric mean of the reproduction and growth N O A E Ls, the geometric mean of the reproduction and growth L O A E Ls was selected.
(d) The mammalian N O A E L-based TRV for chromium is the geometric mean of the reproduction and growth N O A E Ls. However, no bounded N O A E Ls or L O A E Ls were contained in the dataset.
c. The TRV was allometrically adjusted when the body weights of the test species and receptor species differ by two orders of magnitude (DTSC 1999). Sample and Arenal (1999) equation used: Aw = At * (BWt/BWw)^1-b
Where:
Aw = toxicity value of wildlife species
At = toxicity value of test species (TRV)
BWt = body weight of test species (i.e., for copper, test species was based on 100 kg pig)
BWw = body weight of wildlife species (i.e., 0.005 kg for desert shrew)
b = allometric scaling factor (0.94 for mammals)

Acronyms and Abbreviations:
L O A E L = lowest observed adverse effects level
mg/kg-bw/day = milligrams per kilogram of body weight per day
NA = not applicable
ng/kg-bw/day = nanograms per kilogram of body weight per day
N O A E L = no observed adverse effects level
TEQ = toxic equivalency
TRV = toxicity reference value
U S E P A = United States Environmental Protection Agency

References:
Arcadis. 2019. Final Soil Human Health and Ecological Risk Assessment Report, Topock Compressor Station, Needles, California.
U S E P A. 2008. Guidance for Developing Ecological Soil Screening Levels, Interim Final Documents. Available at: https://rais.ornl.gov/guidance/epa_eco.html.

Table 6-5
Desert Shrew Risk Estimate Summary for BCW

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Scenario	Category	C O P E C	BAF Type'	Desert Shrew Depth-Weighted L O A E L HQ TRV Used for RBRG Development SUF = 1	Desert Shrew Depth-Weighted L O A E L HQ Notes	Desert Shrew Area-Weighted L O A E L HQ TRV Used for RBRG Development SUF = 1	Desert Shrew Area-Weighted L O A E L HQ Notes	W O E Result[a]
Baseline	Inorganics	Chromium, hexavalent	Selected BAF	6E-04	None	5E-04	None	HQ less than or equal to 1
Baseline	Inorganics	Chromium, total	Selected BAF	2E-01	None	2E-01	None	HQ less than or equal to 1
Baseline	Inorganics	Copper	Selected BAF	1E-01	None	9E-02	None	HQ less than or equal to 1
Baseline	Dioxins	TEQ Mammals	Selected BAF	**2E+00**	Note 1	**2E+00**	Note 1	See W O E for Alternate BAFs
Baseline	Dioxins	TEQ Mammals	Alternate BAF (USEPA 1999)	8E-02	None	--	None	HQ less than or equal to 1
Baseline	Dioxins	TEQ Mammals	Alternate BAF (Fagervold et al. 2010)	7E-02	None	--	None	HQ less than or equal to 1
2 ft Scouring	Inorganics	Chromium, hexavalent	Selected BAF	7E-04	None	1E-03	None	HQ less than or equal to 1
2 ft Scouring	Inorganics	Chromium, total	Selected BAF	3E-01	None	5E-01	None	HQ less than or equal to 1
2 ft Scouring	Inorganics	Copper	Selected BAF	8E-02	None	8E-02	None	HQ less than or equal to 1
2 ft Scouring	Dioxins	TEQ Mammals	Selected BAF	9E-01	None	6E-01	None	See W O E for Alternate BAFs
2 ft Scouring	Dioxins	TEQ Mammals	Alternate BAF (USEPA 1999)	4E-02	None	--	None	HQ less than or equal to 1
2 ft Scouring	Dioxins	TEQ Mammals	Alternate BAF (Fagervold et al. 2010)	6E-02	None	--	None	HQ less than or equal to 1
5 ft Scouring	Inorganics	Chromium, hexavalent	Selected BAF	9E-04	None	6E-04	None	HQ less than or equal to 1
5 ft Scouring	Inorganics	Chromium, total	Selected BAF	3E-01	None	2E-01	None	HQ less than or equal to 1
5 ft Scouring	Inorganics	Copper	Selected BAF	8E-02	None	8E-02	None	HQ less than or equal to 1
5 ft Scouring	Dioxins	TEQ Mammals	Selected BAF	1E+00	None	1E+00	None	See W O E for Alternate BAFs
5 ft Scouring	Dioxins	TEQ Mammals	Alternate BAF (USEPA 1999)	1E-01	None	--	None	HQ less than or equal to 1
5 ft Scouring	Dioxins	TEQ Mammals	Alternate BAF (Fagervold et al. 2010)	3E-01	None	--	None	Unlikely

Notes:
[a] W O E result for dioxin TEQ is risk conclusion based on 1) L O A E L HQ based on depth-weighted EPCs and assumptions used for RBRG development (i.e., a SUF of 1, congener-specific BAFs, and alternate TRVs), and 2) supporting L O E s. W O E result for metals is risk conclusion based on 1) L O A E L HQ based on area-weighted EPCs and assumptions used for RBRG development (i.e., a SUF of 1 and selected BAFs and TRVs), and 2) supporting L O E s.

Green	L O A E L HQ greater than 1
Yellow	L O A E L HQ greater than 10
Orange	L O A E L HQ greater than 100

Acronyms and Abbreviations:
"--" = not applicable
A O C = area of concern
B A F = bioaccumulation factor
BCW = Bat Cave Wash
C O P E C = constituent of potential ecological concern
E P C = exposure point concentration
HQ = hazard quotient
L O A E L = lowest observed adverse effect level
L O E = line of evidence
R B R G = risk-based remedial goal
S U F = site use factor
T E Q = toxicity equivalent
T R V = toxicity reference value
U S E P A = United States Environmental Protection Agency
W O E = weight of evidence, considering multiple L O E s. If L O A E L HQs are greater than 1, W O E Result is either 1) not expected, 2) unlikely, or 3) possible.

