DOE/OR/01-2950&D2

Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee

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Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee

Date Issued—April 2024

Prepared for the
U.S. Department of Energy
Office of Environmental Management

United Cleanup Oak Ridge LLC
under contract 89303322DEM000067

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PREFACE

This *Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee* (K-31/K-33 Area Groundwater Record of Decision [ROD]) has been prepared in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986, to document the selected remedy for final environmental remediation of groundwater within the K-31/K-33 Area at the East Tennessee Technology Park (ETTP) in Oak Ridge, Tennessee. This K-31/K-33 Area Groundwater ROD documents the selected remedy agreed on by the U.S. Department of Energy (DOE), Tennessee Department of Environment and Conservation, and U.S. Environmental Protection Agency and contains the Responsiveness Summary addressing public comments and/or concerns during the Proposed Plan public comment period held from April 26, 2023, until June 12, 2023, including a public meeting on May 9, 2023.

To evaluate and remediate groundwater, DOE divided the ETTP site into three areas: K-31/K-33 Area, Main Plant Area, and Zone 1 (Figure P.1). This K-31/K-33 Area Groundwater ROD addresses groundwater in the K-31/K-33 Area only. Groundwater in the other portions of ETTP will be addressed in separate CERCLA decision documents.

This decision is based on contents of the Administrative Record file for this project and relies on information from the following principal documents supporting this K-31/K-33 Area Groundwater ROD:

- *Remedial Investigation/Feasibility Study Report for the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2893&D2).
- *Proposed Plan for the Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2922&D2).

These documents and other information of the Administrative Record supporting the decision can be found at the DOE Information Center, at the Office of Scientific and Technical Information, 1 Science.gov Way, Oak Ridge, Tennessee 37830, (865) 241-4780, https://doeic.science.energy.gov/. Operating hours are Monday through Friday, 8:00 a.m. to 6:00 p.m., Eastern Standard Time.

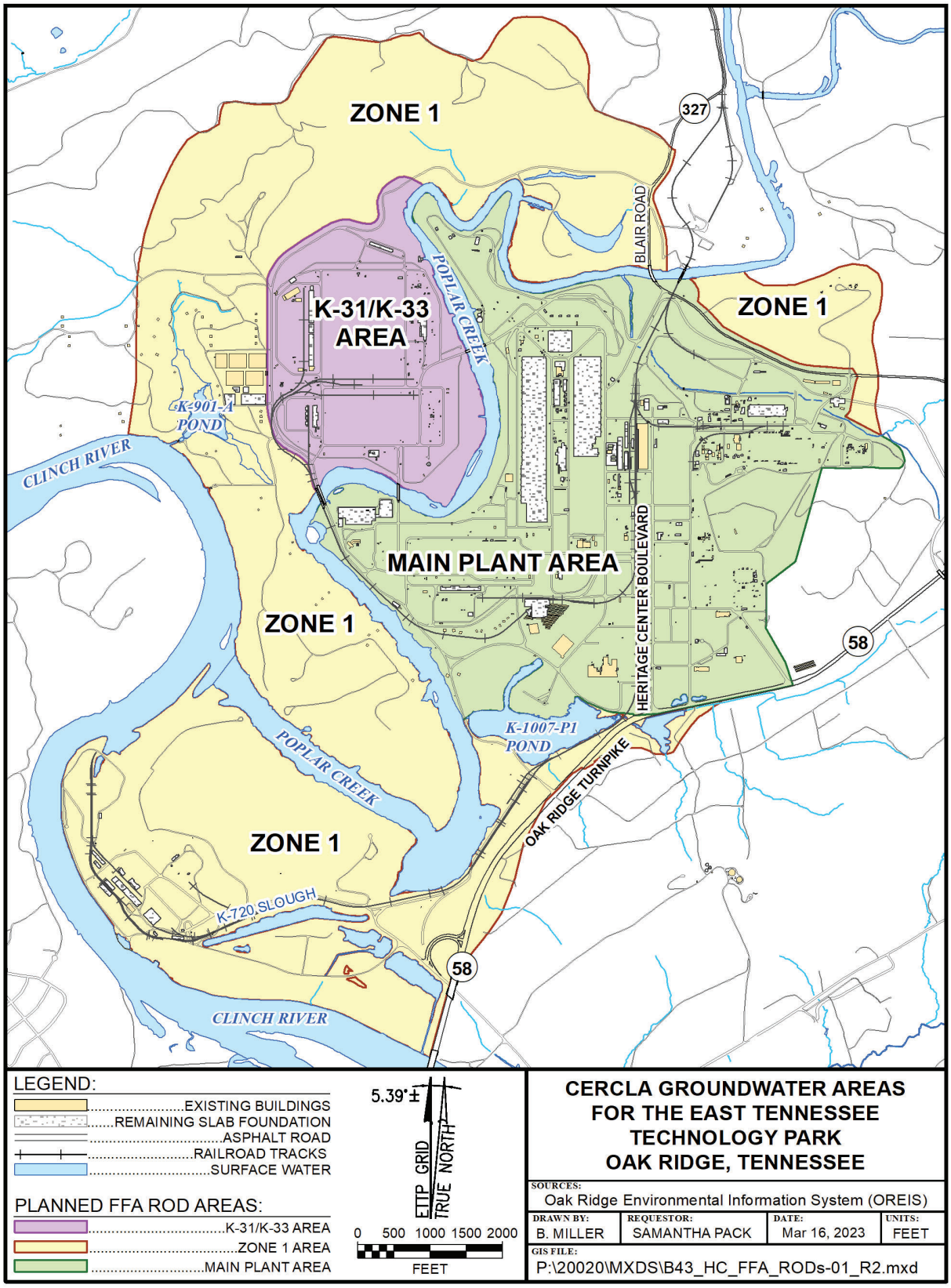

Figure P.1. CERCLA groundwater areas at ETTP.

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FIGURES

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ACRONYMS

amsl	above mean sea level
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
AT123D	Analytical Transient 1-, 2-, 3-Dimensional
AWQC	ambient water quality criteria
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CMP	Comprehensive Monitoring Plan
COC	contaminant of concern
COPC	contaminant of potential concern
CROET	Community Reuse Organization of East Tennessee
CSF	cancer slope factor
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ETTP	East Tennessee Technology Park
FFA	Federal Facility Agreement
FS	feasibility study
FYR	Five-Year Review
HEU	highly enriched uranium
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendments of 1984
ILCR	individual lifetime cancer risk
IROD	Interim Record of Decision
LEU	low enriched uranium
LUC	land use control
LUCIP	Land Use Control Implementation Plan
MCL	maximum contaminant level
MDC	maximum detected concentration
MNA	monitored natural attenuation
MPA	Main Plant Area
NAPL	nonaqueous-phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act of 1969
O&M	operation and maintenance
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORSSAB	Oak Ridge Site-Specific Advisory Board
PCCR	Phased Construction Completion Report
RAR	Remedial Action Report
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act of 1976
RCW	recirculating cooling water
RfC	reference concentration

RfD	reference dose
RI	remedial investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act of 1974
SWMU	solid waste management unit
TDEC	Tennessee Department of Environment and Conservation
UCL95	95% upper confidence limit
UU/UE	unlimited use/unrestricted exposure
WRRP	Water Resources Restoration Program
Y-12	Y-12 National Security Complex

PART 1. DECLARATION

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1.1 SITE NAME AND LOCATION

K-31/K-33 Area at the East Tennessee Technology Park (ETTP)
Oak Ridge Reservation (ORR)
Oak Ridge, Tennessee
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Information System Identification TN1890090003

1.2 STATEMENT OF BASIS AND PURPOSE

This *Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee* (K-31/K-33 Area Groundwater Record of Decision [ROD]) presents the selected remedy for final environmental remediation of groundwater within the K-31/K-33 Area at ETTP, formerly the K-25 site and the Oak Ridge Gaseous Diffusion Plant (ORGDP), on the U.S. Department of Energy's (DOE's) ORR in Oak Ridge, Tennessee (Figure 1.1). The K-31/K-33 Area is an approximate 200-acre area that was used for uranium enrichment activities between 1951–1985.

Environmental cleanup work at ETTP historically was divided into media-specific decisions and actions. ETTP was divided further into two geographic zones for the purpose of evaluating soils, buried waste, and subsurface structures. Zone 1 was defined as the largely undeveloped area surrounding the uranium enrichment and support facilities that comprise the main processing/industrial area. Portions of Zone 1 were used for waste management activities and process support activities, such as power generation. Zone 2 was defined as the Main Plant Area (MPA) in which uranium enrichment, chemical processing, and related support activities occurred. For the purposes of groundwater evaluation, while Zone 1 is being evaluated as a whole, Zone 2 was geographically split between the K-31/K-33 Area to the west of Poplar Creek and the MPA to the east of Poplar Creek (Figure 1.2). The Zone 2 K-31/K-33 Area groundwater is the subject of this ROD. Groundwater in the MPA of ETTP and groundwater in Zone 1 are being addressed under separate decisions and actions.

DOE has developed the final decision for K-31/K-33 Area groundwater in accordance with CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) (42 United States Code Section 9601 et seq.), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] 300). The *Federal Facility Agreement for the Oak Ridge Reservation* (DOE/OR-1014; ORR Federal Facility Agreement [FFA]) was developed to provide a legal framework for remediation activities on the Oak Ridge National Priorities List site and to coordinate remedial activities under CERCLA and the Resource Conservation and Recovery Act of 1976 (RCRA).

The integrated approach in the ORR FFA extends to preparation of decision documents under CERCLA and RCRA. In accordance with the NCP, 40 CFR 300.5, DOE is the lead federal agency for this action; per CERCLA Section 120(e), 42 United States Code Section 9620(e), the NCP at 40 CFR 300.430(f)(iii), and the ORR FFA, the U.S. Environmental Protection Agency (EPA) and DOE jointly select the remedy. As a party to the ORR FFA, the Tennessee Department of Environment and Conservation (TDEC) provides oversight and approval of remedy selection and implementation. In addition, National Environmental Policy Act of 1969 (NEPA) values are incorporated in the documents prepared for this project in accordance with the *Secretarial Policy Statement on the National Environmental Policy Act of 1969* (DOE 1994). This policy states DOE will rely on the CERCLA process for review of actions taken under CERCLA and will address and incorporate NEPA values to the extent practicable in CERCLA evaluations.

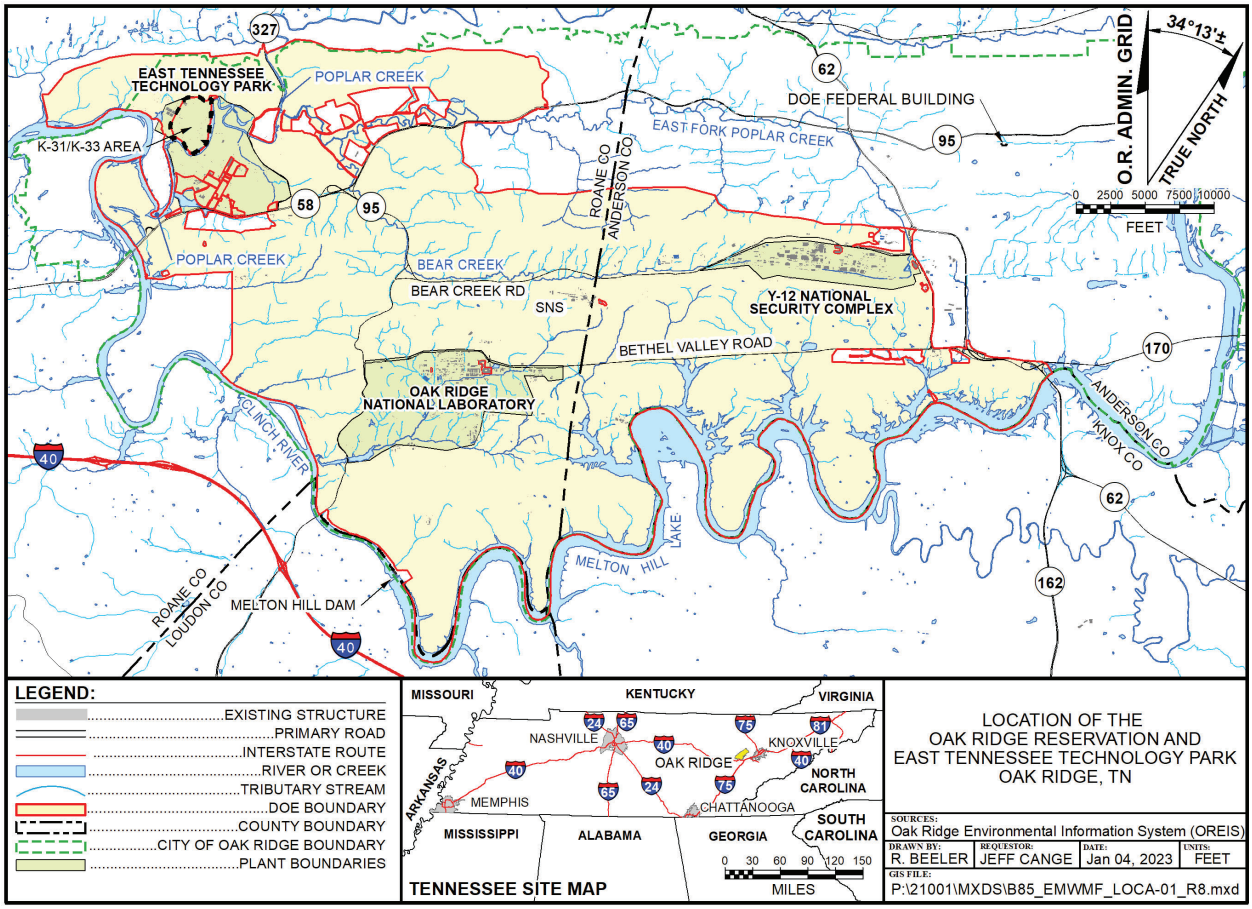

Figure 1.1. Location of ORR and ETTP.

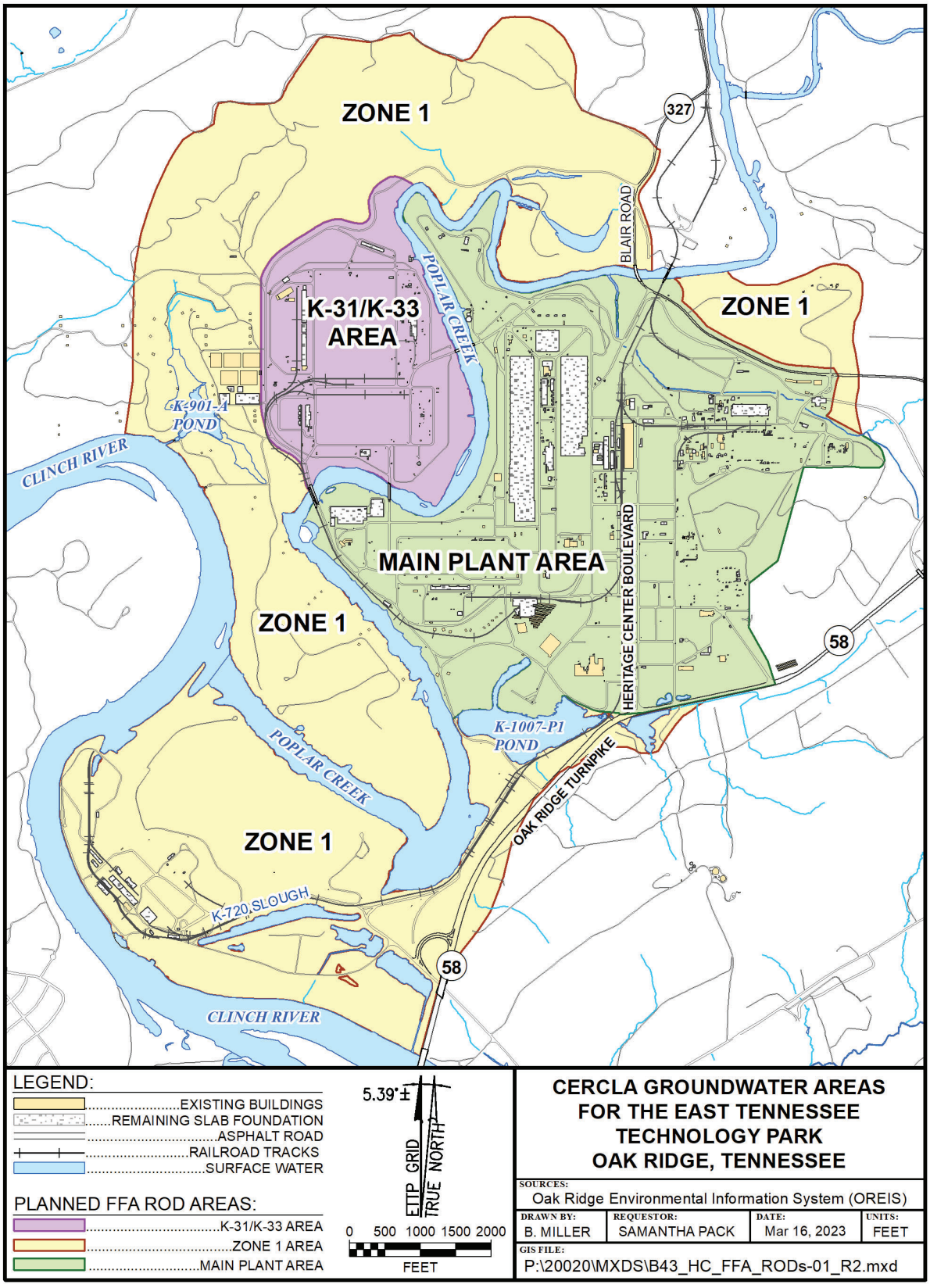

Figure 1.2. CERCLA groundwater areas at ETTP.

The purpose of remediation measures presented in this K-31/K-33 Area Groundwater ROD is to restore groundwater to enable its future beneficial use, consistent with the NCP. Historical groundwater monitoring in the K-31/K-33 Area identified contamination, primarily chromium and nickel, above state and federal drinking water standards in several monitoring wells.

As a result, K-31/K-33 Area groundwater was identified in the list of Oak Ridge Remediation sites in Appendix C of the ORR FFA. EPA's *Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites* (EPA 2015b; Inorganic Monitored Natural Attenuation [MNA] Guidance) was used to select MNA as the remedy. Site conditions at the K-31/K-33 Area do not correspond in full to each line of evidence the guidance recommends be met for remediation via MNA. However, MNA and land use controls (LUCs) were determined, for site-specific reasons, to be an appropriate remedy that is protective of human health and the environment and in compliance with applicable or relevant and appropriate requirements (ARARs). DOE's selection of MNA as the preferred response action for K-31/K-33 Area groundwater is based on the following site-specific factors: biogeochemical reduction, sorption and chemical reduction, advection and dispersion, contamination above drinking water levels occurring sporadically in only a few wells, exceedances generally less than two times the maximum contaminant level (MCL), and overall contaminant concentrations trending downward since monitoring began in the late 1980s.

Soil cleanup actions in the K-31/K-33 Area, completed under the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge Tennessee* (DOE/OR/01-2161&D2; Zone 2 Soil ROD), were based on protection of future industrial workers consistent with the planned reuse of the site as an industrial and/or commercial development. Because these actions were not intended to allow for unlimited use/unrestricted exposure (UU/UE), LUCs have been implemented under the Zone 2 Soil ROD, including controls to prohibit residential development and prevent groundwater use. Because the selected remedy for K-31/K-33 Area groundwater will require an estimated 15 years to achieve groundwater remediation goals, LUCs restricting groundwater use (which includes extraction, consumption, and exposure) have been incorporated into this K-31/K-33 Area Groundwater ROD. DOE will maintain LUCs until concentrations of hazardous substances in the soil and groundwater are at such levels to allow for UU/UE.

This decision is based on documents contained in the Administrative Record file for the K-31/K-33 Area at ETTP. DOE has considered all comments received during the public review period for the *Proposed Plan for the Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2922&D2; K-31/K-33 Area Proposed Plan) in preparation of this K-31/K-33 Area Groundwater ROD. DOE, EPA, and TDEC (parties to the ORR FFA) concur with the selected remedy. DOE is responsible for maintaining, monitoring, and enforcing such LUCs, including in the case these procedural responsibilities are assigned to another party by contract, property transfer agreement, or through other means. In these instances, DOE shall retain ultimate responsibility for remedy integrity.

1.3 ASSESSMENT OF SITE

Water quality monitoring in 20 of the 21 groundwater wells located across the K-31/K-33 Area (excluding 1 well, UNW-044, that is consistently dry) has identified the presence of chromium and nickel in concentrations above health-based drinking water standards that poses a potential threat to human health if the groundwater was used as a drinking water source. Groundwater beneath the K-31/K-33 Area is not presently or foreseeably used for drinking water or other consumptive purposes. However, under TDEC Rule 0400-40-03-.07(4)(b), groundwater beneath the K-31/K-33 site is classified as general use groundwater and is considered a potential source of drinking water.

Under the NCP at 40 CFR 300.430(a)(1)(iii)(F), EPA expects to return usable groundwaters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site. When groundwater restoration to beneficial uses is not practicable, EPA expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction.

The response action (i.e., selected remedy) described in this K-31/K-33 Area Groundwater ROD is necessary to protect the public health or welfare of the environment from actual or threatened releases of hazardous substances into the environment.

1.4 DESCRIPTION OF SELECTED REMEDY

The selected remedy addresses contamination in K-31/K-33 Area groundwater through MNA, which is a groundwater remediation approach that relies on natural processes, including dispersion, sorption, and chemical transformation, to decrease or attenuate concentrations of contaminants in groundwater. The NCP establishes an expectation that treatment will be used to address principal threats at a site, but contaminated groundwater generally is not considered a principal threat unless it is associated with nonaqueous-phase liquids (NAPLs) or other highly contaminated constituents (e.g., several orders of magnitude greater than acceptable risk levels) (EPA 1991). The concentrations of chromium, nickel, and other constituents in K-31/K-33 Area groundwater have exceeded the MCLs by a factor of less than two times the MCL and there is no NAPL present; therefore, K-31/K-33 Area groundwater contamination does not meet criteria for designation as a principal threat.

The selected remedy, MNA, includes the following major components:

- Monitor, evaluate, and report on activities necessary to effectively track the progress of attenuation processes.
- Collect, analyze (in a laboratory), and evaluate groundwater samples.
- Report monitoring results annually and evaluate data to support an assessment of progress toward groundwater restoration.

MNA will be implemented in accordance with EPA's Inorganic MNA Guidance (EPA 2015b) and protocol until cleanup levels are attained and remedial action objectives are satisfied. The selected remedy includes selection of LUCs to prohibit groundwater use (which includes extraction, consumption, and exposure) without prior written approval from DOE, EPA, and TDEC until groundwater remedial action objectives are met or groundwater concentrations are at such levels to allow for UU/UE.

Following approval of this K-31/K-33 Area Groundwater ROD, a Remedial Action Work Plan (RAWP) will be developed on a timeframe under Appendix E or Appendix J of the ORR FFA. The RAWP will establish the schedule and requirements for monitoring and reporting on remedy performance. It will also establish criteria for evaluating whether the MNA remedy is performing consistent with the Inorganic MNA Guidance. If the remedy is not performing as established in the RAWP, then changes to the selected remedy (e.g., selecting a different alternative or other actions such as in situ treatment) will be evaluated and implemented on a timeframe consistent with the Five-Year Review (FYR) process. Changes to this K-31/K-33 Area Groundwater ROD, including changes to the selected remedy, will be documented through the appropriate CERCLA document(s) in accordance with the NCP at 40 CFR 300.435 and *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents* (EPA 1999; EPA ROD Guidance).

In addition to this K-31/K-33 Area Groundwater ROD, DOE intends to issue additional RODs for ETTP groundwater. The MPA Interim ROD (IROD) for Groundwater is currently under review by EPA and TDEC. The MPA IROD for Groundwater will support a future, final Groundwater ROD (or RODs) for the MPA of ETTP. DOE is initiating additional investigations in the MPA to start the process to obtain final decisions in the MPA. The Zone 1 Groundwater Plumes ROD will be issued in the future.

ETTP soils in Zone 2 are being addressed under the Zone 2 Soil ROD. Remaining ecology, surface water, and sediment at ETTP (exclusive of Poplar Creek and the Clinch River) will be addressed in the Remaining Ecology/Surface Water/Sediment ROD, which is currently in the remedial investigation (RI)/feasibility study (FS) phase of the CERCLA process.

1.5 STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action, is cost-effective, and uses permanent solutions and alternative treatment technologies to the maximum extent practicable. The remedy does not satisfy the statutory preference for treatment as a principal element of the remedy because the selected remedy, MNA, is not considered treatment. Nonetheless, MNA was selected because it protects human health and the environment and complies with ARARs while providing the best balance of tradeoffs over treatment with respect to implementability, long-term effectiveness, and permanence at a reasonable cost. MNA is expected to reduce toxicity, mobility, and volume through attenuation processes over time with no residual risk at the conclusion of the response action.

Because the selected remedy will result in hazardous substances, pollutants, or contaminants remaining onsite in groundwater above levels that allow for UU/UE, a review will be conducted every 5 years following remedial action initiation to ensure the remedy remains protective of human health and the environment, in accordance with CERCLA Section 121(c) and the NCP at 40 CFR 300.430(f)(4)(ii). The FYRs will continue until the remedial action objectives are achieved.

1.6 RECORD OF DECISION CERTIFICATION CHECKLIST

The following information is included in Part 2 of this ROD:

- Contaminants of concern (COCs) and their respective concentrations (Section 2.7).
- Baseline risk represented by the COCs (Section 2.7).
- Remediation levels established for the COCs and the basis for these levels (Section 2.12.4).
- How source materials constituting principal threats will be addressed (Section 2.11).
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and the ROD (Section 2.6).
- Potential land and groundwater uses that will be available at the site as a result of the selected remedy (Section 2.12.4).
- Estimated capital, operation and maintenance (O&M), and total present-worth costs; discount rate; and number of years over which the remedy cost estimates are projected (Section 2.12.3).
- Key factor(s) that led to selecting the remedy (Section 2.12.1).

Additional information regarding K-31/K-33 Area groundwater can be found in the Administrative Record generated and approved by the three FFA parties for this K-31/K-33 Area Groundwater ROD.

APPROVALS

Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee DOE/OR/01-2950&D2 April 2024

JOHN MULLIS Digitally signed by JOHN MULLIS Date: 2024.04.11 06:28:13 -04'00'

John A. Mullis II, Manager
Oak Ridge Office of Environmental Management
U.S. Department of Energy

Date

Gregory T. Young Digitally signed by Gregory T. Young Date: 2024.04.30 08:35:03 -05'00'

Greg Young, Deputy Commissioner
Bureau of Environment
Tennessee Department of Environment and Conservation

Date

CAROLINE FREEMAN Digitally signed by CAROLINE FREEMAN Date: 2024.05.09 20:55:51 -04'00'

Caroline Freeman, Director
Superfund and Emergency Management Division
U.S. Environmental Protection Agency, Region 4

Date

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PART 2. DECISION SUMMARY

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2.1 SITE NAME, LOCATION, AND DESCRIPTION

K-31/K-33 Area at ETTP
ORR
Oak Ridge, Tennessee
CERCLA Information System Identification TN1890090003

The 33,477-acre DOE ORR is located within the corporate limits of the city of Oak Ridge, Tennessee, in Roane and Anderson Counties. The ORR is bounded to the south and west by the Clinch River and to the east and north by the developed residential/business portion of the city of Oak Ridge. The ORR hosts three major industrial, research, and production facilities originally constructed as part of the World War II-era Manhattan Project—ETTP, formerly known as the K-25 site and ORGDP; Oak Ridge National Laboratory (ORNL), formerly X-10; and the Y-12 National Security Complex (Y-12).

