U.S. Department of Energy
Hanford Site

June 29, 2020

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Addressees:

CENTRAL PLATEAU GROUNDWATER TRACER STUDY SAMPLING AND ANALYSIS PLAN, DOE/RL-2018-42, REVISION 0

This letter transmits the approved Central Plateau Groundwater Tracer Study Sampling and Analysis Plan, DOE/RL-2018-42, Revision 0, to the U.S. Environmental Protection Agency (EPA) and Washington Department of Ecology (Ecology). This Sampling and Analysis Plan defines the requirements for sampling activities, field and laboratory analytical measurements, and quality assurance processes associated with Phase II of the tracer study described in SGW-60511, Central Plateau Groundwater Tracer Study Work Plan.

The U.S. Department of Energy Hanford has worked closely with EPA and Ecology to incorporate comments and revise the document.

If you have any questions, please contact me, or your staff may contact, Jim Hanson, of my staff, on (509) 373-9068.

Sincerely,

Michael W. Cline Digitally signed by Michael W. Cline
Date: 2020.06.29 16:34:43 -07'00'

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DOE/RL-2018-42 Revision 0

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DOE/RL-2018-42
Revision 0

Central Plateau Groundwater Tracer Study Sampling and Analysis Plan

Prepared for the U.S. Department of Energy
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P.O. Box 550
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Approved for Public Release;
Further Dissemination Unlimited

DOE/RL-2018-42
Revision 0

Central Plateau Groundwater Tracer Study Sampling and Analysis Plan

Date Published
June 2018

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

U.S. DEPARTMENT OF ENERGY | Richland Operations Office
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APPROVED
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Terms

ALARA	as low as reasonably achievable
B Complex	B Tank Farm Complex
BTR	Buyer's Technical Representative
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M HILL Plateau Remediation Company
DOE-RL	U.S. Department of Energy, Richland Operations Office
DOT	U.S. Department of Transportation
DQI	data quality indicator
DQO	data quality objective
DUA	data usability assessment
DUP	field duplicate
EB	equipment blank
ECO	Environmental Compliance Officer
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	field standard
FSO	Field Sample Operations
FWS	Field Work Supervisor
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document*
HSU	hydrostratigraphic unit
MDL	method detection limit
nm	nanometers
OU	operable unit
PNNL	Pacific Northwest National Laboratory
P&T	pump and treat
PQL	practical quantitation limit
QA	quality assurance
QAPjP	Quality Assurance Project Plan

QC	quality control
RPD	relative percent difference
SAP	sampling and analysis plan
SGRP	Soil and Groundwater Remediation Project
SMR	Sample Management and Reporting
SwRI	Southwest Research Institute
TB	trip blank
TIW	tracer injection well
TOW	tracer observation well
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*

1 Introduction

The U.S. Department of Energy, Richland Operations Office (DOE-RL) has directed CH2M HILL Plateau Remediation Company (CHPRC) to perform a groundwater tracer study to assess aquifer characteristics and groundwater flow behavior under pump and treat (P&T) stress conditions at selected locations in the Hanford Site Central Plateau. Chemical tracers will be used to measure groundwater velocity and flow direction. This sampling and analysis plan (SAP) defines the requirements for sampling activities, field and laboratory analytical measurements, and quality assurance (QA) processes associated with Phase II of the tracer study described in SGW-60511, *Central Plateau Groundwater Tracer Study Work Plan*. Additionally, this SAP addresses several tactical aspects of groundwater tracing, including tracer selection, methods for tracer emplacement, and a sampling and analysis strategy for tracking tracer migration with existing downgradient wells.

The Phase II tracer injection field study will assess current aquifer conditions (e.g., flow direction and velocity) influenced by groundwater extraction at two locations: (1) 200-BP-5 Operable Unit (OU) groundwater removal action, in the vicinity of the B Tank Farm Complex (B Complex) in the 200 East Area; and (2) 200-UP-1 OU, in the vicinity of the operating groundwater interim remedial action at U Plant. The 200-BP-5 groundwater OU removal action involves P&T to capture and remove high-concentration uranium and technetium-99 plume areas, and the 200-UP-1 remedial action involves P&T to capture and remove uranium.

In some areas of the Central Plateau (e.g., the 200-BP-5 OU in the northern portion of the 200 East Area), the observed groundwater gradient is nearly flat due to highly transmissive sediments, and flow direction and velocity are difficult to define. In other areas, operation of groundwater extraction and injection wells creates variable local flow gradients that are not consistent with regional conditions under natural gradient. Groundwater tracer studies can provide empirical observation data that can be used to assess the representativeness of groundwater flow simulations.

1.1 Project Scope and Objective

The objective of this study is to collect information that will define groundwater flow direction and velocity at select locations in the Central Plateau. Empirical estimation of these parameters will facilitate refinement of the groundwater movement conceptual model that is based on observed groundwater flow velocity. Groundwater flow will be characterized by releasing known quantities of a chemical tracer into the aquifer at selected tracer injection wells (TIWs) and later observing the arrival and relative concentration of the tracer at one or more downgradient tracer observation wells (TOWs). At both test locations, an extraction well will serve as a TOW. The tracer study data will be used in conjunction with other site data and professional judgment to confirm the anticipated performance of planned removal and remedial actions and to improve agreement between the groundwater contamination conceptual model and numerical models used to estimate subsurface flow and transport. Two locations are included in the Phase II study: Phase IIa will be conducted at the B Complex where groundwater removal action is occurring, and Phase IIb will be conducted at the operating groundwater uranium remedial action in the 200-UP-1 OU in the vicinity of U Plant, downgradient of the 216-U-1 and 216-U-2 Cribs.

Phase II activities include placing doses of two tracers in selected TIWs upgradient of operating P&T extraction wells. A sufficient amount of the tracers will be injected to ensure that the tracers will be quantifiable at the TOWs based on the anticipated groundwater velocity, tracer dispersion, and flow direction. Monitoring activities at existing TOWs will include water-level measurements, continual tracer sensing by in situ probes, and periodic collection and analysis of samples to quantify tracer concentrations in groundwater. The selected TOWs are located at various distances from the TIWs to assess the time of

arrival and tracer concentrations. Tracer arrival measurements will begin before the expected arrival and will continue until after a clearly defined concentration peak is observed at each downgradient TOW. It is anticipated that the tracer will arrive at the extraction well(s) within 2 to 6 months of tracer injection. Post-injection monitoring will commence well in advance of the anticipated arrival time.

The first location selected for field tracer testing will be the B Complex removal action area (Figure 1-1). Two tracers will be utilized in this region to help ensure successful detection at downgradient TOWs. The first tracer will be injected into well 299-E33-341. Well 299-E33-360, which is approximately 340 m (1,115 ft) to the southeast, will be used as an extraction and observation well. The unconfined aquifer in the vicinity of the B Complex consists of Cold Creek gravels and exhibits very high hydraulic conductivity and a small hydraulic gradient. Groundwater movement toward the extraction well is anticipated to be relatively rapid under the induced gradient; estimated travel time is approximately 5 months. After the first tracer is believed to have had adequate time to be captured by the extraction well (e.g., approximately 7 months following the first tracer injection), a second tracer will be injected into well 299-E33-44. This well is closer to the extraction well (approximately 109 m to the northwest) than 299-E33-341, and therefore, the second tracer is more likely to be captured and detected at the extraction well. The estimated time for the second tracer to reach the extraction well is 1.7 months.