Table 6-6
Desert Shrew Risk Estimate Summary for AOC 9

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Scenario	Category	C O P E C	BAF Type'	Desert Shrew Depth-Weighted L O A E L HQ TRV Used for RBRG Development SUF = 1	Desert Shrew Depth-Weighted L O A E L HQ Notes	Desert Shrew Area-Weighted L O A E L HQ TRV Used for RBRG Development SUF = 1	Desert Shrew Area-Weighted L O A E L HQ Notes	W O E Result[a]
Baseline	Inorganics	Chromium, hexavalent	Selected BAF	6E-03	None	4E-03	None	HQ less than or equal to 1
Baseline	Inorganics	Chromium, total	Selected BAF	3E-01	None	3E-01	None	HQ less than or equal to 1
Baseline	Inorganics	Copper	Selected BAF	3E-01	None	3E-01	None	HQ less than or equal to 1
Baseline	Dioxins	TEQ Mammals	Selected BAF	**4E+00**	Note 1	**5E+00**	Note 1	See W O E for Alternate BAFs
Baseline	Dioxins	TEQ Mammals	Alternate BAF (USEPA 1999)	3E-01	None	--	None	HQ less than or equal to 1
Baseline	Dioxins	TEQ Mammals	Alternate BAF (Fagervold et al. 2010)	2E-01	None	--	None	HQ less than or equal to 1

Notes:

[a] W O E result for dioxin TEQ is risk conclusion based on 1) L O A E L HQ based on depth-weighted EPCs and assumptions used for RBRG development (i.e., a SUF of 1, congener-specific BAFs, and alternate TRVs), and 2) supporting L O E s. W O E result for metals is risk conclusion based on 1) L O A E L HQ based on area-weighted EPCs and assumptions used for RBRG development (i.e., a SUF of 1 and selected BAFs and TRVs), and 2) supporting L O E s.

Note 1	L O A E L HQ greater than 1
Note 2	L O A E L HQ greater than 10
Note 3	L O A E L HQ greater than 100

Acronyms and Abbreviations:

"--" = not applicable
A O C = area of concern
B A F = bioaccumulation factor
C O P E C = constituent of potential ecological concern
E P C = exposure point concentration
HQ = hazard quotient
L O A E L = lowest observed adverse effect level
L O E = line of evidence
R B R G = risk-based remedial goal
S U F = site use factor
T E Q = toxicity equivalent
T R V = toxicity reference value
U S E P A = United States Environmental Protection Agency
W O E = weight of evidence, considering multiple L O E s. If L O A E L HQs are greater than 1, W O E Result is either 1) not expected, 2) unlikely, or 3) possible.

Table 6-7
Desert Shrew Risk Estimate Summary for AOC 10

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Scenario	Category	C O P E C	BAF Type'	Desert Shrew Depth-Weighted L O A E L HQ TRV Used for RBRG Development SUF = 1	Desert Shrew Depth-Weighted L O A E L HQ Notes	Desert Shrew Area-Weighted L O A E L HQ TRV Used for RBRG Development SUF = 1	Desert Shrew Area-Weighted L O A E L HQ Notes	W O E Result[a]
Baseline	Inorganics	Chromium, hexavalent	Selected BAF	2E-03	None	2E-03	None	HQ less than or equal to 1
Baseline	Inorganics	Chromium, total	Selected BAF	3E-01	None	3E-01	None	HQ less than or equal to 1
Baseline	Inorganics	Copper	Selected BAF	1E-01	None	1E-01	None	HQ less than or equal to 1
Baseline	Dioxins	TEQ Mammals	Selected BAF	5E-01	None	2E-01	None	See W O E for Alternate BAFs
Baseline	Dioxins	TEQ Mammals	Alternate BAF (USEPA 1999)	4E-02	None	--	None	HQ less than or equal to 1
Baseline	Dioxins	TEQ Mammals	(Fagervold et al. 2010)	5E-02	None	--	None	HQ less than or equal to 1
2 ft Scouring	Inorganics	Chromium, hexavalent	Selected BAF	2E-03	None	3E-03	None	HQ less than or equal to 1
2 ft Scouring	Inorganics	Chromium, total	Selected BAF	2E-01	None	3E-01	None	HQ less than or equal to 1
2 ft Scouring	Inorganics	Copper	Selected BAF	1E-01	None	1E-01	None	HQ less than or equal to 1
2 ft Scouring	Dioxins	TEQ Mammals	Selected BAF	**6E+00**	Note 1	**5E+00**	Note 1	See W O E for Alternate BAFs
2 ft Scouring	Dioxins	TEQ Mammals	Alternate BAF (USEPA 1999)	3E-01	None	--	None	Unlikely
2 ft Scouring	Dioxins	TEQ Mammals	(Fagervold et al. 2010)	2E-01		--	None	HQ less than or equal to 1
5 ft Scouring	Inorganics	Chromium, hexavalent	Selected BAF	8E-04	None	7E-04	None	HQ less than or equal to 1
5 ft Scouring	Inorganics	Chromium, total	Selected BAF	3E-01	None	3E-01	None	HQ less than or equal to 1
5 ft Scouring	Inorganics	Copper	Selected BAF	1E-01	None	1E-01	None	HQ less than or equal to 1
5 ft Scouring	Dioxins	TEQ Mammals	Selected BAF	**4E+00**	Note 1	**4E+00**	Note 1	See W O E for Alternate BAFs
5 ft Scouring	Dioxins	TEQ Mammals	Alternate BAF (USEPA 1999)	1E-01	None	--	None	HQ less than or equal to 1
5 ft Scouring	Dioxins	TEQ Mammals	(Fagervold et al. 2010)	1E-01	None	--	None	HQ less than or equal to 1

Notes:
[a] W O E result for dioxin TEQ is risk conclusion based on 1) L O A E L HQ based on depth-weighted EPCs and assumptions used for RBRG development (i.e., a SUF of 1, congener-specific BAFs, and alternate TRVs), and 2) supporting L O E s. W O E result for metals is risk conclusion based on 1) L O A E L HQ based on area-weighted EPCs and assumptions used for RBRG development (i.e., a SUF of 1 and selected BAFs and TRVs), and 2) supporting L O E s.

Note 1	L O A E L HQ greater than 1
Note 2	L O A E L HQ greater than 10
Note 3	L O A E L HQ greater than 100

Acronyms and Abbreviations:
"--" = not applicable
A O C = area of concern
B A F = bioaccumulation factor
C O P E C = constituent of potential ecological concern
E P C = exposure point concentration
HQ = hazard quotient
L O A E L = lowest observed adverse effect level
L O E = line of evidence
R B R G = risk-based remedial goal
S U F = site use factor
T E Q = toxicity equivalent
T R V = toxicity reference value
U S E P A = United States Environmental Protection Agency
W O E = weight of evidence, considering multiple L O E s. If L O A E L HQs are greater than 1, W O E Result is either 1) not expected, 2) unlikely, or 3) possible.

