LMS/WEL/50510

2026 Deep Monitoring Well Installation Work Plan for the Weldon Spring, Missouri, Site

November 2025

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This document is designed for online viewing.

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Abbreviations

bgs	below ground surface
DOE	U.S. Department of Energy
DQO	data quality objective
DR	decision rule
EPA	U.S. Environmental Protection Agency
ESL	Environmental Sciences Laboratory
FLUTe	Flexible Liner Underground Technology
ft	feet
GWOU	Groundwater Operable Unit
IC	institutional control
MNA	monitored natural attenuation
NLN	National Laboratory Network
O1	Study Objective 1
O2	Study Objective 2
pCi/L	picocuries per liter
TCE	trichloroethene

1.0 Introduction

This work plan describes the objectives, justification, sampling, data quality assurances, and control measures for deep well installation and data collection efforts at the U.S. Department of Energy (DOE) Weldon Spring, Missouri, Site. The Weldon Spring Site is on the National Priority List and is regulated under the Comprehensive Environmental Response, Compensation, and Liability Act.

1.1 Background

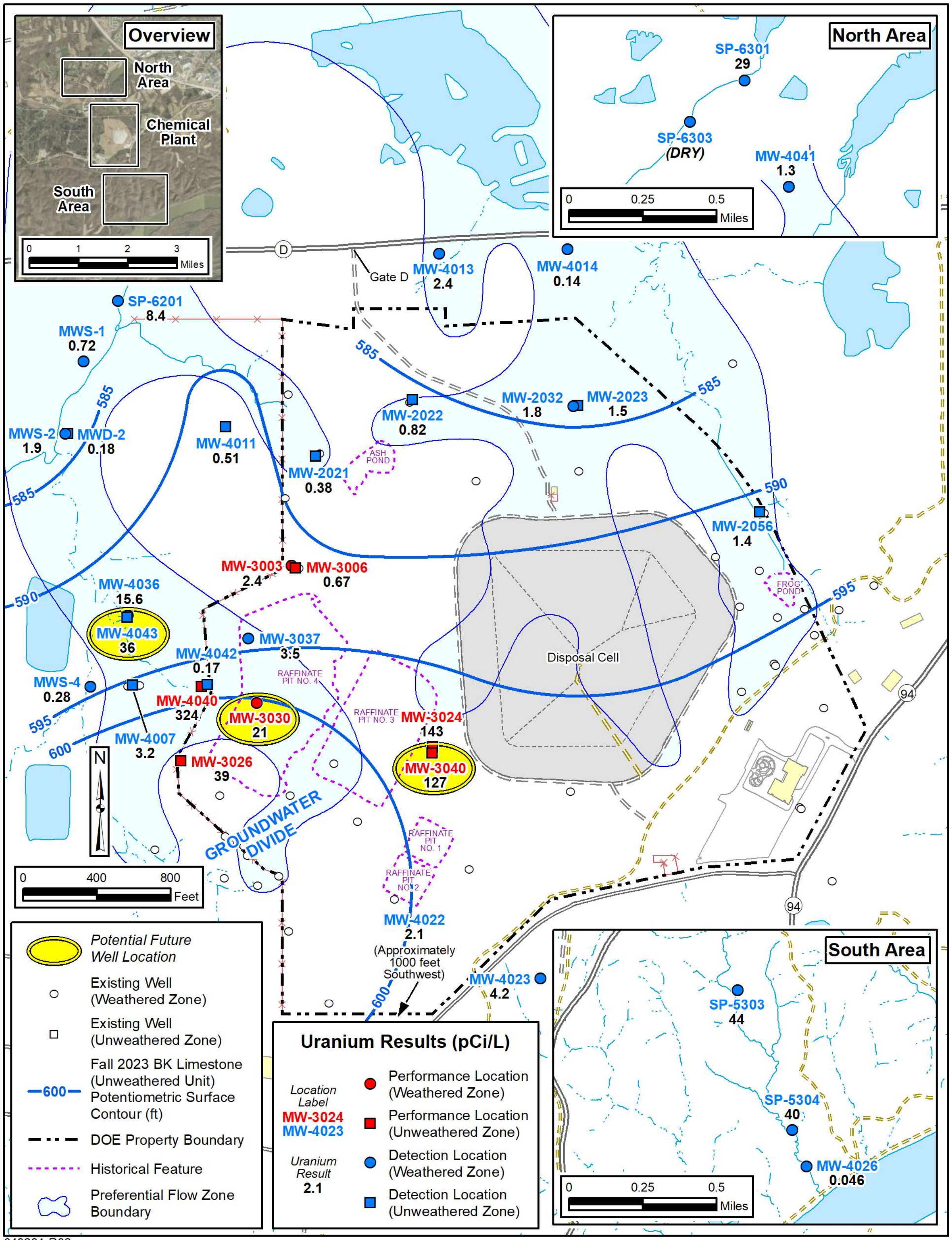
Additional investigation into dissolved uranium in groundwater near the former raffinate pits (raffinate pits) in the transition interval between the weathered and unweathered units (upper unweathered bedrock) began in 2004 with the installation of monitoring wells MW-4040 and MW-3040 (Figure 1). Uranium migration into this interval is the result of high head pressures when the raffinate pits were full, which forced uranium-contaminated water into this low-permeability zone. The persistent elevated concentrations of uranium in upper unweathered unit wells near the raffinate pits, coupled with difficulty in maintaining stable water levels during low-flow micro-purge sampling events, suggest that this interval is poorly connected to the well-connected fracture network that comprises the dominant flow system. The weathered bedrock that overlies the unweathered bedrock is more fractured, resulting in a more connected overall flow system that facilitates flushing of contamination from that interval. The potential exists for flow in the unweathered unit in areas where fractures are interconnected. Figure 1 illustrates locations of performance monitoring (monitor contamination impacted areas) and detection monitoring (monitor for contaminant migration).

1.2 Purpose and Scope

The purpose of this work plan is to detail fieldwork activities and data collection to address data gaps related to the vertical delineation of dissolved uranium and migration pathways in the western portion of the Chemical Plant area. This response to the persistently elevated uranium concentrations at unweathered unit monitoring well locations MW-4040 and MW-3024 or MW-3040[1] follows National Laboratory Network (NLN) collaboration recommendations (DOE 2023b). This work plan includes the following sections:

- A summary of relevant background, historical site operations, and rationale for well installation (Section 1.0)
- The data quality objectives (DQOs) that address the data gaps and steps necessary for the fulfillment of data gaps (Section 2.0)
- Identification of and approach for data collection needs (Section 3.0)
- Summary of testing methodology (Section 3.0)
- Implementation considerations regarding data collection activities, including safety and health, quality assurance, data management, and environmental management (Section 4.0)

[1] In 2004, monitoring well MW-3040 was drilled adjacent to monitoring well MW-3024 due to concerns about its integrity. Monitoring well MW-3040 is screened across the bottom 10 feet of the 20 foot zone that monitoring well MW-3024 was originally screened across and has exhibited concentrations similar to those of monitoring well MW-3024. Monitoring well MW-3024 was repaired and reconfigured in 1996 to be screened across the lower 10 feet of its original screened interval.