ETTP is located near the northwest corner of the ORR in Roane County (Figure 1.1), comprising an area of approximately 2100 acres. To evaluate and remediate groundwater, DOE divided the ETTP site into three areas: K-31/K-33 Area, MPA, and Zone 1. This K-31/K-33 Area Groundwater ROD addresses groundwater in the K-31/K-33 Area only (Figure 1.2). Groundwater in the other portions of ETTP will be addressed in separate CERCLA decision documents.

The K-31/K-33 Area consists of approximately 200 acres in the northwestern portion of ETTP, northwest of the MPA and separated from the MPA by Poplar Creek. It is bounded to the north and west by Zone 1. The K-31/K-33 Area is so named because it includes the former locations of Buildings K-31 and K-33, which enriched uranium using the gaseous diffusion process (Figure 2.1). The area also included ancillary or support facilities (e.g., electrical switchyards and recirculating cooling water [RCW] facilities), as well as an extensive underground utility network.

In accordance with the NCP, 40 CFR 300.5, DOE is the lead federal agency for this action; per CERCLA Section 120(e), 42 United States Code Section 9620(e), the NCP at 40 CFR 300.430(f)(iii), and the ORR FFA, EPA and DOE jointly select the remedy. As a party to the ORR FFA, TDEC provides oversight and approval of remedy selection and implementation.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

ETTP was built by the U.S. Army Corps of Engineers as part of the Manhattan Project beginning in 1942. The facility had five primary process buildings that housed gaseous diffusion cascades that were used to enrich uranium. The K-25, K-27, and K-29 buildings were constructed in the 1940s. The K-33 building was the last cascade building constructed at ETTP and began operations in 1954. The K-31 building began operations in 1951.

The original mission of ETTP was to produce highly enriched uranium (HEU) for nuclear weapons. In 1964, HEU production was discontinued and operations shifted to low enriched uranium (LEU) production for fabrication into fuel elements for commercial and research nuclear reactors. LEU production continued until enrichment operations were placed in a standby mode in 1985. Secondary missions in the final years of ETTP operations included research on new technologies for uranium enrichment (e.g., gas centrifuge and laser isotope separation). The decision to permanently shut down the site was made in 1987.

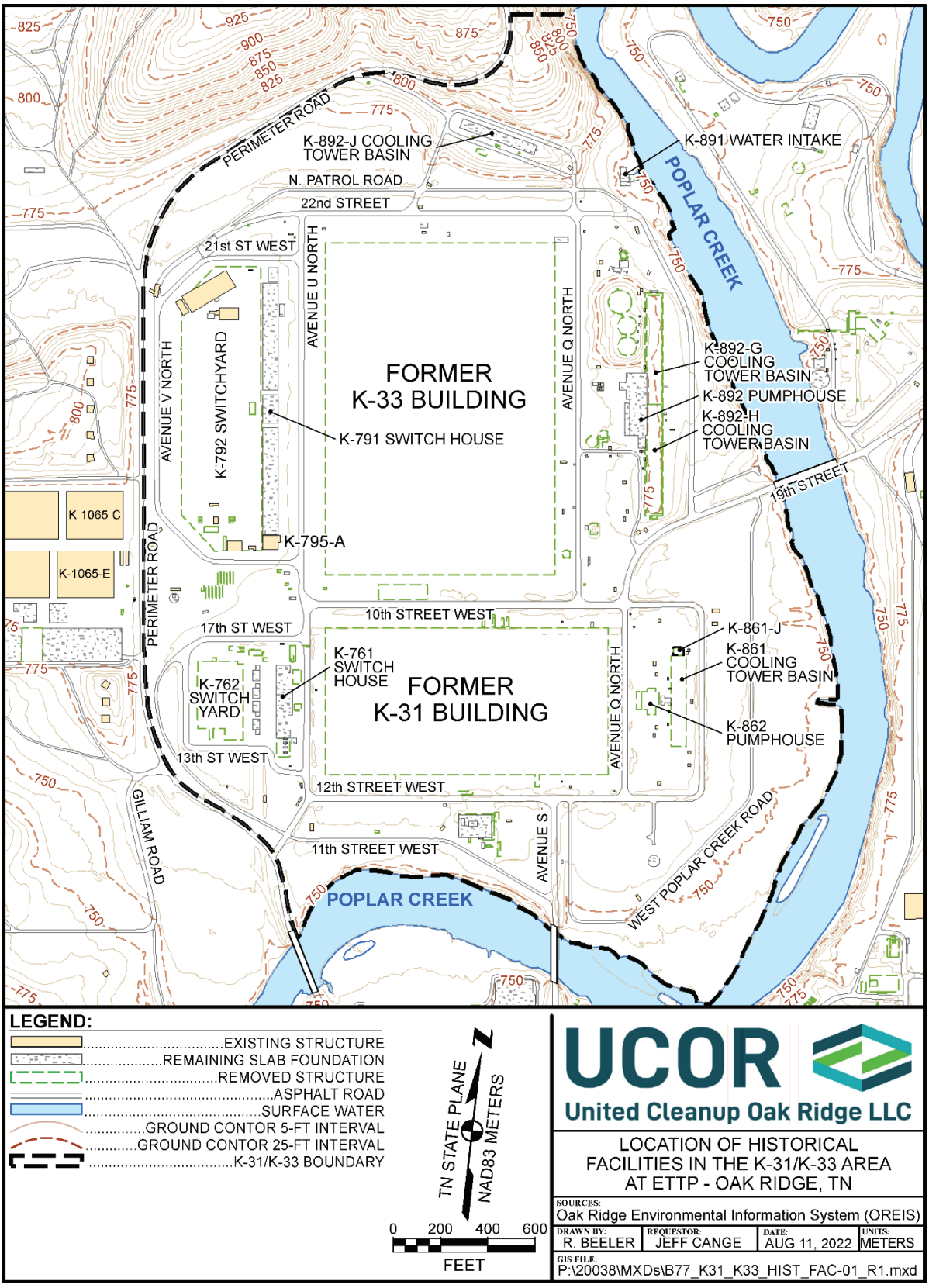

Figure 2.1. K-31/K-33 Area facilities, circa 2000.

Historical missions at ETTP resulted in a legacy of contaminated, inactive facilities; waste disposal areas; and secondarily contaminated media that were a candidate for remediation, including the following:

- buildings and other facilities
- buried waste (burial grounds and landfills)
- buried tanks
- underground waste lines
- utilities
- scrap and debris
- contaminated surface and subsurface soil
- contaminated surface water and sediment
- contaminated groundwater

Potentially hazardous releases from source areas at ETTP were investigated to meet the requirements of RCRA, as amended by the Hazardous and Solid Waste Amendments of 1984 (HSWA), and CERCLA. The ORR was placed on the National Priorities List on November 21, 1989 (54 Federal Register 48184), effective December 21, 1989. In accordance with HSWA requirements, investigations were conducted in the late 1980s across the entirety of the ETTP site to identify and investigate solid waste management units (SWMUs) and areas of concern (AOCs) that could pose a threat to human health or the environment. The identified SWMUs and AOCs were incorporated into the CERCLA investigative process to determine if additional investigations or CERCLA remedial actions were warranted. The resulting remedial actions, as needed, were deferred from HSWA corrective actions to CERCLA cleanup actions.

Remediation efforts on the ORR, including those at ETTP, are governed by the ORR FFA among DOE, EPA Region 4, and TDEC. This agreement became effective on January 1, 1992, and has been amended several times by agreement of the three parties. The ORR FFA defines various federal environmental statutes that are applicable to remedial efforts. One purpose of the ORR FFA is to "establish a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions at the site in accordance with CERCLA, NCP, RCRA, NEPA, appropriate guidance and policy, and in accordance with Tennessee state law."

Appendix I-5, Operable Unit Information Assessment Operating Instructions, of the ORR FFA describes how classified information is evaluated on the ORR for the purpose of environmental restoration. Operations at ETTP were evaluated across the site in accordance with the *Federal Facility Agreement Appendix I-5 Information Assessment for East Tennessee Technology Park, Oak Ridge, Tennessee* (UCOR-5588), and several chemicals were identified as being used in classified operations. Data for those chemicals with comparative criteria (e.g., regional screening levels, Safe Drinking Water Act of 1974 (SDWA) standards, and ambient water quality criteria [AWQC]) were evaluated, and none of the 95% upper confidence limit (UCL95) data exceeded comparative criteria. Therefore, all applicable chemicals are being addressed in environmental restoration efforts at ETTP.

2.2.1 Previous Investigations

Groundwater in the K-31/K-33 Area was initially addressed in the *Groundwater Remedial Site Evaluation Report for the Oak Ridge K-25 Site, Oak Ridge, Tennessee* (DOE/OR/01-1468V1&D1), completed in 1996, which recommended no further action for groundwater in the K-31/K-33 Area due to low concentrations and low risk. The *Remedial Investigation Report for the East Tennessee Technology Park, Oak Ridge,*

Tennessee (DOE/OR/01-1778/V1&D1; 1999 RI Report), completed in 1999, also addressed groundwater in the K-31/K-33 Area. The groundwater evaluation in the 1999 RI Report, which was not approved by the regulatory agencies, found only a residential receptor scenario for groundwater was associated with potential risks above the CERCLA threshold for excess lifetime cancer risks (i.e., greater than 1E-04). Groundwater in the K-31/K-33 Area was again addressed in the *Final Sitewide Remedial Investigation and Feasibility Study for East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2279&D3; 2007 Sitewide RI) for ETTP. Although the 2007 Sitewide RI did not receive EPA and TDEC approval, the investigation likewise concluded potential exposures to groundwater exceeded the 1E-04 risk threshold for a hypothetical residential receptor.

Additional groundwater monitoring in the K-31/K-33 Area has been conducted through semiannual sampling performed by DOE's Water Resources Restoration Program (WRRP). The WRRP routinely samples selected monitoring wells throughout ETTP to track plume-specific and overall contamination trends. Four monitoring wells in the K-31/K-33 Area (two locations with paired bedrock and unconsolidated wells) have been monitored as part of this effort since 2001. The WRRP monitoring results were incorporated into the additional groundwater sampling results collected in support of the *Remedial Investigation/Feasibility Study Report for the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2893&D2; K-31/K-33 Area RI/FS) and will be evaluated further during development of the RAWP for design and implementation of the MNA remedy.

The K-31/K-33 Area RI/FS was prepared in accordance with CERCLA requirements to support the selected remedy decision for K-31/K-33 Area groundwater. The initial (D1) version of the document was submitted to EPA and TDEC for review in June 2021, and the revised (D2) version was approved in October 2022.

The K-31/K-33 Area RI/FS summarized the site operational history, previous investigations, decontamination and decommissioning activities, and completed soil remedial actions. The RI portion of the K-31/K-33 Area RI/FS described potential groundwater contamination source areas and the nature and extent of contamination, including fate and transport modeling. A statistically based trend analysis of groundwater constituents exceeding MCLs under SDWA and/or TDEC water quality rules was included, as well as an evaluation of the potential impact groundwater contamination has on human health and the environment. The FS portion of the K-31/K-33 Area RI/FS defined a range of possible solutions to address these impacts, including potential remedial technologies and an analysis of the alternatives.

Groundwater conditions were assessed based on evaluation of historical and recent groundwater data collected from the 21 monitoring wells in the area, including the 4 monitoring wells sampled as part of the WRRP. The monitoring well network in the K-31/K-33 Area is shown in Figure 2.2. Groundwater data collected in the 5-year period leading up to completion of the D1 version of the K-31/K-33 Area RI/FS (2017–2021) were the focus of this evaluation. Samples collected after 2017 reflect site conditions following completion of the last of the building demolitions. In addition to monitoring well sample collection, five temporary piezometers were installed in the interior portion of the K-31/K-33 Area to address data gaps in the potentiometric surface, in particular whether the former sinkholes (filled during site construction in the early 1950s) had any influence on groundwater flow.

2.2.2 Previous Cleanup Decisions

Initial environmental investigations at ETTP were completed in the late 1980s to meet RCRA requirements, as amended by HSWA. After the ORR was listed on the National Priorities List, environmental work at ETTP was driven by CERCLA requirements. The first set of key CERCLA decisions addressed single-project, higher risk, early actions to remove primary sources of contamination or address primary release mechanisms. In addition, buildings have been demolished through DOE's removal authority under CERCLA. The early actions and facility demolitions are complete.

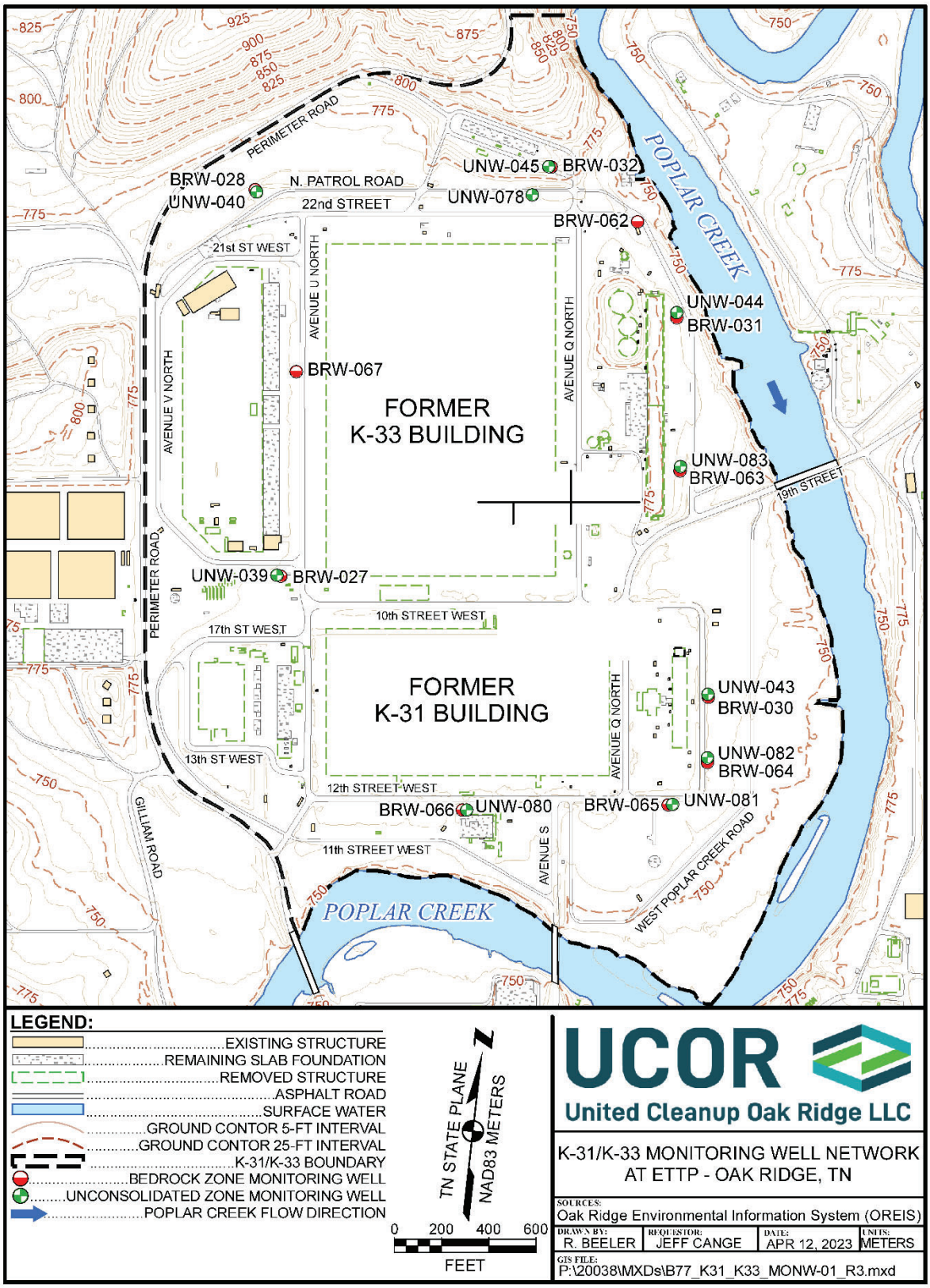

Figure 2.2. Monitoring well network for K-31/K-33 Area.

The second set of key decisions at ETTP addressed soil, buried waste, and subsurface structures. ETTP was divided into two geographical areas to support evaluation and follow-on remediation of these media: Zone 1, consisting of approximately 1400 acres outside the original fence line of the main processing/industrial area; and Zone 2, the approximately 800-acre processing/industrial area inside the original fence line. Historically, Zone 1 was mostly undeveloped, but portions were used for industrial purposes (e.g., power generation) and limited waste disposal. Zone 2 is the MPA and the K-31/K-33 Area and is associated with uranium enrichment and supporting operations, as well as waste treatment and disposal.

Characterization and remedial actions for soil, buried waste, and subsurface structures in Zone 1 were implemented under the *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1997&D2; Zone 1 Soil IROD). Remedial actions in Zone 2 are conducted in accordance with the Zone 2 Soil ROD. Remedial actions under the Zone 1 Soil IROD and Zone 2 Soil ROD were based on protection of both human health and underlying groundwater, but neither ROD included actions that extend below the water table (or below the top of bedrock).

The remaining CERCLA decisions at ETTP will address contamination in groundwater, surface water, and sediment in the ponds, wetlands, and perennial streams in Zones 1 and 2. These decisions will include protection of ecological receptors in aquatic environments (i.e., ponds and streams) as appropriate. CERCLA decisions for the sediment in Poplar Creek, which borders the eastern and southern edges of the K-31/K-33 Area, were addressed in the *Record of Decision for the Clinch River/Poplar Creek Operable Unit, Oak Ridge, Tennessee* (DOE/OR/02-1547&D3). A future ROD for surface water in Poplar Creek (and the Clinch River) will be issued upon completion of CERCLA-driven cleanup work in the ORR, including work for sites upstream from ETTP impacting Poplar Creek, such as Y-12 (Figure 1.1).

As previously stated, ETTP has been split into three distinct areas for the CERCLA groundwater evaluation. In addition to this K-31/K-33 Area Groundwater ROD, there will be separate CERCLA decision documents for groundwater in the MPA and in Zone 1. DOE is planning to address MPA groundwater in stages, beginning with an IROD that focuses on six plume areas with high concentrations of chlorinated volatile organic compounds followed by investigations of remaining contaminated groundwater. A separate ROD is also planned for Zone 1 groundwater plumes.

The CERCLA decision for surface water, sediment, and aquatic ecological receptors at ETTP (exclusive of Poplar Creek and the Clinch River) will be addressed in the Remaining Ecology/Surface Water/Sediment ROD.

2.3 HIGHLIGHTS OF COMMUNITY PARTICIPATION

DOE published a notice of public availability for the K-31/K-33 Area Proposed Plan in the *Oak Ridger* and *Roane County News*. The public notice established a public comment period from April 26, 2023, to June 12, 2023. A public information meeting was held on May 9, 2023, to present the preferred alternative described in the K-31/K-33 Area Proposed Plan and to solicit public input. All comments on the K-31/K-33 Area Proposed Plan are identified and responses are included in Part 3 of this K-31/K-33 Area Groundwater ROD.

DOE has invited public participation through periodic briefings with the Oak Ridge Site-Specific Advisory Board (ORSSAB), a community-based advisory organization established to provide recommendations to DOE on remediation decisions. The cleanup goals presented in this K-31/K-33 Area Groundwater ROD are consistent with recommendations made by the ORR End Use Working Group, an ORSSAB subcommittee. The End Use Working Group was established in 1996 to provide recommendations to DOE on post-remediation ORR land use, cleanup assumptions and goals, and beneficial reuse of portions of the ORR. The group recommended unrestricted industrial end use (to a depth of 10 ft) for Zone 2, including the K-31/K-33 Area.

This K-31/K-33 Area Groundwater ROD presents the selected remedy for K-31/K-33 Area groundwater. The selected remedy was chosen in accordance with CERCLA, as amended by SARA, and to the extent practicable, the NCP. This decision is based on the contents of the Administrative Record for this project, including the following principal documents supporting this K-31/K-33 Area Groundwater ROD:

- K-31/K-33 Area RI/FS
- K-31/K-33 Area Proposed Plan

These documents and other information supporting the selected remedy can be found at the DOE Information Center, at the Office of Scientific and Technical Information, 1 Science.gov Way, Oak Ridge, Tennessee, 37830, (865) 241-4780, https://doeic.science.energy.gov/. Operating hours are Monday through Friday, 8:00 a.m. to 6:00 p.m., Eastern Standard Time.

2.4 SCOPE AND ROLE OF RESPONSE ACTION

This K-31/K-33 Area Groundwater ROD addresses groundwater in the K-31/K-33 Area, which extends vertically from the surface of the water table in the unconsolidated interval down into underlying bedrock. Monitoring of groundwater quality in the 21 monitoring wells located across the K-31/K-33 Area has identified the presence of chromium (primarily hexavalent chromium) and nickel that poses a potential threat to human health if the groundwater was used as a drinking water source.

Under the NCP at 40 CFR 300.430(a)(1)(iii)(F), EPA expects to return usable groundwaters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site. Under TDEC Rule 0400-40-03-.07(4)(b), groundwater beneath the K-31/K-33 site is classified as general use groundwater and is considered a potential source of drinking water. When groundwater restoration to beneficial uses is not practicable, EPA expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction; however, this remedy has made no such practicability determination.

The NCP requires federal SDWA MCLs and non-zero MCL goals be attained for all remedial actions for groundwaters that are current or potential sources of drinking water, where the MCLs/non-zero MCL goals are relevant and appropriate under the circumstances of the release (40 CFR 300.430(e)(2)(i)(B)-(C)). However, groundwater beneath the K-31/K-33 Area is not presently or foreseeably used for drinking water or other consumptive purposes, and this remedy imposes LUCs that ensure it is not used for these or any other purposes.

The MNA remedy selected for this K-31/K-33 Area Groundwater ROD is expected to return K-31/K-33 Area groundwater to its beneficial use in a reasonable timeframe (estimated at 15 years), consistent with NCP and TDEC requirements. Additionally, the remedy is compatible with industrial redevelopment of the site, which offers a potentially significant economic benefit to the surrounding communities. DOE will continue to maintain LUCs prohibiting groundwater use (which includes extraction, consumption, and exposure) without prior written approval from DOE, EPA, and TDEC until the cleanup objectives are achieved or groundwater concentrations are at such levels to allow for UU/UE. If the remedy is not performing as established in the RAWP, changes to the selected remedy (e.g., selecting a different alternative or other actions such as in situ treatment) will be evaluated and implemented on a timeframe consistent with the FYR process. Changes to this K-31/K-33 Area Groundwater ROD, including changes to the selected remedy, will be documented through the appropriate CERCLA document(s) in accordance with the NCP at 40 CFR 300.435 and Section 7, “Documenting Post-ROD Changes: Minor Changes, Explanations of Significant Differences, and ROD Amendments,” of the EPA ROD Guidance.

The MNA remedy is consistent with the charter and objectives of the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2628/V1&D2; ORR Groundwater Strategy). Developed by DOE in collaboration with TDEC and EPA, the ORR Groundwater Strategy provided the framework for (1) identifying potential threats to public health from contaminated groundwater, (2) prioritizing and selecting remedial actions to prevent unacceptable risk and further degradation of groundwater and to restore groundwater to beneficial use wherever practicable, and (3) achieving final ROD cleanup through final groundwater decisions.

The overall cleanup plan for the selected remedy consists of the following primary components:

- Identifying existing monitoring wells to be included in the MNA monitoring network.
- Installing new monitoring wells (if necessary).
- Identifying sampling protocol and analytical methods for collecting data to support monitoring of natural attenuation.
- Identifying the decision logic used to evaluate the progress and effectiveness of natural attenuation.
- Semiannually sampling groundwater at wells within the monitoring network.
- Preparing annual reports, including summarizing data collected and assessing the progress and effectiveness of MNA using the decision logic developed for assessing natural attenuation.
- Optimizing decision logic, natural attenuation monitoring locations, and sample target analytes, as necessary, to assess natural attenuation.

The cleanup plan will be documented in the RAWP.

Previous cleanup decisions are discussed in Section 2.2. The overall site cleanup plan for the K-31/K-33 Area follows (note the K-31/K-33 Area groundwater remedy is shown in bold):

- Completed removal actions to demolish contaminated facilities.
- Completed remedial actions to address contaminated soil, subsurface structures, and buried waste (including sources to groundwater) in the K-31/K-33 Area.
- **Remedial action to address contaminated groundwater underlying the K-31/K-33 Area.**
- Remedial action(s) to address Poplar Creek and the Clinch River.

2.5 SITE CHARACTERISTICS

The K-31/K-33 Area is approximately 190 acres of historically industrialized land in the northwestern portion of ETTP, bounded by Poplar Creek on the east and south, the K-901-A Holding Pond to the west, and to the north by undeveloped portions of Zone 1 (Figure 1.2). The area included the former locations of Buildings K-31 and K-33 (Figure 2.1), where enriched uranium was produced using the gaseous diffusion process. The area also included ancillary or support facilities (e.g., electrical switchyards and RCW facilities), as well as an extensive underground utility network.

Building K-31 began operations in 1951 and Building K-33 began operations in 1954. All enrichment operations were discontinued in 1985, and Buildings K-31 and K-33 were shut down. Between 1998–2005, process equipment was removed under the *Action Memorandum for Equipment Removal and Building*

Decontamination for Buildings K-29, K-31, and K-33, East Tennessee Technology Park, Oak Ridge, Tennessee (DOE/OR/02-1646&D1). Buildings K-31 and K-33 demolition was completed in 2015 under the *Action Memorandum for the Remaining Facilities Demolition Project at East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2049&D2-R). Soil in the K-31/K-33 Area was evaluated and remediated, as required, under the Zone 2 Soil ROD. There are no areas of archaeological or historical importance remaining on the site.

Topographic elevations in the K-31/K-33 Area range from a high of approximately 840 ft above mean sea level (amsl) in the northeastern portion of the area along the toe of Black Oak Ridge to approximately 740 ft amsl along the banks of Poplar Creek (Figure 2.1). Minimal relief characterizes most of the area. Runoff occurs as primarily overland sheet flow directly to Poplar Creek during storm events, as there are no established surface streams draining the area. Runoff also is captured by a network of storm drain catch basins that convey the water to outfalls that discharge to Poplar Creek. Surface runoff and storm drains also discharge to the K-901-A Holding Pond from the western portion of the K-31/K-33 Area.

The unconsolidated overburden materials (i.e., soils) are varied and consist of a range of clay, silty clay, and clayey silt. Limestone gravel intermixed with the clay and clayey silt materials is present in many areas. Occasional thin, sandy lenses are also present. The unconsolidated materials range in thickness up to approximately 40 ft.