Table 6-8
Desert Shrew Risk Estimate Summary for AOC 11

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Scenario	Category	C O P E C	BAF Type'	Desert Shrew Depth-Weighted L O A E L HQ TRV Used for RBRG Development SUF = 1	Desert Shrew Depth-Weighted L O A E L HQ Notes	Desert Shrew Area-Weighted L O A E L HQ TRV Used for RBRG Development SUF = 1	Desert Shrew Area-Weighted L O A E L HQ Notes	W O E Result[a]
Baseline	Inorganics	Chromium, hexavalent	Selected BAF	2E-03	None	3E-03	None	HQ less than or equal to 1
Baseline	Inorganics	Chromium, total	Selected BAF	3E-01	None	3E-01	None	HQ less than or equal to 1
Baseline	Inorganics	Copper	Selected BAF	9E-02	None	9E-02	None	HQ less than or equal to 1
Baseline	Dioxins	TEQ Mammals	Selected BAF	**3E+00**	Note 1	**3E+00**	Note 1	See W O E for Alternate BAFs
Baseline	Dioxins	TEQ Mammals	Alternate BAF (USEPA 1999)	4E-01	None	--	None	HQ less than or equal to 1
Baseline	Dioxins	TEQ Mammals	Alternate BAF (Fagervold et al. 2010)	2E-01	None	--	None	HQ less than or equal to 1

Notes:
[a] W O E result for dioxin TEQ is risk conclusion based on 1) L O A E L HQ based on depth-weighted EPCs and assumptions used for RBRG development (i.e., a SUF of 1, congener-specific BAFs, and alternate TRVs), and 2) supporting L O E s. W O E result for metals is risk conclusion based on 1) L O A E L HQ based on area-weighted EPCs and assumptions used for RBRG development (i.e., a SUF of 1 and selected BAFs and TRVs), and 2) supporting L O E s.

Note 1	L O A E L HQ greater than 1
Note 2	L O A E L HQ greater than 10
Note 3	L O A E L HQ greater than 100

Acronyms and Abbreviations:

"--" = not applicable
A O C = area of concern
B A F = bioaccumulation factor
C O P E C = constituent of potential ecological concern
E P C = exposure point concentration
HQ = hazard quotient
L O A E L = lowest observed adverse effect level
L O E = line of evidence
R B R G = risk-based remedial goal
S U F = site use factor
T E Q = toxicity equivalent
T R V = toxicity reference value
U S E P A = United States Environmental Protection Agency
W O E = weight of evidence, considering multiple L O E s. If L O A E L HQs are greater than 1, W O E Result is either 1) not expected, 2) unlikely, or 3) possible.

Table 6-9
Desert Shrew Risk Estimate Summary for AOC 14

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Scenario	Category	C O P E C	BAF Type'	Desert Shrew Depth-Weighted L O A E L HQ TRV Used for RBRG Development SUF = 1	Desert Shrew Depth-Weighted L O A E L HQ Notes	Desert Shrew Area-Weighted L O A E L HQ TRV Used for RBRG Development SUF = 1	Desert Shrew Area-Weighted L O A E L HQ Notes	W O E Result[a]
Baseline	Inorganics	Chromium, hexavalent	Selected BAF	5E-03	None	5E-03	None	HQ less than or equal to 1
Baseline	Inorganics	Chromium, total	Selected BAF	1E-01	None	1E-01	None	HQ less than or equal to 1
Baseline	Inorganics	Copper	Selected BAF	1E-01	None	1E-01	None	HQ less than or equal to 1
Baseline	Dioxins	TEQ Mammals	Selected BAF	2E-02	None	2E-02	None	HQ less than or equal to 1

Notes:

[a] W O E result for dioxin TEQ is risk conclusion based on 1) L O A E L HQ based on area-weighted EPCs and assumptions used for RBRG development (i.e., a SUF of 1, selected BAFs, and alternate TRVs), and 2) supporting L O E s. W O E result for metals is risk conclusion based on 1) L O A E L HQ based on area-weighted EPCs and assumptions used for RBRG development (i.e., a SUF of 1 and selected BAFs and TRVs), and 2) supporting L O E s.

Note 1	L O A E L HQ greater than 1
Note 2	L O A E L HQ greater than 10
Note 3	L O A E L HQ greater than 100

Acronyms and Abbreviations:

"--" = not applicable
A O C = area of concern
B A F = bioaccumulation factor
C O P E C = constituent of potential ecological concern
E P C = exposure point concentration
HQ = hazard quotient
L O A E L = lowest observed adverse effect level
L O E = line of evidence
R B R G = risk-based remedial goal
S U F = site use factor
T E Q = toxicity equivalent
T R V = toxicity reference value
U S E P A = United States Environmental Protection Agency
W O E = weight of evidence, considering multiple L O E s. If L O A E L HQs are greater than 1, W O E Result is either 1) not expected, 2) unlikely, or 3) possible.

Table 6-10
Desert Shrew Risk Estimate Summary for AOC 27

Post-Soil N T C R A Human Health and Ecological Risk Assessment Report
PG&E Topock Compressor Station
Needles, California

Scenario	Category	C O P E C	BAF Type'	Desert Shrew Depth-Weighted L O A E L HQ TRV Used for RBRG Development SUF = 1	Desert Shrew Depth-Weighted L O A E L HQ Notes	Desert Shrew Area-Weighted L O A E L HQ TRV Used for RBRG Development SUF = 1	Desert Shrew Area-Weighted L O A E L HQ Notes	W O E Result[a]
Baseline	Inorganics	Chromium, hexavalent	Selected BAF	4E-04	None	4E-04	None	HQ less than or equal to 1
Baseline	Inorganics	Chromium, total	Selected BAF	1E-01	None	1E-01	None	HQ less than or equal to 1
Baseline	Inorganics	Copper	Selected BAF	1E-01	None	9E-02	None	HQ less than or equal to 1
Baseline	Dioxins	TEQ Mammals	Selected BAF	9E-01	None	9E-01	None	See W O E for Alternate BAFs
Baseline	Dioxins	TEQ Mammals	Alternate BAF (USEPA 1999)	1E-01	None	--	None	HQ less than or equal to 1
Baseline	Dioxins	TEQ Mammals	Alternate BAF (Fagervold et al. 2010)	8E-02	None	--	None	HQ less than or equal to 1

Notes:

[a] W O E result for dioxin TEQ is risk conclusion based on 1) L O A E L HQ based on depth-weighted EPCs and assumptions used for RBRG development (i.e., a SUF of 1, congener-specific BAFs, and alternate TRVs), and 2) supporting L O E s. W O E result for metals is risk conclusion based on 1) L O A E L HQ based on area-weighted EPCs and assumptions used for RBRG development (i.e., a SUF of 1 and selected BAFs and TRVs), and 2) supporting L O E s.

Note 1	L O A E L HQ greater than 1
Note 2	L O A E L HQ greater than 10
Note 3	L O A E L HQ greater than 100

Acronyms and Abbreviations:

"--" = not applicable
A O C = area of concern
B A F = bioaccumulation factor
C O P E C = constituent of potential ecological concern
E P C = exposure point concentration
HQ = hazard quotient
L O A E L = lowest observed adverse effect level
L O E = line of evidence
R B R G = risk-based remedial goal
S U F = site use factor
T E Q = toxicity equivalent
T R V = toxicity reference value
U S E P A = United States Environmental Protection Agency
W O E = weight of evidence, considering multiple L O E s. If L O A E L HQs are greater than 1, W O E Result is either 1) not expected, 2) unlikely, or 3) possible.