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Abbreviation:
BK Limestone = Burlington-Keokuk Limestone

Figure 1. 2023 Average Dissolved Uranium Concentrations, Fall 2023 Potentiometric Surface Elevations, and Proposed 2026 Monitoring Well Locations in the Unweathered Zone

In response to regulator comments on the Sixth Five-Year Review (DOE 2021), the DOE led a collaboration effort with NLN and others to develop plans to support the monitored natural attenuation (MNA) remedy at the Chemical Plant through additional testing and data collection. The recommendations include: (1) the analysis of the existing core for attenuation mechanisms in addition to dilution and dispersion, (2) the analysis of changes to trends to adopt a longer time frame perspective, and (3) the evaluation of elevated uranium areas in the upper part of the unweathered bedrock to determine the connectivity of flow to the shallower flow system. The results are being used as part of the continued evaluation of the remedy and NLN recommendations. This work plan addresses NLN recommendations 1 and 3 above.

1.3 Hydrogeologic Setting

The Chemical Plant area is in a physiographic transitional area between the Dissected Till Plains of the Central Lowlands province to the north and the Salem Plateau of the Ozark Plateaus province to the south. Subsurface flow and transport in the Chemical Plant area occur primarily in the carbonate bedrock Burlington-Keokuk Limestone. The overlying unconsolidated surficial alluvial materials are clay-rich, mostly glacially derived units, which are generally unsaturated beneath the site. Typical thickness ranges from 20 to 50 feet (ft).

A groundwater divide along the southern boundary of the site is evident on potentiometric maps of both the unweathered and weathered units (Figure 1 and Figure 2). Groundwater movement generally occurs through diffuse flow through porous media until localized zones of discrete flow in higher hydraulic conductivity zones such as fractures, solution channels, and bedding planes are reached. Groundwater north of the divide flows north toward Dardenne Creek and ultimately to the Mississippi River, and groundwater south of the divide flows south to the Missouri River.

The aquifer of concern is the bedrock aquifer in the Mississippian Burlington-Keokuk Limestone. The unit has two different hydrogeologic zones: (1) a shallow, weathered zone and (2) an underlying more competent, unweathered zone. This deeper zone is the focus of this work plan. The transition from weathered to unweathered bedrock is from 20–40 ft below ground surface (bgs) in valleys and 70–90 ft bgs in the high areas between streams in the Chemical Plant area. The unweathered portion is thinly to massively bedded with fracture densities significantly less in the unweathered zone than in the weathered zone. Locally in the Chemical Plant area, downward migrating contamination can become segregated and isolated from the major groundwater flow paths, that promote dilution and dispersion through time.

Most of the wells at the site are completed in the weathered zone of the bedrock where groundwater has the greatest potential to be contaminated. Wells screened in the underlying unweathered zone evaluate vertical migration of contaminants and monitor horizontal migration in the western paleochannel. The irregular contact between the weathered and unweathered units are generally lower in elevation, and hydraulic conductivities are typically higher, in the paleochannel areas. Preferential flow zones have been inferred from bedrock topography, groundwater surface maps, hydraulic conductivity data, and subsurface tracer results (DOE 2005), which coincide with the north-trending bedrock lows that are indicated on the groundwater elevation maps of both the unweathered (Figure 1) and weathered (Figure 2) units.