The geologic units underlying the K-31/K-33 Area include the upper Knox Group formations in the northern portion of the area and the lower Chickamauga Group formations occupying the southern portion of the area. The Knox Group in the vicinity of the K-31/K-33 Area consists of the Kingsport Formation and the Mascot Dolomite (Lemiszki 1994), and the Chickamauga Group consists of the Pond Spring Formation, the Murfreesboro Limestone, the Ridley Limestone, the Lebanon Limestone, and the Carters Limestone. Structurally, these formations strike southwest to northeast and dip to the southeast. The angle of dip ranges from 20 to 50 degrees to the southeast based on measurements obtained from bedrock exposures along Poplar Creek (Lemiszki 1995).

The bedrock primarily consists of interbedded limestone and dolomite with variable bedding thicknesses, from thinly bedded to massive. Calcareous shales and argillaceous limestones also occur. The prevalence of limestone and dolomite has resulted in the formation of karst features, caused by dissolution of the rock by water. Prior to constructing the K-31 and K-33 facilities, there were several large sinkholes present in the area. These were filled to support building construction. Additional evidence of karst processes was observed during installation of the bedrock monitoring wells, several of which encountered mud-filled cavities and small voids in the rock. Fracturing in the bedrock is also variable and generally decreases with depth.

Groundwater occurs in both the unconsolidated overburden and bedrock in the area, primarily as a single, unconfined, water table aquifer. However, semiconfined conditions can occur in deeper portions of the competent bedrock. Saturated overburden thickness is variable due to the uneven bedrock surface but can be as much as 25 ft thick. Groundwater flow in the saturated overburden follows mapped hydraulic gradients, which generally mimic the topography, but locally can be influenced by anthropogenic features (e.g., cut and fill activities during construction, underground utilities, and subsurface foundations). Vertical groundwater flow in the overburden can be influenced by hydraulic head conditions in the underlying bedrock.

The depth to water ranges from approximately 6 to 31 ft below ground surface (bgs) over most of the K-31/K-33 Area, with depths of 45 ft bgs on the higher topographic knob at the K-892-J Cooling Tower basin in the northernmost part of the area. The potentiometric surface generated from water level data indicates groundwater flow in both the unconsolidated zone and bedrock generally follows a semi-radial pattern toward Poplar Creek. Unconsolidated zone flow paths are generally short and terminate at Poplar Creek. Bedrock zone groundwater flow paths are more complex given that flow is controlled by secondary features (e.g., faults, joints, bedding surfaces, and karstic conduits). Hydraulic conductivity values, based on slug test results from the monitoring wells, range from 1.1E-06 to 2.8E-02 cm/sec.

Horizontal hydraulic gradients in the K-31/K-33 Area are highest during the wet season when precipitation rates are high, evapotranspiration rates are low, and the Watts Bar Reservoir is lowered to its winter (low-pool) level, which also results in lowering of water levels in Poplar Creek. Water levels rise in interior areas while the surrounding surface water bodies are at their lowest elevation during these conditions. Conversely, horizontal gradients are generally lowest in the summer dry season when groundwater levels become depressed and the Watts Bar Reservoir pool levels are at their seasonal high point.

Vertical hydraulic gradients for the K-31/K-33 Area well pairs (one well screened in the unconsolidated zone adjacent to a well screened in the bedrock) are mostly downward, from the unconsolidated zone toward the underlying bedrock. Slight upward gradients were observed at two of the eight well pairs, with water level data for the February and March 2021 period. In general, downward gradients are present in the southeastern and western portions of the K-31/K-33 Area. Upward gradients in the northeastern and northwestern portions of the area may be indicative of semiconfined conditions in the bedrock underlying some parts of the area.

Monitoring groundwater quality in the K-31/K-33 Area has been ongoing since 1989 from 21 groundwater monitoring wells. Paired wells at the K-31/K-33 Area were installed at locations surrounding the two uranium process buildings and adjacent to other potential historical contaminant sources (e.g., the cooling towers/basins and RCW lines). The wells are paired to evaluate contaminants in both the unconsolidated and bedrock zones and the spatial patterns of vertical gradients.

Groundwater data indicate chromium (primarily hexavalent chromium) and nickel have been the most commonly occurring constituents with concentrations exceeding MCLs. The remedial action described in this K-31/K-33 Area Groundwater ROD is intended to address this contamination.

The K-31/K-33 buildings included an RCW system, which provided cooling to the gaseous diffusion process and included thousands of linear feet of piping and associated cooling towers and cooling tower basins. Beginning in the late 1950s, both the RCW system and the ETTP firewater system used a corrosion inhibitor additive that contained hexavalent chromium. The RCW system was also a potential source for nickel due to the widescale presence of nickel in the process piping and associated equipment that was in contact with the cooling water.

The release of RCW from pipeline and cooling tower basin leaks, deposition of cooling tower mist near RCW cooling towers, flushing of fire hydrants, and release of metals from concrete rubble during demolition of the building slabs were identified as the primary sources and release mechanisms for chromium and nickel detected in K-31/K-33 Area groundwater. These releases, representing a surface or shallow subsurface release pathway, migrated downward through the soil column by the process of infiltration to eventually reach underlying groundwater.

DOE has performed a number of activities to eliminate potential sources of groundwater contamination, beginning with RCW system shutdown in 1985. In the mid-1990s, sludge was removed from the cooling tower basins, above-ground basins were demolished, and below-ground basins were backfilled. Buildings and slabs demolitions were completed in 2012 (Building K-33) and 2015 (Building K-31). These demolition activities led to chromium releases that had leached from the pulverized concrete into water used for dust suppression. The chromium releases, detected in stormwater samples, were short termed and ended after the concrete debris was removed from the site. Soil characterization investigations in the K-31/K-33 Area for the Zone 2 Soil ROD did not identify any significant areas of soil contamination that could be considered a continuing source of groundwater contamination for chromium, nickel, or other potential contaminants.

Historically, suspended solids in unfiltered groundwater samples collected from the K-31/K-33 Area wells, as shown by elevated turbidity values, have influenced laboratory analyses for chromium, nickel, and other metals. Historical data show a general correlation between these metals concentrations and turbidity levels in the samples, with higher turbidity results associated with elevated concentrations of metals, including many results exceeding respective MCLs. This relationship was substantiated further by the absence of MCL exceedances in the corresponding filtered samples (i.e., filtering removes most of the suspended solids). Following installation of dedicated, low-flow sampling pumps in 2019 that are sampled in accordance with EPA-approved methods, the number of wells with results exceeding MCLs has been significantly reduced (Figure 2.3). Table 2.1 summarizes which contaminants exceeded MCLs over the timeframe represented in Figure 2.3.

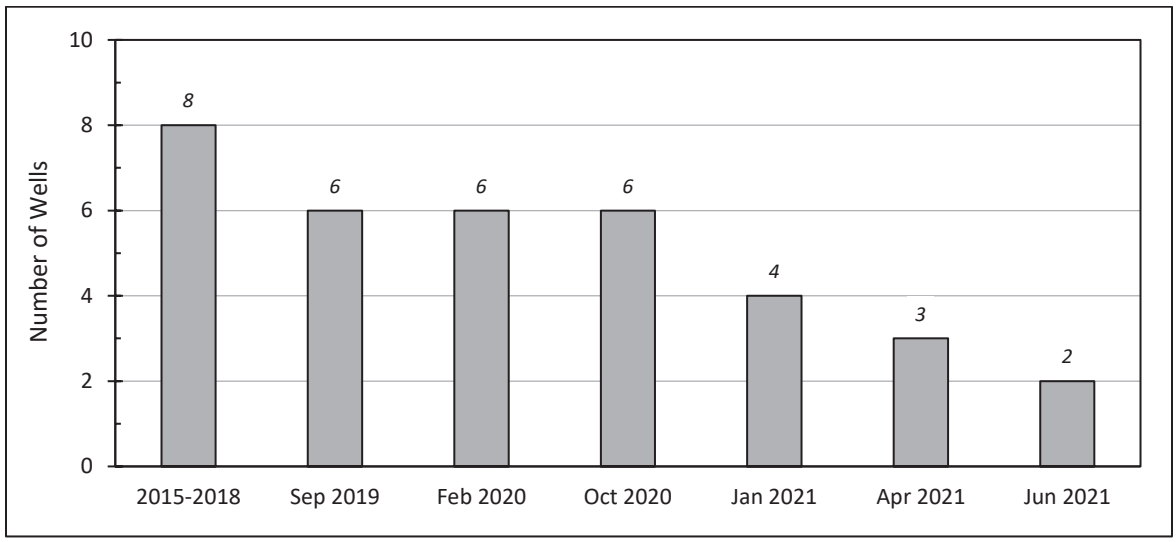

Figure 2.3. Number of K-31/K-33 Area monitoring wells with MCL exceedances.

In the June 2021 groundwater sampling event—the final, comprehensive sampling event conducted to support the K-31/K-33 Area RI/FS—MCL exceedances were detected in samples from 2 of the 20 wells that were sampled in the eastern portion of the K-31/K-33 Area. The June 2021 results were less than twice the MCL at the following locations:

- UNW-083: 0.123-mg/L nickel in the unfiltered sample compared to the 0.1-mg/L MCL
- BRW-030: 0.143-mg/L total chromium in the unfiltered sample compared to the 0.1-mg/L MCL

See Figures 2.4 and Figure 2.5 for a graphical representation of chromium and nickel data from UNW-083 and BRW-030, respectively. Note that references to chromium concentrations throughout this document are referring to total chromium measurements. There is no federal or state regulatory criterion for hexavalent chromium; therefore, while hexavalent chromium is the most prevalent chromium species detected in K-31/K-33 Area groundwater, total chromium measurements are used for comparison to the MCL.

The K-31/K-33 Area RI/FS presented the results of a statistical evaluation of groundwater data using the Mann-Kendall trend analysis tool, which determines whether a set of data values (in this case, groundwater sample results for specific contaminants from K-31/K-33 Area monitoring wells) is increasing or decreasing over time, and whether the trend in any direction is statistically significant.

Table 2.1. Summary of MCL exceedances in 2017–2021 groundwater sample results

Constituent	Unfiltered groundwater 2015–2018 Well	Unfiltered groundwater May–September 2019 Well	Unfiltered groundwater February/March 2020 Well	Unfiltered groundwater October/November 2020 Well	Unfiltered groundwater January/February 2021 Well	Unfiltered groundwater April 2021 Well	Unfiltered groundwater June 2021 Well
Alpha activity	UNW-040, UNW-080, UNW-081	None	None	UNW-040	None	None	None
Antimony	UNW-080	BRW-027, UNW-082, UNW-083	None	None	None	None	None
Arsenic	None	None	UNW-039, UNW-045[a]	None	None	None	None
Beryllium	None	None	UNW-045[a]	None	None	None	None
Chromium	BRW-027, BRW-030, BRW-031, UNW-043, UNW-080, UNW-083	BRW-030, UNW-039, UNW-083	BRW-030, BRW-031, UNW-039, UNW-045[a]	BRW-030, BRW-031, UNW-039, UNW-083	BRW-030, UNW-039	BRW-030, UNW-039	BRW-030
Lead	UNW-080, UNW-081	None	UNW-045[a]	UNW-040	None	None	None
Nickel	UNW-043, UNW-083	UNW-039, UNW-043, UNW-083	UNW-039, UNW-043, UNW-083	UNW-039, UNW-043, UNW-083	UNW-039, UNW-043, UNW-083	UNW-039, UNW-083	UNW-083

[a]Turbidity level was 1000 nephelometric turbidity units.

BRW = bedrock zone monitoring well
MCL = maximum contaminant level
UNW = unconsolidated zone monitoring well

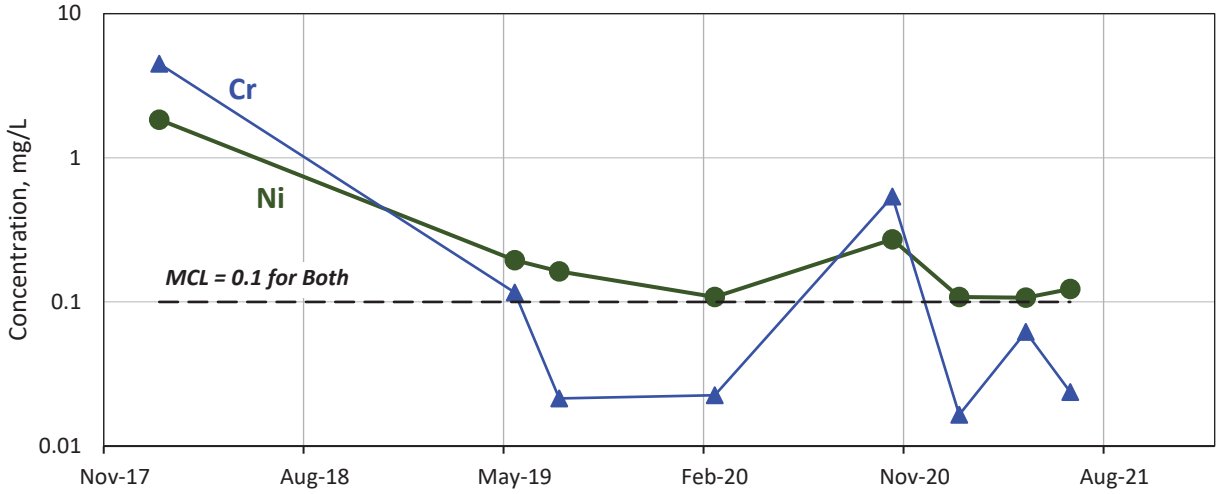

Figure 2.4. Chromium and nickel in unfiltered samples from UNW-083, 2017–2021.

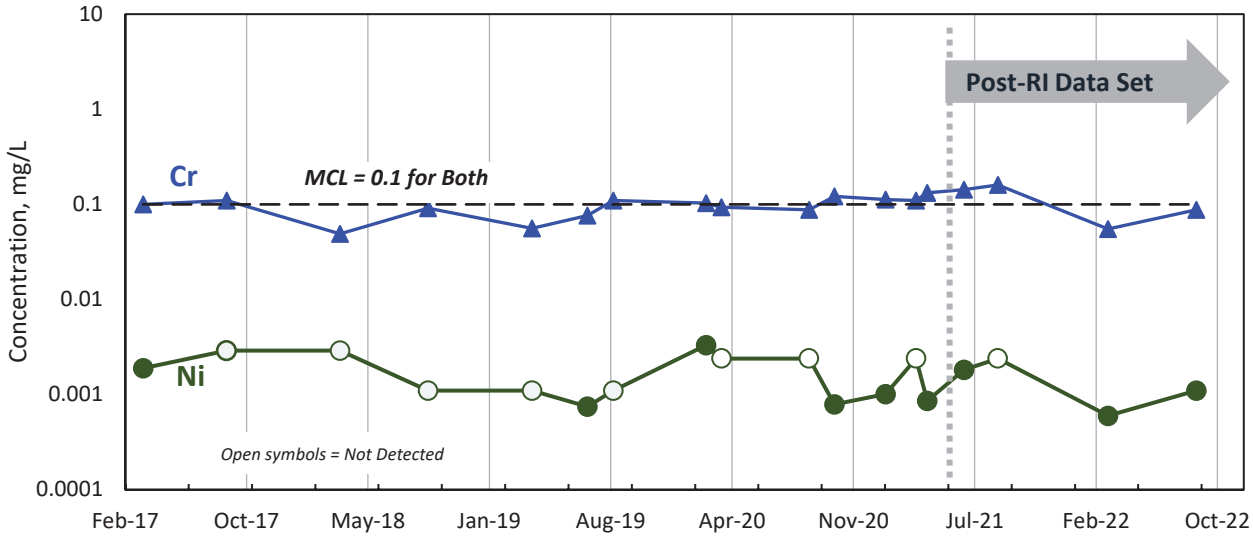

Figure 2.5. Chromium and nickel in unfiltered samples from BRW-030, 2017–2022.

Nickel concentrations in UNW-083 have generally decreased since 2017, and the Mann-Kendall analysis of nickel results indicates a significant downward trend over the past 5 years. Figure 2.4 presents a plot of both chromium and nickel results for unfiltered samples collected from UNW-083 for this 5-year period. This well is not part of the WRRP water quality program semiannual sampling at the K-31/K-33 Area, and it has not been sampled since June 2021.

Chromium concentrations in BRW-030 have fluctuated above and below the MCL since 2017, and the Mann-Kendall trend analysis has indicated an increasing trend during the 5-year evaluation period. Figure 2.5 plots both chromium and nickel results for unfiltered samples collected from BRW-030 for this 5-year period, plus results from the WRRP water quality program semiannual sampling. Exceedances of the chromium MCL are in 9 out of the 15 sampling events in this 5-year period. These exceedances are represented by results from unfiltered samples that surpass the MCL of 0.1 mg/L by an additional 0.06 mg/L (60 parts per billion) or less. Figure 2.6 shows the locations of UNW-083 and BRW-030 with the June 2021 MCL exceedances and the measured concentrations.

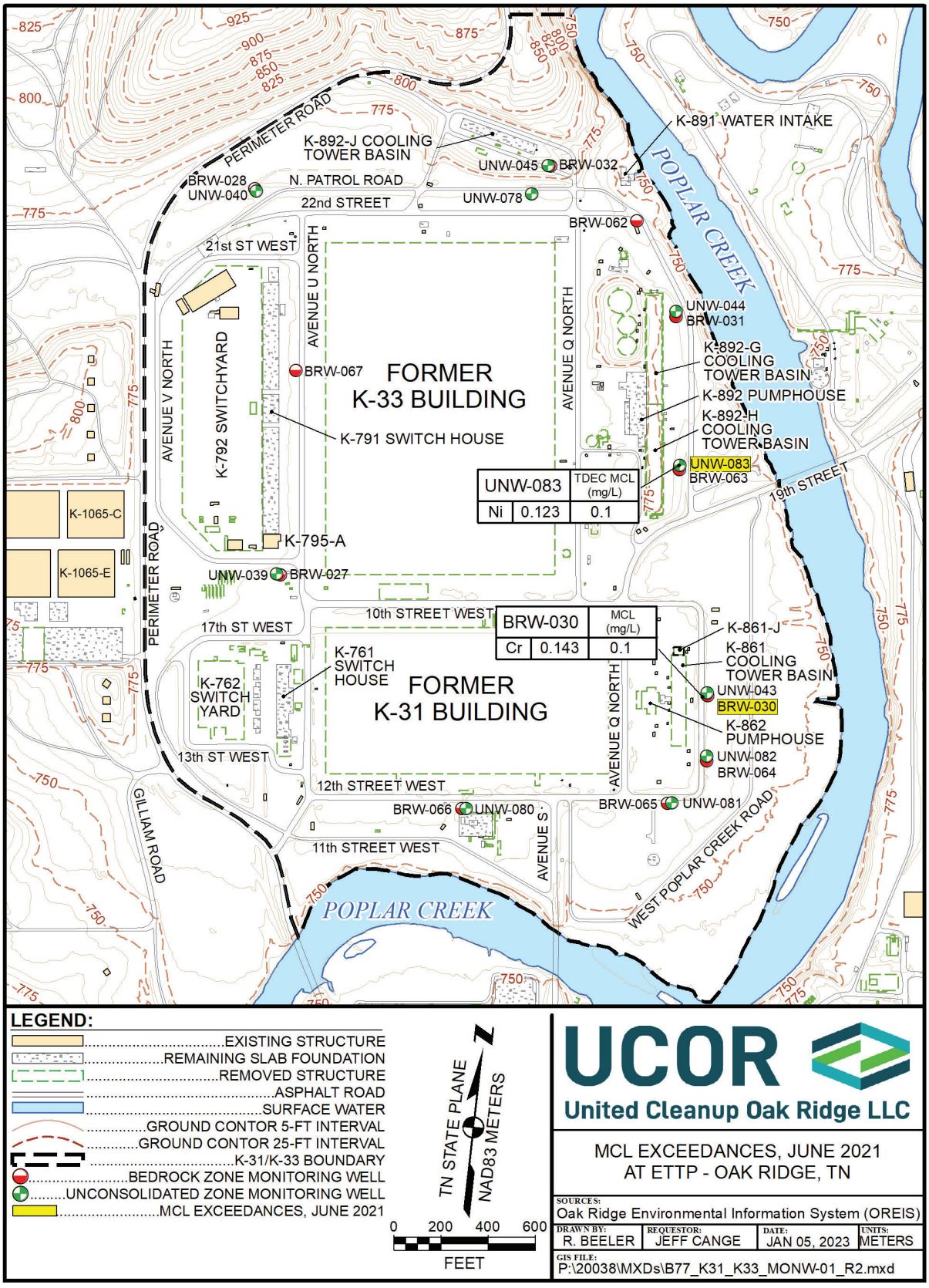

Figure 2.6. Monitoring wells with MCL exceedances based on June 2021 sampling.

The episodic nature of the MCL exceedances in BRW-030 was shown by results from the WRRP semiannual sampling of well pair BRW-030 and UNW-043 (Figure 2.5 and Figure 2.7, respectively). The samples collected from BRW-030 in March and August of 2022 were both less than the MCL. Variability in groundwater data was demonstrated further by the detection of chromium slightly above the MCL in the unfiltered sample collected from UNW-043 in September 2022. Chromium was last detected in UNW-043 above the MCL in March 2017. The results for UNW-043 and BRW-030 updated with the 2022 data points indicate contamination levels in these two wells may fluctuate in the near term.

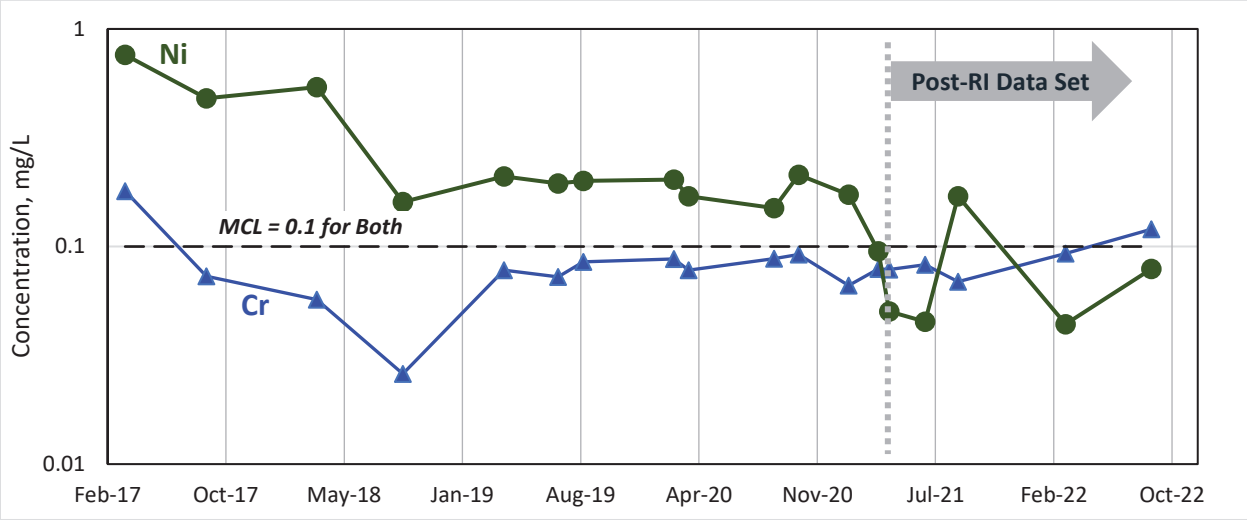

Figure 2.7. Chromium and nickel in unfiltered samples from UNW-043, 2017–2022.

Fate and transport modeling for the K-31/K-33 Area using the Analytical Transport 1-, 2-, and 3-Dimentional Simulation groundwater model indicates neither chromium nor nickel is predicted to migrate an appreciable distance from the monitoring wells that have had MCL exceedances and neither is expected to reach Poplar Creek. Semiannual surface water sampling downstream of the K-31/K-33 Area has demonstrated the absence of chromium (i.e., all results for chromium were non-detect) in Poplar Creek since 2019 (K-31/K-33 Area RI/FS). The absence of significant migration away from these wells is due to the lack of ongoing releases of contamination, gradual depletion of source material from historical releases, and effects of natural attenuation processes within the groundwater.

The fate and transport modeling was performed using the Analytical Transient 1-, 2-, 3-Dimensional (AT123D) model, which computes the spatial-temporal concentration distribution of chemicals in the aquifer system and predicts the transient spread of a chemical plume through a groundwater aquifer. The fate and transport processes accounted for in AT123D are advection, dispersion, adsorption/retardation, and decay. This model can be used as a tool for estimating the dissolved concentration of a chemical in three dimensions in groundwater resulting from a mass release (either a continuous, instant, or depleting source) over a source area (i.e., point, line, area, or volume source).

Important assumptions used in the analysis using AT123D are:

- Using the distribution co-efficient (K_d) and retardation factor (R_d) to describe the reaction term of the transport equation assumes an equilibrium relationship exists between the solid- and solution-phases concentrations and the relationship is linear and reversible.
- Flow and transport are not affected by density variations.

- The groundwater aquifer is homogenous and isotropic (i.e., uniform hydraulic conductivity).
- Only one constituent can be modeled at a time, ignoring interactions between multiple constituents.

Major assumptions for fate and transport modeling and modeling results can be found in Appendix B of the K-31/K-33 Area RI/FS. The modeling conducted for evaluating MNA can be found in Appendix C of the K-31/K-33 Area RI/FS.

Fate and transport modeling results predicted natural attenuation processes within the groundwater would reduce contaminant concentrations to below MCLs across the K-31/K-33 Area in about 15 years. The analysis indicates MNA would be an effective remedial action for groundwater.

2.6 CURRENT AND POTENTIAL FUTURE LAND USES

Following ETTP facility shutdown, a vision for the future use of the facility was developed jointly by DOE, TDEC, EPA, and stakeholders from Oak Ridge and surrounding communities. For ETTP in general and the K-31/K-33 Area in particular, this vision included transitioning from a DOE-controlled uranium enrichment facility to a commercial/industrial park. This future land use allowed DOE to propose and select remedial actions for soil that were protective of future site workers.

The Zone 2 Soil ROD, which addresses soil, including the K-31/K-33 Area, has an "unrestricted industrial land use" as the basis for defining its remedial action objectives. This reasonably anticipated future land use for Zone 2 (i.e., unrestricted industrial) is further defined as an industrial worker onsite 2000 hr/year for 25 years to 10 ft bgs. Based on input from the three ORR FFA parties and from the public, 10 ft was selected as an acceptable depth to allow for most industrial uses, including activities necessary to build basements and to repair or install utilities. An industrial land use is a logical extension of those areas of ETTP used historically for industrial purposes because of the availability of standard utility and transportation infrastructure to support industrial activities and the relative ease of conversion to reuse for industrial purposes. (Note the land use restrictions for Zone 2 may be modified as part of the Zone 2 Soil ROD's Remedial Action Report [RAR].)

2.6.1 Current Land Use

Current land uses in the K-31/K-33 Area are industrial, consistent with anticipated land uses identified in the Zone 2 Soil ROD. The entire parcel (185 acres) was transferred to the Community Reuse Organization of East Tennessee (CROET) in 2017 through the Covenant Deferral Request process based on CERCLA Section 120(h)(3)(C) requirements. CROET leased the K-31 area (60 acres) to Consolidated Nuclear Security LLC, the contractor responsible for constructing the Y-12 Uranium Processing Facility. The leased area is being used as a lay-down yard and storage area for Y-12 Uranium Processing Facility components. In 2021, CROET transferred the K-33 footprint (125 acres) to Kairos Power LLC, who plans to use the site for constructing and operating a low-power demonstration reactor.