Table 6-11
Comparison of Tissue Exposure Point Concentrations for Dioxin TEQ in the Baseline (No Scouring) Scenario (from 2019 HHERA)
Bat Cave Wash (0 to 0.5 foot bgs)

Post-Soil NTCRA Human Health and Ecological Risk Assessment
PG&E Topock Compressor Station
Needles, California

Approach	Constituent	Units	Soil EPCs [a] - 95% UCL	Soil EPCs [a] - 95% UCL Method	BAFs - Plants	BAFs - Terrestrial Invertebrates	Tissue EPCs - Plants	Tissue EPCs - Terrestrial Invertebrates	TEFs [b] - Mammal	TEFs [b] - Avian	Tissue EPCs (Mammal TEF Applied) - Plants	Tissue EPCs (Mammal TEF Applied) - Terrestrial Invertebrates	Tissue EPCs (Avian TEF Applied) - Plants	Tissue EPCs (Avian TEF Applied) - Terrestrial Invertebrates
Congener-Specific Approach (U S E P A 1999)	1,2,3,4,6,7,8-hpcdd	ng/kg	7414	KM H-UCL	0.00029	0.081	2.15	601	0.01	0.001	0.022	6.01	0.00	0.60
Congener-Specific Approach (U S E P A 1999)	1,2,3,4,6,7,8-hpcdf	ng/kg	1417	KM H-UCL	0.000062	0.017	0.088	24	0.01	0.01	0.00088	0.24	0.00	0.24
Congener-Specific Approach (U S E P A 1999)	1,2,3,4,7,8,9-hpcdf	ng/kg	7.876	95% KM Approximate Gamma UCL	0.0022	0.62	0.017	4.88	0.01	0.01	0.00017	0.049	0.00017	0.049
Congener-Specific Approach (U S E P A 1999)	1,2,3,4,7,8-hxcdd	ng/kg	37.15	KM H-UCL	0.0017	0.49	0.063	18	0.1	0.05	0.0063	1.8	0.0032	0.91
Congener-Specific Approach (U S E P A 1999)	1,2,3,4,7,8-hxcdf	ng/kg	12.64	95% KM Approximate Gamma UCL	0.00043	0.121	0.005	1.53	0.1	0.1	0.00054	0.15	0.00054	0.15
Congener-Specific Approach (U S E P A 1999)	1,2,3,6,7,8-hxcdd	ng/kg	702	KM H-UCL	0.00067	0.19	0.470	133	0.1	0.01	0.047	13	0.0047	1.3
Congener-Specific Approach (U S E P A 1999)	1,2,3,6,7,8-hxcdf	ng/kg	19.97	KM H-UCL	0.0011	0.3	0.022	5.99	0.1	0.1	0.0022	0.60	0.0022	0.60
Congener-Specific Approach (U S E P A 1999)	1,2,3,7,8,9-hxcdd	ng/kg	258.1	KM H-UCL	0.00078	0.22	0.201	57	0.1	0.1	0.020	5.7	0.020	5.7
Congener-Specific Approach (U S E P A 1999)	1,2,3,7,8,9-hxcdf	ng/kg	0.935	95% KM (t) UCL	0.0035	1	0.003	0.94	0.1	0.1	0.00033	0.094	0.00033	0.094
Congener-Specific Approach (U S E P A 1999)	1,2,3,7,8-pecdd	ng/kg	9.44	KM H-UCL	0.0052	1.46	0.049	14	1	1	0.049	14	0.049	14
Congener-Specific Approach (U S E P A 1999)	1,2,3,7,8-pecdf	ng/kg	1.233	95% KM (t) UCL	0.0011	0.32	0.001	0.39	0.03	0.1	0.000041	0.012	0.00014	0.039
Congener-Specific Approach (U S E P A 1999)	2,3,4,6,7,8-hxcdf	ng/kg	5.219	95% KM (t) UCL	0.0038	1.07	0.020	5.58	0.1	0.1	0.0020	0.56	0.0020	0.56
Congener-Specific Approach (U S E P A 1999)	2,3,4,7,8-pecdf	ng/kg	131.7	95% KM (Chebyshev) UCL	0.009	2.54	1.19	335	0.3	1	0.36	100	1.2	335
Congener-Specific Approach (U S E P A 1999)	2,3,7,8-tcdd	ng/kg	6.176	95% KM Approximate Gamma UCL	0.0056	1.59	0.035	9.82	1	1	0.035	9.8	0.035	9.8
Congener-Specific Approach (U S E P A 1999)	2,3,7,8-tcdf	ng/kg	2.106	KM H-UCL	0.0045	1.27	0.009	2.67462	0.1	1	0.00095	0.27	0.0095	2.7

Table 6-11
Comparison of Tissue Exposure Point Concentrations for Dioxin TEQ in the Baseline (No Scouring) Scenario
Bat Cave Wash (0 to 0.5 foot bgs)

Post-Soil NTCRA Human Health and Ecological Risk Assessment
PG&E Topock Compressor Station
Needles, California