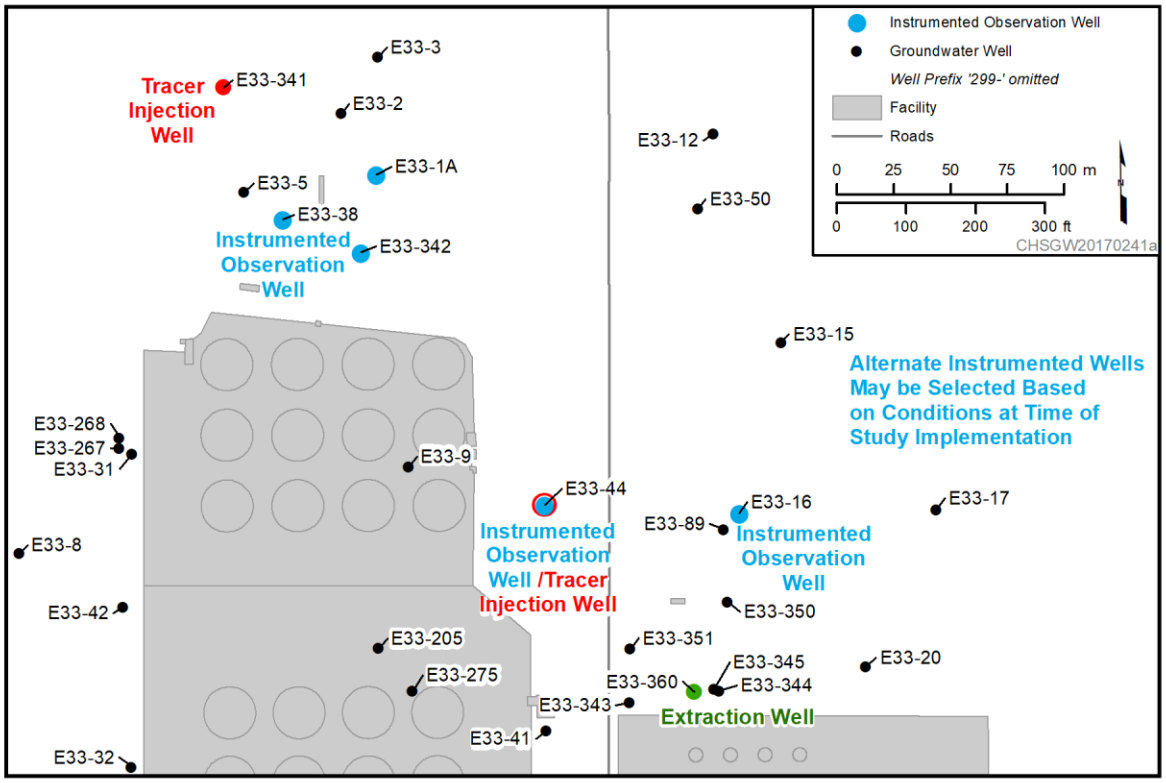


Figure 1-1. Location of Injection, Extraction, and Observation Wells in the B Complex Removal Action Area

The second tracer study location is near the extraction wells of the 200-UP-1 groundwater OU uranium plume remedial action (Figure 1-2). This action currently uses three groundwater extraction wells in the vicinity of U Plant in the 200 West Area. Anticipated travel times between most wells in this area are >1 year based on the aquifer transmissivity and observed hydraulic gradient. Therefore, the selected study wells include a TIW (299-W19-36) near one of the extraction wells (299-W19-113), which will serve as the primary TOW. Another well, 299-W19-34A, is located between the injection and extraction wells and may also be used as a TOW. All three wells are completed within the upper portion of the shallow unconfined aquifer. A single injection of one tracer will be made at well 299-W19-36. This well is roughly 55 m (180.4 ft) upgradient of extraction well 299-W19-113, and the estimated transit time between the two wells is 6 months.

The arrival of the tracers will be monitored at existing wells along the estimated flow paths between the TIW wells and the extraction well. The monitoring approach includes deploying quantitative, in situ sensors in observation wells to detect the tracer using high-frequency, real-time measurements and periodic confirmatory sampling and quantitative laboratory analysis of the tracer in groundwater samples collected from the observation and extraction wells. Groundwater velocity will be determined based on the arrival time of the tracer and the known distances between the injection well and each observation well. Different arrival estimates may be used (e.g., initial arrival, time corresponding to 50% maximum concentration, and the time of maximum concentration).

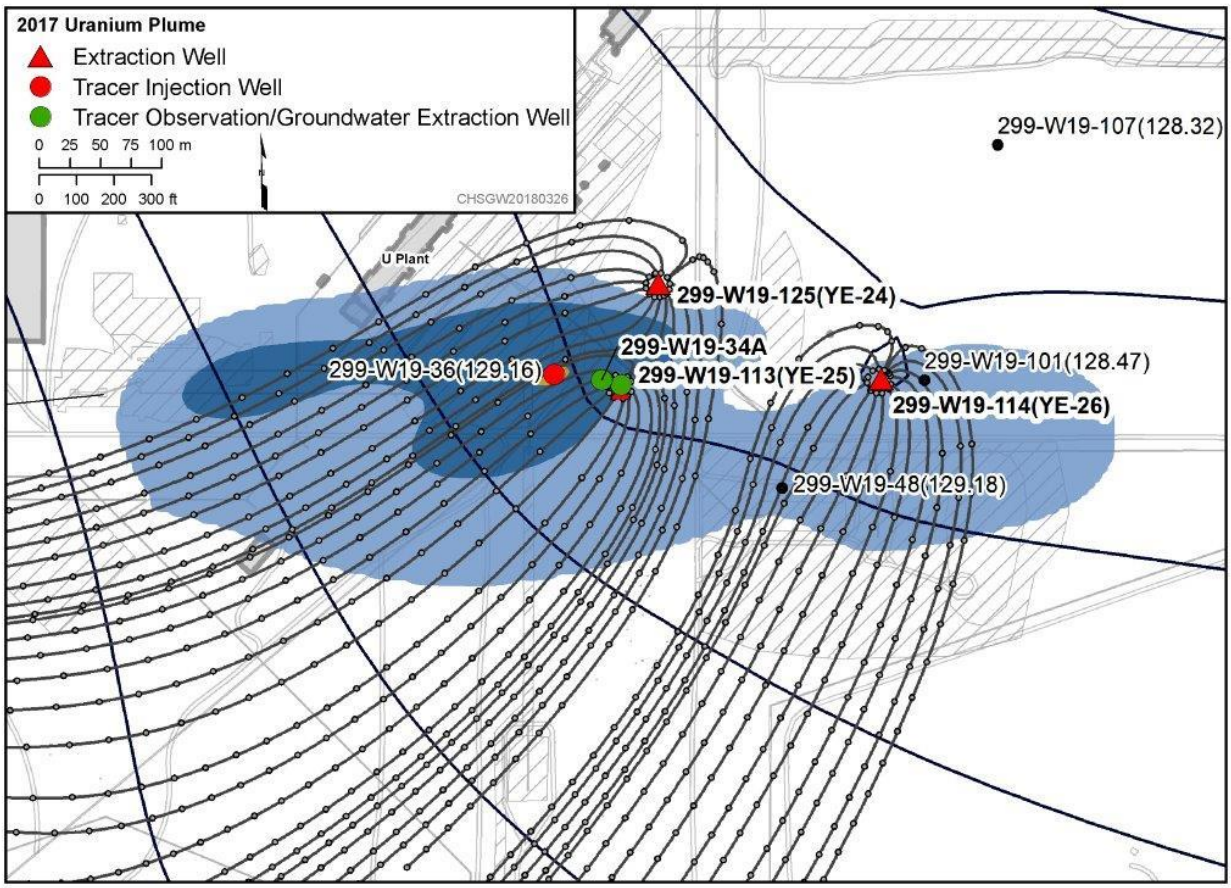


Figure 1-2. Location of Injection, Extraction, and Observation Wells in the 200-UP-1 OU and Simulated Flow Direction/Particle Tracks

1.2 Background

This section discusses hydrogeology and groundwater flow. The hydrogeology and groundwater flow described in this SAP is focused on (1) the northern portion of the 200 East Area underlying the 200-BP-5 OU and (2) the portion of 200 West Area underlying the U Plant vicinity in the 200-UP-1 OU. Additional information is provided extending into the area just south of Gable Mountain and Gable Butte.

1.2.1 Site Hydrogeology: 200-BP-5

The general hydrogeology of the 200-BP-5 OU consists of a suprabasalt sediment framework with three stratigraphic sequences: the Ringold Formation, Cold Creek unit, and Hanford formation. The positions of these sequences relative to overall Hanford sitewide geology can be seen in Figure 1-3.