The deeds transferring the properties to CROET and Kairos Power LLC contain restrictions for the K-31/K-33 Area that limit development to industrial and commercial uses; allow for continued DOE access as needed to complete CERCLA cleanup actions; and prohibit groundwater extraction, consumption, exposure, or use, in any way. The deeds also restrict unpermitted soil disturbances deeper than 10 ft bgs on the properties.

In addition to on-site considerations for land and groundwater resource uses, off-site land and resource uses are considered. Current residential areas are located offsite to the north and west of the K-31/K-33 Area in ETTP. DOE conducted the *Offsite Groundwater Assessment Remedial Site Evaluation* (DOE/OR/01-2715&D2; Offsite Groundwater Remedial Site Evaluation) from fiscal years 2014–2016 to

investigate groundwater quality and potential off-site migration of contaminants from the ORR. The study included sampling 15 residential wells and springs downgradient of ETTP. The study did not identify any contamination issues or other impacts at these 15 wells and springs sampled during the fiscal years 2014–2016 time period. Continued sampling in accordance with Phase 2 of the Offsite Groundwater Remedial Site Evaluation at a subset of five downgradient monitoring locations in fiscal years 2019–2021 has documented the absence of off-site contamination issues in those five residential wells.

The K-31/K-33 Area is located adjacent to the downstream stretch of Poplar Creek, around Poplar Creek Mile 3.0, before its confluence with the Clinch River at Clinch River Mile 12.0. This stretch of Poplar Creek is also downstream from the confluence of East Fork Poplar Creek, which carries discharge from Y-12. Poplar Creek is classified for recreational use in addition to its use as habitat for fish and aquatic life. The Clinch River, including the lower portions of Poplar Creek, is included as part of the proposed Pellissippi Blueway, a stretch of the Clinch River including other navigable streams/features and user access points mapped primarily for flatwater paddling. Several National Pollutant Discharge Elimination System permits are in place at ETTP for discharge into Poplar Creek or Clinch River watersheds, including DOE's ongoing cleanup work of legacy contamination, other government operations, and private industry.

2.6.2 Anticipated Future Uses

The anticipated future use of the K-31/K-33 Area (i.e., unrestricted industrial) is a continuation of the current industrial use of the site and is consistent with the Zone 2 Soil ROD remedial action objectives to assure the soil actions completed under that ROD will remain protective of future site workers. Poplar Creek is also anticipated to continue to be used for recreational purposes.

Future groundwater use in the K-31/K-33 Area is improbable and would require prior approval from DOE, EPA, and TDEC. Groundwater would be of limited use to future owners or tenants due to the complex geology, availability of the nearby Clinch River as a water source, and availability of the existing municipal water supply. Although drinking water use is not anticipated, under TDEC Rule 0400-40-03-.07(4)(b), groundwater beneath the K-31/K-33 site is classified as general use groundwater and, therefore, is considered a potential source of drinking water. Groundwater modeling completed for the selected remedy predicted MCLs will be achieved in approximately 15 years, at which time, current prohibitions on groundwater use will be evaluated to determine if the LUCs are still required.

Future residential use of the K-31/K-33 Area is prohibited through the LUCs established under the Zone 2 Soil ROD and is inconsistent with the Zone 2 Soil ROD remedial action objectives. For any property leased, sold, or transferred, DOE will comply with the requirements of CERCLA Section 120(h) regarding property transfer, including provisions for use restrictions and continued maintenance of LUCs.

2.7 SUMMARY OF SITE RISKS

This section summarizes potential risks to human health from exposure to groundwater contamination beneath the K-31/K-33 Area. The remedial action objectives described below were selected, at least in part, on their ability to mitigate these risks once the selected remedy is successfully implemented.

Soil in the K-31/K-33 Area was previously characterized and remediated, as necessary, to support future reuse of the site for industrial or commercial purposes. Other uses of the site (e.g., residential) are prohibited, and remaining concentrations of contaminants in the soil do not allow for UU/UE. After completing required soil remedial actions, the soil met no further action criteria, as defined by the Zone 2 Soil ROD and documented in the various Phased Construction Completion Reports (PCCRs) for soils in the K-31/K-33 Area (Table 2.2). This determination allowed DOE to proceed with property transfers in

Table 2.2. No further action PCCRs for K-31/K-33 Area soils

Abbreviated document title	Document number	EUs	Approval date
FY 2006 PCCR	DOE/OR/01-2317&D2	Z2-02, Z2-07, Z2-09, and Z2-10	December 2006
Addendum to the FY 2006 PCCR	DOE/OR/01-2317&D2/A1	Z2-10	January 2016
FY 2007 PCCR	DOE/OR/01-2723&D2	Z2-01, Z2-03, and Z2-08	May 2008
Addendum to the FY 2007 PCCR	DOE/OR/01-2723&D2/A2	Z2-03	September 2016
PCCR for EUs Z2-04 and Z2-05	DOE/OR/01-2590&D1	Z2-04 and Z2-05	November 2012
Addendum to the PCCR for EUs Z2-04 and Z2-05	DOE/OR/01-2590&D1/A1	Z2-05	April 2016
FY 2015 PCCR for EU Z2-06	DOE/OR/01-2699&D2	Z2-06	January 2017

EU = exposure unit
FY = fiscal year
PCCR = Phased Construction Completion Report

accordance with CERCLA Section 120(h)(3), with established LUCs, including prohibiting use of groundwater (which includes extraction, consumption, and exposure) without prior written approval from DOE, EPA, and TDEC, and other LUCs preventing unacceptable exposures to residual contamination. Figure 2.8 shows the locations of the Zone 2 soil exposure units associated with each of the PCCRs and PCCR Addenda.

2.7.1 Summary of Baseline Human Health Risk Assessment

Baseline risks are defined as those potential impacts to human health that might occur if no remedial action or institutional controls are implemented at a site. A baseline human health risk assessment (HHRA) was performed for the K-31/K-33 Area RI/FS to estimate the human health risk that could result from potential exposure to chemicals or radionuclides detected in K-31/K-33 Area groundwater.

The baseline HHRA was developed using methods from EPA's *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part A)* (EPA 1989), Part D (Standardized Planning, Reporting, and Review of Superfund Risk Assessments) (EPA 2001a), Part E (Supplemental Guidance for Dermal Risk Assessment) (EPA 2004), and Part F (Supplemental Guidance for Inhalation Risk Assessment) (EPA 2009a); *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors* (EPA 2014a); and *Region 4 Human Health Risk Assessment Supplemental Guidance* (EPA 2018). The baseline HHRA provides the basis for taking a remedial action and identifies the contaminants and exposure pathways that need to be addressed by the action.

2.7.1.1 Data evaluation and identification of COPCs

The baseline HHRA included groundwater data from 20 of the 21 monitoring wells in the K-31/K-33 Area, excluding 1 well that is consistently dry. The dataset includes samples from both unconsolidated zone and bedrock monitoring wells collected between 2017–2021. Although both unfiltered and filtered groundwater samples were collected, the HHRA used only unfiltered data to characterize risks, in accordance with EPA guidance (EPA 2014b).

Data from all monitoring well samples collected and analyzed between 2017–2021 were included in the HHRA dataset, including samples from which results were skewed by high concentrations of suspended solids indicated by high turbidity values. Low-flow, micropurge pumps were installed in K-31/K-33 Area wells in 2019, an action that resulted in significant decreases in the level of turbidity in groundwater samples.

The baseline HHRA quantitatively evaluated groundwater at the K-31/K-33 Area based on a dataset of samples from all the wells in the monitoring network, which includes all groundwater data collected from both the unconsolidated and bedrock zones, combined over the 20 monitoring wells for which data are available from the 5-year period of evaluation. In addition, the baseline HHRA quantitively evaluated groundwater at the K-31/K-33 Area looking at the wells individually.

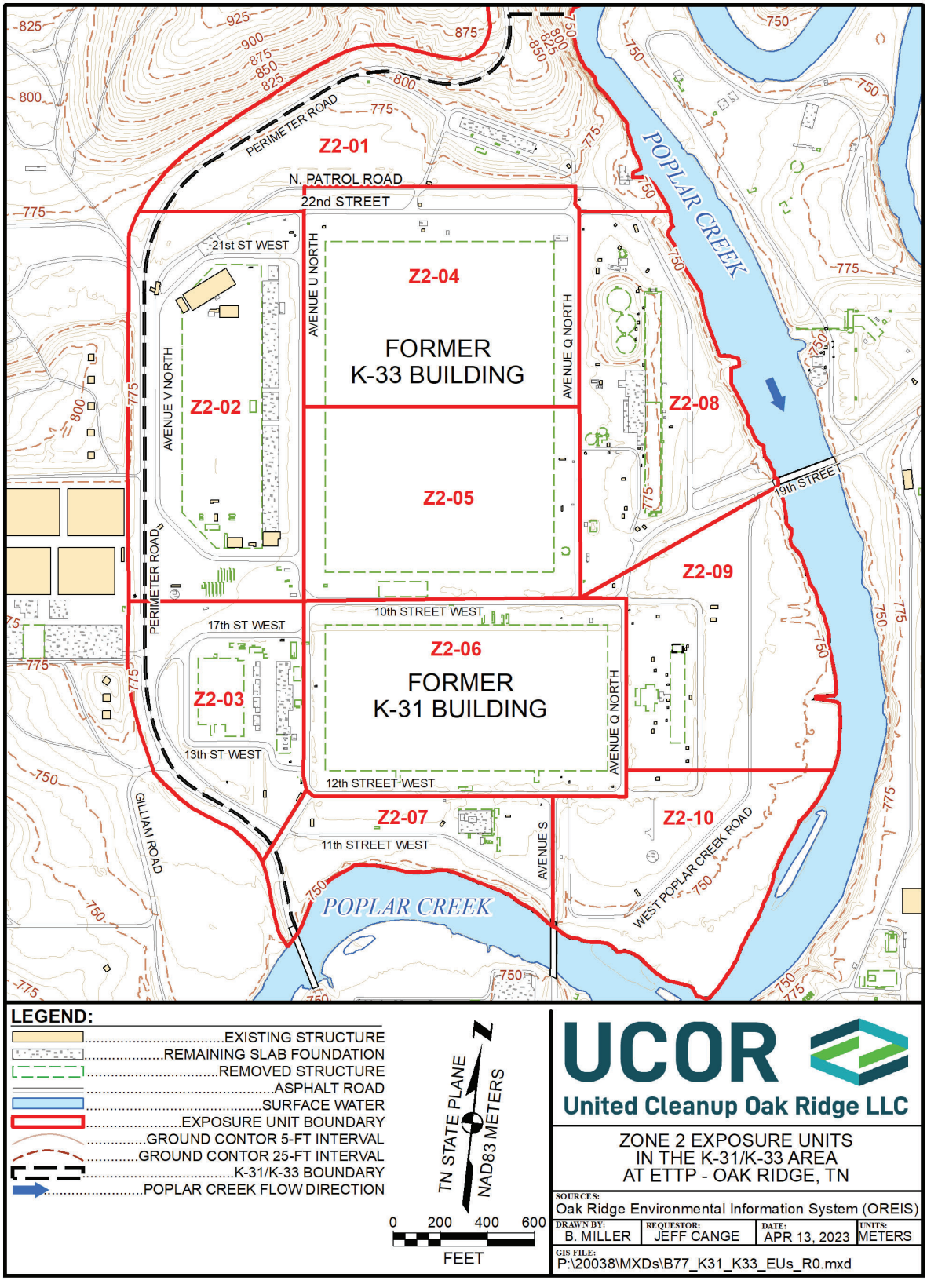

Figure 2.8. Zone 2 exposure units in K-31/K-33 Area.

The data evaluation identified contaminants of potential concern (COPCs), which are analytes (both chemicals and radionuclides) associated with potential impacts to human health. COPCs were identified under both an industrial use scenario, which is the current and anticipated future land use for the K-31/K-33 Area, and a hypothetical future residential use scenario, consistent with EPA's *Summary of Key Existing EPA CERCLA Policies for Groundwater Restoration* (2009b) guidance on how to evaluate risks in groundwater and the expectation to return groundwater to beneficial use and as a potential source of drinking water. The evaluations used a target cancer risk of 1E-06 and/or a noncarcinogenic target hazard quotient (HQ) of 0.1 for both residential and industrial scenarios.

Chemical constituents in groundwater, and more specifically the maximum detected concentrations (MDCs), were compared to their corresponding regional screening levels for tap water (EPA 2021a). Likewise, MDCs for radionuclides were compared to the corresponding preliminary remediation goal for tap water (ORNL 2021). Volatile chemicals (i.e., volatile organic compounds and mercury) were also evaluated against EPA's vapor intrusion screening levels to determine COPCs associated with vapor intrusion pathways (EPA 2021b). Finally, groundwater MDCs were evaluated against contaminant-specific MCLs. While MCLs are not risk-based values, they are identified as ARARs required for implementation of the selected remedy for K-31/K-33 Area groundwater. The ARARs for this K-31/K-33 Area Groundwater ROD are included in Appendix A.

2.7.1.2 Exposure assessment

The exposure assessment step of the baseline HHRA included characterizing the exposure setting and identifying plausible and assumed human receptors, environmental migration and receptor exposure pathways, routes of human exposure (i.e., ingestion, dermal contact, inhalation, and external radiation exposures), and quantifications of exposures. Current and expected future use of the area will be limited to industrial and commercial uses. Residential and agricultural uses will not be permitted due to LUCs established by the Zone 2 Soil ROD and this K-31/K-33 Area Groundwater ROD. Recreational or natural resource conservation land uses are not anticipated because of the continued industrial usage of the site (Consolidated Nuclear Security LLC and Energy*Solutions*) and plans for future development (i.e., Kairos Power LLC).

Both the Zone 2 Soil ROD and the deeds transferring the K-31/K-33 parcels prohibit extracting, consuming, exposing, or using, in any way, groundwater underlying the K-31/K-33 Area without prior approval from the ORR FFA parties. Even though using groundwater as a source of potable water is not permitted, the CERCLA process requires a quantitative evaluation of risks through a variety of potential exposure pathways, including use of groundwater as a potable water supply.

The baseline HHRA evaluated the potential for adverse health effects for groups of people associated with an industrial scenario (i.e., industrial or commercial worker and construction worker) and a hypothetical residential scenario (i.e., adult resident and child resident). These hypothetical residents were assumed to be living in the K-31/K-33 Area and using groundwater for drinking water and for other potable purposes (e.g., washing, laundry, and garden irrigation).

TDEC Rule 0400-40-03-.07(4)(b) (TDEC 2019) designates all groundwater in the state as general use groundwater (acceptable for use as drinking water), except for groundwater that has been specifically designated otherwise in the Rule. This designation would apply to groundwater on the ORR, including groundwater in the K-31/K-33 Area. Similarly, the mission of the Superfund program is to protect human health and the environment, consistent with CERCLA as implemented by the NCP, in part by restoring contaminated groundwaters to their beneficial use wherever practical (40 CFR 300.430(a)(1)(iii)(F)). The NCP requires federal SDWA MCLs and non-zero MCL goals be attained for all remedial actions for groundwaters that are current or potential sources of drinking water, where the MCLs/non-zero MCL goals

are relevant and appropriate under the circumstances of the release (40 CFR 300.430(e)(2)(i)(B)-(C)). Consequently, both residential use and industrial use of groundwater (including as a drinking water source) were evaluated in the baseline HHRA.

Evaluation of groundwater as a potable source under the residential land use scenario represents the most health-conservative of all groundwater exposure scenarios because it represents the least restrictive scenario and the widest range of potential receptors, including children. Consequently, evaluation of groundwater use by a hypothetical resident typically results in the most elevated adverse health risks of all receptor scenarios for groundwater exposures.

Based on land use and groundwater exposure pathways consideration, a human health conceptual exposure model was developed for K-31/K-33 Area groundwater. The conceptual exposure model, which is depicted in tabular form in Table 2.3, presents the sources of groundwater contamination, potential groundwater exposure points, exposed receptor populations, and exposure routes that were evaluated for chemical and radiological COPCs.

Table 2.3. Conceptual exposure model of HHRA

Sources	Environmental exposure medium	Exposure point	Exposure route	Exposed population
Chemical COPCs				
Spills, leaks, releases from concrete rubble, and cooling tower mist	Groundwater (potable use)	Residents' tap water	Ingestion, dermal contact, inhalation of volatiles from domestic water use	Hypothetical residents (adults and children)
		Industrial facility's tap water	Ingestion, dermal contact, inhalation of volatiles	Hypothetical industrial worker (adults)
	Groundwater (vapor intrusion)	Residents' indoor air	Inhalation of volatiles	Hypothetical residents (adults and children)
		Industrial facility's indoor air	Inhalation of volatiles	Hypothetical industrial worker (adults)
Radionuclide COPCs				
Spills and leaks	Groundwater	Residents' tap water	Ingestion (soil and produce), inhalation, immersion	Hypothetical residents (adults and children)
		Industrial facility's tap water	Ingestion, inhalation, immersion	Hypothetical industrial worker (adults)

COPC = contaminant of potential concern
HHRA = human health risk assessment

Estimates of chemical and radiological COPC concentrations at the groundwater points of potential human exposure are necessary to evaluate exposures to potentially exposed individuals. These concentrations are termed exposure point concentrations (EPCs). EPA's most recent groundwater EPC guidance (EPA 2014b) recommends monitoring wells within the core/center of a plume, where the highest contaminant concentrations are typically detected, be used to calculate groundwater EPCs. Groundwater contamination in the K-31/K-33 Area is not associated with discrete plumes but rather intermittent exceedances of MCLs at a limited number of wells.

Given the absence of definable plumes, DOE calculated groundwater EPCs for the baseline HHRA using available data from all 20 wells collected from the 5-year period of evaluation for the RI (2017–2021). In addition, DOE calculated groundwater EPCs for the baseline HHRA using data from each individual well for the same duration based on the health-conservative assumption that COPC concentrations in each well could be representative of the core of a plume (or multiple plumes). The EPC for each COPC was determined as the lesser of the MDC and the UCL95 on the mean concentration, in accordance with EPA's groundwater EPC guidance (EPA 2014b).

EPCs were used in combination with exposure factors from EPA guidance to estimate chemical intake and radionuclide exposure via each exposure pathway for each receptor (including both adult and child for the residential scenario). Conservative, default exposure assumptions for the resident and site-specific exposure assumptions for the industrial worker were used. Quantifying exposure involved determining the mass of substance in contact with the body per unit of body weight per unit of time. For nonradiological contaminants, these exposure estimates were expressed as milligrams of chemical per kilogram of body weight per day (mg/kg-day) and are termed intakes. The intakes were calculated for each pathway for each COPC using the parameters for the standard industrial worker and the representative EPCs.

DOE will recalculate the EPCs after approval of the RAWP to incorporate groundwater data collected as part of the overall monitoring plan. The approach for performing this calculation and any expanded analytical requirements will be developed with input from TDEC and EPA as part of the data quality objective planning process supporting the RAWP. These revised EPCs will be compared to the baseline HHRA EPCs to confirm concentrations of metals have decreased in groundwater representative of current conditions after the incorporation of sampling methods to reduce turbidity.

2.7.1.3 Toxicity assessment

A toxicity assessment describes the quantitative relationship between the extent of exposure to a chemical or radionuclide and the types of injury or disease. This quantitative relationship generally takes the form of toxicity values that are identified for use in risk characterization. Toxicity values used in the risk assessment included cancer slope factors (CSFs) used to calculate chemical and radiological cancer risks and reference doses (RfDs) and reference concentrations (RfCs) used to determine systemic toxicity following exposures to noncarcinogenic chemicals. Toxicity criteria applied in the baseline HHRA to evaluate chemical and radiological COPCs identified in K-31/K-33 Area groundwater are presented in Appendix G of the K-31/K-33 Area RI/FS.

Chemical CSFs were used to quantitatively define the relationship between daily intake of a chemical and its incremental lifetime cancer risk (ILCR), while RfDs and RfCs were used to quantitatively define the relationship between daily intake of a chemical and the resulting systemic toxicity. CSFs used in this assessment are upper-bound estimates of the probability of a response per unit intake of a carcinogen over a lifetime; RfDs and RfCs used in the assessment are estimates of a daily exposure level that is likely to be without an appreciable risk of deleterious effects during a lifetime. The primary sources of oral and inhalation toxicity values were the Integrated Risk Information System (EPA 2021c), EPA Provisional Peer-Reviewed Toxicity Values (EPA 2021d), Agency for Toxic Substances and Disease Registry (ATSDR 2021), California Environmental Protection Agency toxicity database (California EPA 2021), and EPA's Health Effects Assessment Summary Tables (EPA 1997 for chemicals, EPA 2001b for radionuclides).

For each carcinogenic chemical COPC, the CSF for evaluating the dermal absorption exposure route was calculated by dividing the oral CSF by the corresponding oral absorption efficiency. For each noncarcinogenic chemical COPC, the RfD for evaluating the dermal absorption exposure route was calculated by multiplying the oral RfD by the corresponding oral absorption efficiency.

Toxicity-related health impacts from exposure to radiation and radionuclides are expressed as the risk of developing cancer. Cancer risks from ingestion, inhalation, and external radiation exposures to COPCs and decay chain progeny in groundwater were estimated using EPA's most recent internal and external radiation CSFs. The most recent CSFs were obtained from ORNL's *Calculation of Slope Factors and Dose Coefficients* (ORNL 2014) that were derived for morbidity. CSFs were used to convert exposures to radionuclides to carcinogenic risk.

2.7.1.4 Risk characterization

During risk characterization, pathway-specific exposure estimates for each COPC are mathematically combined with corresponding toxicity values to calculate noncarcinogenic HQs or cancer risks for the exposure scenarios. The objective is to determine whether exposure to chemical and/or radiological COPCs in K-31/K-33 Area groundwater poses risks that exceed target levels for human health effects.

Risk characterization approach for K-31/K-33 Area groundwater

Cancer risks are estimated as the incremental probability of an individual developing cancer over a 70-year lifetime because of exposure to a carcinogen (chemical or radionuclide). Cancer risks represent probabilities calculated by multiplying the chronic daily intake averaged over a 70-year lifetime by the corresponding CSF for each carcinogen. These probabilities are expressed in scientific notation as an ILCR. For example, a cancer risk or ILCR of 1E-06 represents a 1 in 1 million chance of developing cancer as a result of site-related exposure. An ILCR of 1E-05 represents a 1 in a 100,000 chance and so on.

All chemical and radiological cancer risks are compared to EPA's target risk range of 1E-06 to 1E-04. EPA considers the lower limit of this range (i.e., 1E-06) as being the point of departure from which risk-management decisions are made. Cancer risks estimated to be below the lower limit of the range or within the range itself (i.e., less than or equal to the upper limit of 1E-04) indicate no significant probability or excess risk of the occurrence(s) of cancerous effects in an exposed population. However, cancer risks calculated to be greater than 1E-04 indicate the need for further analysis and possible remedial action.

The estimate of the total site cancer risk accounts for exposure to multiple carcinogens and exposure routes. In the baseline HHRA for K-31/K-33 Area groundwater, the carcinogenic risks for chemicals were summed across all COPCs and across all exposure pathways to determine a total risk estimate for each groundwater receptor scenario (industrial, residential adult, and residential child). Similarly, the carcinogenic risks for radionuclides were summed across all radiological COPCs and across all exposure pathways to determine a total risk estimate for radionuclides in groundwater.

The potential for adverse noncarcinogenic effects from exposure to a given chemical COPC is expressed as the HQ. The HQ is the ratio of the estimated chronic daily intake associated with an exposure pathway to the corresponding RfD or RfC. To evaluate cumulative effects from an exposure to more than one noncarcinogen, the chemical-specific HQs were summed for each exposure route to obtain the route-specific hazard index (HI) (e.g., groundwater ingestion, inhalation of vapors in groundwater, and groundwater dermal contact). The exposure route-specific HIs were, in turn, summed together to determine the receptor HI for groundwater. For noncancer effects, if the total groundwater HI exceeded 1, chemicals were then segregated according to which organ they target (i.e., relative to potentially adverse systemic effects), and the HQs for each target organ were summed to determine the organ-specific HI. The target organ-specific HIs were then compared to the benchmark HI of 1.

Risk characterization results for K-31/K-33 Area groundwater

Risks and hazards were quantified using data collected from 20 of the 21 monitoring wells (excluding the 1 well that is consistently dry) in the K-31/K-33 Area. The HHRA also compared EPCs to federal and state drinking water standards (MCLs). MCLs are based on a combination of factors including potential toxicity as well as background concentrations and treatment technology considerations. COPCs were identified as COCs if the EPC exceeded an MCL, regardless of the total risk or hazard associated with other chemicals present in the groundwater. The risks and hazards are presented in Table 2.4.

Carcinogenic and noncarcinogenic risks exceeded EPA's acceptable risk range for both the industrial and residential exposure scenarios. Risks outside the acceptable range of 1E-04 to 1E-06 were identified.

Table 2.4. Summary of risks and hazards for hypothetical residential and industrial receptors

	Cancer risk		Noncancer risk			
	Total ILCR		Total HI		Organ-specific maximum HI[a]	
Exposure pathway	Chemical	Radionuclide	Child	Adult	Child	Adult
Hypothetical resident	1E-03	2E-05	5	3	1	0.7
Hypothetical industrial worker	2E-04	5E-06	NA	1	NA	--

[a]Target organ hazard quotients for neurological effects (aluminum, fluoride, manganese, and selenium), dermal effects (arsenic, selenium, thallium, and vanadium), gastrointestinal effects (beryllium, copper, and iron), renal effects (cadmium and uranium), and whole-body effects (antimony and nickel) are summed to calculate organ-specific HIs when the total HIs of all the residential and/or industrial contaminants of potential concern is greater than 1.

-- denotes no HI greater than 1 using target organ hazard quotients.

HI = hazard index
ILCR = increased lifetime cancer risk
NA = not applicable as there is no child receptor for industrial exposures

Risks and hazards were also quantified using data from each individual well in the K-31/K-33 Area. The HHRA also compared EPCs from each individual well to federal and state MCLs. Risks outside the acceptable range of 1E-04 to 1E-06 were identified for 15 of the 20 wells for hypothetical residential receptors (ranging from 2E-04 to 4E-03) and for 4 of the 20 wells for industrial receptors (ranging from 3E-04 to 6E-04). HIs greater than 1 were identified for 18 of the wells, with individual COPC or organ-specific HIs exceeding 1 (ranging from 2 to 14) for 11 of the 20 wells for hypothetical residential receptors. HIs greater than 1 were identified for 7 of the wells, with individual COPC or organ-specific HIs exceeding 1 (ranging from 2 to 5) for 4 of the 20 wells for industrial receptors. The risks and hazards for the well-by-well analyses are provided in Chapter 5 and Appendix G of the K-31/K-33 Area RI/FS. Similar to the results for the analyses of all the wells, carcinogenic and noncarcinogenic risks exceeded EPA's acceptable risk range for both the industrial and residential exposure scenarios in the well-by-well analyses. Risks outside the acceptable range of 1E-04 to 1E-06 were identified.

2.7.1.5 Identification of COCs in K-31/K-33 Area groundwater

Once risks and hazards were characterized, COCs were then determined for K-31/K-33 Area groundwater based on EPA Region 4 guidance (EPA 2018). COCs are those contaminants that are the predominant contributors to total receptor groundwater cancer risks and noncancer hazards. Receptor-specific carcinogenic COCs in groundwater are identified as any chemical or radiological COPC associated with a cancer risk greater than 1E-05, when the total groundwater risk (i.e., summed across all COPCs and exposure routes for the receptor) exceeds EPA's target risk range. Receptor-specific noncarcinogenic COCs in groundwater are identified as any chemical COPC with an HQ greater than 0.1 that contributes to a total target organ HI that is greater than 1.