Approach	Constituent	Units	Soil EPCs [a] - 95% UCL	Soil EPCs [a] - 95% UCL Method	BAFs - Plants	BAFs - Terrestrial Invertebrates	Tissue EPCs - Plants	Tissue EPCs - Terrestrial Invertebrates	TEFs [b] - Mammal	TEFs [b] - Avian	Tissue EPCs (Mammal TEF Applied) - Plants	Tissue EPCs (Mammal TEF Applied) - Terrestrial Invertebrates	Tissue EPCs (Avian TEF Applied) - Plants	Tissue EPCs (Avian TEF Applied) - Terrestrial Invertebrates
Congener-Specific Approach (U S E P A 1999)	ocdd	ng/kg	68608	95% H-UCL	0.000067	0.019	4.60	1304	0.0003	0.0001	0.0014	0.39	0.00046	0.13
Congener-Specific Approach (U S E P A 1999)	ocdf	ng/kg	13371	95% KM (Chebyshev) UCL	0.00009	0.025	1.20	334	0.0003	0.0001	0.00036	0.10	0.00012	0.033
Congener-Specific Approach (U S E P A 1999)	Dioxin TEQ	ng/kg									**0.5**	**153**	**1.3**	**371**
Congener-Specific Approach (Fagervold et al. 2010)[c]	1,2,3,4,6,7,8-hpcdd	ng/kg	7414	KM H-UCL	Not available	0.20	'Not available	1467	0.01	0.001	'Not available	14.67	'Not available	1.47
Congener-Specific Approach (Fagervold et al. 2010)[c]	1,2,3,4,6,7,8-hpcdf	ng/kg	1417	KM H-UCL	'Not available	0.36	'Not available	504	0.01	0.01	'Not available	5.04	'Not available	5.04
Congener-Specific Approach (Fagervold et al. 2010)[c]	1,2,3,4,7,8,9-hpcdf	ng/kg	7.876	95% KM Approximate Gamma UCL	'Not available	0.34	'Not available	2.66	0.01	0.01	'Not available	0.027	'Not available	0.027
Congener-Specific Approach (Fagervold et al. 2010)[c]	1,2,3,4,7,8-hxcdd	ng/kg	37.15	KM H-UCL	'Not available	0.23	'Not available	8.51	0.1	0.05	'Not available	0.9	'Not available	0.43
Congener-Specific Approach (Fagervold et al. 2010)[c]	1,2,3,4,7,8-hxcdf	ng/kg	12.64	95% KM Approximate Gamma UCL	'Not available	0.48	'Not available	6.01	0.1	0.1	'Not available	0.60	'Not available	0.60
Congener-Specific Approach (Fagervold et al. 2010)[c]	1,2,3,6,7,8-hxcdd	ng/kg	702	KM H-UCL	'Not available	0.19	'Not available	135	0.1	0.01	'Not available	14	Not available	1.4
Congener-Specific Approach (Fagervold et al. 2010)[c]	1,2,3,6,7,8-hxcdf	ng/kg	19.97	KM H-UCL	'Not available	0.59	'Not available	11.7	0.1	0.1	'Not available	1.17	'Not available	1.17
Congener-Specific Approach (Fagervold et al. 2010)[c]	1,2,3,7,8,9-hxcdd	ng/kg	258.1	KM H-UCL	'Not available	0.13	'Not available	33	0.1	0.1	'Not available	3.3	'Not available	3.3
Congener-Specific Approach (Fagervold et al. 2010)[c]	1,2,3,7,8,9-hxcdf	ng/kg	0.935	95% KM (t) UCL	'Not available	1.22	'Not available	1.14	0.1	0.1	'Not available	0.114	'Not available	0.114

Table 6-11
Comparison of Tissue Exposure Point Concentrations for Dioxin TEQ in the Baseline (No Scouring) Scenario
Bat Cave Wash (0 to 0.5 foot bgs)

Post-Soil NTCRA Human Health and Ecological Risk Assessment
PG&E Topock Compressor Station
Needles, California

Approach	Constituent	Units	Soil EPCs [a] - 95% UCL	Soil EPCs [a] - 95% UCL Method	BAFs - Plants	BAFs - Terrestrial Invertebrates	Tissue EPCs - Plants	Tissue EPCs - Terrestrial Invertebrates	TEFs [b] - Mammal	TEFs [b] - Avian	Tissue EPCs (Mammal TEF Applied) - Plants	Tissue EPCs (Mammal TEF Applied) - Terrestrial Invertebrates	Tissue EPCs (Avian TEF Applied) - Plants	Tissue EPCs (Avian TEF Applied) - Terrestrial Invertebrates
Congener-Specific Approach (Fagervold et al. 2010)[c]	1,2,3,7,8-pecdd	ng/kg	9.44	KM H-UCL	'Not available	0.18	'Not available	1.73	1	1	'Not available	2	'Not available	2
Congener-Specific Approach (Fagervold et al. 2010)[c]	1,2,3,7,8-pecdf	ng/kg	1.233	95% KM (t) UCL	'Not available	0.79	'Not available	0.97	0.03	0.1	'Not available	0.029	'Not available	0.097
Congener-Specific Approach (Fagervold et al. 2010)[c]	2,3,4,6,7,8-hxcdf	ng/kg	5.219	95% KM (t) UCL	'Not available	0.33	'Not available	1.74	0.1	0.1	'Not available	0.17	'Not available	0.17
Congener-Specific Approach (Fagervold et al. 2010)[c]	2,3,4,7,8-pecdf	ng/kg	131.7	95% KM (Chebyshev) UCL	'Not available	0.56	'Not available	74	0.3	1	'Not available	22	'Not available	74
Congener-Specific Approach (Fagervold et al. 2010)[c]	2,3,7,8-tcdd	ng/kg	6.176	95% KM Approximate Gamma UCL	'Not available	1.65	'Not available	10.2	1	1	'Not available	10.2	'Not available	10.2
Congener-Specific Approach (Fagervold et al. 2010)[c]	2,3,7,8-tcdf	ng/kg	2.106	KM H-UCL	'Not available	1.21	'Not available	2.54	0.1	1	'Not available	0.25	'Not available	2.5
Congener-Specific Approach (Fagervold et al. 2010)[c]	ocdd	ng/kg	68608	95% H-UCL	'Not available	0.25	'Not available	17318	0.0003	0.0001	'Not available	5.20	'Not available	1.73
Congener-Specific Approach (Fagervold et al. 2010)[c]	ocdf	ng/kg	13371	95% KM (Chebyshev) UCL	'Not available	0.27	'Not available	3665	0.0003	0.0001	'Not available	1.10	'Not available	0.366
Congener-Specific Approach (Fagervold et al. 2010)[c]	Dioxin TEQ	ng/kg									**'Not available**	**80**	**'Not available**	**105**

Table 6-11
Comparison of Tissue Exposure Point Concentrations for Dioxin TEQ in the Baseline (No Scouring) Scenario
Bat Cave Wash (0 to 0.5 foot bgs)

Post-Soil NTCRA Human Health and Ecological Risk Assessment
PG&E Topock Compressor Station
Needles, California

Approach	Constituent	Units	Soil EPCs [a] - 95% UCL	Soil EPCs [a] - 95% UCL Method	BAFs - Plants	BAFs - Terrestrial Invertebrates	Tissue EPCs - Plants	Tissue EPCs - Terrestrial Invertebrates	TEFs [b] - Mammal	TEFs [b] - Avian	Tissue EPCs (Mammal TEF Applied) - Plants	Tissue EPCs (Mammal TEF Applied) - Terrestrial Invertebrates	Tissue EPCs (Avian TEF Applied) - Plants	Tissue EPCs (Avian TEF Applied) - Terrestrial Invertebrates
E R A Approach	TEQ avian	ng/kg	108.2	95% H-UCL	0.0056	ln(Ci) = 1.182 * ln(Cs) + 3.533	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	**0.61**	**703**
E R A Approach	TEQ mammals	ng/kg	204.4	95% H-UCL	0.0056	ln(Ci) = 1.182 * ln(Cs) + 3.533	Not applicable	Not applicable	Not applicable	Not applicable	**1.1**	**1491**	Not applicable	Not applicable

Notes:
[a] Soil EPCs calculated for BCW surface soil (0 to 0.5 foot bgs) using ProUCL 5.1; ProUCL-recommended UCLs and UCL methods are presented.
[b] Toxic Equivalentcy Factors (TEFs) from Van den Berg (2006) for mammals and Van den Berg (1998) for birds.
[c] Bioaccumulation Factors calculated using soil-to-earthworm 2,3,7,8-TCDD BAF for soil SW-20 (BAF = 1.65) and congner-specific earthworm bioaccumulation equivalency factors. See Table 6-34.