The uppermost basalt member of the Saddle Mountains Basalt in the 200-BP-5 OU is generally the Elephant Mountain Member. This member defines the base of the unconfined aquifer in the OU, with the exception of the Gable Gap, located approximately 2 km (1.2 mi) north of the B Complex. In the Gable Gap area, portions of the Elephant Mountain, Pomona, Esquatzel, and Asotin members of the Saddle Mountains Basalt were removed by erosion, exposing, and interconnecting the lower permeability Rattlesnake Ridge and Selah interbed aquifers to the unconfined aquifer. Figures A-2 and A-4 of PNNL-19702, *Hydrogeologic Model for the Gable Gap Area, Hanford Site*, provide cross sections of this area.

Locally, beneath the B Complex, the stratigraphic sequence above the basalt consists of the unconsolidated Cold Creek unit sediments overlain by the high-energy glacial fluvial sediments of the Hanford formation (Figures 1-3 and 1-4). The B Complex unconfined aquifer exhibits little lateral heterogeneity and consists of high-conductivity Cold Creek gravels (Figure 1-4). These gravels exhibit extremely high hydraulic conductivity (e.g., >1,000 m/d), resulting in a nearly flat hydraulic gradient across the study area (e.g., about 1E-05 m/m).The very flat water table gradient in the 200 East Area results in high levels of uncertainty associated with the groundwater flow velocity and direction (SGW--54165, *Evaluation of the Unconfined Aquifer Hydraulic Gradient Beneath the 200 East Area, Hanford Site*). High-resolution pressure transducers have been used at select monitoring wells to provide data of adequate quality and quantity to correct for the barometric changes. In addition, those wells were corrected for deviation from vertical using gyroscopic survey measurements. Even with these efforts, hydraulic gradient estimations frequently remain inconclusive over short distances (i.e., across the B Complex). Thus, flow directions are generally vetted based on plume movement. More recently, regional-derived gradients are used to infer local water table gradient conditions (Figure 1-5).

Depth to water beneath B Complex averages about 77.6 m (255 ft) below ground surface and the average water table elevation is about 121.7 m. The period for water level measurements from which the average depth to water and water table elevation were calculated spans from January 2016 to February 2019. These estimates were made using information from the wells displayed on the map in Figure 1-1. Aquifer thickness averages about 3 m (9.8 ft) beneath the B Complex and the groundwater flow rate is estimated to be between 0.26 and 0.28 m/d to the southeast (DOE/RL-2018-65, *Hanford Site RCRA Groundwater Monitoring Report for 2018*).

Groundwater at the B Complex exhibited a flow direction reversal in 2011, based on groundwater contaminant plume migration and calculations derived from water-level data from the low-gradient network (SGW-54165). Where groundwater flow had previously been toward the north-northwest, after 2011, the flow direction assumed the conditions illustrated in Figure 1-5. Further discussion and recent interpretation of the hydrogeology in the 200 East Area is provided in the 200-BP section of DOE/RL-2016-67, *Hanford Site Groundwater Monitoring Report for 2016*.

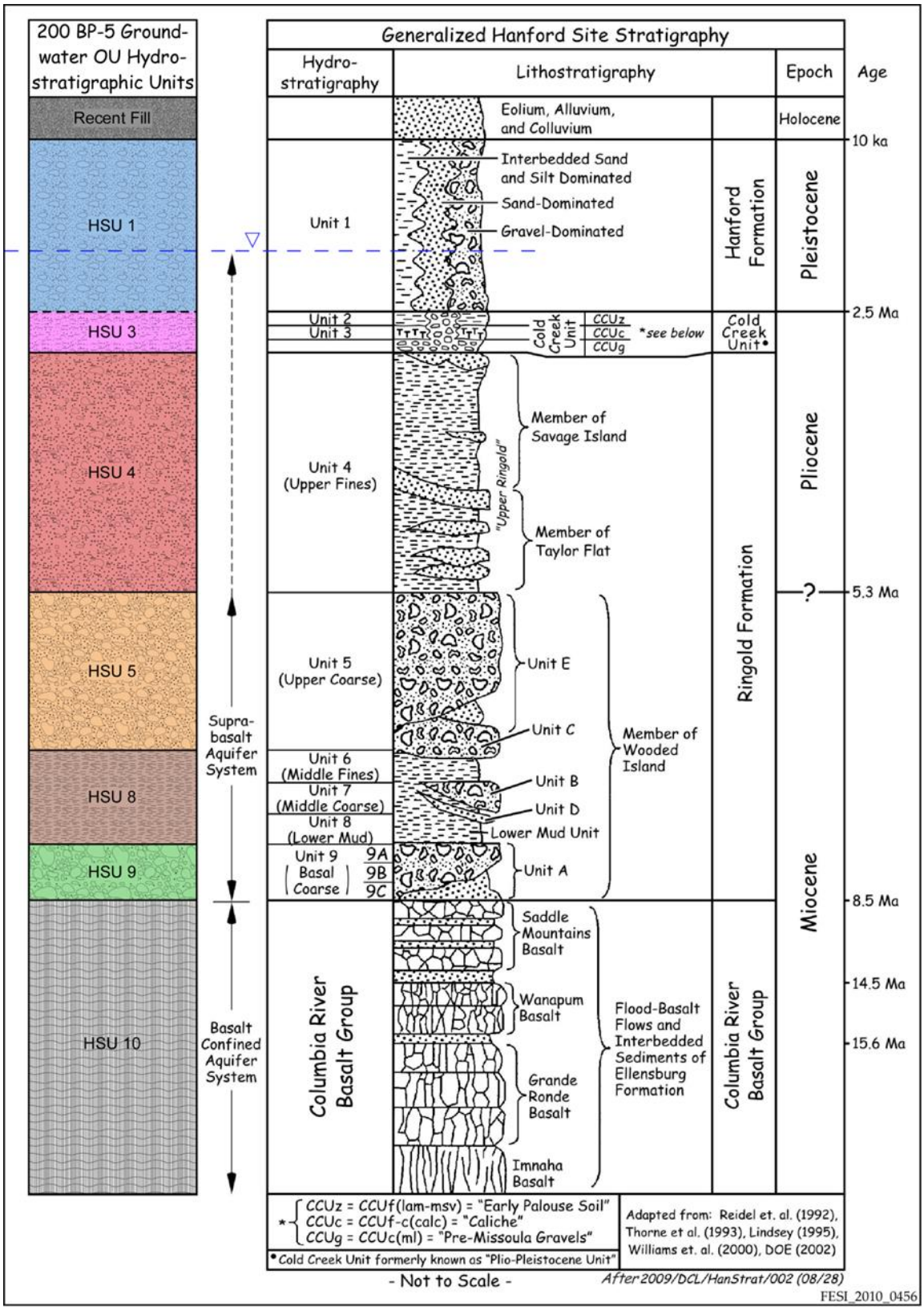
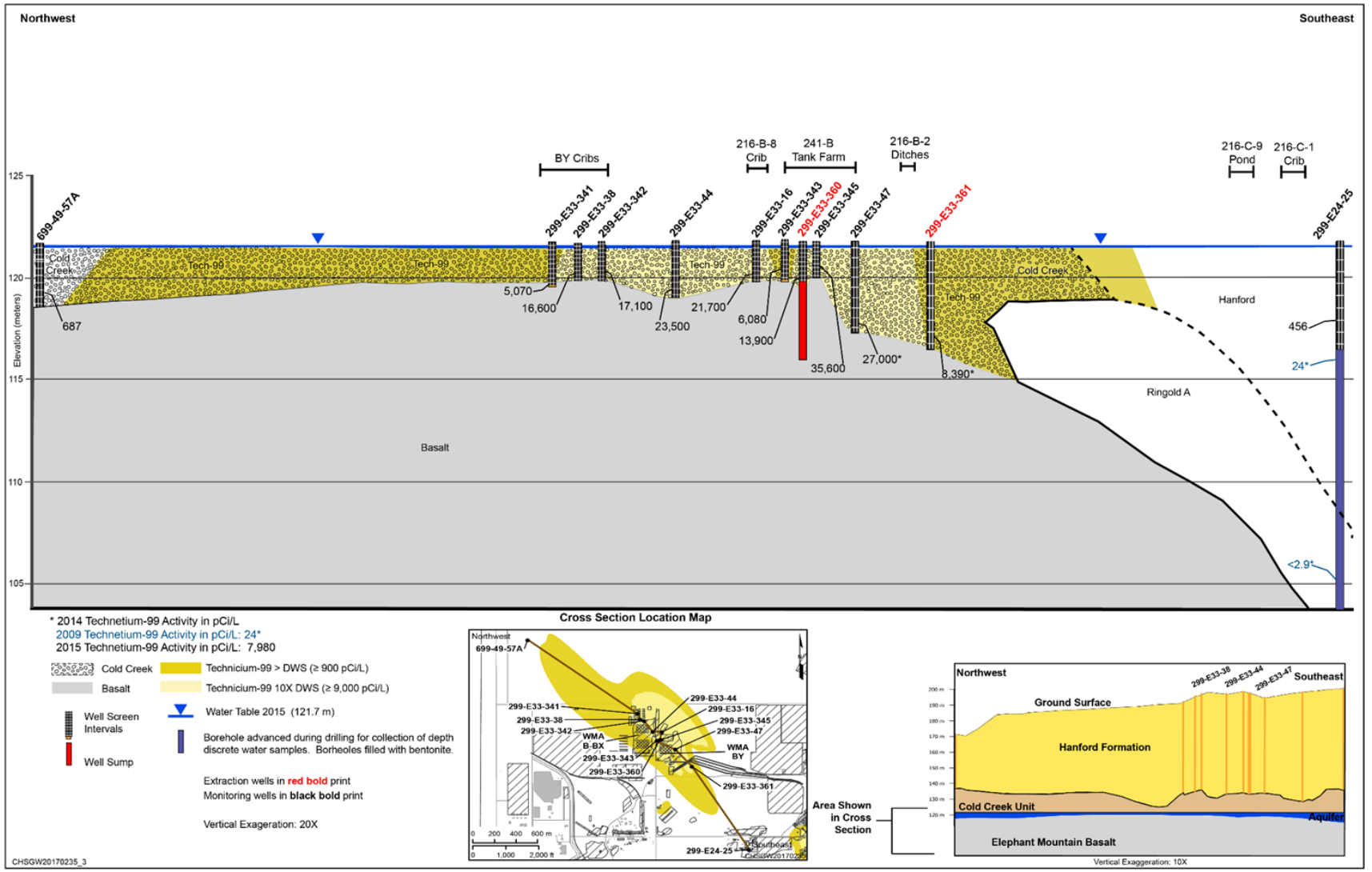