Results of the risk and hazard characterization using all the wells (based on data from all 20 of the wells collected from 2017 to 2021) were used to identify the COCs because the exposures are estimated to occur over a period greater than 25 years and the analysis better represents the dynamic nature of groundwater in an area over that time period. Additional COCs were not selected based on the well-by-well analyses after consideration of uncertainties associated with factors such as limited data in individual wells, turbidity in the groundwater, review of filtered groundwater data, and presence of naturally occurring inorganics and radionuclides in groundwater. Additional details are provided in Chapter 5 and Appendix G of the K-31/K-33 Area RI/FS.

COCs identified based on EPC exceedance of MCL

Total chromium and nickel are COCs based on EPC exceedances for the respective MCLs for both the residential and industrial land use scenarios (Table 2.5). Additional constituents (alpha activity, antimony, arsenic, beryllium, and lead) are included in numeric criteria for groundwater in Section 2.12.4 because they have exceeded the MCLs between 2017 and 2021 in one or more groundwater monitoring wells.

Table 2.5. COCs for K-31/K-33 Area groundwater based on EPC exceedance of MCL

COC	Frequency of detection	Units	Minimum	Maximum	Mean	UCL95	EPC	Basis of EPC[a]	MCL
Chromium (total)	122/169	µg/L	1.7	4490	112	210	210	UCL95	100[b]
Nickel	114/169	µg/L	0.6	1840	78.8	114	114	UCL95	100

[a]EPC is the smaller of the maximum detected concentration and the UCL95.
[b]The U.S. Environmental Protection Agency's drinking water standard of 100 µg/L for total chromium applies to all forms of chromium, including hexavalent chromium.

Notes: -The mean, median, standard deviation, UCL95, and upper tolerance limit on individual concentrations with 95% confidence and 95% coverage (UTL 95/95) were calculated using the Kaplan-Meier method.
-Samples or non-detects have higher concentrations than detects.
-A nonparametric UTL95/95 requires at least 59 samples.

COC = contaminant of concern
EPC = exposure point concentration
MCL = maximum contaminant level
UCL95 = 95% upper confidence limit

COCs for hypothetical residential scenario

Based on calculated risks and HIs under a hypothetical residential scenario, two metals were identified as COCs: arsenic and hexavalent chromium. The total estimated cancer risk for future residents using site groundwater as a potable water source was 1E-03 due primarily to ingestion and dermal contact exposures to hexavalent chromium. Arsenic also contributed to the cancer risk for the potable water pathway.

When noncancer effects were summed for COPCs with similar target organs, none of the HIs for individual COPCs or COPCs with similar target organs were greater than 1 for the child or adult. As a result, no COCs were identified based on noncarcinogenic effects. No volatiles were identified as COCs in the vapor intrusion pathway for the residential scenario.

COCs for industrial scenario

Hexavalent chromium was identified as a COC under both the industrial and residential land use scenarios. The total estimated cancer risk for future industrial workers using site groundwater as a potable water source was 2E-04 due primarily to ingestion and dermal contact exposures to hexavalent chromium.

When noncancer effects were summed for COPCs with similar target organs, none of the HIs for individual COPCs or COPCs with similar target organs were greater than 1. As a result, no COCs were identified for the industrial worker based on noncarcinogenic effects. Similarly, no volatiles were identified as COCs in the vapor intrusion pathway for the industrial exposure scenario.

2.7.1.6 Uncertainties analysis

Uncertainty is inherent in selecting key input parameters and in every step of the risk assessment process. Sources of uncertainty discussed in the baseline HHRA included assumptions in the exposure parameters and exposure models, COPCs that lack screening levels in the estimating of potential exposures and in risk calculations used to identify COCs including exposure parameters, exposure models, toxicity values used in calculating risks, background data comparisons, estimating EPCs, analytical limitations, and sampling limitations. One specific area of uncertainty impacting the risk assessment was quantifying the exposures of COCs to reflect current representative concentrations in groundwater (e.g., biased results by including highly turbid groundwater samples and by aggregating groundwater samples data used for EPCs). To minimize uncertainty associated with use of the EPCs associated with the 20 wells versus EPCs from each individual well with EPCs that are likely biased high and the incorporation of data from samples with high turbidity, EPCs will be recalculated with more recent data representing current conditions collected after incorporation of sampling methods to reduce turbidity. Additional details regarding uncertainties are provided in Chapter 5 and Appendix G of the K-31/K-33 Area RI/FS.

2.7.2 Summary of Ecological Risk Assessment

Ecological risk was not evaluated for the K-31/K-33 Area because the site is an industrial area and groundwater that does not express at the surface is not an exposure pathway for ecological receptors. Ecological receptors exposed to ETTP surface water and sediment (excluding the Clinch River and Poplar Creek) are being addressed as part of the ongoing investigation for the future Remaining Ecology/Surface Water/Sediment ROD. Surface water in Poplar Creek, including ecological receptors, is being addressed in the future Clinch River/Poplar Creek ROD. Potential impacts resulting from the discharge of K-31/K-33 Area groundwater directly into Poplar Creek (and not the waterbody itself) will be evaluated during implementation of the MNA remedy to satisfy a remedial action objective of protecting surface water. Details concerning the scope of any required groundwater or surface water monitoring will be defined during development of the RAWP.

2.7.3 Conclusion and Basis for Action Based on Risk Assessment

Soil in the K-31/K-33 Area was remediated under the Zone 2 Soil ROD and meets the remedial action objectives for protection of industrial workers and groundwater, as documented in the various PCCRs listed in Table 2.2. No further action is required for K-31/K-33 Area soil. LUCs prohibit other land uses (e.g., residential), and groundwater use (which includes extraction, consumption, and exposure) without prior written approval from DOE, EPA, and TDEC has been prohibited in absence of a final groundwater remedy. Groundwater use prohibitions are also included under this K-31/K-33 Area Groundwater ROD until the remedial action objectives are met or groundwater concentrations are at such levels to allow for UU/UE (see Section 2.12.2.2).

The risk assessment summarized in this chapter for groundwater in the K-31/K-33 Area has determined groundwater poses an unacceptable risk to human health under both an industrial use and a hypothetical residential use scenario based on calculations of both cancer and noncancer risk. The response action selected in this K-31/K-33 Area Groundwater ROD is necessary to protect the public health and welfare of the environment from actual or threatened releases of hazardous substances into the environment.

2.8 REMEDIAL ACTION OBJECTIVES

Remedial action objectives are medium-specific goals for protecting human health and the environment. As indicated in EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, the objectives identified in an FS "should be as specific as possible but not so specific that the range of alternatives that can be developed is unduly limited" (EPA 1988). Draft remedial action objectives are identified in the FS stage to evaluate whether technologies and alternatives should be able to meet the goals of the action. Remedial action objectives are finalized as part of the ROD development and approval process.

The CERCLA NCP requires federal SDWA MCLs and non-zero MCL goals be attained for all remedial actions for groundwaters that are current or potential sources of drinking water, where the MCLs/non-zero MCL goals are relevant and appropriate under the circumstances of the release (40 CFR 300.430I(2)(i)(B)-(C)).

TDEC Rule 0400-40-03-.07, "Ground Water Classification," establishes the classification scheme for groundwater throughout Tennessee. Subsection 0400-40-03-.07(4)(b) of the Rule designates all groundwater in the state as general use groundwater, except for groundwater in specific locations that has been designated otherwise. Groundwater beneath the K-31/K-33 Area (and elsewhere on the ORR) is classified as general use groundwater, and as such, is considered a potential source of drinking water.

Groundwater designated as general use must meet the state's numeric water quality criteria under TDEC 0400-40-03-.03(1)(j) and (k) for surface waters classified as a domestic water supply and must contain no other constituents that pose an unreasonable risk to public health or the environment (TDEC 0400-40-03-.08(2)). Water quality criteria set out in TDEC 0400-40-03-.03(1)(j) are consistent with SDWA MCLs.

The remedial action objectives for K-31/K-33 Area groundwater are as follows:

- Restore groundwater to drinking water standards (federal and state).
- Prevent exposure of humans, including industrial and construction workers, via dermal contact, ingestion, and/or inhalation to groundwater containing COCs above protective levels and prevent on-site consumption of groundwater above MCLs or applicable state groundwater criteria that are ARARs.
- Prevent adverse impacts to surface water quality from migration of contaminated groundwater that could result in exceedances of applicable state or federal ambient water quality standards or impairing the usefulness of the surface water for its classified use.

The use classifications for the Clinch River Basin, which includes Poplar Creek, are listed in TDEC 0400-40-04-.09. The use classifications for Poplar Creek Mile 0.5 to its origin are Fish and Aquatic Life, Recreation, Livestock Watering and Wildlife, and Irrigation. The K-31/K-33 Area is just downstream of approximately Poplar Creek Mile 3.0.

Restoring K-31/K-33 Area groundwater to drinking water standards is the primary goal (remedial action objective) of the remedial action described in this K-31/K-33 Area Groundwater ROD. The other remedial action objectives are used to establish criteria for protecting human health and adjacent surface waters until the restoration goal is achieved. Consequently, these other remedial action objectives will factor prominently in the development of the performance monitoring program for the MNA remedy.

2.9 DESCRIPTION OF REMEDIAL ALTERNATIVES

The scope of the groundwater remedial action for the K-31/K-33 Area is based on the distribution and magnitude of groundwater contamination in the area. There are 21 monitoring wells at the site, as shown in Figure 2.6, but 1 of the wells has been dry since the 1990s. Samples from 9 of these 20 wells have not had an MCL exceedance over the past 5 years. The remaining 11 wells are associated with intermittent MCL exceedances, and within this group, there are 4 wells with more persistent MCL exceedances. The remedial alternatives developed in the K-31/K-33 Area RI/FS focus on locations where sampling over the 5-year evaluation period (2017–2021) identified contamination above MCLs, primarily chromium and nickel contamination.

Three remedial alternatives were developed and evaluated:

- Alternative 1: No action
- Alternative 2: MNA and LUCs (DOE's preferred alternative)
- Alternative 3: Pump and treat with MNA and LUCs

Table 2.6 summarizes the major components, cost, and estimated time to achieve remedial action objectives for each remedial alternative. The remedial alternatives developed were a set of technology combinations that will result in the most promising alternatives to achieve cleanup objectives. These remedial alternatives are described in depth in the K-31/K-33 Area RI/FS. Alternatives 2 and 3 include additional components, such as performance monitoring and FYRs.

Table 2.6. Summary of remedial alternatives

Alternative	Description	Cost ($)/Timeframe (years)
Alternative 1 – No action	The no action alternative is included to provide a baseline for comparison to other alternatives, as required by the NCP. Under this alternative, no remediation, monitoring, or LUCs will occur. Future contamination trends will not be evaluated or reported	Cost: $0 Timeframe: not applicable
Alternative 2 – MNA and LUCs	Alternative 2 relies on naturally occurring processes to attenuate (reduce) the concentration, toxicity, or mobility of contaminants. These processes are closely monitored and evaluated over time to determine progress toward remedial action objectives. LUCs will be implemented to prohibit groundwater use and notify future landowners concerning the presence of contaminated groundwater. The LUCs remain in place until remedial action objectives are achieved. The estimated costs include installing and monitoring additional wells; however, the need for, number, and exact locations of additional wells will be addressed during development of the RAWP	Capital cost: $131,000 Total present-worth cost: $2 million Annual O&M present-worth cost: $84,000 Timeframe: 15 years
Alternative 3 – Pump and treat with MNA and LUCs	Alternative 3 extracts and treats groundwater with the highest concentrations of chromium and nickel, targeting specific areas with more persistent exceedances of MCLs. MNA will be implemented in areas where monitoring well data have shown lower contaminant concentrations (and only intermittent MCL exceedances). Groundwater will be pumped out of specially constructed extraction wells. A dedicated water treatment plant will be constructed near the extraction wells to treat extracted groundwater. The treatment process will consist of a bag filter (to remove suspended solids), followed by ion-exchange units that will use two different ion-exchange resins to remove chromium and nickel. Treated water will be discharged to the Clinch River in accordance with the Clean Water Act and TDEC regulations. MNA and LUCs will be implemented as described in Alternative 2	Capital cost: $2,355,000 Total present-worth cost: $11.2 million Annual O&M present-worth cost: $882,000 Timeframe: 10 years

Note: Costs represent direct project costs only and do not include all program-level management and overhead burdens.

LUC = land use control
MCL = maximum contaminant level
MNA = monitored natural attenuation
NCP = National Oil and Hazardous Substances Pollution Contingency Plan
O&M = operation and maintenance
RAWP = Remedial Action Work Plan
TDEC = Tennessee Department of Environment and Conservation

2.9.1 Alternative 1 – No Action

Under this alternative, no remediation, monitoring, or LUCs are planned for groundwater in the K-31/K-33 Area. While contaminants would likely attenuate over a long period of time, the pace of attenuation would not be assessed, the nature and extent of contamination in the future would be unknown, and there would be no knowledge of how much attenuation has occurred over time.

2.9.2 Alternative 2 – Monitored Natural Attenuation and Land Use Controls

Alternative 2 relies on natural attenuation processes to achieve the remedial action objectives. Monitoring these processes and evaluating contaminant concentration trends are conducted through a formalized monitoring program developed as part of the RAWP. Monitoring results and trend evaluation are reported annually in the ORR Remediation Effectiveness Report. LUCs are implemented to prevent access to groundwater and place limits on future site use until remedial action objectives are achieved or groundwater concentrations are at such levels to allow for UU/UE. A duration of 15 years is estimated, as presented in Appendix E of the K-31/K-33 Area RI/FS, for all the wells to achieve MCLs at the site. FYRs are completed until the remedial action objectives are achieved.

2.9.3 Alternative 3 – Pump and Treat with Monitored Natural Attenuation and Land Use Controls

In Alternative 3, specially constructed groundwater extraction wells are installed in two areas with the most persistent detections of chromium and nickel above the MCLs (Figure 2.9). Groundwater is pumped out of the extraction wells and treated in an above-ground treatment plant designed and operated to effectively remove contamination and meet surface water discharge criteria.

Further evaluations are performed during the remedial design, but for the K-31/K-33 Area RI/FS and this K-31/K-33 Area Groundwater ROD, the treatment process was assumed to consist of filtration (to remove suspended solids), followed by ion-exchange units that use appropriate ion-exchange resins necessary to remove chromium, nickel, and other metals. Treated water is then discharged to the Clinch River in accordance with Clean Water Act requirements and other ARARs (Appendix D of the K-31/K-33 Area RI/FS). Outside the two areas addressed through pump and treat in Alternative 3, MNA is also implemented as described for Alternative 2. Because active measures are taken for the two areas with the highest concentrations of nickel and chromium contamination, the overall timeframe to achieve remedial action objectives for Alternative 3 is 10 years. LUCs are implemented to prevent access to groundwater until the remedial action objectives are achieved or groundwater concentrations are at such levels to allow for UU/UE. FYRs are completed until the remedial action objectives are achieved.

2.10 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

CERCLA Section 121, as amended, specifies statutory requirements for remedial actions. These requirements include protection of human health and the environment, compliance with ARARs, a preference for permanent solutions that incorporate treatment as a principal element to the maximum extent practicable, and cost effectiveness. To assess whether alternatives meet the requirements, the following nine criteria (EPA 1988) are identified in the NCP (40 CFR 300.430(f)(2)) and must be evaluated for each alternative (Section 300.430I(9)(iii)).

The first two criteria are threshold criteria that relate directly to statutory findings that must be documented in a final ROD. The next five criteria—balancing criteria—address performance of the alternative and verify the alternative is realistic. The last two modifying criteria are considered after public comment is received on the Proposed Plan. Provided below is a brief explanation of the nine CERCLA evaluation criteria.

- Overall protection of human health and the environment addresses whether a remedial action provides overall protection of human health and the environment. This criterion must be met for a remedial alternative to be eligible for selection.
- Compliance with ARARs addresses whether a remedial action meets all applicable or relevant and appropriate federal and state environmental requirements or provides grounds for invoking a waiver of the requirements. This criterion must be met for a remedial alternative to be eligible for selection.
- Long-term effectiveness and permanence considers the ability of an alternative to protect human health and the environment over time.
- Reduction of toxicity, mobility, or volume through treatment evaluates an alternative's use of treatment to reduce harmful effects of contaminants, their ability to move in the environment, and the amount of contamination present.
- Short-term effectiveness refers to potential adverse effects on workers, human health, and the environment during the construction and implementation phases of a remedial action.
- Implementability refers to the technical and administrative feasibility of a remedial action alternative, including the availability of materials and services needed to implement the alternative.

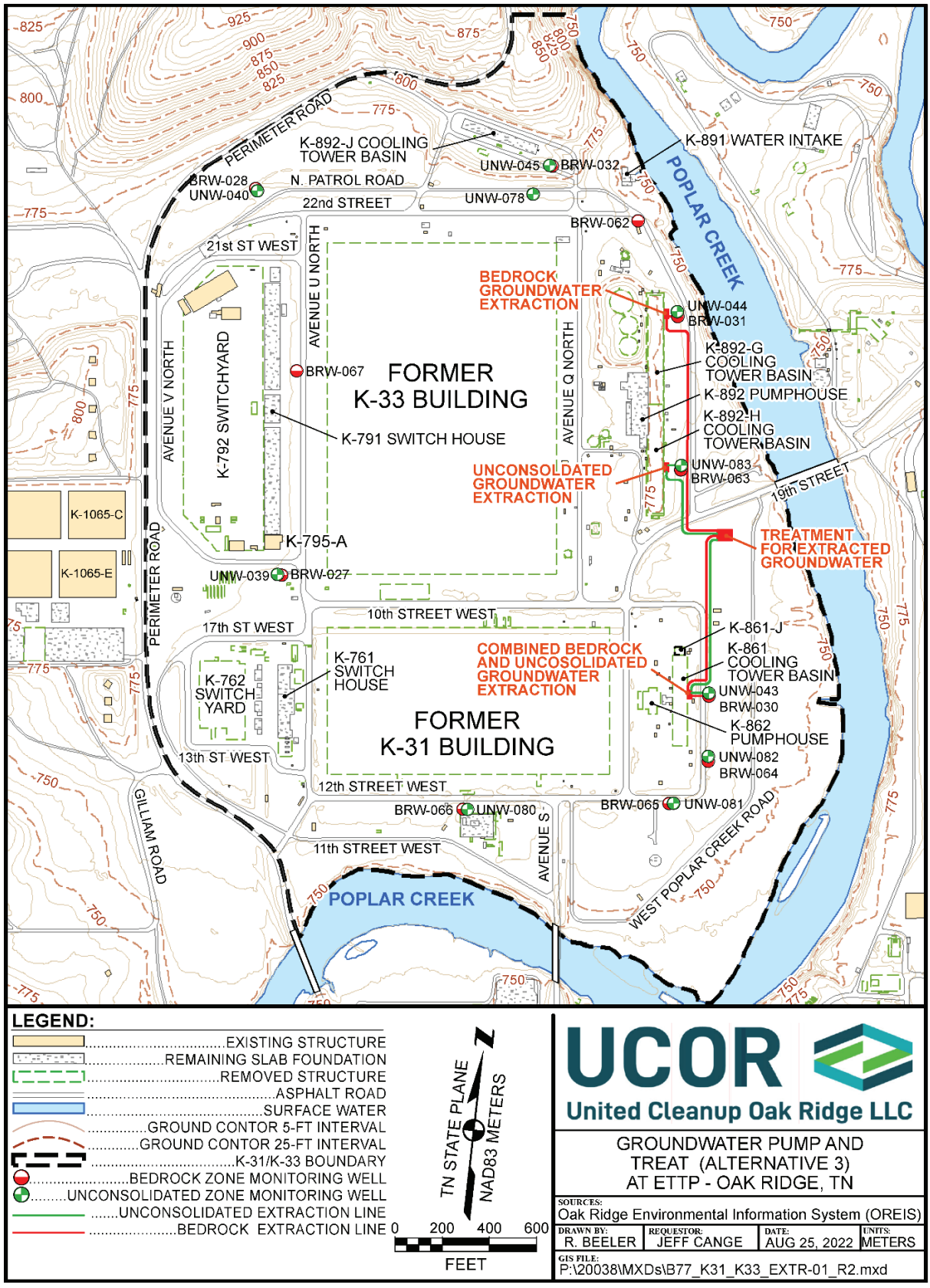

Figure 2.9. Groundwater pump-and-treat layout for Alternative 3.

- Cost refers to an evaluation of the capital, O&M, and monitoring costs for each alternative, including present-worth costs.
- State acceptance indicates whether the state concurs with the preferred alternative.
- Community acceptance assesses the general public response to the Proposed Plan following a review of public comments received during the public comment period. The remedial action is selected only after comments are received on the Proposed Plan.
- NEPA considerations.

In addition to these CERCLA evaluation criteria, DOE policy directs the substantive requirements of NEPA be incorporated into CERCLA decision documents (DOE 1994). Elements common to both CERCLA and NEPA include protectiveness, compliance with ARARs, long-term effectiveness and permanence, short-term effectiveness, and cost. These elements were considered in the comparative analysis of the alternatives. Additional NEPA values not specifically included in CERCLA criteria include socioeconomic impacts, environmental justice, irreversible and irretrievable commitment of resources, and cumulative impacts.

Table 2.7 summarizes how each alternative performs against threshold and balancing criteria. Rankings reflect a qualitative ranking that highlights the relative strengths and weaknesses of each alternative.

Table 2.7. Summary of comparative analysis

CERCLA criteria	Alternative 1 – No action	Alternative 2 – MNA and LUCs	Alternative 3 – Pump and treat with MNA and LUCs
Protection of human health and the environment	○	●	●
Compliance with ARARs	○	●	●
Long-term effectiveness and permanence	NA	●	●
Reduction of toxicity, mobility, or volume through treatment	NA	◎	◎
Short-term effectiveness	NA	●	●
Implementability	NA	●	◎
Present-worth cost	$0	$2 million	$11.2 million
Estimated time to achieve remedial action objectives	NA	15 years	10 years

Relative ranking: High ● Moderate ◎ Low ○

ARAR = applicable or relevant and appropriate requirement
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
LUC = land use control
MNA = monitored natural attenuation
NA = not applicable; criterion was not evaluated because it did not pass threshold criteria

Overall protection of human health and the environment. Alternative 1 is not protective of human health and the environment because no action would be taken to reduce or monitor groundwater contamination levels, nor would there be any LUCs to prevent exposures to contaminated groundwater. Alternatives 2 and 3 are both considered to be protective of human health and the environment because groundwater contamination levels would be reduced either through extraction and treatment (Alternative 3) or through MNA processes (Alternative 2). LUCs would be used to prevent exposures and manage risks at the site until the remedial action objectives are achieved under Alternatives 2 and 3.

Compliance with ARARs. Alternative 1 would not achieve chemical-specific ARARs, which include enforceable numerical standards. Alternatives 2 and 3 would be specifically designed and implemented to achieve ARARs.

Long-term effectiveness and permanence. Alternative 1 was not assessed for this criterion because it did not pass threshold criteria for protection of human and the environment or compliance with ARARs. For Alternatives 2 and 3, long-term effectiveness and permanence are comparable, although Alternative 3 is expected to perform slightly better due to the shorter predicted timeframe to achieve remedial action objectives. Both alternatives result in permanent removal of contamination. Alternative 3 accomplishes this removal through extraction of contaminated groundwater with aboveground treatment that transfers contaminants to treatment media that will have to be properly managed and disposed of in compliance with ARARs.

Alternative 2 relies on naturally occurring attenuation processes, primarily adsorption and precipitation, to transfer contaminants from groundwater onto aquifer matrix materials (soil and bedrock surfaces). Contaminant concentrations are expected to decrease over time until remedial action objectives are achieved, which is expected to take longer than the active measures in Alternative 3.

Reduction of toxicity, mobility, or volume through treatment. Alternative 1 was not assessed for this criterion because it did not pass threshold criteria. Alternative 3 uses active treatment with physicochemical treatment processes and natural attenuation, whereas Alternative 2 relies solely on natural attenuation. Attenuation is generally considered passive treatment. More contaminant mass is expected to be removed from groundwater with Alternative 3, although both alternatives will achieve remedial action objectives. Both alternatives reduce contaminant mass, but there is the potential for some of the contaminant reductions to be reversed if groundwater geochemistry is significantly altered. Alternative 3 entails transferring contaminants to treatment media and creating residuals (spent ion-exchange resins) that will require further management and off-site disposal. Alternatives 2 and 3 are comparable for this criterion.

Short-term effectiveness. Alternative 1 was not assessed for this criterion because it did not pass threshold criteria. There are more risks to remediation workers with Alternative 3, as compared to Alternative 2, due to increased construction activities and need for continuous operation of the treatment plant. Both alternatives can be implemented in a manner that protects the surrounding community. The environmental footprint of Alternative 3 is greater than that of Alternative 2 due to electricity, material, and chemical demands of the treatment system that is expected to operate for 10 years. Both Alternatives 2 and 3 were considered comparable for this criterion.

Implementability. Alternative 1 was not assessed for this criterion because it did not pass threshold criteria. Alternative 3 has more construction elements than Alternative 2, resulting in potential for greater operational challenges. Groundwater extraction systems previously installed in the MPA of ETTP have experienced extensive fouling of extraction wells and pipelines, which is expected to occur at the K-31/K-33 Area. Alternative 3 was judged to be more susceptible to schedule impacts related to potential difficulties in maintaining efficient operation of the groundwater extraction system. Both alternatives can be implemented in a manner that would not limit additional remedial actions, should they be considered necessary in the future.

Both alternatives have similar monitoring well requirements, but Alternative 3 requires more monitoring to verify pump-and-treat performance, compliance with surface water discharge requirements, and ongoing evaluation of treatment system performance. Alternative 3 has a greater impact on future use of the property due to the need of installing pump-and-treat infrastructure (i.e., conveyance piping, treatment system, and utilities). Alternative 2 scored higher than Alternative 3 for this criterion.

Cost. Alternative 1 was not assessed for this criterion because it did not pass threshold criteria. The capital costs and net present-value costs for Alternatives 2 and 3 are shown in Table 2.6. Alternative 3 costs are significantly greater than those for Alternative 2 due to the need for construction and operation of extraction wells, a groundwater treatment plant, and related infrastructure. The costs for Alternative 2 include installing and monitoring additional wells to support the MNA evaluation. The need for, number, and exact locations of these additional wells will be addressed during development of the RAWP, in consultation with TDEC and EPA.

State acceptance. State involvement has been solicited throughout the CERCLA-based remedy selection process. TDEC supports the preferred alternative (Alternative 2 – MNA and LUCs), and its final concurrence will be solicited following review of all comments received during the public comment period.

Community acceptance. Section 2.3 summarizes community participation in evaluating K-31/K-33 Area Groundwater ROD remediation options; comments provided by the public are addressed in Part 3.

NEPA values. NEPA values are incorporated into the alternatives evaluation consistent with DOE policy. There is little difference between the irreversible and irretrievable commitment of resources between alternatives.