Acronyms and Abbreviations:
BAF = bioaccumulation factor
BCW = Bat Cave Wash
EPC = exposure point concentration
H-UCL = upper confidence limit based upon Land's H-statistic
hpcdd = heptachlorodibenzo-p-dioxin
hpcdf = heptachlorodibenzofuran
hxcdd = hexachlorodibenzo-p-dioxin
hxcdf = hexachlorodibenzofuran
In(Ci) = natural log of the invertebrate prey concentration
In(Cs) = natural log of the soil concentration
KM = Kaplan Meier
ng/kg = nanograms per kilogram
ocdd = octachlorodibenzo-p-dioxin
ocdf = octachlorodibenzofuran
pecdd = pentachlorodibenzo-P-dioxin
pecdf = pentachlorodibenzofuran
tcdd = tetrachlorodibenzo-p-dioxin
tcdf = tetrachlorodibenzofuran
TEF = toxic equivalency factor
TEQ = toxicity equivalent
UCL = upper confidence limit
U S E P A = U.S. Environmental Protection Agency

References:
Fagervold, SK, Y Chai, JW Davis, M Wilken, G Cornelissen, and U Ghosh. 2010. Bioaccumulation of polychlorinated dibenzo-p-dioxins/dibenzofurans in E. fetida from floodplain soils and the effect of activated carbon amendment. Environ Sci Technol. 44(14):5546-52.
Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter, II, and T.L. Ashwood. 1998a. Development and Validation of Bioaccumulation Models for Earthworms. ES/ER/TM-220. Oak Ridge National Laboratory, Oak Ridge, TN. 93 pp.47.
U S E P A. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. U.S. Environmental Protection Agency Peer Review Draft. August.
Van den Berg, et al. 1998. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environ Health Perspect 106(12):775-792.
Van den Berg, et al. 2006. The 2005 World Health Organization reevaluation of human and mammalian TEFs for dioxins and dioxin-like compounds. Toxicological Sciences 93:223-241.

Table 6-12
Development of Soil-to-Invertebrate BAFs Using Fagervold et al. (2010) Data (from 2019 HHERA)

Post-Soil NTCRA Human Health and Ecological Risk Assessment
PG&E Topock Compressor Station
Needles, California

Constituent	Units	Calculation of Soil-to-Invertebrate BEFs - SW-20 [c] BAF (foc = 0.38%)	Calculation of Soil-to-Invertebrate BEFs - SW-20 BEF [a]	Calculation of Soil-to-Invertebrate BEFs - Note	Calculation of Soil-to-Invertebrate BEFs - SW-265 BAF (foc = 5.6%)	Calculation of Soil-to-Invertebrate BEFs - SW-265 BEF [a]	Calculation of Soil-to-Invertebrate BEFs - Note	Calculation of Soil-to-Invertebrate BEFs - Average BEF	Terrestrial Invertebrate BAFs [b]
1,2,3,4,6,7,8-hpcdd	ng/kg	0.185	0.11		0.023	0.13		0.12	0.20
1,2,3,4,6,7,8-hpcdf	ng/kg	0.399	0.24		0.034	0.19		0.22	0.36
1,2,3,4,7,8,9-hpcdf	ng/kg	0.338	0.20		NC	NA	ND in soil	0.20	0.34
1,2,3,4,7,8-hxcdd	ng/kg	NC	NA	ND in soil	0.025	0.14	based on DL in tissue	0.14	0.23
1,2,3,4,7,8-hxcdf	ng/kg	0.584	0.35		0.04	0.22		0.29	0.48
1,2,3,6,7,8-hxcdd	ng/kg	NC	NA	ND in soil	0.021	0.12		0.12	0.19
1,2,3,6,7,8-hxcdf	ng/kg	0.777	0.47		0.043	0.24		0.35	0.59
1,2,3,7,8,9-hxcdd	ng/kg	NC	NA	ND in soil	0.014	0.08	based on DL in tissue	0.078	0.13
1,2,3,7,8,9-hxcdf	ng/kg	1.22	0.74		0.025	0.14	based on DL in tissue	0.74	1.22
1,2,3,7,8-pecdd	ng/kg	NC	NA	ND in soil	0.02	0.11	based on DL in tissue	0.11	0.18
1,2,3,7,8-pecdf	ng/kg	0.931	0.56		0.07	0.39		0.48	0.79
2,3,4,6,7,8-hxcdf	ng/kg	0.372	0.23		0.032	0.18		0.20	0.33
2,3,4,7,8-pecdf	ng/kg	0.725	0.44		0.044	0.24		0.34	0.56
2,3,7,8-tcdd	ng/kg	1.65	1.00		0.18	1.00		1.00	1.65
2,3,7,8-tcdf	ng/kg	1.28	0.78		0.124	0.69		0.73	1.21

Table 6-12
Development of Soil-to-Invertebrate BAFs Using Fagervold et al. (2010) Data (from 2019 HHERA)

Post-Soil NTCRA Human Health and Ecological Risk Assessment
PG&E Topock Compressor Station
Needles, California

Constituent	Units	Calculation of Soil-to-Invertebrate BEFs - SW-20 [c] BAF (foc = 0.38%)	Calculation of Soil-to-Invertebrate BEFs - SW-20 BEF [a]	Calculation of Soil-to-Invertebrate BEFs - Note	Calculation of Soil-to-Invertebrate BEFs - SW-265 BAF (foc = 5.6%)	Calculation of Soil-to-Invertebrate BEFs - SW-265 BEF [a]	Calculation of Soil-to-Invertebrate BEFs - Note	Calculation of Soil-to-Invertebrate BEFs - Average BEF	Terrestrial Invertebrate BAFs [b]
ocdd	ng/kg	0.294	0.18		0.023	0.13		0.15	0.25
ocdf	ng/kg	0.319	0.19		0.025	0.14		0.17	0.27

Notes:
Soil BAFs and BEFs from Fagervold et al. (2010).
[a] BEFs calculated as congener-specific BAF / 2,3,7,8-TCDD BAF. When congener was not detected in soil BAF was calculated.
When congener was not detected in tissue, BAF based on reporting limit in tissue.
[b] Terrestrial Invertebrate BAF = 2,3,7,8-TCDD BAF for soil SW-20 x congener-specific BEF.
[c] Soil SW-20 considered most similar to Topock soils based on low organic carbon content (foc).
2,3,7,8-TCDD BAF for SW-20 used to calculate Terrestrial Invertebrate BAFs as described in note b.