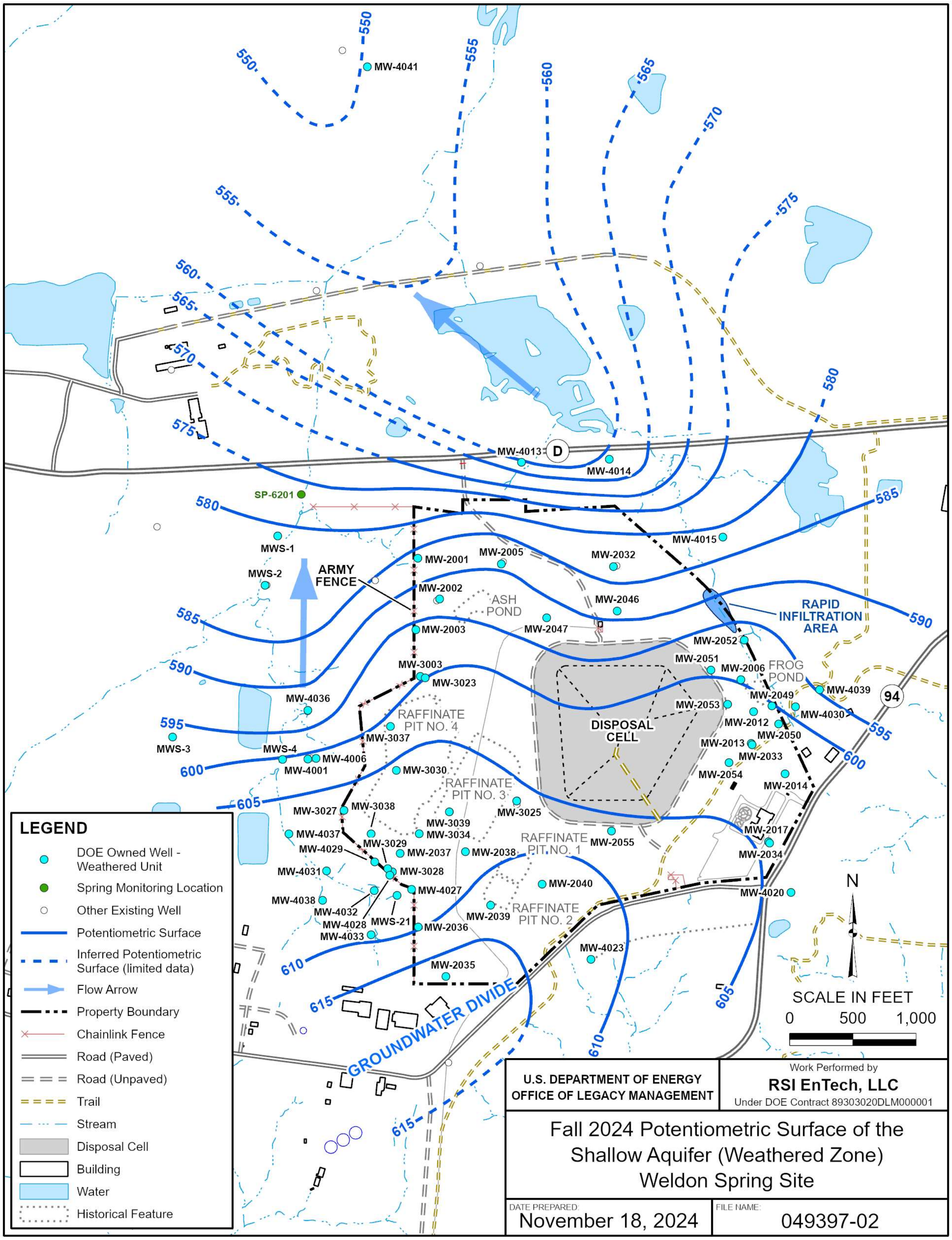


Figure 2. Fall 2024 Potentiometric Surface Map of the Shallow Aquifer in the Weathered Zone

There is a downward vertical gradient west and north of the former raffinate pits. This area is on a topographic high where groundwater recharge and a downward gradient are expected. However, comparative water elevations farther to the northwest, as seen in collocated monitoring wells MW-4036 and MW-4043 (Figure 1), transition to an upward gradient that is maximized during wet periods, typically in the spring. North of the site, the topography is lower and is an area of groundwater discharge with lakes and springs.

1.4 Contamination in the Bedrock Unit

The raffinate pits were the primary historical source for uranium contamination in groundwater. Dissolved uranium entered the shallow aquifer via infiltration through the thin overburden beneath the pits. As such, the highest uranium concentrations in the Chemical Plant area occur in the upper part of the unweathered zone beneath and adjacent to the former raffinate pits. The persistence of elevated uranium is attributed to the lower hydraulic conductivity of the unweathered unit, resulting in less flushing than the shallower more permeable zones.

Within the underlying unweathered unit, uranium concentrations are highest in the upper portion of the unit with monitoring locations (monitoring wells MW-3040 and MW-4040, Figure 1) installed in 2004 to vertically delineate uranium remaining from past infiltration and migration of raffinate pit waters. Since 2007, both monitoring wells MW-3040 and MW-4040 have remained relatively stable with uranium concentrations near 125 picocuries per liter (pCi/L) and 320 pCi/L, respectively.

Deep monitoring well MW-4042 (Figure 1, nested location with monitoring well MW-4040), installed in 2007, is screened deeper into the unweathered unit where uranium concentrations have remained consistently below 0.3 pCi/L since 2011. Uranium in monitoring well MW-4042 was initially slightly elevated (2 pCi/L) following installation as it was drilled through the shallower elevated uranium zone but reached (semi) equilibrium with the surrounding aquifer in a few years. This indicates that uranium has not migrated into this deeper area of the unweathered zone at this location.

2.0 Data Quality Objectives

DQOs were generally developed in accordance with U.S. Environmental Protection Agency (EPA) guidance (EPA 2006). This DQO process is intended to identify any data gaps and provide a systematic planning tool for developing scientifically sound and cost-effective data collection plans to meet the project's objectives. Implementation of the DQO process for this work plan generally follows seven major planning steps recommended by EPA:

[1] State the problem.

  [a] Define the problem that necessitates the study.

[2] Identify the study objectives.

  [a] Identify the key questions and study objectives along with identifying alternative actions or outcomes.

[3] Identify information inputs.

  [a] Identify the types and sources of information needed to address study questions and objectives.

[4] Define the study boundaries.

  [a] Identify the spatial boundaries and temporal limits of the study.

[5] Develop the analytic approach.

  [a] Identify parameters of interest and develop the logic for inference.

[6] Specify performance and acceptance criteria.

  [a] Develop performance criteria for new data being collected.

[7] Plan for obtaining data.

  [a] Define the plan that meets performance criteria for obtaining the required data.

2.1 Step 1: State the Problem

The presence of uranium in the upper part of the unweathered unit within and in the area adjacent to the former raffinate pits necessitates that the vertical extent of contamination be more thoroughly delineated. An enhanced well network that more comprehensively monitors for potential downward migration is being proposed.

The final remedy for the Groundwater Operable Unit (GWOU) is MNA with institutional controls (ICs). In February 2004, EPA approved a remedy of MNA with ICs to limit groundwater use during the period of remediation (DOE 2004). MNA relies on natural processes to reduce contaminant concentrations over time. The GWOU Record of Decision establishes remedial goals and performance standards for MNA. In 2004, wells screened in the upper portion of the unweathered unit, monitoring wells MW-3040 and MW-4040, were installed to delineate the vertical extent of uranium in the Raffinate Pits area. Uranium concentrations have consistently been near or above the 100 pCi/L trigger value in monitoring well MW-3040 and 3-fold higher in monitoring well MW-4040, west of former Raffinate Pit No. 4. Farther west of Raffinate Pit No. 4, uranium concentrations vary seasonally in weathered unit monitoring well MW-4036 in response to changing vertical hydraulic gradients indicated by the hydraulic head data from unweathered unit monitoring well MW-4043. Deep monitoring well MW-4042 was installed adjacent to the highest uranium concentration monitoring well MW-4040 in 2007, delineating the vertical extent of contamination west of Raffinate Pit No. 4. Vertical downgradient monitoring near and beneath the former Raffinate Pits area is recommended, which has led to the following problem statement:

> Elevated uranium concentrations in the upper portion of the unweathered bedrock groundwater in and adjacent to the former Raffinate Pits area, confirmed by the data collected from monitoring wells MW-3040 and MW-4040, have increased concern about the long-term protectiveness of the MNA remedy and hydraulic communication between the weathered and underlying unweathered bedrock in the area. Thus, uranium contamination in the unweathered bedrock requires additional characterization.

2.2 Step 2: Identify the Study Objectives

The following study objectives and associated study questions were developed to identify data gaps.