Figure 1-3. Generalized Stratigraphy of the Hanford Site



Source: DOE/RL-2017-11, *Removal Action Work Plan for the 200-BP-5 Operable Unit Groundwater Extraction*.

Figure 1-4. Northwest to Southeast Hydrogeologic Cross Section through the B Complex Area of the 200-BP-5 Groundwater OU

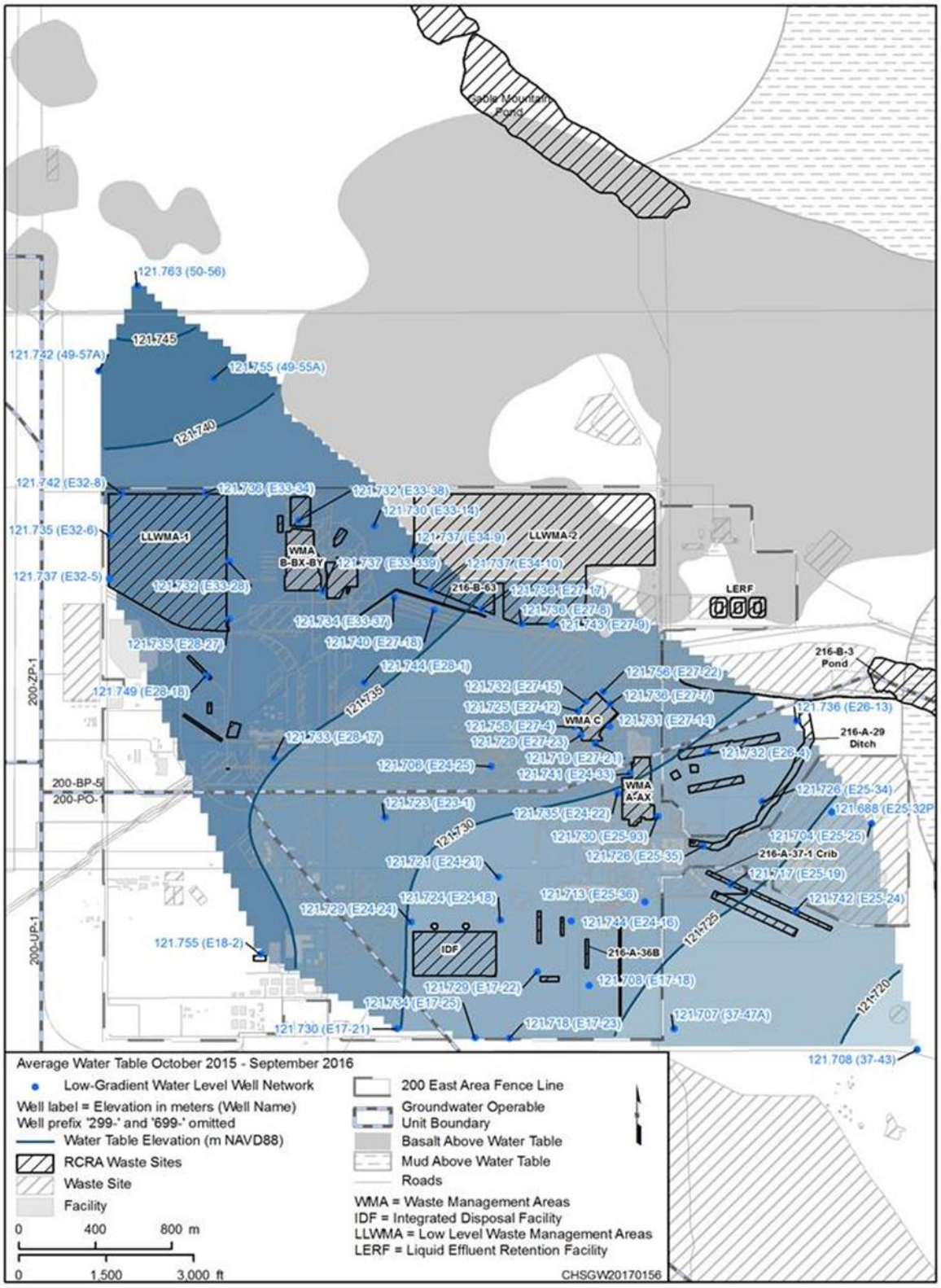


Figure 1-5. Inferred Groundwater Elevation in the 200 East Area, 2016

A treatability test to assess the aquifers ability to sustain a P&T system beneath the B Complex was completed in 2015 and reported in DOE/RL-2015-75, *Aquifer Treatability Test Report for the 200--BP--5 Groundwater Operable Unit*. The report concluded that extraction rates > than 586 L/min (150 gal/min) can be sustained in the unconfined aquifer at the B Complex. The hydraulic conductivity was determined to be 1.88 E+04 m/day. A maximum drawdown of 10.4 cm (4.09 in.) was observed in the extraction well while pumping at 568 L/min (150 gpm). Drawdown in observation wells was typically measured in millimeters, but was discernible as far as 134 m (440 ft) northeast of the pumping well. After pumping ended, well recovery was quick (< than 24 hours). The aquifer is expected to accommodate the injection of a dye solution with minimal impacts to the water table.