Acronyms and Abbreviations:
BAF = bioaccumulation factor
BEF = bioaccumulation equivalency factor
DL = laboratory detection limit
foc = fraction organic carbon
hpcdd = heptachlorodibenzo-p-dioxin
hpcdf = heptachlorodibenzofuran
hxcdd = hexachlorodibenzo-p-dioxin
hxcdf = hexachlorodibenzofuran
NA = not available
NC = not calculated
ND = not detected
ocdd = octachlorodibenzo-p-dioxin
ocdf = octachlorodibenzofuran
pecdd = pentachlorodibenzo-P-dioxin
pecdf = pentachlorodibenzofuran
tcdd = tetrachlorodibenzo-p-dioxin
tcdf = tetrachlorodibenzofuran

References
Fagervold, SK, Y Chai, JW Davis, M Wilken, G Cornelissen, and U Ghosh. 2010. Bioaccumulation of polychlorinated dibenzo-p-dioxins/dibenzofurans in E. fetida from floodplain soils and the effect of activated carbon amendment. Environ Sci Technol. 44(14):5546-52

Table 6-13
Terrestrial Wildlife Risk Estimate Comparison for Dioxin TEQ (SUF = 1, Selected TRVs) Using Different Bioaccumulation Approaches (from 2019 HHERA)

Post-Soil NTCRA Human Health and Ecological Risk Assessment
PG&E Topock Compressor Station
Needles, California

Category	COPEC	Terrestrial Receptors	Soil EPC [a,b] (ng/kg)	Diet Composition (fraction) - Diet	Diet Composition (fraction) - Soil	Tissue EPCs (ng/kg dw) - Terrestrial Plants	Tissue EPCs (ng/kg dw) - Terrestrial Insects	Body Weight (kg)	Intake Estimates (kg dw/kg-day) - Food Ingestion Rate	Intake Estimates (kg dw/kg-day) - Soil Ingestion Rate	Site Use Factor (unitless)	Dose From Dietary Components (ng/kg-day)[b] - Terrestrial Plants	Dose From Dietary Components (ng/kg-day)[b] - Terrestrial Insects	Dose From Dietary Components (ng/kg-day)[b] - Soil	Total Dose (mg/kg-day)	TRV (ng/kg-day) - NOAEL	TRV (ng/kg-day) - LOAEL	HQ (unitless)[c] - NOAEL	HQ (unitless)[c] - LOAEL	Note	Risk-Based Remediation Goal (mg/kg)[d] - NOAEL	Risk-Based Remediation Goal (mg/kg)[d] - LOAEL
Dioxins (presented in ng/kg) - Calculations Based on TCDD Bioaccumulation (Sample et al. 1998)	TEQ Avian	Gambel's Quail	108	100% Plants	0.1	0.6	703	0.2	0.04	0.004	1	0.02	NA	0.4	0.5	14	140	0.03	0.003	None	3332	33322
Dioxins (presented in ng/kg) - Calculations Based on TCDD Bioaccumulation (Sample et al. 1998)	TEQ Avian	Cactus Wren	108	100% Insects	0.09	0.6	703	0.04	0.2	0.02	1	NA	129	2	131	14	140	9	0.9	None	16	115
Dioxins (presented in ng/kg) - Calculations Based on TCDD Bioaccumulation (Sample et al. 1998)	TEQ Mammals	Desert Shrew	204	100% Insects	0.02	1	1491	0.005	0.2	0.004	1	NA	303	0.8	303	1	10	303	**30**	Note 1	2	11
Dioxins (presented in ng/kg) - Calculations Based on TCDD Bioaccumulation (Sample et al. 1998)	TEQ Mammals	Merriam's Kangaroo Rat	204	100% Plants	0.02	1	1491	0.03	0.08	0.002	1	0.09	NA	0.4	0.5	1	10	0.5	0.05	None	411	4109
Dioxins (presented in ng/kg) - Calculations Based on USEPA (1999) Congener Bioaccumulation	TEQ Avian	Gambel's Quail	108	100% Plants	0.1	1	371	0.2	0.04	0.004	1	0.05	NA	0.4	0.5	14	140	0.03	0.003	None	3144	31441
Dioxins (presented in ng/kg) - Calculations Based on USEPA (1999) Congener Bioaccumulation	TEQ Avian	Cactus Wren	108	100% Insects	0.09	1	371	0.04	0.2	0.02	1	NA	68	2	70	14	140	5	0.5	None	22	217
Dioxins (presented in ng/kg) - Calculations Based on USEPA (1999) Congener Bioaccumulation	TEQ Mammals	Desert Shrew	204	100% Insects	0.02	0.5	153	0.005	0.2	0.004	1	NA	31	0.8	32	1	10	32	**3**	Note 1	6	64
Dioxins (presented in ng/kg) - Calculations Based on USEPA (1999) Congener Bioaccumulation	TEQ Mammals	Merriam's Kangaroo Rat	204	100% Plants	0.02	0.5	153	0.03	0.08	0.002	1	0.04	NA	0.4	0.4	1	10	0.4	0.04	None	456	4563
Dioxins (presented in ng/kg) - Calculations Based on Fagervold et al. (2010) Congener Bioaccumulation	TEQ Avian	Cactus Wren	108	100% Insects	0.09	NA	105	0.04	0.2	0.02	1	NA	19	2	21	14	140	2	0.2	None	72	721
Dioxins (presented in ng/kg) - Calculations Based on Fagervold et al. (2010) Congener Bioaccumulation	TEQ Mammals	Desert Shrew	204	100% Insects	0.02	NA	80	0.005	0.2	0.004	1	NA	16	0.8	17.1	1	10	17	**2**	Note 1	12	119

Table 6-13
Terrestrial Wildlife Risk Estimate Comparison for Dioxin TEQ (SUF = 1, Selected TRVs) Using Different Bioaccumulation Approaches (from 2019 HHERA)

Post-Soil NTCRA Human Health and Ecological Risk Assessment
PG&E Topock Compressor Station
Needles, California

Notes:
[a] Receptors assumed to be exposed to surface soil (0 to 0.5 foot bgs) only.
[b] Soil EPCs calculated for Bat Cave Wash exposure area. See Table 6-33.
[c] Total dose equation is presented below:
Total Dose (mg/kg-day) = $[(EPC_{soil} \times SIR) + (EPC_{plants} \times FIR \times F_{plants}) + (EPC_{insects} \times FIR \times F_{insects}) + (EPC_{mammals} \times FIR \times F_{mammals})] \times SUF$
[d] HQ = Total Dose / TRV