- **Objective 1 (O1):** Define the vertical and lateral extent of uranium contamination in the unweathered unit.
  - How adequate is the uranium contamination extent represented in the current conceptual site model and groundwater monitoring network?
  - How do uranium concentrations vary seasonally among the weathered, upper unweathered, and deep unweathered units?
- **Objective 2 (O2):** Evaluate potential groundwater migration pathways in the deep unweathered unit.
  - What is the degree of vertical and lateral fracture systems and bedding planes that may control uranium migration?
  - What is the variability of vertical and horizontal hydraulic gradients among the weathered, upper unweathered, and deep unweathered units?
  - What are the attenuation controls on uranium transport?
  - Are the pathways and transport controls understood well enough and the data adequate to support the technical impracticability waiver for the unweathered unit in the Raffinate Pits area?
  - Can the uranium fixed trigger level for monitoring Objective 2[2] well locations be revised to provide a benefit for evaluating MNA performance?

2.3 Step 3: Identify Information Inputs

The following information inputs were identified to meet each study objective.

- **O1 Information Inputs:** Define the vertical and lateral extent of uranium contamination in the unweathered unit.
  - Data in the existing NLN recommendation document (DOE 2023b) and recent groundwater and contaminant characterization studies, including *High-Purge Volume Sample Testing Results for the Weldon Spring, Missouri, Site* (DOE 2023a), *Uranium Analysis of Rock Core Samples from the Weldon Spring, Missouri, Site* (DOE 2024a), and *Borehole Dilution Testing Results for the Weldon Spring, Missouri, Site* (DOE 2025a), provide information on uranium extent and migration properties.
  - Groundwater monitoring data from the three newly installed wells.
  - The monitoring well MW-4043 pad currently accommodates two existing wells: monitoring well MW-4036 (weathered unit) and monitoring well MW-4043 (upper portion of the unweathered unit). The pad is located west of Raffinate Pit No. 4, within the western paleochannel.

[2] Note that the GWOU designates wells as Objectives 1 through 5. This is not related to the DQO Objective 1 and Objective 2.

- The monitoring well MW-3030 pad accommodates one existing well: monitoring well MW-3030 (weathered unit). The pad is in the areal footprint of Raffinate Pit No. 4.
- The monitoring well MW-3040 pad accommodates three existing wells: monitoring wells MW-3040 (upper unweathered unit), MW-3024[3] (upper unweathered unit), and MW-3025 (shallow weathered unit). The pad lies just outside the eastern boundary of former Raffinate Pit No. 3.

- **O2 Information Inputs:** Evaluate potential groundwater migration pathways in the deep unweathered aquifer.
  - Use transmissivity data obtained using the Flexible Liner Underground Technology (FLUTe) method to identify high hydraulic conductivity and high electrical conductivity preferential flow paths in the fracture system and bedding planes in the potential screen interval range.
  - Use geophysical methods such as gamma ray, resistivity, temperature, or interval flow testing to support the selection of final screen elevations by identifying high hydraulic conductivity zones.
  - Collect and sample secondary mineral precipitates along fracture and bedding planes from the well core to evaluate uranium attenuation mechanisms.
  - Monitor water elevations in existing and newly installed wells to evaluate hydraulic gradients and potential communication and update to Objective 2 trigger values.

2.4 Step 4: Define Study Boundaries

The horizontal spatial boundaries of the study are generally identical for each DQO, constrained by proposed well installations that are collocated with existing monitoring well pads. The western boundary will be constrained by monitoring well pad MW-4036/MW-4043 and along the eastern boundary by monitoring well pad MW-3040. This west-to-east axis from these two locations extends approximately 1500 ft. The groundwater divide in the unweathered unit bisects Raffinate Pit No. 3 between these boundary locations (Figure 1). The groundwater divide is farther south near the southern site boundary in the shallower weathered unit (Figure 2). The southern and northern boundaries are generally constrained by elevated uranium concentrations reported at the above mentioned monitoring wells as defined in the 2023 Site Annual Report (DOE 2024b).

The vertical extent ranges from average baseline water table elevation, approximately 20 and 50 ft bgs at the western and eastern horizontal boundaries, respectively, to a depth of approximately 115 ft bgs and 165 ft bgs at the western and eastern horizontal boundaries, respectively. The bottom vertical extent is defined by the estimated total depth of the potential screen range of proposed well installations. The precise vertical extent is ultimately dependent on the bottom elevated screen depth at newly installed wells. The transition from the weathered to the unweathered unit is from 20–40 ft bgs within the spatial study boundary.

[3] In 2004, monitoring well MW-3040 was drilled adjacent to monitoring well MW-3024 due to concerns about its integrity. Monitoring well MW-3040 is screened across the bottom 10 ft of the 20 ft zone that monitoring well MW-3024 was originally screened across and has exhibited concentrations similar to those of monitoring well MW-3024. Monitoring well MW-3024 was repaired and reconfigured in 1996 to be screened across the lower 10 ft of its original screened interval.

Material from drill cuttings and cored intervals will be geologically logged along the entire depth profile of the respective borehole. Sampling will target intervals with a relatively high quantity of fractures and secondary mineralization within the weathered and unweathered units, and the transition zone between the two units.

Groundwater monitoring and data evaluation of newly installed wells will be included into the LTS&M groundwater sampling program as part of the Chemical Plant monitoring well network as outlined in the *Long-Term Surveillance and Maintenance Plan for the U.S. Department of Energy Weldon Spring, Missouri, Site* (DOE 2025b). Each well in the LTS&M network at the Chemical Plant is assigned an objective specific to the MNA monitoring strategy. The proposed wells will be initially designated as Objective 4 wells (monitor for vertical extent and migration). The Objective for each well will be verified and updated as necessary as part of the five-year review process.

2.5 Step 5: Develop Analytical Approach

This step of the DQO process includes defining the parameters of interest, determining appropriate parameter estimation methods, and developing decision rules (DRs). The EPA document *Guidance on Systemic Planning Using the Data Quality Objectives Process* (EPA 2006) distinguishes between hypothesis testing and estimation approaches. The DQOs for this work plan primarily utilize estimation approaches rather than formal hypothesis testing. The following parameters of interest were defined for each objective:

- **O1 Parameters:** Define the vertical and lateral extent of uranium contamination in the deep unweathered unit
  - The vertical and horizontal distribution of uranium at proposed well locations (as shown in Figure 1)) will be collectively used with the existing groundwater monitoring network to delineate contamination extent and update the uranium occurrence and transport model for the site
- **O2 Parameters:** Evaluate potential groundwater migration pathways in the deep unweathered aquifer
  - Transmissivity variability in identified zones of fracturing and bedding planes
  - Vertical and horizonal hydraulic gradients between collocated wells and across the groundwater monitoring network by continuous logging (i.e., transducers) and in-person, manual water level measurements
  - Chemical characterization of uranium and other constituents of interest in solid and sorbed forms from fracture systems and bedding planes
  - Temporal dissolved uranium concentrations in newly installed and existing well locations at Objective 2 wells