1.2.2 Site Hydrogeology: 200-UP-1

The 200-UP-1 OU underlies the southern portion of the 200 West Area, which is on the western side of the Central Plateau. Surface elevations above the OU range from approximately 183 m (600 ft) to >213 m (700 ft) above mean sea level. Basalt of the Columbia River Basalt Group and a sequence of overlying sediments comprise the geology of the 200-UP-1 OU. The overlying sediments are approximately 169 m (555 ft) thick and primarily consist of the Ringold Formation and the Hanford formation, which are composed primarily of sand and gravel, with some silt layers. Sedimentary layers are generally laterally continuous across the study area in the vicinity of U Plant, a former radioactive waste reprocessing facility. Sediments in the vadose zone are the Ringold Formation (the uppermost Ringold unit E and the upper Ringold unit), Cold Creek unit, and Hanford formation. The following geologic units are above the basalt bedrock, in descending sequence:

- Unconsolidated sand and gravel of the Hanford formation (hydrostratigraphic unit [HSU] 1)
- Fine- to coarse-grained sediment of the Cold Creek unit (HSU 3)
- Semiconsolidated silt, sand, and gravel of the Ringold Formation unit 5 (HSU 5)
- Silt and clay of the Ringold Formation lower mud unit 8 (HSU 8)
- Semiconsolidated silt, sand, and gravel of the Ringold Formation unit 9 (HSU 9)

Groundwater in the study area is found in an unconfined aquifer within the Ringold Formation unit E and also in a confined unit within the underlying Ringold Formation unit A; these two units are separated by the fine-textured Ringold Formation lower mud unit (Figure 1-6). The aquifer of interest for this study is the uppermost unconfined aquifer unit.

Depth to water near U Plant averages about 85.4 m (280 ft) below ground surface and the average water table elevation is about 129.0 m. The period for water level measurements from which the average depth to water and water table elevation were calculated spans from January 2016 to February 2019 (Figure 1-7). These estimates were made using information from the wells displayed on the map in Figure 1-2. Aquifer thickness is about 60 m (197 ft) (Figure 1-6) and the groundwater flow rate is about 0.31 m/d to the southeast (DOE/RL-2018-65, *Hanford Site RCRA Groundwater Monitoring Report for 2018*).

Groundwater contamination by uranium apparently originating from historical releases to the 216-U-1 and 216-U-2 Cribs within the study area is the subject of a current P&T remedial action. This system has operated long enough to establish apparent local groundwater capture areas. Figure 1-2 shows simulated groundwater particle tracks illustrating the apparent flow directions within the capture area of the three operating groundwater extraction wells.

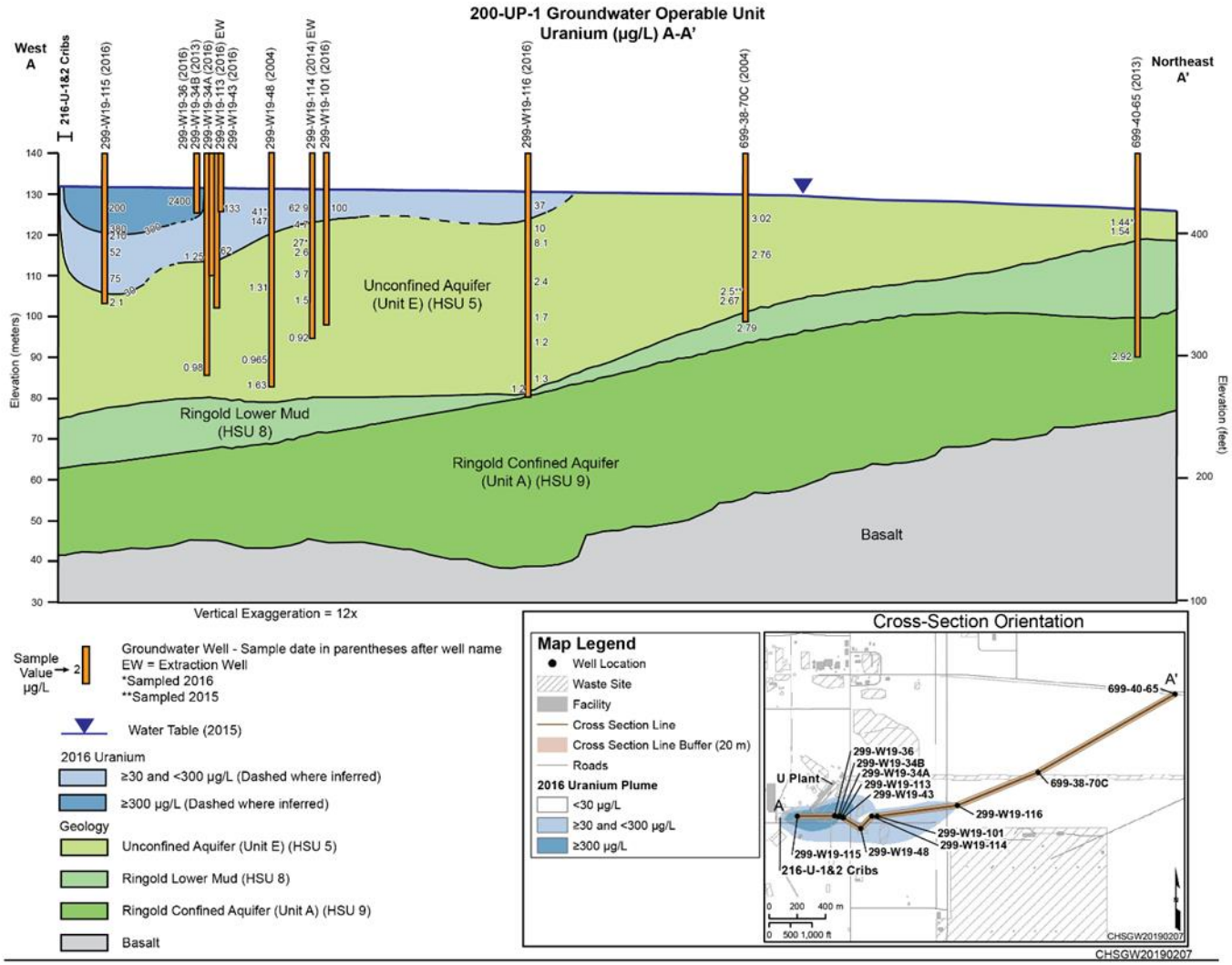


Figure 1-6. Hydrogeologic Cross Section through the U Plant Area of the 200-UP-1 Groundwater OU from West to East