2.11 PRINCIPAL THREATS

Principal threats are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health and the environment should exposure occur (EPA 1991). The NCP establishes an expectation that treatment will be used to address principal threats at a site, when practicable. Contaminated groundwater generally is not considered a principal threat unless it is associated with NAPLs or other highly contaminated constituents (EPA 1991). The concentrations of chromium, nickel, and other contaminants in K-31/K-33 Area groundwater that have exceeded MCLs by a factor of less than two times the MCL do not meet criteria for designation as a principal threat. The designation of principal threat does not apply to this K-31/K-33 Area Groundwater ROD.

2.12 SELECTED REMEDY

DOE, with concurrence from EPA and TDEC, has determined Alternative 2, MNA and LUCs, offers the best combination of protectiveness and cost-effectiveness with minimal impacts to reuse of the site.

2.12.1 Summary of Rationale for Selected Remedy

Alternative 2 was selected by the tri-parties with the agreement existing data and newly collected data will be reevaluated, recognizing the uncertainty could impact Alternative 2 successfulness. Therefore, the FFA parties agreed additional monitoring/analytical requirements, trend analysis, and project decision criteria will be developed as part of the RAWP, with the goal of closely monitoring remedy effectiveness following implementation. If the remedy is not performing as established in the RAWP, then changes to the selected remedy (e.g., selecting a different alternative or other actions such as in situ treatment) will be evaluated and implemented on a timeframe consistent with the FYR process. Changes to this K-31/K-33 Area Groundwater ROD, including changes to the selected remedy, will be documented through the appropriate CERCLA document(s) in accordance with the NCP at 40 CFR 300.435 and EPA ROD Guidance.

Alternative 2 meets threshold criteria under CERCLA Section 121 and is protective of human health and the environment. The remedy is intended to restore groundwater to its beneficial use as a drinking water source through natural attenuation processes that will be monitored until contaminant concentrations reach MCL-based cleanup levels. Alternative 2 will be designed and implemented to comply with ARARs (listed in Appendix A) and is consistent with EPA's expectations for groundwater remedies under CERCLA.

Alternative 2 can be readily implemented. The existing monitoring well network at the site can be used for MNA sampling and evaluation (the need for installing additional monitoring wells will be determined during development of the RAWP). MNA monitoring (including data analysis and reporting) included with Alternative 2 would use most of the procedures, equipment, and personnel used for current monitoring activities in the K-31/K-33 Area. LUCs are required for Alternative 2.

The following decisive factors led to selecting Alternative 2:

- Alternatives 2 and 3 are expected to accomplish the goal of restoring groundwater to its beneficial use; however, the costs for Alternative 2 were significantly less than those for Alternative 3.
- Concentrations of COCs are not significantly greater than MCL-based cleanup levels, and overall concentrations have exhibited a downward trend since monitoring began in the late 1980s.
- MNA is expected to achieve remedial action objectives within approximately 15 years, a timeframe that is reasonable given site conditions and future use. The expected timeframe for Alternative 3 is 10 years.
- Groundwater is currently not being used, and LUCs will remain in place to prevent exposure to groundwater until remedial action objectives are achieved.
- Performance of the remedy (both MNA and LUCs) can be easily monitored and assessed to determine if the remedy is functioning as required.
- If the remedy is not performing as established in the RAWP, changes to the selected remedy (e.g., selecting a different alternative or other actions such as in situ treatment) will be evaluated and implemented on a timeframe consistent with the FYR process. Changes to this K-31/K-33 Area Groundwater ROD, including changes to the selected remedy, will be documented through the appropriate CERCLA document(s) in accordance with the NCP at 40 CFR 300.435 and the EPA ROD Guidance.

In summary, Alternative 2 provides the best balance of tradeoffs with respect to the nine criteria against which alternatives are evaluated. The MNA with LUCs action is cost effective and constitutes a permanent solution to the groundwater contamination problem. Although active treatment measures are not part of the MNA remedy, natural attenuation processes will achieve the same result; namely, reducing groundwater contamination to meet drinking water standards (MCLs).

2.12.2 Description of Selected Remedy

Based on the comparative analysis and considering all information currently available, DOE has determined Alternative 2, MNA and LUCs, is the preferred remedial action alternative to address contaminated groundwater in the K-31/K-33 Area at ETTP. Given the relatively low levels of contamination and the absence of current or expected exposures to this contamination, DOE believes Alternative 2 will provide a cost-effective approach to cleaning up the groundwater, as required by CERCLA and TDEC regulations. The specific components of the remedy are described below.

2.12.2.1 MNA

MNA relies on natural processes that reduce or attenuate contaminant concentrations in groundwater. These processes may also reduce the toxicity or mobility of the contaminants. Using MNA as the remedial action essentially involves continuous monitoring of groundwater conditions to measure and evaluate progress toward achieving remedial action objectives. The natural processes applicable to chromium (including hexavalent chromium), nickel, and inorganic contaminants in groundwater include:

- bioreactions (biogeochemical reduction)

- abiotic reactions (sorption and geochemical reduction)
- advection and dispersion

EPA and the Interstate Technical and Regulatory Council provide guidance on evaluating site conditions and groundwater monitoring data to verify attenuation processes are performing as expected and to measure progress toward groundwater cleanup (EPA 2007a, 2007b, 2015a, 2015b; ITRC 2010).

A groundwater monitoring program based on EPA's Inorganic MNA Guidance (EPA 2015b) will be used to track remedy performance. MNA program design will commence with a tri-party data quality objectives effort that will focus on monitoring locations, the need for installing additional monitoring wells, the frequency of sampling, and the specific constituents to be analyzed and monitored. The data quality objectives will also address methods for evaluating monitoring data and may include if-then decision statements to guide the program if future monitoring results indicate the remedy is not performing as expected. The agreed-upon scope for the monitoring program will form the basis of the RAWP to be prepared following ROD approval.

Potential impacts resulting from the discharge of K-31/K-33 Area groundwater directly into Poplar Creek (and not the waterbody itself) will be evaluated during implementation of the MNA remedy to satisfy a remedial action objective of protecting surface water. Details concerning the scope of any required surface water monitoring will be defined during development of the RAWP.

Monitoring to assess remedy performance will begin once EPA and TDEC approve the RAWP. For planning and estimating purposes, quarterly sampling is assumed to be performed for the first 2 years of monitoring to provide a baseline with sufficient data to support statistically based trend analyses. After the second year, sampling will revert to a semiannual basis. Monitoring results will be reported in annual Remediation Effectiveness Reports that DOE prepares as required by the ORR FFA. These annual reports are also submitted for EPA and TDEC review and approval.

Groundwater modeling was used to estimate the timeframe for MNA processes to reduce contaminant concentrations below MCLs. Based on this modeling, MCLs will be achieved in approximately 15 years. Locations with lower levels of contamination are expected to achieve MCLs before this time. Well abandonment (decommissioning) will occur at the end of the project. Wells will be decommissioned via grout placement, with all above-well infrastructure removed. The selected remedy's performance will be documented in an RAR.

2.12.2.2 LUCs

LUCs related to groundwater use and activities potentially resulting in exposures to contaminated groundwater (e.g., drilling or excavation) will be implemented under this K-31/K-33 Area Groundwater ROD in parallel with the MNA action and will remain in place until groundwater is returned to beneficial use or groundwater concentrations are at such levels that would allow for UU/UE. The remedial action objectives in this K-31/K-33 Area Groundwater ROD (Section 2.8) require groundwater to meet federal and state requirements for drinking water that would then allow for UU/UE of the groundwater. Therefore, meeting remedial action objectives for groundwater is the same as the groundwater concentrations allowing for UU/UE. The K-31/K-33 Area as a whole will require implementation of certain LUCs until all media addressed under CERCLA allow for UU/UE.

Other Zone 2 Soil ROD LUCs to prevent exposure to residual contamination in Zone 2 soils, including the K-31/K-33 Area soils, will continue under the Zone 2 Soil ROD until concentrations of hazardous substances in the soil are at such levels to allow for UU/UE. The soil cleanup work in Zone 2 was specifically based on industrial land use and not designed to support UU/UE. Unrestricted industrial use in the K-31/K-33 Area prohibits other uses (e.g., company childcare centers, recreation areas, gardens for food).

For the K-31/K-33 Area (Figure 1.2), LUCs prohibit the use of groundwater for any purpose and may include additional requirements for constructing buildings and maintaining the integrity of any current or future remedial or monitoring system (e.g., monitoring wells) until groundwater remedial action objectives are achieved. The quitclaim deeds for the K-31/K-33 Area provide an additional description of the groundwater restriction that, at the time, flowed down from the requirements under the Zone 2 Soil ROD. The quitclaim deeds for the K-31/K-33 Area prohibit groundwater use, extraction, consumption, and exposure without prior written approval from DOE, EPA, and TDEC.

The LUCs under the Zone 2 Soil ROD will remain in place until site conditions allow for UU/UE. For this K-31/K-33 Area Groundwater ROD, LUCs related to groundwater use or activities involving potential exposures to groundwater will remain in place until the remedial action objectives are achieved. DOE is responsible for maintaining, monitoring, and enforcing such LUCs, including in the case these procedural responsibilities are assigned to another party by contract, property transfer agreement, or through other means. In these instances, DOE shall retain ultimate responsibility for remedy integrity.

A LUC Implementation Plan (LUCIP) for ETTP has been developed in accordance with the *Land Use Control Assurance Plan for the Oak Ridge Reservation* (DOE/OR/01-1824&D0) that was published with a memorandum of understanding between the FFA tri-party. The ETTP LUCIP is found in the *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2477&D4; ETTP RAR Comprehensive Monitoring Plan [CMP]). The current ETTP LUCIP is outlined in Chapter 6 of the ETTP RAR CMP and detailed in Appendix D of the ETTP RAR CMP. The ETTP RAR CMP will be updated to incorporate the additional LUCs for this K-31/K-33 Area Groundwater ROD and to ensure the appropriate level of detail is included in the LUCIP. Changes to the ETTP LUCIP will include, but are not limited to, adding K-31/K-33 Area groundwater as a specific subject (i.e., affected area) of the applicable LUCs to clarify these LUCs are separate from the general LUCs for restricting groundwater use at ETTP Zone 2 established by the Zone 2 Soil ROD.

The LUCs established in this K-31/K-33 Area Groundwater ROD have the following objective:

- Prevent unauthorized access to or use of groundwater.

The LUCs in the following list will apply to the K-31/K-33 Area. Table 2.8 lists the purpose, duration, and implementation of the LUCs for the K-31/K-33 Area. Only the property record restrictions for restrictions on groundwater use, property record notices, and the excavation/penetration permit program for the existence and location of contaminated groundwater are required by this K-31/K-33 Area Groundwater ROD. Because these LUCs are existing LUCs for ETTP, an in-depth generic description of each one can be found in the ETTP RAR CMP. Site-specific information pertaining to the conditions of use for each LUC has been included in the bullets below. The LUCs are as follows:

- **Property restrictions.** The purpose is to restrict property use and/or prohibit groundwater use by imposing limitations. All property use is restricted to industrial use at ETTP Zone 2. All groundwater within the K-31/K-33 Area is restricted for use (including any groundwater extraction, consumption, and exposure) at least until the remedial action objectives of this K-31/K-33 Area Groundwater ROD are met.
- **Property record notices.** The purpose is to notify the public about the existence and location of regulated hazardous substances and the location of land that is not appropriate for UU/UE and limitations on the use. A general property record notice that restricts access/use of groundwater has been filed for ETTP. Because the remedy for K-31/K-33 Area groundwater will not leave hazardous waste or asbestos-containing material in place, a specific property record notice for K-31/K-33 Area groundwater will not be required upon remedial action completion; whereas, this will be a requirement for other areas of ETTP, including Zone 2 soils, upon completion of the respective remedial actions.

Table 2.8. LUCs for the K-31/K-33 Area selected remedy as they apply to the existing ETTP LUCIP (ETTP RAR CMP[a])

Type of control	Purpose of control	Duration	Implementation	ROD
1. Property record restrictions:				
A. Land use	Impose limitations to restrict use of property	Until concentrations of hazardous substances are at such levels to allow for UU/UE	Drafted and implemented by DOE upon transfer of affected areas. Recorded by DOE in accordance with state law at County Register of Deeds office (verified every 5 years)	NA[b]
B. Groundwater	Prohibit groundwater use[c]	Until remedial action objectives of this K-31/K-33 Area Groundwater ROD have been reached or until concentrations in groundwater are at such levels to allow for UU/UE	Drafted and implemented by DOE upon transfer of affected areas. Recorded by DOE in accordance with state law at County Register of Deeds office	K-31/K-33 Area Groundwater
C. Vapor intrusion	Mitigate the vapor intrusion pathway on existing and future enclosed building structures, as needed	Until the concentrations of volatile organic compound vapors reach levels to allow for UU/UE	Drafted and implemented by DOE upon transfer of affected areas. Recorded by DOE in accordance with state law at County Register of Deeds office	NA[b]
2. Property record notices	Notify anyone searching records about existence and location of contaminated areas and limitations on their use	Until remedial action objectives of this K-31/K-33 Area Groundwater ROD have been reached or until concentrations in groundwater are at such levels to allow for UU/UE	Recorded by DOE in accordance with state law at County Register of Deeds office and copied to the appropriate zoning office (verified every 5 years). (1) Tennessee Code Annotated notice of land use restrictions after signing the ROD. (2) Upon completion of remedial action that leaves hazardous substances in place	K-31/K-33 Area Groundwater[d]
3. Excavation/ Penetration permit program	Notify worker/ developer (i.e., permit requestor) on extent of contamination and prohibit or limit excavation/ penetration activity	Until remedial action objectives of this K-31/K-33 Area Groundwater ROD have been reached or until concentrations in groundwater are at such levels to allow for UU/UE	Implemented by DOE and its contractors. Initiated by permit request (verified annually)	K-31/K-33 Area Groundwater
4. Access controls (e.g., fences, gates, signs, and portals)	Control and restrict access to workers and the public to prevent unauthorized uses	Until concentrations of hazardous substances are at such levels to allow for UU/UE	Maintained by DOE (verified annually)	NA[b]

Table 2.8. LUCs for the K-31/K-33 Area selected remedy as they apply to the existing ETTP LUCIP (ETTP RAR CMP[a]) (cont.)

[a]ETTP RAR CMP. *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2477&D4).
[b]While NA to K-31/K-33 Area groundwater, this LUC is part of the ETTP LUCIP, which is included in the ETTP RAR CMP, and applies to ETTP sitewide.
[c]Consistent with language in the quitclaim deeds for property transfer, the prohibition of groundwater use includes the prohibition of any groundwater use, extraction, consumption, and exposure without prior written approval from DOE, the U.S. Environmental Protection Agency, and the Tennessee Department of Environment and Conservation.
[d]A general property record notice that restricts access/use of groundwater has been filed for ETTP. Because the remedy for K-31/K-33 Area groundwater will not leave hazardous waste or asbestos-containing material in place, a specific property record notice for K-31/K-33 Area groundwater will not be required upon remedial action completion; whereas, this will be a requirement for other areas of ETTP, including Zone 2 soils, upon completion of the respective remedial actions.

CMP = Comprehensive Monitoring Plan
DOE = U.S. Department of Energy
ETTP = East Tennessee Technology Park
LUC = land use control
LUCIP = Land Use Control Implementation Plan
NA = not applicable
RAR = Remedial Action Report
ROD = Record of Decision
UU/UE = unlimited use/unrestricted exposure

- **Excavation/Penetration permit program.** The purpose is to notify the worker/developer (i.e., permit requestor) on the extent of contamination and prohibit or limit excavation/penetration activity to ensure the excavation/penetration activity is conducted safely. For K-31/K-33 Area groundwater, permit requesters will be notified of the presence of contaminated groundwater at applicable depths and the ongoing groundwater remedial action until its completion. The permit program has already been established for the K-31/K-33 Area as part of Zone 2, and DOE and/or its agent will maintain responsibility for the program (including on transferred land) until concentrations of hazardous substances are at levels to allow for UU/UE. Per the quitclaim deeds for the K-31/K-33 Area, excavation/penetration below 10 ft bgs requires prior DOE approval.

LUCs in Table 2.8 are those presented in the ETTP LUCIP in the ETTP RAR CMP, including those listed as not applicable for the K-31/K-33 Area groundwater remedy. Property record restrictions for land use and the vapor intrusion controls are in the ETTP LUCIP for application across ETTP sitewide. Access controls are only required for specific areas of ETTP. Vapor intrusion LUCs are not specified for K-31/K-33 Area groundwater because quantified risk calculations for potential exposure in hypothetical residential and hypothetical commercial/industrial buildings were below the target risk of 1×10^{-4} or an HI of 1 (K-31/K-33 Area RI/FS); however, vapor intrusion controls are an ETTP sitewide requirement in the ETTP LUCIP, which is included in the ETTP RAR CMP.

2.12.3 Cost Estimate for Selected Remedy

Cost information is based on direct construction costs and present-worth analysis of long-term O&M costs. Complete remedy costs for Alternative 2 are estimated to be approximately $2 million. DOE assumed EPA and TDEC input during development of the MNA monitoring program for the RAWP would identify the need for additional monitoring wells to track performance of the MNA remedy. Consequently, the cost estimate includes the assumption eight new monitoring wells (four unconsolidated and four bedrock wells) will be installed. The MNA monitoring program design in the RAWP will provide the rationale for installing additional monitoring wells. Final costs for the additional wells would be included in the actual construction costs for the project.

The long-term O&M costs included in the estimate are based on 15 years of monitoring (groundwater sampling and analysis), maintaining the monitoring network, and reporting. Costs for maintaining and verifying LUCs are included within ETTP RAR CMP costs. For cost-estimating purposes, the wells are assumed to be sampled quarterly for the first 2 years and then semiannually thereafter until remedial action objectives are achieved.

The estimate also assumed sampling results and concentration trends would support a reduction in the number of wells that need to be monitored for the MNA remedy over time. This assumption was made because the number of wells with MCL exceedances has declined significantly over the past 5 or so years, there is no evidence to suggest this trend will be reversed, and several wells are assumed to reach remedial action objectives more quickly than others. Criteria for removing wells from the monitoring network will be defined, with input from EPA and TDEC, during development of the RAWP.

For cost-estimating purposes, DOE assumed half of the wells would be removed from the monitoring network after the first 5 years of MNA performance monitoring. The remaining wells would continue to be monitored for the following 10 years, totaling 15 years—the predicted timeframe until remedial action objectives are achieved. These assumptions were made for cost-estimating purposes for this K-31/K-33 Area Groundwater ROD and will be revisited as part of RAWP development.

Table 2.9 summarizes the estimated costs for Alternative 2. The cost information is based on the best available information regarding the anticipated scope of the remedial alternative at the time the K-31/K-33 Area Proposed Plan was finalized. Changes in the cost elements may occur because of inflation and/or new information collected during development of the RAWP.

Table 2.9. Cost summary for selected remedy

Type	Description	Cost
Capital cost[a]	Monitoring well installation (eight wells)	$165,000
O&M	Quarterly sampling/analysis/reporting (project start through year 2)	$730,000
	Semiannual sampling/analysis/reporting (years 3–5)	$541,000
	Semiannual sampling/analysis/reporting (years 6–15)	$552,000
	Decommissioning of wells	$47,000
	Total lifecycle cost	$2,035,000

[a]Capital cost includes cost of regulatory documents.

O&M = operation and maintenance

2.12.4 Expected Outcomes of Selected Remedy

Implementing MNA and LUCs will not impact future land uses of the K-31/K-33 Area, which will be a continuation of current industrial and commercial uses. The property has already been transferred, and neither its current nor future use is impacted by the timeframe for achieving remedial action objectives. The LUCs implemented through transfer of the property include prohibitions on groundwater use (including extraction, consumption, and exposure) without prior written approval from DOE, EPA, and TDEC and other controls intended to prevent potential exposures to contaminated groundwater. LUCs will also prevent any actions that would interfere with the groundwater remedial actions, including preventing damage to any groundwater monitoring wells or otherwise interfering with groundwater monitoring.

Other LUCs associated with the Zone 2 Soil ROD, which does not allow for UU/UE, will continue to control future land uses (i.e., no residential development) and limit potential exposures to all Zone 2 contaminated soil and groundwater elsewhere in Zone 2. These controls will remain in place until site

conditions allow for UU/UE. Groundwater use restrictions may be discontinued with EPA and TDEC concurrence once the remedial action objectives are achieved and groundwater meets TDEC criteria for general use groundwater. Applicable LUCs will also be included in an RAR for the selected remedy.

Table 2.10 lists the drinking water standards for the constituents that have been detected in concentrations exceeding the MCL in samples since 2017 in groundwater monitoring wells. Future sampling and analysis of groundwater as part of the MNA remedy at the K-31/K-33 Area will target the constituents previously detected above MCLs (and/or risk-based levels) to achieve the numerical criteria in Table 2.10. In addition, some supplemental analytical testing will be conducted. Expanded analytical testing will be developed in the RAWP and may include a selection of the COPCs derived from the supplemental well-by-well strategy of the baseline HHRA (Section 2.7.1), listed in Table 2.11. The remedy includes the expectation that groundwater will achieve the levels listed in Table 2.10 for the COCs.

Table 2.10. Numeric criteria for K-31/K-33 Area groundwater

Chemical	Value	Selection basis[a]
Alpha activity[b]	15 pCi/L	Federal MCL, TDEC MCL
Antimony	0.006 mg/L	Federal MCL, TDEC MCL, Tennessee groundwater quality criteria
Arsenic	0.010 mg/L	Federal MCL, TDEC MCL, Tennessee groundwater quality criteria
Beryllium	0.004 mg/L	Federal MCL, TDEC MCL, Tennessee groundwater quality criteria
Chromium (total)[c]	0.1 mg/L	Federal MCL, TDEC MCL, Tennessee groundwater quality criteria
Lead	0.005 mg/L[d,e]	Tennessee groundwater quality criteria
Nickel	0.1 mg/L[f]	TDEC MCL, Tennessee groundwater quality criteria

[a]TDEC MCLs are listed in TDEC Chapter 0400-45-01-.06(1) and (5) for inorganics and radionuclides, respectively (TDEC 2019). Currently, all federal MCLs are identical to the TDEC MCLs; the federal MCLs are listed in 40 Code of Federal Regulations (CFR) 141.62(b) and 40 CFR 141.66(c) for inorganics and radionuclides, respectively. Tennessee groundwater quality criteria at TDEC 0400-40-03-.08 incorporate by reference the domestic water supply criteria in TDEC Chapter 0400-40-03-.03(1)(j).

[b]Multiple transuranics may be present and cumulatively contribute to exceedance of the gross alpha MCL (15 pCi/L). Typically, all gross alpha activity is assumed to be due to uranium when it exceeds the MCL (40 CFR 141.26(a)(5)). During the remedial investigation, samples were collected for uranium due to the gross alpha particle activity being above its respective MCL; although uranium has not been detected in any of the groundwater samples above its MCL (30 pCi/L) over the 5-year period (2017–2021), it will be evaluated through ongoing monitoring in addition to gross alpha activity as part of the selected remedy until the MCL for gross alpha activity is achieved.

[c]The drinking water standard of 0.1 mg/L for total chromium applies to all forms of chromium, including hexavalent chromium, which is a contaminant of concern for groundwater based on risks identified in both the residential and industrial land use scenarios.

[d]Lead and copper are regulated by a treatment technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, then water systems must take additional steps.

[e]In addition to the Tennessee lead groundwater quality criterion of 0.005 mg/L for domestic water supply in TDEC Chapter 0400-40-03-.03, the State also has an MCL/treatment technique under the State's Safe Drinking Water Act of 1974 program (TDEC Chapter 0400-45-01).

[f]The U.S. Environmental Protection Agency has deleted both the MCL and the MCL goal for nickel from the CFR, which was vacated by a court ruling. Tennessee has retained the nickel MCL in its current regulations.

TDEC 2019. Chapter 0400-40-03, *General Water Quality Criteria*, Rule 0400-40-03-.03, "Criteria for Water Uses," and Rule 0400-40-03-.07, "Ground Water Classification," Rules of the Tennessee Department of Environment and Conservation, Nashville, TN, Revised September 2019. URL: https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20190911.pdf.

MCL = maximum contaminant level
TDEC = Tennessee Department of Environment and Conservation

Table 2.11. Additional potential groundwater monitoring constituents based on baseline HHRA COPCs for hypothetical future residential use[a]

Additional groundwater monitoring constituents		
Fluoride	Sulfate	Aluminum
Cadmium	Chromium, hexavalent	Cobalt
Copper	Iron	Lithium
Manganese	Mercury	Selenium
Silicon	Thallium	Uranium
Vanadium	Chloroform	Trichloroethene
Beta activity	Technetium-99	Thorium-230
Thorium-232	Uranium-233/234	Uranium-235/236
Uranium-238	PFDA	PFHpA
PFHxS	PFNA	PFUA
PFHxA		

[a]These constituents do not apply to all monitoring locations; final analytical and monitoring requirements for the monitoring well network and how data will be evaluated will be developed in the Remedial Action Work Plan.

COC = contaminant of concern
HHRA = human health risk assessment
PFDA = perfluorodecanoic acid
PFHpA = perfluoroheptanoic acid
PFHxA = perfluorohexanoic acid
PFHxS = perfluorohexanesulfonic acid
PFNA = perfluorononanoic acid
PFUA = perfluoroundecanoic acid

In addition, the monitoring plan developed for the RAWP will evaluate if data needs to address any potential impacts to surface water (i.e., Poplar Creek) from groundwater discharges exist. The monitoring plan will consider what data will be needed to ensure groundwater discharges are not adversely impacting surface water quality at levels that could result in exceedances of applicable state or federal AWQC (Table 2.12) or impairing the usefulness of the surface water for its classified use.

Table 2.12. Numeric surface water quality criteria applicable to K-31/K-33 Area groundwater that enters and becomes surface water

Chemical	Criteria	Criteria basis[a]
Antimony	0.64 mg/L	Recreation
Arsenic	0.01 mg/L	Recreation
Chromium, oxide	0.074 mg/L	Fish and Aquatic Life
Chromium, hexavalent	0.011 mg/L	Fish and Aquatic Life
Lead	0.0025 mg/L	Recreation
Nickel	0.052 mg/L	Fish and Aquatic Life

[a]Water quality criteria listed are based on the available and most stringent criteria outlined between Tennessee Department of Environment and Conservation 0400-40-.03(3)(g) and (4)(j).

2.13 STATUTORY DETERMINATION

Under CERCLA Section 121, selected remedies must protect human health and the environment, comply with ARARs, be cost-effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that, as their principal element, use treatment that significantly or permanently reduces the volume, toxicity, or mobility of hazardous wastes. The following sections discuss how the selected remedy addresses those statutory requirements.

2.13.1 Overall Protection of Human Health and Environment

Protectiveness is achieved through a combination of LUCs and monitoring to ensure no exposures to unacceptable contaminant levels in groundwater. Once remedial action objectives are achieved, there would be no groundwater-related risks in the K-31/K-33 Area and maintaining protectiveness with regard to groundwater would not require any further controls.

2.13.2 Compliance with Applicable or Relevant and Appropriate Requirements

The selected remedy is intended to meet all ARARs (Appendix A), including chemical-specific requirements of the TDEC Water Quality Rules. The remedy will also meet all applicable or relevant and appropriate action- and location-specific requirements. The MNA remedy will not require any ARAR waivers. In the absence of point-source discharges, it is anticipated that groundwater modeling, coupled with groundwater monitoring, will be sufficient to demonstrate compliance with the ARARs for the groundwater-to-surface water transition at the K-31/K-33 Area. The details of how the modeling and monitoring are implemented will be in the K-31/K-33 Area RAWP.