2.5.1 Step 5: Decision Rules

DRs are developed to determine when and what types of data collection efforts are needed. At decision points, subject matter experts will convene to assess the data and determine the path forward. The following DRs may apply for completion of the work plan objectives:

- **DR1:** Final locations for drilling will be selected based on previously reported uranium concentrations, water levels, and hydraulic gradients related to the spatial and vertical study boundaries. Comparison to relevant trigger values and the 20 pCi/L standard will be employed for delineation efforts. (Task 1, Section 2.7)
- **DR2:** Screen interval range using transmissivity profiling, geophysical testing, and geological logging will be determined. (Tasks 1 and 2, Section 2.7)
- **DR3:** If a greater temporal frequency of hydraulic head data is required during follow-up studies, then pressure transducers will be installed in relevant wells. (Task 3, Section 2.7)
- **DR4:** Existing site hydrogeochemical data will be used in combination with newly acquired data (as part of this study) to reduce uncertainty and update the GWOU conceptual site model. (Task 3, Section 2.7)
- **DR5:** Incorporation of previous site investigations and acquired uranium content from new well installations will provide decision input for uranium contamination delineation. (Task 3, Section 2.7)
- **DR6:** Quantification of solid-phase concentrations of uranium will help decide if a subset of samples require sequential extraction to evaluate the bonding relationship with aquifer solids. (Task 3, Section 2.7)
- **DR7:** Monitoring objective designation at each newly installed well will be evaluated after concentrations stabilize. (Task 4, Section 2.7)
- **DR8:** If warranted, the uranium Objective 2 trigger level will be revised if supported by newly acquired data after concentrations have stabilized. (Task 4, Section 2.7)

2.5.2 Step 5: Analytical Methods

- **O1 Analytical Methods:** Define the vertical and lateral extent of uranium contamination in the deep unweathered unit.
  - Spatial interpolation of dissolved uranium and other geochemical parameters will be the primary means of identifying plume delineation.
- **O2 Analytical Methods:** Evaluate potential groundwater migration pathways in the deep unweathered aquifer.
  - Vendor-provided software and instrumentation will be used for transmissivity data collection derived from the hydrological investigation.
  - Water level monitoring will be used to identify spatial and vertical hydraulic gradients.
  - Elemental analysis and sequential extraction testing will be used to assess geochemical parameters of solid-phase samples. Interpolation of geochemical processes will be completed on all acquired data. Statistical evaluation and geochemical modeling software (e.g., PHREEQC) may be used to assess geochemical controls.
  - Statistical evaluation of uranium concentrations at Objective 2 well locations will be performed.

2.6 Step 6: Specify Performance and Acceptance Criteria

Performance and acceptance criteria are used to determine whether the DQOs have been met. These criteria establish the acceptable range of error for parameter estimates.

- **O1:** Define the vertical and lateral extent of uranium contamination in the deep unweathered unit.
  - Plume delineation estimations, based on newly acquired empirical data from groundwater sampling, will be compared with estimates of past data to confirm adequacy and usability.
  - In general, contracted laboratory procedures will guide the acceptance criteria for data developed for dissolved-phase contaminants. Laboratory quality assurance and quality control manuals develop protocols for acceptance or rejection of results and in some instances provide data that contain a qualifier. Where applicable, these qualifiers will be reviewed, and metadata will be evaluated to determine whether specific data points should be deleted from a dataset.
- **O2:** Evaluate potential groundwater migration pathways in the deep unweathered aquifer.
  - In general, contracted laboratory procedures will guide the acceptance criteria for data developed for solid-phase content. Laboratory quality assurance and quality control manuals develop protocols for acceptance or rejection of results and in some instances provide data that contain a qualifier. Where applicable, these qualifiers will be reviewed, and metadata will be evaluated to determine whether specific data points should be deleted from a dataset.
  - Aquifer tests, such as transmissivity testing, geophysical testing, and others will be performed through established procedures or industry-established methods as provided by the subcontractor. Resulting hydrologic data will be compared with data obtained from prior field investigations. The new data will be analyzed by a qualified hydrogeologist who will ensure that new and existing data are incorporated and interpreted according to standard practice. Anomalous data or spurious results will be reviewed and eliminated, explained, or reduced as appropriate.
  - Newly installed well monitoring objective designation will be evaluated after concentrations have stabilized.

The three new deep wells will be drilled at locations with shallower wells completed in zones with elevated uranium. When drilling through contaminated zones, it is likely that some contamination will be pulled into the deeper zone. This is usually a temporary condition that dissipates in a few years unless a continuous pathway is created. An example is the MW-4040/MW-4042 monitoring well pair (Figure 3). Monitoring well MW-4040 was drilled in 2004 to vertically delineate the uranium extent near Raffinate Pit No. 4. It unexpectedly encountered elevated uranium in the upper part of the unweathered bedrock unit. This led to a deeper monitoring well, MW-4042, being drilled in 2007 near monitoring well MW-4040 to delineate the vertical extent of uranium at this location. Uranium concentrations at monitoring well MW-4042 were slightly elevated from 2007 till 2011 by uranium introduced to the deeper zone during drilling (Figure 3). This cautions that initial elevated uranium concentrations (if observed) in the three new deeper wells may not be indicative of uranium concentrations in that zone but a result of drilling that will dissipate over the next few years. Casing may be used when drilling the new wells to seal off shallow contaminated zones, thereby limiting the possibility of dragging contamination down to deeper zones.

Reevaluation of Objective 2 uranium trigger values will be completed based on newly acquired data to determine if a revised trigger value is warranted for the GWOU MNA remedy performance.