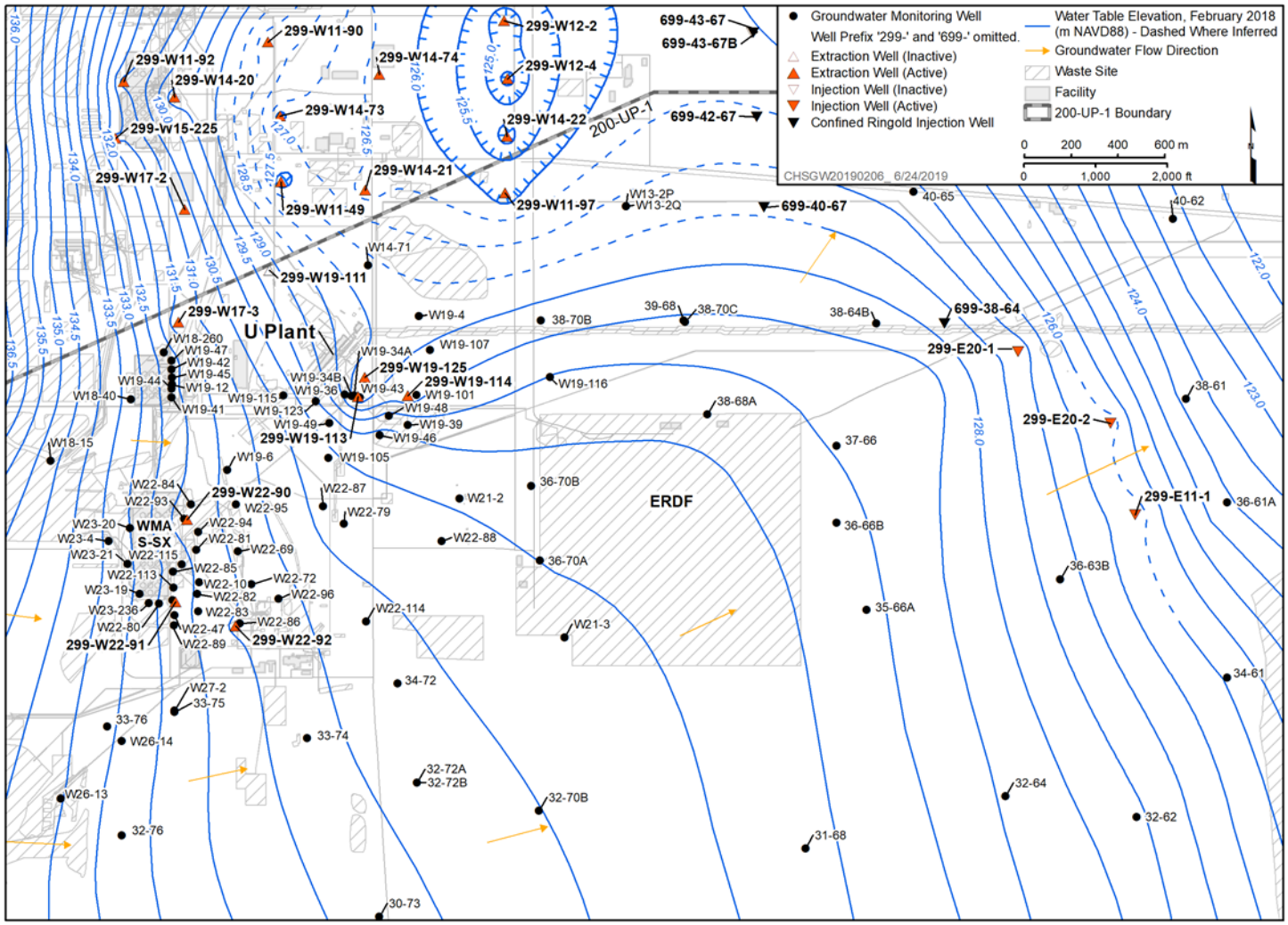


Figure 1-7. 200-UP-1 Water Table Map, 2018

1.3 Data Quality Objectives

The data quality objectives (DQO) process is a systematic planning approach for defining data collection requirements. The DQO process, as described in EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4), was used to develop the sampling and analytical requirements to support the tracer study. Although the data collection and interpreted results of this study will not be used as a basis for selection between alternative actions, the DQO process nonetheless provides a basis to identify specific data needs for this study. This was documented in Appendix A of SGW-60511. The main outcomes of the DQO process are summarized in this section.

1.3.1 Statement of the Problem

The purpose of the Phase II tracer study is to provide empirical measurements of groundwater flow direction and velocity in selected target locations. The information will be used to refine fate and transport simulations and can also support performance assessments of groundwater remedial actions.

1.3.2 Principal Study Questions and Data Needs

Table 1-1 lists the principal study questions to be resolved, data needs, measurements, and sources of data.

Table 1-1. DQO Principal Study Questions and Data Needs

Principal Study Question 1	Does the movement of an emplaced groundwater tracer confirm the anticipated groundwater movement expected with the groundwater removal action at the B Complex?	
Discussion	The anticipated flow direction is southeast. Preferential flow through highly permeable Cold Creek gravels at B Complex is expected to result in a travel time of approximately 5 months from the first injection well to the removal action extraction well. The estimated travel time from the second injection well (299-E33-44) to the extraction well is slightly <2 months.	
Data Need	**Measurement/Observation and Location/Frequency**	**Source of Data**
Tracer injection volume and concentration	Two tracers will be used. A single injection of the first tracer will be made in well 299-E33-341. Following the observed passage of the tracer at the 200-BP-5 removal action extraction well or after a minimum of 7 months have passed (if the tracer is not detected), a single injection of a second tracer will be made at well 299-E33-44. For both injections, enough tracer must be utilized to enable detection at the 200-BP-5 removal action extraction well after accounting for expected dispersion.	Manufacturer's information. Documentation of concentration and volume of tracer solution injected.

Table 1-2. DQO Principal Study Questions and Data Needs

Data Need	Measurement/Observation and Location/Frequency	Source of Data
Tracer concentration time series in observation wells	For the first portion of the test (i.e., first tracer injection), automated in situ fluorescence measurements will be performed at least daily at four to six observation wells located along the inferred flow path(s) between the injection well (299-E33-341) and the removal action extraction well (299-E33-360). The TOWs include 299-E33-38, 299-E33-1A, 299-E33-342, 299-E33-44, and 299-E33-16. For the second portion of the test (i.e., second tracer injection), in situ fluorescence measurements will be performed at least daily at the removal action extraction well. For both test portions, laboratory-based fluorescence measurements will be performed on samples from the TOWs. These samples will include grab samples and optional samples collected using activated carbon samplers. Sampling frequency will vary by location, but weekly samples will be collected at each appropriate downgradient sampling location once the tracer's arrival at that location is projected to occur within 3 to 4 weeks based on in situ measurements.	Sampling and analysis, in situ measurements. Estimated PQL = 0.05 µg/L.
Principal Study Question 2	Does the movement of an emplaced groundwater tracer confirm the anticipated groundwater movement expected with the groundwater remedial action at the uranium plume in the vicinity of U Plant?	
Discussion	The anticipated flow direction is east. Groundwater flow rates in this area are relatively low; a 6-month travel time is estimated from the injection well to the observation well.	
Data Need	**Measurement/Observation and Location/Frequency**	**Source of Data**
Tracer injection volume and concentration	A single injection of tracer will be made in well 299-W19-36. Enough tracer must be injected to enable detection at the nearby extraction well, 299-W19-113, after accounting for expected dispersion.	Manufacturer's information. Documentation of concentration and volume of tracer solution injected.
Tracer concentration time series in observation wells	If resources allow, automated in situ fluorescence measurements will be performed at least daily at the optional observation well (299-W19-34A). Additionally, laboratory-based fluorescence measurements will be performed on samples from the observation well (if used) and the extraction well, 299-W19-113. These samples will include grab samples and samples collected using activated carbon samplers. Sampling frequency at the monitoring locations will initially be every 2 weeks, but this will increase to weekly once the tracer arrival is expected within 3 to 4 weeks.	Sampling and analysis, in situ measurements. Estimated PQL = 0.05 µg/L.

DQO = data quality objective
PQL = practical quantitation limit
TOW = tracer observation well

1.3.3 Acceptance Criteria and Decision Statement

Two primary parameters are used for evaluating tracer study data: (1) following injection, the time when the tracer is first detected at an observation well (i.e., the arrival time), and (2) the time when the tracer maximum concentration is observed at an observation well. The following decision statement will be used to determine whether sufficient information has been collected to achieve the test objectives:

Decision Statement. If the arrival time and the subsequent time of maximum concentration are identified and recorded, then the active tracer emplacement study will be considered successfully concluded at that location. Otherwise, monitoring will continue until sufficient time has passed as determined by project management personnel. In the event the extraction wells are shut down for extended time periods during the tests, the monitoring period may be extended as directed by project management personnel.

1.4 Tracer Selection

As described in SGW-60511, several classes of tracers, including inorganic ions, radionuclides, and fluorescent dyes, were evaluated for use in this study. Inorganic ions such as bromide were excluded due to background salt concentrations in the study areas and the potential for unrepresentative transport (i.e., density flow effects) due to the very high concentrations of salts that would be required. Radionuclides were ruled out because the Central Plateau is broadly contaminated with many radioactive constituents. Tritium is often used as a conservative groundwater tracer, but tritium is a contaminant of concern in the study areas, and it would not be desirable to introduce more tritium into the Central Plateau.