2.13.3 National Environmental Policy Act of 1969

NEPA is not an ARAR. However, throughout the CERCLA process, NEPA values are incorporated in accordance with the Secretarial Policy Statement on NEPA (DOE 1994).

2.13.4 Cost Effectiveness

MNA is cost effective as it is the lowest cost alternative out of the two actions—Alternative 2 (MNA and LUCs) and Alternative 3 (pump and treat with MNA and LUCs). MNA requires less construction costs and lacks the more significant O&M costs of a pump and treat system. Construction costs for MNA primarily are limited to potential new monitoring wells.

2.13.5 Use of Permanent Solutions and Alternative Treatment Technologies to Maximum Extent Practicable

MNA constitutes a permanent solution to the groundwater contamination problem. Although active treatment measures are not part of the MNA remedy, natural attenuation processes will achieve the same result; namely, reducing groundwater contamination to meet drinking water standards (MCLs).

2.13.6 Preference for Treatment as Principal Element

This remedy does not meet the statutory preference for treatment as a principal element. MNA was determined to protect human health and the environment while providing the best balance of tradeoffs over treatment with respect to implementability, long-term effectiveness, and permanence at a reasonable cost.

2.13.7 Five-Year Review Requirements

Because the selected remedy (Alternative 2 – MNA and LUCs) will result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for UU/UE, a statutory review will be conducted within 5 years after initiation and at least every 5 years thereafter to ensure the remedy will be protective of human health and the environment. FYRs are currently conducted for K-31/K-33 Area soils under the Zone 2 Soil ROD requirements, and these reviews will continue until site conditions allow for UU/UE. DOE will submit the results of these FYRs for EPA and TDEC approval in accordance with the requirements of the CERCLA/NCP and ORR FFA for the Oak Ridge NPL Site.

For the K-31/K-33 Area groundwater remedial action, FYRs will be conducted until groundwater contaminant concentrations are below MCLs (Table 2.10). The first review will be prepared after this K-31/K-33 Area Groundwater ROD is approved, within the first 5 years after remedial action initiation, and again every 5 years until the remedial action objectives are met or groundwater concentrations are at such levels to allow for UU/UE.

The purpose of the FYR, as stated in EPA's *Comprehensive Five-Year Review Guidance* (EPA 2001c), is to evaluate remedy implementation and performance to determine if the remedy is or will be protective of human health and the environment. Each FYR includes six components: (1) summary of community involvement, (2) document review, (3) data review and analysis, (4) site inspection, (5) interviews, and (6) protectiveness determination. Information gathered and evaluated for the first five components supports completion of the sixth component, the protectiveness determination for the remedy.

The protectiveness determination is based on answering the following questions:

- Is the remedy functioning as intended?
- Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives still valid?
- Has any other information come to light that could call into question protectiveness of the remedy?

In addition to the protectiveness determination, the FYR will identify any issues affecting remedy performance and will recommend follow-up actions, if needed. If the remedy is not performing as established in the RAWP, changes to the selected remedy (e.g., selecting a different alternative or other actions such as in situ treatment) will be evaluated and implemented on a timeframe consistent with the FYR process. Changes to this K-31/K-33 Area Groundwater ROD, including changes to the selected remedy, will be documented through the appropriate CERCLA document(s) in accordance with the NCP at 40 CFR 300.435 and Section 7 of the EPA ROD Guidance.

2.14 DOCUMENTATION OF SIGNIFICANT CHANGES

The K-31/K-33 Area Proposed Plan, approved by EPA and TDEC and released for public comment in March 2023, identified Alternative 2 – MNA and LUCs as the preferred alternative for remediating groundwater in the K-31/K-33 Area. DOE reviewed all written and verbal comments submitted during the public comment period. No significant changes to the remedy, as originally identified in the K-31/K-33 Area Proposed Plan, were determined to be necessary or appropriate.

2.15 REFERENCES

40 Code of Federal Regulations 300, et seq. *National Oil and Hazardous Substances Pollution Contingency Plan*, 1990, U.S. Environmental Protection Agency, Washington, D.C.

42 United States Code Chapter 103, 9601 et seq. *Comprehensive Environmental Response, Compensation, and Liability*.

42 United States Code Chapter 103, 9620 et seq. *Federal Facilities*.

ATSDR 2021. *Agency for Toxic Substances and Disease Registry, Minimal Risk Levels*, Revised March 2021, ATSDR Division of Toxicology and Human Health Sciences Atlanta, GA. URL: https://www.atsdr.cdc.gov/mrls/index.html.

California EPA 2021. *California Environmental Protection Agency, Toxicity Criteria Database*, Revised November 2019, California Office of Environmental Health Hazard Assessment, Sacramento, CA. URL: https://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary.

DOE 1994. *Secretarial Policy Statement on the National Environmental Policy Act of 1969*, U.S. Department of Energy, Washington, D.C.

DOE/OR/01-1468V1&D1. *Groundwater Remedial Site Evaluation Report for the Oak Ridge K 25 Site, Volume 1, Main Text*, 1996, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1778/V1&D1. *Remedial Investigation Report for the East Tennessee Technology Park, Oak Ridge, Tennessee, Volume 1: Technical Summary Report*, 1999, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1824&D0. *Land Use Control Assurance Plan for the Oak Ridge Reservation*, 1999, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1997&D2. *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2022, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2049&D2-R. *Action Memorandum for the Remaining Facilities Demolition Project at East Tennessee Technology Park, Oak Ridge, Tennessee*, 2003, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2161&D2. *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2005, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2279&D3. *Final Sitewide Remedial Investigation and Feasibility Study for East Tennessee Technology Park, Oak Ridge, Tennessee*, 2007, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2317&D2. *Fiscal Year 2006 Phased Construction Completion Report for the Zone 2 Soils, Slabs, and Subsurface Structures at East Tennessee Technology Park, Oak Ridge, Tennessee*, 2006, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2317&D2/A1. *Addendum to the Fiscal Year 2006 Phased Construction Completion Report for the Zone 2 Soils, Slabs, and Subsurface Structures at East Tennessee Technology Park, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2477&D4. *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2014, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2590&D1. *Phased Construction Completion Report for Exposure Units Z2-04 and Z2-05 in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2590&D1/A1. *Addendum to the Phased Construction Completion Report for Exposure Units Z2-04 and Z2-05 in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2628/V1&D2. *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*, 2014, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2699&D2. *Phased Construction Completion Report for Exposure Unit Z2-06 in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2017, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2715&D2. *Offsite Groundwater Assessment Remedial Site Evaluation, Oak Ridge, Tennessee*, 2017, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2723&D2. *Fiscal Year 2007 Phased Construction Completion Report for the Zone 2 Soils, Slabs, and Subsurface Structures at East Tennessee Technology Park, Oak Ridge, Tennessee*, 2008, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2723&D2/A2. *Addendum to the Fiscal Year 2007 Phased Construction Completion Report for the Zone 2 Soils, Slabs, and Subsurface Structures at East Tennessee Technology Park, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2893&D2. *Remedial Investigation/Feasibility Study Report for the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee,* 2022, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2922&D2. *Proposed Plan for the Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee*, 2023, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/02-1547&D3. *Record of Decision for the Clinch River/Poplar Creek Operable Unit, Oak Ridge, Tennessee*, 1997, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/02-1646&D1. *Action Memorandum for Equipment Removal and Building Decontamination for Buildings K-29, K-31, and K-33, East Tennessee Technology Park, Oak Ridge, Tennessee*, 1997, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

EPA. Safe Drinking Water Act of 1974 regulation. URL: Chromium in Drinking Water | US EPA.

EPA 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final, EPA/540/G-89/004, Directive 9355.3-01, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

EPA 1989. *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part A)*, EPA/540/1/89/002, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

EPA 1991. *A Guide to Principal Threat and Low-Level Threat Waste*, Directive 9380.3-06FS, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA 1997. *Health Effects Assessment Summary Tables (HEAST) FY-1997 Update*, EPA/540/R/97/036, PB97-921199, U.S. Environmental Protection Agency, Office of Research and Development, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA 1999. *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*, Directive 9200.1-23P, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA 2001a. *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments), Final*, Directive 9285.7-47, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

EPA 2001b. *Radionuclide Table: Radionuclide Carcinogenicity Slope Factors* (Federal Guidance Report No. 13 Morbidity Risk Coefficients, in Units of Picocuries), Office of Radiation and Indoor Air. URL: https://www.epa.gov/radiation/radionuclide-table-radionuclide-carcinogenicity-slope-factors.

EPA 2001c. *Comprehensive Five-Year Review Guidance*, EPA/540/R/01/007, Directive 9355.7-03B-P, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA 2004. *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)*, EPA/540/R/99/005, Directive 9285.7-02EP, U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation, Washington, D.C.

EPA 2007a. *Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Vol. 1, Technical Basis for Assessment*, EPA/600/R-07/139, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH.

EPA 2007b. *Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Vol. 2, Assessment for Non-Radionuclides Including Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Nitrate, Perchlorate, and Selenium*, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH.

EPA 2009a. *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment)*, EPA/540/R/070/002, Directive 9285.7-82, U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation, Washington, D.C.

EPA 2009b. *Summary of Key Existing EPA CERCLA Policies for Groundwater Restoration*, Directive 9283.1-33, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

EPA 2014a. *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors*, Directive 9200.1-120, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA 2014b. *Determining Groundwater Exposure Point Concentrations, Supplemental Guidance*, Directive 9283.1-42, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA 2015a. *Frequently Asked Questions (FAQS) About Update of Standard Default Exposure Factors*, Directive 9285.6-03, originally dated February 6, 2014, updated September 14, 2015, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA 2015b. *Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites*, Directive 9283.1-36, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA 2018. *Region 4 Human Health Risk Assessment Supplemental Guidance*, Scientific Support Section, Superfund Division, EPA Region 4, U.S. Environmental Protection Agency, Washington, D.C.

EPA 2021a. *Regional Screening Levels for Chemical Contaminants at Superfund Sites (November 2021)*, Accessed May 1, 2022. URL: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables.

EPA 2021b. *Vapor Intrusion Screening Levels (VISL) Calculator (May 2021)*, Accessed September 16, 2021. URL: https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator.

EPA 2021c. *USEPA's Integrated Risk Information System*, Accessed February 15, 2021. URL: https://www.epa.gov/iris.

EPA 2021d. *Provisional Peer-Reviewed Toxicity Values for Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate* (*CASRN 29420-49-3)*, EPA/690/R/21/001F, U.S. Environmental Protection Agency, Center for Public Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH. URL: https://cfpub.epa.gov/ncea/pprtv/recordisplay.cfm?deid=350061.

Federal Register 1990. "Final National Contingency Plan," 55 FR 8758–8760, March 8, 1990.

ITRC 2010. *Technical Regulatory Guidance, A Decision Framework for Applying Monitored Natural Attenuation Processes to Metals and Radionuclides in Groundwater*, APMR-1, prepared by the Interstate Technology and Regulatory Counsel Attenuation Processes for Metals and Radionuclides Team, Washington, D.C.

Lemiszki, P.J. 1994. *Geologic Mapping of the Oak Ridge K-25 Site, Oak Ridge, Tennessee*, K/ER-111, Environmental Sciences Division, Oak Ridge National Laboratory and Department of Geological Sciences, University of Tennessee, Oak Ridge, TN.

Lemiszki, P.J. 1995. *Mesoscopic Structural Analysis of Bedrock Exposures at the Oak Ridge K-25 Site, Oak Ridge, Tennessee*, K/ER-259, Oak Ridge National Laboratory, Environmental Sciences Division, Oak Ridge, TN.

ORNL 2014. *Calculation of Slope Factors and Dose Coefficients*, ORNL/TM-2013/00, Oak Ridge National Laboratory, Center for Radiation Protection Knowledge, Oak Ridge, TN. URL: https://epa-sprg.ornl.gov/pdfs/SlopesandDosesFinal.pdf.

ORNL 2021. *Preliminary Radiation Goals for Radionuclides Calculator (June 2021)*, Accessed April 16, 2022. URL: https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search.

TDEC 2019. Chapter 0400-40-03, *General Water Quality Criteria*, Rule 0400-40-03-.03, "Criteria for Water Uses," and Rule 0400-40-03-.07, "Ground Water Classification," Rules of the Tennessee Department of Environment and Conservation, Nashville, TN, Revised September 2019. URL: https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20190911.pdf.

UCOR-5588. *Federal Facility Agreement Appendix I-5 Information Assessment for East Tennessee Technology Park, Oak Ridge, Tennessee*, 2022, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

PART 3. RESPONSIVENESS SUMMARY

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RESPONSIVENESS SUMMARY

This Responsiveness Summary was prepared in accordance with the requirements of Section 117(b) of CERCLA, as amended. The purpose of this Responsiveness Summary is to summarize and respond to public comments on the K-31/K-33 Area Proposed Plan.

This Responsiveness Summary achieves two of the major objectives of the CERCLA process—it documents community concerns about both the site and the preferred remedy, and it demonstrates how public comments are integrated into the decision-making process. This Responsiveness Summary also provides DOE with the opportunity to formally respond to public comments as an element of the decision-making process.

The K-31/K-33 Area Proposed Plan was issued for public comment on April 26, 2023, and the review period was completed on June 12, 2023, for a total review period of 33 business days. This Responsiveness Summary presents DOE's responses to comments received from the public review and comment period. DOE received comments from two individual commenters via public meeting comments and an additional source through correspondence sent via U.S. Postal Service. Other methods were also available, including email, comment cards submitted directly to DOE representatives, and comment cards turned in at public meetings. Below are responses to the comments:

Comment 1: Doug Colclasure. "Both this and the Main Plant document have a very brief paragraph, in this case, it's on page seven, that the deed restricts disturbance of the soil on the property to no more than 10 feet below ground level. Our – our hope (inaudible) reindustrialization prospects (inaudible) aware of this and how is that going to restrict the reindustrialization of the property? It seems there are projects that are being considered now that would require more than 10 feet. I can't – I haven't seen the Kairos reactor or the – or the Coqui Pharma project reactor documents, but it almost seems certain that they would need footers below 10 feet. Thank you."

Response 1: The 10-ft-below-ground-surface restriction at the East Tennessee Technology Park allows for excavation/penetration below 10 ft through the excavation/penetration permit program, with the applicable approvals required by and as described in the quitclaim deeds.

A series of Federal Facility Agreement tri-party letters was circulated in 2014 regarding soil penetration and/or excavation to depths greater than 10 ft below the ground surface in the greater K-33 Area, including Exposure Units Z2-01, Z2-02, Z2-03, Z2-08, Z2-09, Z2-04, and Z2-05. These letters (dated June 20, 2014; June 23, 2014; June 24, 2014; October 14, 2014; and November 3, 2014) indicate excavation/penetration below depths of 10 ft for the K-31/K-33 Area is acceptable without receiving prior approval from the U.S. Environmental Protection Agency (EPA) or the Tennessee Department of Environment and Conservation (TDEC). For the K-31/K-33 Area, only the U.S. Department of Energy (DOE) must approve excavations/penetrations below 10 ft. However, there is a separate restriction on groundwater use, extraction, and exposure without prior approval from EPA, TDEC, and DOE that is still applicable to the K-31/K-33 Area. This process is consistent with the quitclaim deeds for the K-31/K-33 Area.

Comment 2: Ellen Smith. **"**I appreciate that this is a site that's industrial. It's going to be covered by a lot of paved surfaces and buildings and so forth. It does reduce the potential risk to the public and potential for anybody to access groundwater, for that matter, and it helps make it easier to consider monitored natural attenuation. I am concerned, as was Mr. Colclasure, about the depth of excavation. It's my understanding in years past that the limited depth of excavation was an interim requirement during such time as RI/FS work was being carried out at the site. It wasn't necessarily going to be a permanent restriction. I think that, as a city council member, I'm concerned that the community may not get what we thought we were going to get as a cleaned-up site, if that limited depth of excavation becomes permanent. So, I'm concerned about that.

And another concern that I have is about the hexavalent chromium, which is actually the most significant contaminant identified in the document for groundwater at the site. And my impression is that most of the chromium data that's been collected in the RI/FS process has been total chromium. We got good information on the – on the distribution of the different species of chromium, that hexavalent chromium is the toxic one. It wasn't clear to me whether all chromium was assumed to be hexavalent for purposes of evaluating against the standards or whether – or whether there was some notion that some of it wasn't hexavalent. So that's one concern I have about hexavalent chromium.

The other is that hexavalent chromium isn't something that readily attenuates. It – the sense that I got in the document was that the natural attenuation we're looking for is basically a slow dilution, fusion, and advection, coupled with the likelihood of some sort of degradation or – or chemical reduction to other forms of chromium that don't have the same toxicity. But I didn't see any indication of analysis to identify what in the groundwater environment was going to be fostering any kind of chemical reduction to the other kinds of chromium. And I think that's – I would like to know what processes we're relying on rather than saying we're treating the site as a black box we're hoping to get because numbers have been declining. There must be something going on that's causing them to decline. I'd like to know what we are depending on to provide a reduction in toxicity and if there is nothing in there to accelerate the reduction of chrome to other forms, I'd like to see something done to provide, whether it's humic acids or soils that can be added to the ground or something, some sort of a passive barrier to reduce the chromium. Those are my concerns and they're mostly about hexavalent chromium. Thank you."

Response 2: The 10-ft-below-ground-surface restriction at the East Tennessee Technology Park allows for excavation/penetration below 10 ft through the excavation/penetration permit program, with the applicable approvals required by and as described in the quitclaim deeds.

A series of Federal Facility Agreement tri-party letters was circulated in 2014 regarding soil penetration and/or excavation to depths greater than 10 ft below the ground surface in the greater K-33 Area, including Exposure Units Z2-01, Z2-02, Z2-03, Z2-08, Z2-09, Z2-04, and Z2-05. These letters (dated June 20, 2014; June 23, 2014; June 24, 2014; October 14, 2014; and November 3, 2014) indicate excavation/penetration below depths of 10 ft for the K-31/K-33 Area is acceptable without receiving prior approval from the U.S. Environmental Protection Agency (EPA) or the Tennessee Department of Environment and Conservation (TDEC). For the K-31/K-33 Area, only the U.S. Department of Energy (DOE) must approve excavations/penetrations below 10 ft. However, there is a separate restriction on groundwater use, extraction, and exposure without prior approval from EPA, TDEC, and DOE that is still applicable to the K-31/K-33 Area. This process is consistent with the quitclaim deeds for the K-31/K-33 Area.

Chapter 7 of the *Remedial Investigation/Feasibility Study Report for the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2893&D2; K-31/K-33 Area Remedial Investigation [RI]/Feasibility Study [FS]) states, "Groundwater sampling results from 2021 have shown that the total chromium concentrations in the K-31/K-33 groundwater are largely comprised of the hexavalent chromium species." Appendix C of the K-31/K-33 Area RI/FS describes the different mechanisms that could result in hexavalent chromium reduction. Appendix B of the K-31/K-33 Area RI/FS describes the results of a groundwater model that was completed for the project site and indicates contaminant concentrations will decrease over time. The information in these two appendices provided a weight-of-evidence approach that supports the conclusion that future hexavalent chromium concentrations are likely to decrease over time. After Appendices B and C of the K-31/K-33 Area RI/FS were finalized, additional groundwater data were collected at the site as part of routine monitoring. These data indicate hexavalent chromium concentrations are generally decreasing in groundwater. Please note, after the remedy is implemented, the U.S. Department of Energy, U.S. Environmental Protection Agency, and Tennessee Department of Environment and Conservation will be evaluating groundwater data. If future data indicate groundwater concentrations are not likely to achieve maximum contaminant levels (MCLs) in the future,

the selected remedy can be changed or modified through the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 process.

The federal MCL for chromium in groundwater is 0.100 mg/L. This standard applies to all forms of chromium in groundwater; there is no separate enforceable standard for hexavalent chromium.

Comments 3 through 13 from the Roane County Environmental Review Board review comments on the *Proposed Plan for the Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2922&D2) in letter dated June 12, 2023

Comment 3: Section 1 Introduction: States that NEPA values have been incorporated into the CERCLA documentation prepared for this project. Section 6 Evaluation of Remedial Action Alternatives, 2nd column, last paragraph, page 16: It is stated in addition to criteria prescribed under CERCLA, DOE policy directs substantive elements of analysis under NEPA be incorporated into CERCLA decision documents.

Additional NEPA values include socioeconomic impacts, environmental justice, and ecological impacts. These NEPA values need to be addressed and included in this Proposed Plan for the ROD for K-31/K-33 Area groundwater.

Response 3: U.S. Department of Energy (DOE) policy (DOE 1994, 2010) directs that Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) documents will incorporate National Environmental Policy Act of 1969 (NEPA) values to the extent practicable.

DOE uses the U.S. Environmental Protection Agency's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final* (OSWER 9355.3-01) and *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents* (OSWER 9200.1-23P) as the primary instruments to integrate the requirements of NEPA and CERCLA. Elements common to both CERCLA and NEPA include protectiveness, compliance with applicable or relevant and appropriate requirements, long-term effectiveness and permanence, short-term effectiveness, and cost. These elements were considered in the comparative analysis of the alternatives. Additional NEPA values not specifically included in CERCLA criteria include socioeconomic impacts, environmental justice, irreversible and irretrievable commitment of resources, and cumulative impacts. These elements are included in the alternatives evaluation where applicable and to the extent practicable.

Comment 4: Section 2. Scope of Proposed Remedial Action, last paragraph, page 5: Groundwater sampling previously identified other contaminants above respective maximum contaminant levels (MCLs), include antimony, arsenic, beryllium, lead, and gross alpha activity. It is indicated concentrations of these have been below MCLs in recent samples.

Describe the highest levels and timeframes, along with the current values and when these samples were taken.

Response 4: Table 1 summarizes the requested information for all K-31/K-33 Area groundwater wells with sample results between 2017 and 2021. June 2021 is the last comprehensive (i.e., all wells) sampling campaign to support the remedial investigation. In addition to the information provided in Table 1, the overall number of wells with maximum contaminant level exceedances has decreased over time, as shown in Figure 1.

Comment 5: Section 2.1.1 Site Overview, 2nd column, next to last paragraph, page 5: Sentence "Secondary missions at ETTP, beginning in the 1970s and continuing untill...."

"untill" should be "until."

Response 5: Yes, this is a typographical error and should read "until."

Table 1. Summary of K-31/K-33 Area groundwater wells, 2017–2021

Constituent	Frequency of detection	Units	Detected			Date of maximum detection	MCL[a]	Date of last MCL exceedance	June 2021 maximum detection
			Minimum	Mean	Maximum				
Antimony	18 / 178	µg/L	0.05	2.18	6.71	05/29/2019	6	07/18/2019	2.14
Arsenic	26 / 178	µg/L	0.82	6.08	17.1	03/03/2020	10	02/11/2021	7.65
Beryllium	8 / 178	µg/L	0.23	14.2	88.9	02/09/2021	4	02/09/2021	ND
Lead	27 / 178	µg/L	0.42	33.4	457	02/09/2021	15	02/09/2021	1.48
Alpha activity	64 / 177	pCi/L	1.21	21.6	432	02/09/2021	15	02/11/2021	4.32

[a]Tennessee Department of Environment and Conservation (TDEC) MCLs are listed in TDEC Chapter 0400-45-01. All federal non-zero MCL goals are equivalent to their respective MCLs and are, therefore, not listed in this table. Currently, all federal MCLs are identical to the TDEC MCLs; therefore, the federal MCLs are not listed here.

MCL = maximum contaminant level
ND = non-detect

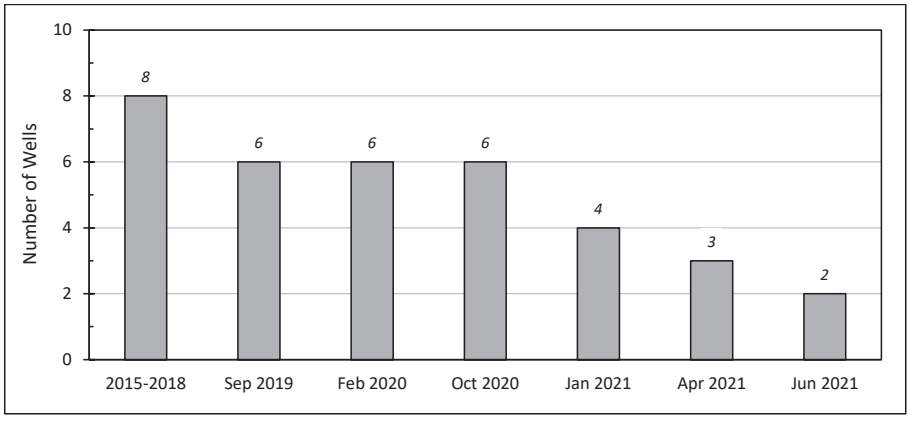

Figure 1. Number of K-31/K-33 Area monitoring wells with maximum contaminant level exceedances.

Comment 6: Section 2.1.1, Site Overview, 2nd column, second paragraph, page 6: It is indicated that an Interim ROD and Amendment to the IROD were issued for Zone 1 soils. It is stated that all Zone 1 remedial actions are complete.

Was there ever a Final ROD issued for Zone 1 soils? If not, why?

Response 6: Yes, the *Record of Decision for Final Soil Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2711&D3; Zone 1 Final Soils Record of Decision [ROD]) was transmitted to the U.S. Environmental Protection Agency (EPA) and Tennessee Department of Environment and Conservation (TDEC) on April 20, 2022, for review and comment. The Zone 1 Final Soils ROD does not recommend any additional actions for Zone 1 soils, because all actions were addressed through the *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1997&D2) or have been deferred to other, future decision documents. These future decision documents are the Remaining Ecology/Surface Water/Sediment ROD and the Zone 1 Groundwater Plumes ROD; both are currently in the remedial investigation phase of work and will include public comment periods after future Proposed Plans are approved by EPA and TDEC. The public comment period for the *Proposed Plan for Final ROD for Soils in Zone 1 at East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2648&D4) was held in 2016.

Comment 7: Section 2.1.2 Site History and Status: Page 6: "A future ROD will be issued for surface water in Poplar Creek (and the Clinch River) upon completion of the CERCLA-driven cleanup work in the ORR."

Will this ROD have a public comment period?

Response 7: Yes, a public comment period will be held after the future Proposed Plan for Poplar Creek/Clinch River has been approved by the U.S. Environmental Protection Agency and Tennessee Department of Environment and Conservation. Note the schedule for this future ROD is in the *Federal Facility Agreement for the Oak Ridge Reservation*, Appendix J, "Non-Enforceable Projected Milestones," with a planning start date of 2041. The intent is to complete any upstream Comprehensive Environmental Response, Compensation, and Liability Act of 1980 watershed actions, which include actions associated with the Y-12 National Security Complex.

Comment 8: Section 2.1.3 Site Characteristics, 2nd column, last paragraph, page 7: It is stated that MCL exceedances occurred primarily in samples of increased turbidity. Filtered samples that limit turbidity primarily show absence of MCL exceedances.

What is being done to remediate the groundwater with higher turbidity levels? The contaminants are present in the suspended particles. How are these contaminated suspended particles being addressed?