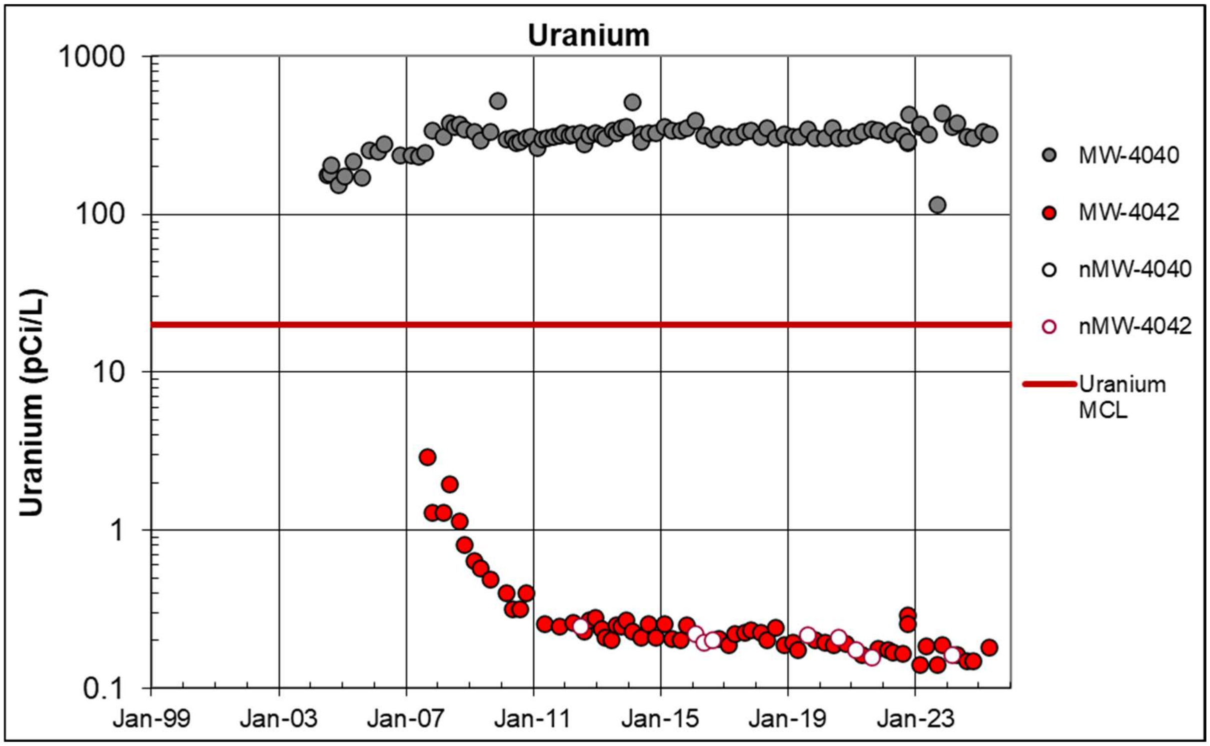


Figure 3. Uranium Time-Concentration Plot at Monitoring Wells MW-4040 and MW-4042

2.7 Step 7: Plan for Obtaining Data

The data collection plan is presented in Section 3.0. The following is a summary of tasks to fulfill the DQOs:

Task 1: Well installation

- Well installation and development (applies to O1 and O2)

Task 2: Discrete activities during field activities

- Transmissivity testing (applies to O2)
- Geophysical testing including gamma ray logging, resistivity logging, temperature logging, or interval flow testing (applies to O2)
- Core sampling (applies to O2)
- Installation of pressure transducers in newly installed wells (applies to O1)

Task 3: Post-field activities

- Transmissivity data processing (applies to O2)
- Dissolved uranium plume delineation (applies to O1)
- Solid-phase and sequential extraction laboratory testing (applies to O2)

Task 4: Groundwater monitoring, well classification, and trigger value designations

- Inclusion of newly installed wells into the groundwater sampling program (applies to O1 and O2)
- Evaluation of newly installed well monitoring objective designations (applies to O2)
- Review of Objective 2 trigger values and the need for revision based on newly acquired data (applies to O2)

3.0 Data Collection

A description of the 2026 drilling campaign and follow-up activities in fulfillment of the DQOs is stated below. The data collection effort to address the DQOs will consist of field activity, analytical testing, groundwater sampling, and data evaluation. Identified individual tasks and DRs are described in the sections below.

3.1 Task 1: Drilling Method

Drilling will consist of using a hollow stem auger in alluvium material, from the surface to the bedrock interface. Once bedrock is encountered, wireline core or air rotary will be used in the weathered and unweathered bedrock for the remaining entirety of the borehole depth. Because these wells will be drilled through shallower contaminated zones, consideration should be given to isolating the contaminated zone by a string of casing before deepening. Drilling will be conducted in accordance with Missouri regulations 10 CSR 23-4, “Monitoring Well Construction Code.” *(Subject to modification based on DR1)*

Conductor casing may be used when drilling the new wells to seal off shallow contaminated zones, thereby limiting the possibility of dragging contamination down to deeper zones.

3.2 Well Locations (Task 1)

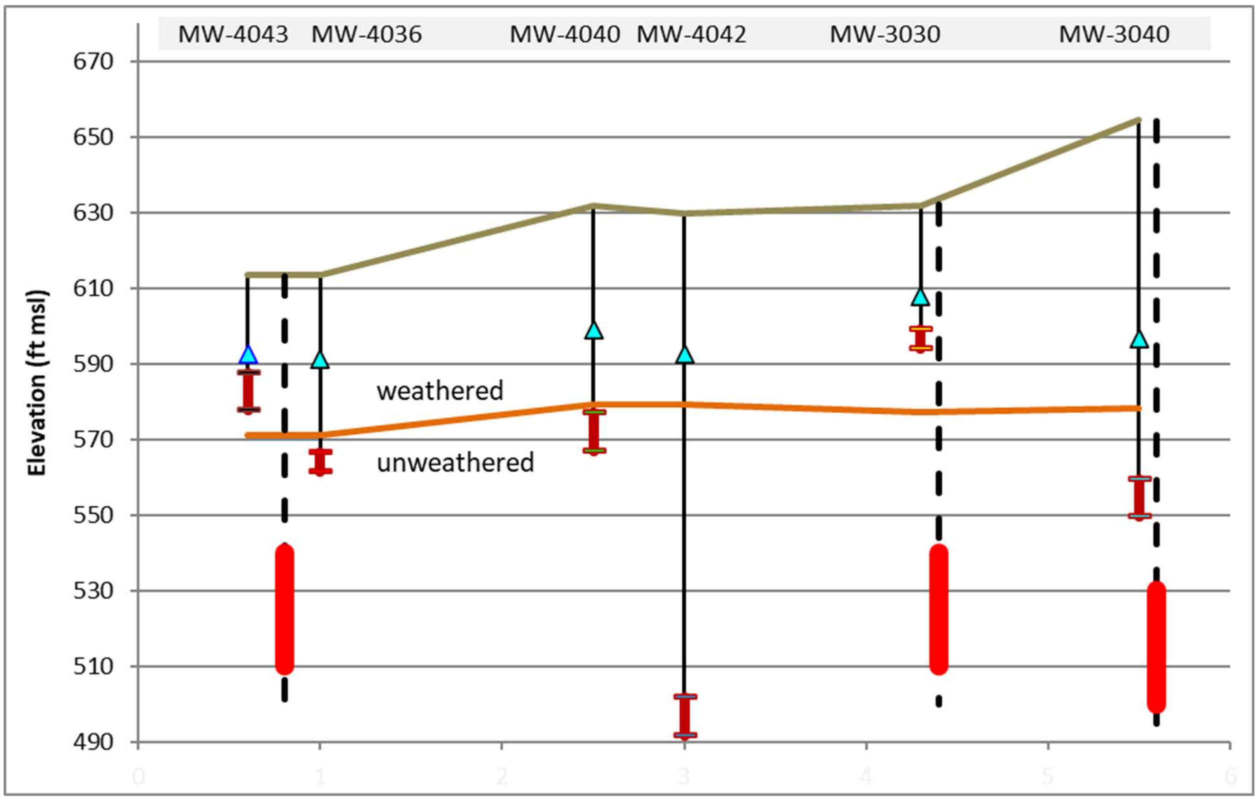
The proposed monitoring well locations are shown in Figure 1. All proposed well locations are on federal, DOE, and U.S. Army property and within the designated institutional controls areas. *(Subject to modification based on DR1)*