Note 1	LOAEL HQ greater than 1

Abbreviations:
COPEC = constituent of potential ecological concern
dw = dry weight
dw/kg-day = dry weight per kilogram per day
EPC = exposure point concentration
EPC_{soil} = exposure point concentration in soil (ng/kg dw)
EPC_{plants} = exposure point concentration in plants (ng/kg dw)
$EPC_{insects}$ = exposure point concentration in insects (ng/kg dw)
$EPC_{mammals}$ = exposure point concentration in mammals (ng/kg dw)
F_{plants} = fraction of plants in diet
$F_{insects}$ = fraction of insects in diet
$F_{mammals}$ = fraction of mammals in diet
FIR = food ingestion rate (kg dw/kg bw-day)
HQ = hazard quotient (unitless)
kg = kilogram
kg dw/kg bw-day = kilograms per kilogram of body weight per day
LOAEL = lowest observed adverse effect level (mg/kg-day)
mg/kg = milligrams per kilogram
mg/kg-day = milligrams per kilogram per day
ng/kg = nanograms per kilogram
ng/kg-day = nanograms per kilogram per day
NA = not applicable
NOAEL = no observed adverse effect level (mg/kg-day)
SIR = soil ingestion rate (kg dw/kg bw-day)
SUF = site use factor (fraction)
TCDD = tetrachlorodibenzo-p-dioxin
TEQ = toxicity equivalent
TRV = toxicity reference value (mg/kg-day)

References:
Fagervold, SK, Y Chai, JW Davis, M Wilken, G Cornelissen, and U Ghosh. 2010. Bioaccumulation of polychlorinated dibenzo-p-dioxins/dibenzofurans in E. fetida from floodplain soils and the effect of activated carbon amendment. Environ Sci Technol. 44(14):5546-52.
Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter, II, and T.L. Ashwood. 1998a. Development and Validation of Bioaccumulation Models for Earthworms. ES/ER/TM-220. Oak Ridge National Laboratory, Oak Ridge TN. 93 pp.47
USEPA. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. U.S. Environmental Protection Agency Peer Review Draft. August

Table 6-14
Alternate Dioxin Toxicity Reference Values for Small Mammals

Soil Human Health and Ecological Risk Assessment Addendum
PG&E Topock Compressor Station
Needles, California

Dioxin Congener	Study Type	Test Organism	Study Duration	Endpoints	Exposure Route	Dietary Concentration(s)	Reported Toxicity Value(s)	Test Species N O A E L	Test Species L O A E L	TRV N O A E L - (ng/kg-day)	TRV L O A E L - (ng/kg-day)	Source/Comments
2,3,7,8-TCDD	Lab	Sprague Dawley Rats	13 weeks (91 days)	Growth	Gavage	Control and four daily doses: 0.71, 7.1, 71.4, and 714 ng/kg_{bw}-day.	N O A E L, L O A E L	7.1 ng/kg_{bw}-day	71.4 ng/kg_{bw}-day	7.10	71.40	Kociba et al. (1976)
2,3,7,8-TCDD	Lab	Sprague Dawley Rats	2 years	Growth	Gavage	Control and three daily doses: 0.001, 0.01, and 0.1 $\mu g/kg_{bw}$-day	N O A E L, L O A E L	0.001 $\mu g/kg_{bw}$-day	0.01 $\mu g/kg_{bw}$-day	1	10	Kociba et al. (1978)
2,3,7,8-TCDD	Lab	Rats	Three generations	Reproduction	Diet	Control and three daily doses: 0.001, 0.01, and 0.1 $\mu g/kg_{bw}$-day	N O A E L, L O A E L	0.001 $\mu g/kg_{bw}$-day	0.01 $\mu g/kg_{bw}$-day	1	10	Murray et al. (1979)
2,3,7,8-TCDD	Lab	Sprague Dawley Rats (Female)	128 days	Growth	Gavage	Control and five daily doses: 0.85, 3.4, 13.6, 54.3, and 217 ng/kg_{bw}-day	N O A E L, L O A E L	54.3 ng/kg_{bw}-day	217 ng/kg_{bw}-day	54.30	217	Croutch et al. (2005). Average daily doses reported by U S E P A (2012) in summary of this study. Dosing scheme was initial loading of 0, 0.0125, 0.05, 0.2, 0.8, or 3.2 $\mu g/kg_{bw}$ at time zero followed by a "maintenance dose" dose rate about one-tenth of the loading dose every 3 days.
2,3,7,8-TCDD	Lab	Sprague Dawley Rats (Female)	2 years	Survival	Gavage	Control and five doses; 3, 10, 22, 46, and 100 ng/kg_{bw} 5 days per week	N O A E L	100 ng/kg_{bw}	--	71.40	NA	Walker et al. (2006). Dose concentrations were converted to averaged daily doses (i.e., TRV units) by the authors.
2,3,7,8-TCDD	Lab	Sprague Dawley Rats (Female)	2 years	Growth	Gavage	Control and five doses; 3, 10, 22, 46, and 100 ng/kg_{bw} 5 days per week	N O A E L, L O A E L	10 ng/kg_{bw}	22 ng/kg_{bw}	7.10	15.70	Walker et al. (2006). Dose concentrations were converted to averaged daily doses (i.e., TRV units) by the authors.
NA	NA	NA	NA	NA	NA	NA	NA	All Studies	Average	23.65	64.82	
NA	NA	NA	NA	NA	NA	NA	NA	All Studies	Geomean	7.62	30.01	
NA	NA	NA	NA	NA	NA	NA	NA	All Studies	N	6	5	
NA	NA	NA	NA	NA	NA	NA	NA	Bounded Studies (Reproduction & Growth)	Average	14.10	64.82	
NA	NA	NA	NA	NA	NA	NA	NA	Bounded Studies (Reproduction & Growth)	Geomean	4.9	30.01	Selected Alternate L O A E L-based TRV
NA	NA	NA	NA	NA	NA	NA	NA	Bounded Studies (Reproduction & Growth)	N	5	5	

Acronyms and Abbreviations:
L O A E L = lowest observed adverse effect level
$\mu g/kg_{bw}$-day = micrograms per kilogram body weight per day
NA = not applicable
ng/kg_{bw}-day = nanograms per kilogram body weight per day
N O A E L = no observed adverse effect level
TRV = toxicity reference value
U S E P A = United States Environmental Protection Agency

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Appendix BCW
Soil HHERA for BCW Exposure Area

Appendix AOC 9
Soil HHERA for AOC 9 Exposure Area

Appendix AOC 10
Soil HHERA for AOC 10 Exposure Area

Appendix AOC 11
Soil HHERA for AOC 11 Exposure Area

Appendix AOC 14
Soil HHERA for AOC 14 Exposure Area

Appendix AOC 27
Soil HHERA for AOC 27 Exposure Area

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