Fluorescent dyes have several attributes that make them favorable for groundwater tracer studies:

- Fluorescent dye, specifically sodium fluorescein, has been successfully used in the Central Plateau for natural gradient tracer studies (HW-60601, *Aquifer Characteristics and Ground-Water Movement at Hanford*) and is detectable at very low concentrations.
- The last reported use of fluorescein dye as a groundwater tracer was in 1957 in an area of relatively high groundwater velocity, so measurable residues should not be present. Measurements of the fluorescence background in water from the study area (discussed below) confirmed the absence of residual fluorescein.
- Fluorescent dyes are generally not reactive with mineral aquifer formations such as those encountered in the Central Plateau, so they should be effective as a conservative groundwater tracer.
- Historical groundwater tracer studies placed a modest quantity of fluorescein dye (i.e., 45 kg [100 lb]) at relatively high concentration (i.e., 45 kg [100 lb] of dye in 378 L [100 gal] of water) in the injection well(s).
- Fluorescent dyes are readily available and relatively inexpensive (e.g., about $50 to $375/gal of concentrated liquid in commercial packaging).
- Fluorescent dyes generally exhibit low environmental toxicity, and some (e.g., rhodamine B) have been approved for use in potable water systems.
- Recent technical developments for fluorescent dye detection instruments provide quantitative measurement capabilities of in situ groundwater at very low levels (e.g., about 0.01 µg/L) and at high-frequency measurement rates.

Potential drawbacks for fluorescent dyes include (1) sorption by organic materials in the aquifer, which could result in overestimation of travel times and dispersion, and (2) possible measurement interference by other dissolved constituents (e.g., humic and fulvic acids and uranium complexes) that could fluoresce at similar wavelengths. Information on possible interferences from dissolved constituents is provided in Section 1.4.1.

Based on their favorable properties and previous successful use at the Hanford Site, fluorescent dyes were chosen for this study. Candidate dyes that have been widely used for water-tracing applications include rhodamine B, rhodamine WT, and fluorescein. Rhodamine B was commonly used in the 1960s but has largely been replaced by rhodamine WT because rhodamine B has a tendency to adsorb onto suspended sediments. Neither rhodamine WT nor fluorescein exhibits this behavior. Therefore, only rhodamine WT and fluorescein were regarded as viable dye tracers for this work.

1.4.1 Laboratory Evaluation of Candidate Dye Tracers

Laboratory experiments were conducted to evaluate the relative suitability of rhodamine WT and fluorescein for tracing groundwater flow in the Central Plateau. These dye performance experiments evaluated tracer detectability (i.e., measurement sensitivity) and potential interferences in Hanford Site groundwater. Tests were conducted by Southwest Research Institute (SwRI), located in San Antonio, Texas. A brief summary of the results is provided here; more information is provided in SwRI, 2018, "Central Plateau Groundwater Tracer Exploratory Study."

The first group of measurements evaluated the fluorescence spectra of the candidate dyes in deionized water (approximately 10 µg/L). Both dyes exhibited well-defined emission spectra consistent with literature reports. Rhodamine WT had an emission maximum at 578 nm (555 nm excitation), and fluorescein maximum emission was at 515 nm (490 nm excitation). Both of the spectra had very flat baselines, as expected for a deionized water matrix, which should not contain other fluorescent components. The fluorescein peak from the test was approximately 5 times more intense than that of rhodamine WT, suggesting that fluorescein should have a lower detection limit.

SwRI was supplied with filtered and unfiltered groundwater from B Complex extraction well 299-E33-360 and the UP-1 extraction well 299-W19-113 to evaluate potential interferences. The samples were analyzed for total organic carbon, iron, and uranium, which are all known potential contributors to fluorescence interference in water analyses. Table 1-2 summarizes the compositional results. Separate fluorescence spectra of the supplied groundwater samples were then measured using the rhodamine WT and fluorescein excitation wavelengths (555 and 490 nm). All four of the groundwater samples exhibited very low-intensity responses, but these were attributed to Rayleigh scattering (elastic scattering of light from very small particles in the water) rather than fluorescence emission. The scattering effect was reduced by approximately 5 times in the filtered water from well 299-E33-360 when the excitation source was optimized for fluorescein (490 nm), but no significant change was observed in the same water when the excitation was configured for rhodamine WT (555 nm). Sample filtration did not appear to affect the low-intensity responses of the samples from well 299-W19-113. Additionally, the low-level responses observed for all samples were less than the associated practical quantitation limits (PQLs) for both dyes (discussed below). In summary, no substantial intrinsic background fluorescence was found in the groundwater samples submitted for testing.

Table 1-2. Concentrations of Potential Interfering Constituents in Test Area Groundwater

Sample Location	TOC (mg/L)	Iron (mg/L)	Uranium (mg/L)
299-E33-360	0.226 – 0.254	0.0877 – 0.0897	0.211 – 0.215
299-W19-113	<0.2 – 0.721	<0.005 – 0.0287	0.149 – 0.150

Note: Two samples (filtered and unfiltered) were measured for each location.
TOC = total organic carbon

Another group of measurements made by SwRI was focused on determining the detection limits for rhodamine WT and fluorescein in deionized water. Calibration curves were prepared by measuring the fluorescence intensity of standard solutions spanning 0 to 50 µg/L for rhodamine WT and 0 to 10 µg/L for fluorescein. These ranges reflect the lower end of the anticipated tracer concentration in groundwater during the aquifer tracer study. Both dyes exhibited excellent linearity over the measured range of concentrations. Next, multiple measurements of low-concentration solutions of the dyes in deionized water were made to determine the method detection limit (MDL) and PQL for each dye. The MDL for rhodamine WT was 0.008 µg/L, and the PQL was 0.025 µg/L. Corresponding values for fluorescein were more than an order of magnitude lower (MDL = 0.0006; PQL = 0.005). MDLs and PQLs were also determined for each dye in the groundwater samples from the two wells. In actual groundwater media, rhodamine WT had MDLs of 0.0035 to 0.0055 µg/L (PQL = 0.025 µg/L), and fluorescein had MDLs of 0.0012 to 0.0015 µg/L (PQL = 0.005 µg/L). Thus, relative to rhodamine WT, significantly smaller quantities of fluorescein could be used to obtain detectable concentrations at downgradient observation points.

1.4.2 Toxicity of Candidate Dye Tracers

Several reports (e.g., Smart and Laidlaw, 1977, "An Evaluation of Some Fluorescent Dyes for Water Tracing"; Field et al., 1995, "An Assessment of the Potential Adverse Properties of Fluorescent Tracer Dyes Used for Groundwater Tracing"; Behrens et al., 2001, "Toxicological and Ecotoxicological Assessment of Water Tracers") have concluded that rhodamine WT and fluorescein have low toxicity and are suitable for use in water-tracing applications. Both dyes have extensive histories for tracing water flows and have been used in potable water systems. The location of the planned tracer tests (i.e., Hanford Site Central Plateau) is distant from areas of groundwater discharge to surface water; dispersion and dilution are expected to reduce the dye concentrations to nondetectable levels well before affected groundwater discharges to the Columbia River. Historical use of fluorescein as a groundwater tracer in the 200 East Area exhibited dramatically reduced dye concentration over distance (e.g., concentration reduction of 1×10^{-7} at a distance of 3,505 m [11,500 ft] downgradient of the point of dye emplacement [HW-60601]). Potential toxic effects to aquatic receptors are, therefore, not considered significant under the prescribed test conditions in this SAP.

1.4.3 Dye Selection

Both rhodamine WT and fluorescein appear to be viable tracers for tracing groundwater flow in the Central Plateau. Fluorescein was chosen for the first injection at the B Complex and for the test at 200-UP-1 due to fluorescein's lower detection limit. As noted previously, greater measurement sensitivity for fluorescein will enable a smaller quantity of tracer to be used in the groundwater tracing tests as well as increased likelihood of detection at downgradient locations. Rhodamine WT will be used for the second injection at the B Complex. Since rhodamine WT's fluorescence spectrum is distinct from that of

fluorescein, the use of rhodamine in the second injection portion of the test will help minimize potential interferences from any residual fluorescein from the first injection.