3.3 Screen Interval Determination (Task 1)

Screen interval range will be identified by visual inspections of the core by a field geologist for the presence of fractures and bedding planes and by real-time FLUTe transmissivity data (Section 3.4). Screen intervals for respective monitoring wells are anticipated to be 10 ft in length, selected from the screen range shown in Table 1 and Figure 4. *(Subject to modification based on DR1 and DR2)*

Table 1. Approximate Depths and Potential Screen Ranges for Proposed 2026 Monitoring Well Locations

Depths (ft) bgs	Monitoring Well MW-4043 Pad	Monitoring Well MW-3030 Pad	Monitoring Well MW-3040 Pad
Top of bedrock	27	24	34
Intermediate casing	65	82	115
Screen range (select based on fractures)	75–115	90–130	125–165
Total depth of well	115	132	165



Notes: Proposed wells are dashed lines. The potential depth range of 10 foot screen intervals is denoted by bright red vertical lines. Existing wells show screened intervals (dark red) and 2024 average water elevations (blue triangles) along the west to east trending bisect. Areal location of existing and proposed well locations are presented in Figure 1. Horizontal distances are not to scale.

Abbreviation: msl = mean sea level

Figure 4. Cross Section of Proposed Approximate Screen Intervals of Proposed 2026 Monitoring Well Locations

3.4 Transmissivity Testing (Task 2)

The FLUTe transmissivity profile conducted over the prospective screen zone range will identify high density fracture zones to assist in screen interval determination. FLUTe transmissivity profiling allows transmissivity measurements in fractured rock through the emplacement of a watertight, nylon liner that is filled with water to create a constant driving head as the liner is everted down a borehole. Transmissivity estimates are obtained by measuring the descent rate of the liner as it travels down the open borehole. As the liner passes and seals fractures present along the borehole wall, the changes in liner velocity allow for the identification of transmissive fractures (Keller et al. 2014). FLUTe profiling will be performed by a third-party contractor. *(Subject to modification based on DR2)*

3.5 Geophysical Testing (Task 2)

Where competent to remain open following drilling, geophysical logging will be utilized in these new boreholes to create logs of geophysical parameters to identify transmissive features and zones. The borehole geophysical methods will be used at the time of drilling to select well screen depths which will also depend upon the degree of saturated conditions within the borehole following drilling.

Additionally, heat pulse flow meter logging may be performed during the geophysics acquisition and can be a helpful tool for measuring vertical flow profiles and identifying transmissive fractures that could be acting as conduits for groundwater flow pathways. A heat pulse flow meter survey could be used alongside the FLUTe transmissivity profile to help provide a more robust interpretation of flow pathways. All geophysical work will be performed by a third-party contractor. *(Subject to modification based on DR2)*

3.6 Transducer Probe Installation (Task 2)

Transducers may be installed to record water-level variations and temperature at all newly installed monitoring locations. If installed, transducer downloads and specific conductance field measurements will be collected semiannually during routine sampling events. Sampling may be quarterly for the first year after installation. Data will be used to evaluate flow direction and gradient changes throughout the year. *(Subject to modification based on DR3 and DR4)*

3.7 Solid-Phase Core Sampling (Task 2)

The drilling process will obtain a continuous core from the ground surface to the bottom of the borehole. The focus during sampling will be on the collection of materials at and below the weathered and unweathered transition zone along fractures and bedding planes. The core will be preferentially selected for sampling from areas with dark precipitate material (iron- or clay-rich) within fractures that are most likely to have sorbed or precipitated uranium. *(Subject to modification based on DR3 and DR4)*

3.8 Sample Logging and Preservation (Task 2)

Core material will be visually logged for geological properties (e.g., lithologic description, degree of fractures, presence of secondary precipitates, texture, and signs of oxidation). All core materials will be archived, labeled accordingly, and dried for potential future laboratory testing. Archived samples will be placed in dedicated wax-lined, waterproof core boxes. At the completion of fieldwork, all core boxes will be transported to the onsite conex box for long-term storage. *(Subject to modification based on DR2)*

3.9 Solid-Phase Testing (Task 3)

Core material from the unweathered zone will be preferentially selected for sampling from areas with dark material within fractures based on visual observations by the field geologist. These dark coatings represent areas of a higher degree of sorbed or precipitated uranium (DOE 2024a). The samples will be shipped and tested at the Environmental Sciences Laboratory (ESL) at the Office of Legacy Management Field Support Center at Grand Junction, Colorado. A list of analytes and analytical methods is presented in Table 2Table 2. *(Subject to modification based on DR6)*

Table 2. Analytical Methods and Constituents for Solid-Phase Core Geochemical Analysis

Analyte	Analytical Method
Iron	EPA SW-846 Method 6010
Manganese	EPA SW-846 Method 6010
Calcium	EPA SW-846 Method 6010
Uranium	EPA SW-846 Method 6020
Sulfate	EPA SW-846 Method 9056
Total organic carbon	EPA SW-846 Method 9060
Total inorganic carbon	EPA SW-846 Method 9060

3.10 Sequential Extraction (Task 3)

A subset of interval samples may undergo sequential extraction testing for the quantification of iron, manganese, and uranium. Testing will be conducted at the ESL in Grand Junction, Colorado. An estimated 10% of intervals will undergo testing but will be dependent on receipt and evaluation of solid-phase results.