Response 8: The turbidity described in Section 2.1.3 is turbidity in the sample due to particulates that can become suspended during the sample collection process and is not an intrinsic property of the surrounding groundwater. This turbidity was due to the methodology for collecting groundwater samples, which can disturb undissolved particulates in the well and mix them with the groundwater sample. In 2019, during remedial site evaluations, the U.S. Department of Energy (DOE) installed low-flow, micropurge pumps in 19 wells. Low-flow pumps are designed to provide less disturbance of undissolved particulates and to, therefore, reduce turbidity in the groundwater samples. This provides a more accurate representation of the dissolved contaminants in the groundwater. DOE will continue to use low-flow pumps and techniques for collecting groundwater samples in the K-31/K-33 Area.

Comment 9: Section 3 Summary of Site Risks: This section discusses ecological risks associated with groundwater contamination. Seeps were identified by the USGS in 1995 in the southern and southeastern portions of the K-31/K-32 [sic] area as primarily wet-weather conveyances.

Considering the potential for greater rainfall due to climate change and the flooding that has occurred in recent years, these seeps should not be ignored as sources of ecological contamination and should be monitored. This is notable because the wells with exceedances and/or recommended for treatment under Alternative 3 are along Popular Creek.

Response 9: A remedial action objective has been established in the K-31/K-33 Area Groundwater Record of Decision to prevent adverse impacts to surface water quality from migration of contaminated groundwater that could result in exceedances of applicable state or federal ambient water quality standards or impairing the usefulness of the surface water for its classified use. The selected remedy is expected to meet that objective, and the methodology by which that will be evaluated will be in the Remedial Action Work Plan. A future decision document for surface water in the Clinch River and Poplar Creek will evaluate potential impacts resulting from the discharge of groundwater, including historical discharges, into Poplar Creek. The effects of climate change on selected remedies on the Oak Ridge Reservation are evaluated as part of the Five-Year Review process.

Comment 10: Section 7.1.1 MNA: States that the scope for the monitoring program will form the basis of the Remedial Action Work Plan (RAWP).

Will this RAWP be made available for public involvement and comment? Since details of surface water monitoring are not included in this ROD, public involvement should be considered.

Response 10: In the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 document process, the Proposed Plan is open for comments both at the associated public meeting and via alternate written routes (Mr. Roger Petrie, Oak Ridge Office of Environmental Management Federal Facility Agreement Project Manager, P.O. Box 2001, Oak Ridge, Tennessee 37831 or OakRidgeEM@orem.doe.gov). The U.S. Department of Energy (DOE) provides responses to public comments in the subsequent Record of Decision, Part 3, Responsiveness Summary, which will become publicly available as part of the Administrative Record. Remedial Action Work Plans are generally not provided to the public for comment because they are technical documents to describe how the selected remedy will be implemented as led by DOE, and they will be independently reviewed by the U.S. Environmental Protection Agency and Tennessee Department of Environment and Conservation for comment and approval.

Comment 11: Section 7.1.1, MNA, 1st column, 3rd paragraph, page 20 and Section 7.1.3 FYR, 2nd column, 1st paragraph, page 20: The NMA [sic] section states that annual Remediation Effectiveness Reports will be submitted for ETP [sic] and TDEC review and approval. The FYR describes evaluating site conditions every 5 years.

What is included in the annual Remediation Reports, particularly sampling and testing results? What is the difference between these two reports?

Response 11: Remediation Effectiveness Reports (RERs) are required by the Oak Ridge Reservation (ORR) Federal Facility Agreement to annually evaluate effectiveness of remedies across the ORR regarding a wide range of site-specific performance criteria. Performance criteria may include sampling and testing results, trend evaluations, and land use control verification, among others. The Five-Year Review (FYR) is a statutory requirement of remedies under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 where residual contamination prohibits unlimited use and unrestricted exposure

at the site. The FYR serves a similar purpose as an RER; however, the FYR follows specific U.S. Environmental Protection Agency guidance and includes an updated Protectiveness Statement for each decision or operable unit.

Comment 12: Section 8 Natural Resource Damages, page 21: It is recognized that Natural Resource Damage claims under CERCLA may be applicable.

How does this relate to the Oak Ridge NRDA: Restoration and Compensation Determination Plan/Environmental Assessment issued in December 2022 and the NRDA issued in 2009 that created the Black Oak Conservation Easement? If the K-31/K-33 Area damages are already part of either/both of those NRDAs, then this ROD should include and address the previous NRDA(s).

Response 12: Natural Resource Damage Assessment-related damages for groundwater beneath and flowing offsite from the Oak Ridge Reservation are addressed under the *December 2022 Oak Ridge Reservation Natural Resource Damage Assessment Restoration and Compensation Determination Plan/Environmental Assessment*. This would include groundwater addressed under the K-31/K-33 Area Groundwater Record of Decision.

Comment 13: Section 10 Community Participation, pages 21-22: There is no Invitation to Comment by the public on this document present on the DOE Information Center Website. It is unclear how the public comment period was communicated to Roane County government (e.g., County Executive) or to the public.

It is suggested that invitations to comment be communicated to the Roane County Executive and the Roane County Environmental Review Board (RCERB).

Page 1 of this document in the 1st column, 5th bullet describes how to participate in selecting or modifying the preferred remedial action alternative by attending public meetings and by a 45-day public comment period. However, this bulleted paragraph leaves dates blank.

Response 13: Yes, this version of the *Proposed Plan for the Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2922&D2) was transmitted to the U.S. Environmental Protection Agency (EPA) and Tennessee Department of Environment and Conservation (TDEC) for review and approval. EPA and TDEC approval of the document is the precursor to the public meeting and finalizes the document; therefore, the date, time, and location of the public meeting were largely unknown at the time of this submittal. While the intent was to hold a meeting at the U.S. Department of Energy (DOE) Information Center (DOEIC), due to venue requirements, an alternate location was obtained and communicated with the public comment period announcement. It is correct that the public comment announcement was not posted to the DOEIC website, which manages and maintains the Administrative Record documents for the Record of Decision; however, the announcement for the public meeting and comment period was made on the DOE Oak Ridge Environmental Management website and social media accounts as well as in several local newspaper outlets.

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APPENDIX A.
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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A1. INTRODUCTION

The applicable or relevant and appropriate requirements (ARARs) described in this appendix to the *Record of Decision for Groundwater in the K-31/K-33 Area at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2950&D1; K-31/K-33 Area Groundwater Record of Decision [ROD]) apply to groundwater in the K-31/K-33 Area at the East Tennessee Technology Park (ETTP) in the U.S. Department of Energy's Oak Ridge Reservation (ORR).

Both the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), Section 121, and Title 40, Code of Federal Regulations (CFR), Part 300.430(f)(1)(ii)(B), specify remedial actions for cleanup of hazardous substances must attain or have legally waived ARARs under federal or more stringent state environmental laws. Inherent in the interpretation of ARARs is the assumption protection of human health and the environment is ensured.

Applicable requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site" (40 CFR 300.5). A requirement is applicable if all the jurisdictional and site-specific prerequisites of the requirement are met (i.e., if the requirement directly and fully addresses the situation at the site).

Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (40 CFR 300.5). The criteria for determining relevance and appropriateness are listed at 40 CFR 300.400(g)(2). A relevant and appropriate requirement must be complied with to the same extent as an applicable requirement.

To qualify as a state ARAR mandating cleanup standards under 40 CFR 300.400(g)(4) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), a state requirement must be: (1) promulgated (of general applicability and legally enforceable), (2) an environmental or facility siting law or regulation, (3) substantive (not procedural or administrative), (4) more stringent than a comparable federal requirement, (5) identified by the state in a timely manner, and (6) consistently applied throughout the state. Pursuant to U.S. Environmental Protection Agency (EPA) guidance (EPA 1988), where EPA has delegated to the state of Tennessee the authority to implement a federal program, the Tennessee regulations replace the equivalent federal requirements as the potential ARARs.

CERCLA on-site remedial response actions must comply with only the substantive requirements of a regulation to obtain federal, state, or local permits (CERCLA Section 121(e)). To ensure CERCLA response actions proceed as rapidly as possible, EPA has reaffirmed this position in the final NCP (55 Federal Register 8756, March 8, 1990). Substantive requirements directly pertain to the actions or conditions at a site, while administrative requirements facilitate their implementation (e.g., approval of or consultation with administrative bodies, documentation, permit issuance, reporting, record keeping, and enforcement). EPA recognizes certain administrative requirements (e.g., consultation with state agencies and reporting) are accomplished through state involvement and public participation. These administrative requirements should also be observed if they are useful in determining cleanup standards at the site (55 Federal Register 8757).

The NCP at 40 CFR 300.400(e)(1) exempts on-site actions from having to obtain federal, state, or local permits and defines on-site as meaning "the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for the implementation of the response action." However, on-site actions must still be in compliance with any substantive permit requirements. Off-site actions must comply with only requirements that are legally applicable, but they must comply with both the substantive and administrative parts of those requirements. Permits, if required, must be obtained for all remedial activities conducted offsite (40 CFR 300.400(e)(2)). Statutory waivers of ARARs (40 CFR 300.430(f)(1)(ii)(C)) may not be used for off-site actions.

EPA has noted in its CERCLA guidance that if attainment of a numerical value that is a potential chemical-specific ARAR is impossible because the background level of the chemical subject to CERCLA authority is higher than that of the potential ARAR, the numerical criterion would not be considered an ARAR (EPA 1991).

ARARs include federal and state regulations designed to protect the environment; ARARs do not include occupational safety regulations. EPA requires compliance with the Occupational Safety and Health Administration standards in Section 300.150 of the NCP, independent of the ARARs process. Therefore, neither the regulations promulgated by the Occupational Safety and Health Administration nor DOE Orders related to occupational safety are addressed as ARARs. These regulations would appear in the appropriate health and safety plans for this action.

In addition to ARARs, 40 CFR 300.400(g)(3) states federal or state non-promulgated advisories or guidance may be identified as to-be-considered (TBC) guidance for contaminants, conditions, and/or actions at the site. TBC guidance include non-promulgated criteria, advisories, guidance, and proposed standards. TBC guidance are not ARARs because they are neither promulgated nor enforceable. TBC guidance may be used to interpret ARARs and to determine remediation levels when ARARs do not exist for particular contaminants or are not sufficiently protective to develop cleanup goals. TBC guidance, such as guidance or policy documents, developed to implement regulations may be considered and used where necessary to ensure protectiveness.

Table A.1 lists numeric chemical-specific ARARs for groundwater. The constituents listed in Table A.1 were selected because they exceeded the maximum contaminant level (MCL) in the past 5 years. The sections below and Table A.2 provide a full listing of chemical-, location-, and action-specific ARARs.

Table A.1. Numeric criteria for K-31/K-33 Area groundwater

Chemical	Value	Selection basis[a]
Alpha activity[b]	15 pCi/L	Federal MCL, TDEC MCL
Antimony	0.006 mg/L	Federal MCL, TDEC MCL, Tennessee groundwater quality criteria
Arsenic	0.010 mg/L	Federal MCL, TDEC MCL, Tennessee groundwater quality criteria
Beryllium	0.004 mg/L	Federal MCL, TDEC MCL, Tennessee groundwater quality criteria
Chromium (total)[c]	0.1 mg/L	Federal MCL, TDEC MCL, Tennessee groundwater quality criteria
Lead	0.005 mg/L[d,e]	Tennessee groundwater quality criteria
Nickel	0.1 mg/L[f]	TDEC MCL, Tennessee groundwater quality criteria

Table A.1. Numeric criteria for K-31/K-33 Area groundwater (cont.)

[a]TDEC MCLs are listed in TDEC Chapter 0400-45-01-.06(1) and (5) for inorganics and radionuclides, respectively (TDEC 2019). Currently, all federal MCLs are identical to the TDEC MCLs; the federal MCLs are listed in 40 Code of Federal Regulations (CFR) 141.62(b) and 40 CFR 141.66(c) for inorganics and radionuclides, respectively. Tennessee groundwater quality criteria at TDEC 0400-40-03-.08 incorporate by reference the domestic water supply criteria in TDEC Chapter 0400-40-03-.03(1)(j).

[b]Multiple transuranics may be present and cumulatively contribute to exceedance of the gross alpha MCL (15 pCi/L). Typically, all gross alpha activity is assumed to be due to uranium when it exceeds the MCL (40 CFR 141.26(a)(5)). During the remedial investigation, samples were collected for uranium due to the gross alpha particle activity being above its respective MCL; although uranium has not been detected in any of the groundwater samples above its MCL (30 pCi/L) over the 5-year period (2017–2021), it will be evaluated through ongoing monitoring in addition to gross alpha activity as part of the selected remedy until the MCL for gross alpha activity is achieved.

[c]The drinking water standard of 0.1 mg/L for total chromium applies to all forms of chromium, including hexavalent chromium, which is a contaminant of concern for groundwater based on risks identified in both the residential and industrial land use scenarios.

[d]Lead and copper are regulated by a treatment technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, then water systems must take additional steps.

[e]In addition to the Tennessee lead groundwater quality criterion of 0.005 mg/L for domestic water supply in TDEC Chapter 0400-40-03-.03, the State also has an MCL/treatment technique under the State's Safe Drinking Water Act of 1974 program (TDEC Chapter 0400-45-01).

[f]The U.S. Environmental Protection Agency has deleted both the MCL and the MCL goal for nickel from the CFR, which was vacated by a court ruling. Tennessee has retained the nickel MCL in its current regulations.

TDEC 2019. Chapter 0400-40-03, *General Water Quality Criteria*, Rule 0400-40-03-.03, "Criteria for Water Uses," and Rule 0400-40-03-.07, "Ground Water Classification," Rules of the Tennessee Department of Environment and Conservation, Nashville, TN, Revised September 2019. URL: https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20190911.pdf.

MCL = maximum contaminant level
TDEC = Tennessee Department of Environment and Conservation

Table A.2. ARARs

Media/Location/Action	Requirement	Prerequisite	Citation
	Chemical-specific		
Remediation of contaminated groundwater	Except for naturally occurring levels, general use groundwater: • shall not contain constituents that exceed those levels specified in TDEC Chapter 0400-40-03-.03 subparagraphs j (levels equivalent to Safe Drinking Water Act of 1974 MCLs) and k (quantities detrimental to public health or that impair use of the water as domestic water supply), and • shall contain no other constituents at levels and conditions that pose an unreasonable risk to the public health or the environment	Presence of contaminants in groundwater of the State designated as general use groundwater, as defined in TDEC 0400-40-03-.07(4)(b)—applicable	TDEC 0400-40-03-.08(2)(a) and (b)
	MCLs are promulgated maximum concentration levels for contaminants in public drinking water supplies. Must not exceed MCLs in public community water systems, as measured at the consumer's tap. See Table A.1 for a list of specific numeric criteria	Release of contaminants to groundwater or actions potentially impacting groundwater—relevant and appropriate	TDEC 0400-45-01-.06(1) TDEC 0400-45-.01-.06(5) 40 CFR 141.62(b) and 40 CFR 141.66(c)
Protection of surface water	Groundwater that enters a stream or other water classified as surface water becomes surface water and is subject to respective criteria applicable to that water. The board expects the department will use prudent judgment where groundwater mixes with water on the surface of the ground	Groundwater that enters surface water—applicable	TDEC 0400-40-03-.07(1)(e)
	Since all streams are classified for more than one use, the most stringent criteria will be applicable		TDEC 0400-40-03-.02(5)
	Numeric water quality criteria for use of Fish and Aquatic Life and Recreation. For specific numeric criteria applicable to the K-31/K-33 Area, see Table A.3 [Note: In the absence of point-source discharges, it is anticipated that groundwater modeling, coupled with groundwater monitoring, will be sufficient to demonstrate compliance with the ARARs for the groundwater-to-surface water transition at the K-31/K-33 Area. The details of how the modeling and monitoring are implemented will be in the K-31/K-33 Area RAWP.]		TDEC 0400-40-03-.03(3)(g) TDEC 0400-40-03-.03(4)(j)

Table A.2. ARARs (cont.)

Media/Location/Action	Requirement	Prerequisite	Citation
	Location-specific		
	Floodplains		
Presence of floodplain, as defined in 10 CFR 1022.4	Incorporate floodplain management goals into planning, regulatory, and decision-making processes, and, to the extent practicable, reduce the risk of flood loss; minimize the impact of floods on human safety, health, and welfare; restore and preserve natural and beneficial values served by floodplains; require the construction of DOE structures and facilities to be, at a minimum, in accordance with Federal Emergency Management Agency National Flood Insurance Program building standards; and promote public awareness of flood hazards by providing conspicuous delineations of past and probable flood heights on DOE property that is in an identified floodplain	DOE actions that involve potential impacts to, or take place within, floodplains—applicable	10 CFR 1022.3(a)(1) through (6)
	Undertake careful evaluation of potential effects of any proposed floodplain action Avoid, to the extent possible, long- and short-term adverse impacts associated with occupancy and modification of floodplains Avoid direct and indirect support of development in a floodplain wherever there is a practicable alternative Identify, evaluate, and, as appropriate, implement alternative actions that may avoid or mitigate adverse floodplain impacts		10 CFR 1022.3(b), (c), and (d)
	Describe the proposed action and include a map showing its location with respect to the floodplain. For actions located in a floodplain, the nature and extent of the flood hazard shall be described, including the nature and extent of hazards associated with any high-hazard areas		10 CFR 1022.13(a)(1)
	Discuss positive and negative, direct and indirect, and long- and short-term effects of the proposed action on the floodplain. Include impacts on the natural and beneficial floodplain values (Section 1022.4) appropriate to the location under evaluation. In addition, the effects of a proposed floodplain action on lives and property shall be evaluated		10 CFR 1022.13(a)(2)
	Consider alternatives to the proposed action that avoid adverse impacts and incompatible development in the floodplain, including alternate sites, alternate actions, and no action. DOE shall evaluate measures that mitigate adverse effects of actions in a floodplain including, but not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically sensitive areas		10 CFR 1022.13(a)(3)
	If no practicable alternative to locating or conducting the action in the floodplain is available, then before taking action, design or modify the action to minimize potential harm to or within the floodplain, consistent with the policies set forth in Executive Order 11988		10 CFR 1022.14(a)

Table A.2. ARARs (cont.)

Media/Location/Action	Requirement	Prerequisite	Citation
	Action-specific		
	General		
Activities causing fugitive dust emissions	Shall take reasonable precautions to prevent particulate matter from becoming airborne; reasonable precautions shall include, but are not limited to, the following: • use, where possible, water or chemicals for control of dust, and • apply asphalt, water, or suitable chemicals on dirt roads, materials stock piles, and other surfaces, which can create airborne dusts	Use, construction, alteration, repair, or demolition of a building, or appurtenances or a road or the handling transport or storage of material—applicable	TDEC 1200-3-8-.01(1) TDEC 1200-3-8-.01(1)(a) TDEC 1200-3-8-.01(1)(b)
	Shall not cause or allow fugitive dust to be emitted in such a manner as to exceed 5 min/hr or 20 min/day beyond property boundary lines on which emission originates		TDEC 1200-3-8-.01(2)
Airborne radionuclide emissions	Emissions of radionuclides to ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive an effective dose equivalent of 10 mrem per year	Radionuclide air emissions from point sources, as well as diffuse or fugitive emissions, at DOE facilities—applicable	40 CFR 61.92 and TDEC 1200-3-11-.08(6)
	Groundwater monitoring activities		
Placement of monitoring wells	Well(s) shall be designed, constructed, and operated in such a manner that their use does not cause any underground source of drinking water to contain any substances that are toxic, carcinogenic, mutagenic, or teratogenic, other than those of natural origin, at levels and conditions that violate primary drinking water standards or adversely affect the health of persons and does not cause a violation of water quality standards	Class V injection systems—relevant and appropriate (to placement of monitoring wells)	TDEC 0400-45-06-.14(1)(b) and TDEC 0400-45-06-.14(7)(b) and (8)(a)
Construction and abandonment of monitoring wells	Establishes quality and workmanship requirements for drilling, installing, and abandoning wells, and for sampling, borehole geophysical logging, and hydrologic testing. The substantive requirements of this procedure are TBC guidance for construction and abandonment of monitoring wells	Construction and abandonment of monitoring wells—TBC	*Standard Specifications for Installation, Well Drilling, and Abandonment*, United Cleanup Oak Ridge LLC Technical Specification No. SPG-00000-A005/Rev 2, 10/14/11

Table A.2. ARARs (cont.)

Media/Location/Action	Requirement	Prerequisite	Citation
Closure of monitoring wells	Before abandonment, clean well of obstructions and disinfect using bleach or hypochlorite granules to produce free chlorine residual concentrations of 25 parts per million	Plugging and closure of a water production well—relevant and appropriate	TDEC 0400-45-09-.16(1)(a)–(c)
	Use one of several different methods to close well depending on depth of well, construction details, whether it is cased or uncased, and whether or not it intercepts multiple aquifers		TDEC 0400-45-09-.16(2)(a)–(c)
	Backfill must be placed so there are no gaps or bridging. Backfill top must be level with land surface		TDEC 0400-45-09-.16(2)(d)
	Wells extending into more than one aquifer shall be filled and sealed in such a way that exchange of water from one aquifer to another is prevented		TDEC 0400-45-09-.16(3)
	Flowing wells must be treated to reduce flow to zero before sealing		TDEC 0400-45-09-.16(4)
	An alternate method of closure may be approved by TDEC		TDEC 0400-45-09-.16(5)

ARAR = applicable or relevant and appropriate requirement
CFR = Code of Federal Regulations
DOE = U.S. Department of Energy
MCL = maximum contaminant level
TBC = to be considered
TDEC = Tennessee Department of Environment and Conservation

A2. CHEMICAL-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Chemical-specific ARARs provide health- or risk-based concentration limits or discharge limits in various environmental media (i.e., surface water, groundwater, soil, and air) for specific hazardous substances, pollutants, or contaminants.

The CERCLA NCP requires federal Safe Drinking Water Act of 1974 (SDWA) MCLs and non-zero MCL goals be attained for all remedial actions for groundwaters that are current or potential sources of drinking water, where the MCLs/non-zero MCL goals are relevant and appropriate under the circumstances of the release (40 CFR 300.430(e)(2)(i)(B)-(C)).

The numeric criteria associated with SDWA MCLs are provided in Table A.1. These criteria are useful for understanding the breadth of the situation in K-31/K-33 Area groundwater, although future end use for the site is not intended to allow for groundwater use as a drinking water source.

Tennessee Department of Environment and Conservation (TDEC) Rule 0400-40-03-.07(4)(b) (TDEC 2019) designates all groundwater in the state as general use groundwater (except for groundwater that has been specifically designated otherwise); thus, this general use groundwater designation applies to groundwater on the ORR. Groundwater designated as general use must meet the state's numeric water quality criteria under TDEC 0400-40-03-.03(1)(j) and (k) for surface waters classified as a domestic water supply and must contain no other constituents that pose an unreasonable risk to public health or the environment (TDEC 0400-40-03-.08(2)). Water quality criteria set out in TDEC 0400-40-03-.03(1)(j) largely reflect the MCLs (see Table A.1); however, there are some differences. For example, the gross alpha criterion is only listed in the TDEC 0400-45-01 Rules, and a more stringent numerical criterion for lead is found in the TDEC 0400-40-03.03 Rule.

Surface water bodies in Tennessee are assigned use classifications by the Tennessee Water Quality Control Board. The use classifications for the Clinch River Basin, which includes Poplar Creek, are listed in TDEC 0400-40-04-.09. The use classifications for Poplar Creek include Fish and Aquatic Life, Recreation, Livestock Watering and Wildlife, and Irrigation. Only the Fish and Aquatic Life and Recreation uses have specific numeric surface water quality criteria set for particular compounds. Where K-31/K-33 Area groundwater enters Popular Creek, the groundwater becomes surface water and must meet the surface water quality criteria. The specific numeric surface water quality criteria available for K-31/K-33 Area groundwater are provided in Table A.3.

Table A.3. Numeric surface water quality criteria applicable to K-31/K-33 Area groundwater that enters and becomes surface water

Chemical	Criteria	Criteria basis[a]
Antimony	0.64 mg/L	Recreation
Arsenic	0.01 mg/L	Recreation
Chromium, oxide	0.074 mg/L	Fish and Aquatic Life
Chromium, hexavalent	0.011 mg/L	Fish and Aquatic Life
Lead	0.0025 mg/L	Recreation
Nickel	0.052 mg/L	Fish and Aquatic Life

[a]Water quality criteria listed are based on the available and most stringent criteria outlined between Tennessee Department of Environment and Conservation 0400-40-.03(3)(g) and (4)(j).

A3. LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Location-specific requirements establish restrictions on permissible concentrations of hazardous substances or establish requirements for how activities will be conducted because they are in special locations (e.g., wetlands, floodplains, critical habitats, historic districts, and streams).

A3.1. Floodplains

Floodplains (e.g., adjacent to Poplar Creek) could potentially be impacted by remediation activities. In accordance with 10 CFR 1022, remedial actions must avoid, to the extent possible, long- and short-term adverse impacts to floodplains. Mitigation measures listed in 10 CFR 1022.12, which include minimum grading requirements, runoff controls, and design and construction constraints, would need to be implemented to restore/preserve the beneficial values of the floodplains.

A4. ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Performance-, design-, or action-specific requirements set controls or restrictions on particular kinds of activities related to managing waste and are usually technology- or activity-based standards or limitations, depending on the type of waste.

A4.1. Monitored Natural Attenuation

Guidance for the use of monitored natural attenuation (MNA) is provided by EPA in the preamble to the final NCP (55 Federal Register 8732); in its *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (EPA 1999); and in its *Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Site* (EPA 2015). The guidance defines those sites where MNA may be appropriate and addresses reasonable timeframes for remediation and performance monitoring and evaluation. EPA notes reasonable restoration time periods may range from very rapid (1 to 5 years) to relatively extended (perhaps several decades) and states if there are readily available drinking water sources of sufficient quality and yield that may be used as an alternative water supply, the necessity for rapid restoration of the contaminated groundwater may be reduced (55 Federal Register 8732).

Additional groundwater monitoring wells may be installed as part of the MNA remedy. As such, groundwater monitoring well requirements presented in Table A.2 would be ARARs/TBC guidance.

Due to the relatively low contaminant concentrations in the groundwater, any wastewater (e.g., investigation-derived waste, decon water, well development, etc.) would not be Resource Conservation and Recovery Act of 1976 characteristic waste and would be sent to the existing treatment systems at ETTP (e.g., the Chromium Wastewater Treatment System) or an ORR-permitted wastewater treatment facility. Any wastewater will be characterized prior to treatment, and any treated wastewater would be characterized at existing treatment facilities to ensure all substantive discharge requirements would be met.

A5. REFERENCES

40 Code of Federal Regulations 300, et seq. *National Oil and Hazardous Substances Pollution Contingency Plan*, 1990, U.S. Environmental Protection Agency, Washington, D.C.

Federal Register 1990. "Final National Contingency Plan," 55 FR 8758–8760, March 8, 1990.

EPA 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final, EPA/540/G-89/004, Directive 9355.3-01, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

EPA 1991. *ARARs Q's & A's: General Policy, RCRA, CWA, SDWA, Post-ROD Information, and Contingent Waivers*, Directive 9234.2-01/FS-A, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA 1999. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, Final Directive 9200.4-17P, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA 2015. *Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites*, Directive 9283.1-36, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

TDEC 2019. Chapter 0400-40-03, *General Water Quality Criteria*, Rule 0400-40-03-.03, "Criteria for Water Uses," and Rule 0400-40-03-.07, "Ground Water Classification," Rules of the Tennessee Department of Environment and Conservation, Nashville, TN, Revised September 2019. URL: https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20190911.pdf

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