Sequential extraction testing will provide information on the stability (or leachability) of the solid mineral fraction of uranium mass along with the sorbed fraction complexed with iron and manganese oxyhydroxide. The relative contribution of uranium in each sample extracted via different solvents indicates how strongly or weakly the mineralized, sorbed, and complexed uranium are bound to the solid matrix and the relative susceptibility for uranium remobilization. The uranium mass shown to be stable or immobile may be deemed to be a lower risk for contamination and transport. Analysis of the core from past drilling activities has shown evidence of uranium attenuation (DOE 2024a). Sequential extractions will be performed using the following progression:

- Deionized water removes any easily dissolved minerals such as evaporites. These are minerals that form as near-surface groundwater evaporates and can include minerals that contain uranium.
- Bicarbonate extraction removes loosely adsorbed uranium, such as that adsorbed onto weak oxyhydroxide sites.
- Five percent nitric acid extraction removes strongly adsorbed uranium. Nitric acid may also dissolve minerals in which uranium can coprecipitate, such as calcite.

- Strong acid digestion (lithium metaborate) dissolves all environmentally available mineralogical species. By design, elements bound in silicate structures are not normally dissolved by this procedure because they are not usually mobile and released in the environment.

(Subject to modification based on DR6)

3.11 Groundwater Monitoring Program Inclusion (Task 4)

Groundwater monitoring and data evaluation of newly developed wells will be included into the LTS&M groundwater sampling program as part of the Chemical Plant monitoring well network, which currently consists of 67 DOE-owned wells. However, long-term data trends and contaminant delineation are not representative until the aquifer stabilizes to (quasi)equilibrium conditions, which may take several years. Under the GWOU monitoring program, total uranium, nitroaromatic compounds, trichloroethene (TCE), and nitrate are monitored at selected locations throughout the Chemical Plant area. The sampling locations target areas of highest impact in the shallow aquifer and migration pathways associated with paleochannels in the Burlington-Keokuk Limestone. Deeper monitoring wells MW-4042 and MW-3006 are sampled to assess potential vertical migration in the Raffinate Pits area. Deeper horizontally downgradient wells are sampled to assess potential vertical migration in areas horizontally downgradient of the impacted areas. A list of the contaminant of concern analytes and analytical methods is presented in Table 3. Additionally, groundwater parameters for water quality characterization purposes will be collected and analyzed. *(Subject to modification based on DR7 and DR8)*

Table 3. Contaminant of Concern List and Analytical Methods

Analyte	Analytical Method
Uranium (total)[1]	EPA SW-846 Method 6020
Nitrate (as nitrogen)[1]	EPA 353.2
TCE[1]	EPA SW-846 Method 8260B
Nitroaromatic compounds[1]	EPA SW-846 Method 8321A
Metals[2]	EPA SW-846 Method 6020
Sulfate	EPA SW-846 Method 9056
Total dissolved iron	EPA SW-846 Method 6010
Oxidation-reduction potential	Field[3]
Ferrous iron	Field[3]
pH	Field[3]
Temperature	Field[3]
Total suspended solids	SM2540-D

Notes:

[1] Denotes constituents of concern (uranium, nitrate as nitrogen, TCE, and nitroaromatic compounds [2,4-dinitrotoluene, 2,6-dinitrotoluene, 2,4,6-trinitrotoluene, 1,3,5-trinitrobenzene, and 1,3-dinitrobenzene, and nitrobenzene]).

[2] Metal species include arsenic, barium, chromium, cobalt, copper, lead, manganese, nickel, selenium, silver, thallium, and zinc.

[3] Field identifies analytes that will be quantified by field methods following procedures as described in the Quality Assurance Project Plan (DOE 2023c).

4.0 Well Installation

All work pertaining to well installation shall be conducted in accordance with all federal, state, tribal, and local agency regulations, DOE requirements, and LMS policies and procedures. Applicable documentation regarding compliance with this plan and all other requirements shall be captured on the applicable forms and retained as records as outlined in the *Long-Term Surveillance and Maintenance Plan for the U.S. Department of Energy Weldon Spring, Missouri, Site* (DOE 2025b).

5.0 References

10 CSR 23-4. "Monitoring Well Construction Code," *Code of State Regulations*.

DOE (U.S. Department of Energy), 2004. *Record of Decision for the Final Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site*, DOE/GJ/79491-936a, Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri, January.

DOE (U.S. Department of Energy), 2005. *Interim Remedial Action Report for the Groundwater Operable Unit of the Weldon Spring Site*, DOE/GJ/79491-952, Office of Legacy Management, March.

DOE (U.S. Department of Energy), 2021. *Weldon Spring Site Sixth Five-Year Review*, LMS/WEL/S31922, Office of Legacy Management, September.

DOE (U.S. Department of Energy), 2023a. *High-Purge Volume Sample Testing Results for the Weldon Spring, Missouri, Site*, LMS/WEL/43593, Office of Legacy Management, August.

DOE (U.S. Department of Energy), 2023b. *LM National Laboratory Network Collaboration Report Weldon Spring, Missouri, Site*, LMS/WEL/S38166, Rev. 1, Office of Legacy Management, August.

DOE (U.S. Department of Energy), 2023c. *Quality Assurance Project Plan, Weldon Spring, Missouri, Site*, LM-PLAN-3-22-2.0-0.0, LMS/WEL/40833-0.0, Office of Legacy Management, January.

DOE (U.S. Department of Energy), 2024a. *Uranium Analysis of Rock Core Samples from the Weldon Spring, Missouri, Site*, LMS/WEL/S45601, Office of Legacy Management, April.

DOE (U.S. Department of Energy), 2024b. *Weldon Spring, Missouri, Site Annual Report for Calendar Year 2023*, LMS/WEL/46308, Office of Legacy Management, July.

DOE (U.S. Department of Energy), 2025a. *Borehole Dilution Testing Results for the Weldon Spring, Missouri, Site*, LMS/WEL/48873, Office of Legacy Management, April.

DOE (U.S. Department of Energy), 2025b. *Long-Term Surveillance and Maintenance Plan for the U.S. Department of Energy Weldon Spring, Missouri, Site*, LMS/WEL/S00790-2.1, Office of Legacy Management, April.

EPA (U.S. Environmental Protection Agency), 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4, Office of Environmental Information, February.

Keller, C.E., J.A. Cherry, and B.L. Parker, 2014. “New Method for Continuous Transmissivity Profiling in Fractured Rock,” *Groundwater* 52(3):352–367.