2 Quality Assurance Project Plan

A Quality Assurance Project Plan (QAPjP) establishes the quality requirements for environmental data collection. It includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection requirements and controls based on the QA elements found in EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5), and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD). The *Department of Defense (DoD) Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories* (DoD/DOE QSM, 2019) is also discussed. Section 7.8 of Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan* (hereinafter referred to as the Tri-Party Agreement Action Plan) requires the QA/quality control (QC) and sampling and analysis activities to specify the QA requirements for past-practice processes. This QAPjP also describes the applicable requirements and controls based on guidance found in Washington State Department of Ecology (Ecology) Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, and EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5). This QAPjP supplements the contractor's environmental QA program plan.

The QAPjP references are included in Chapter 6. This QAPjP includes the following sections, which describe the quality requirements and controls applicable to Hanford Site OU groundwater monitoring activities:

- Section 2.1, "Project Management"
- Section 2.2, "Data Generation and Acquisition"
- Section 2.3, "Assessment and Oversight"
- Section 2.4, "Data Review and Usability"

2.1 Project Management

This section includes project goals, planned management approaches, and planned output documentation.

2.1.1 Project/Task Organization

Project organization is described in the following sections and illustrated in Figure 2-1.

2.1.1.1 Regulatory Agencies

The U.S. Environmental Protection Agency (EPA) is responsible for regulatory oversight of cleanup projects and activities in the 200-UP-1 OU, and Ecology is responsible for regulatory oversight at the B Complex. The lead regulatory agencies have approval authority for the work being performed under this SAP. The agencies will work with the DOE-RL to resolve concerns over the work described in this SAP in accordance with Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Orde*r (Tri-Party Agreement), although the planned tracer study is not a Tri-Party-Agreement-mandated activity.

2.1.1.2 DOE-RL Manager

Hanford Site cleanup is the responsibility of the DOE-RL. The DOE-RL Manager is responsible for authorizing the contractor to perform activities at the Hanford Site under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA); *Resource Conservation and Recovery Act of 1976*; *Atomic Energy Act of 1954*; and the Tri-Party Agreement (Ecology et al., 1989a).

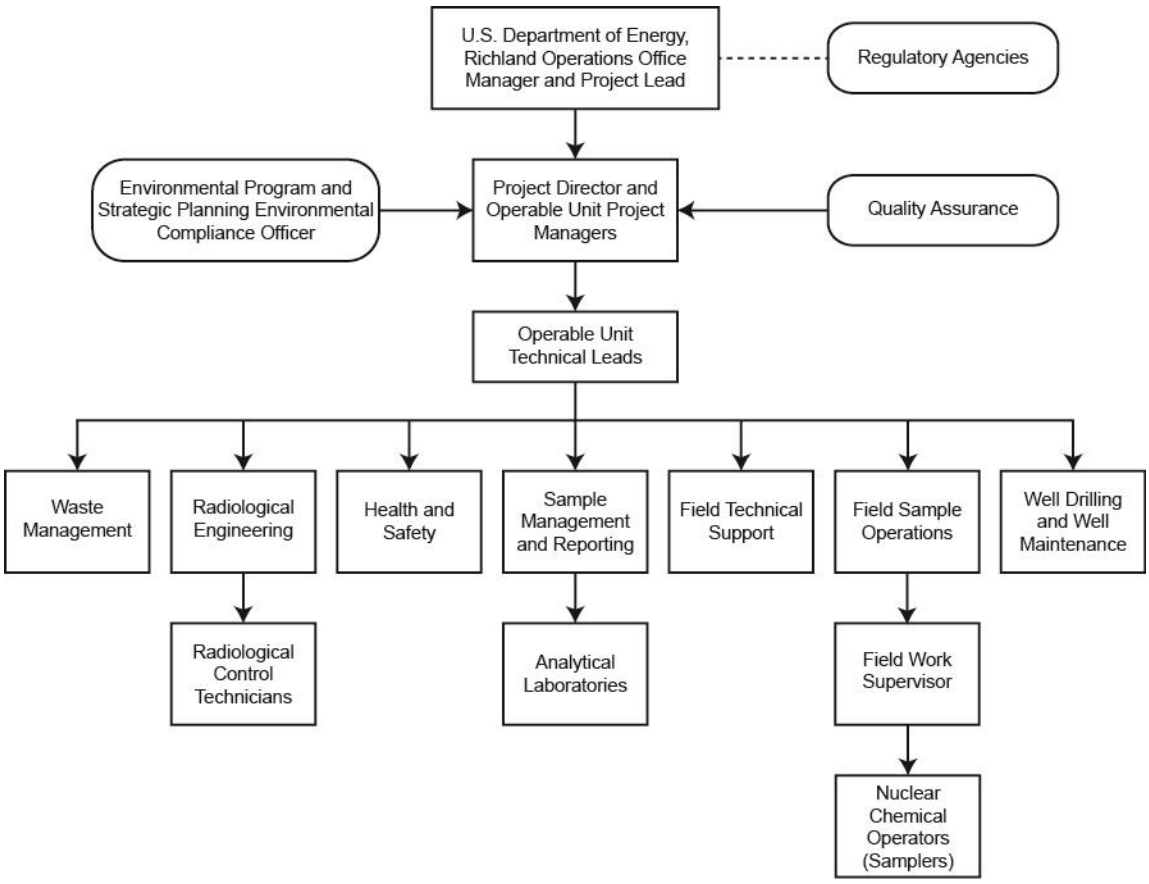


Figure 2-1. Project Organization

2.1.1.3 DOE-RL Project Lead

The DOE-RL Project Lead is responsible for providing day-to-day oversight of the contractor's performance of the work scope, working with the contractor to identify and work through issues, and providing technical input to DOE-RL management.

2.1.1.4 Soil and Groundwater Remediation Project Remedy Selection & Implementation Director

The Soil and Groundwater Remediation Project (SGRP) Remedy Selection & Implementation Director provides oversight and coordinates with DOE-RL and primary contractor management in support of sampling and reporting activities. The SGRP Remedy Selection & Implementation Director also provides support to the OU Project Manager to ensure that work is performed safely and cost effectively.

2.1.1.5 Operable Unit Project Managers

The OU Project Managers (or designees) are responsible and accountable for the project-related activities including coordinating with DOE-RL, regulators, and contactor management in support of sampling activities to ensure work is performed safely and cost effectively. In addition, the OU Project Managers (or designees) are also responsible for managing sampling documents and requirements, field activities, subcontracted tasks, and for ensuring the project file is properly maintained.

2.1.1.6 Operable Unit Technical Leads

The OU Technical Leads are responsible for developing specific sampling design, analytical requirements, and QC requirements, either independently or as defined through a systematic planning process. The OU Technical Leads ensure that sampling and analysis activities as delegated by the OU Project Managers are carried out in accordance with the SAP and work closely with the Environmental Compliance Officer (ECO), QA, Health and Safety, the Field Work Supervisor (FWS), and the Sample Management and Reporting (SMR) group to integrate these and other technical disciplines in planning and implementing the work scope.

2.1.1.7 Sample Management and Reporting

The SMR group oversees offsite analytical laboratories, coordinates laboratory analytical work to ensure that laboratories conform to the requirements of this plan, and verifies that laboratories are qualified for performing Hanford Site analytical work. The SMR group generates field sampling documents, labels, and instructions for field sampling personnel and develops the sample authorization form, which provides information and instruction to the analytical laboratories. The SMR group ensures that field sampling documents are revised to reflect approved changes. The SMR group receives analytical data from the laboratories, ensures the data are appropriately reviewed, performs data entry into the Hanford Environmental Information System database, and arranges for data validation and recordkeeping. The SMR group is responsible for resolving sample documentation deficiencies or issues associated with Field Sample Operations (FSO), laboratories, or other entities. The SMR group is responsible for informing the OU Project Managers of any issues reported by the analytical laboratories.

2.1.1.8 Field Sample Operations

FSO is responsible for planning and coordinating field sampling resources and provides the FWS for sampling operations. The FWS directs the nuclear chemical operators (samplers), who collect samples in accordance with this SAP and corresponding standard methods and work packages. The FWS ensures that deviations from field sampling documents or issues encountered in the field are documented appropriately (e.g., in the field logbook). The FWS ensures that samplers are appropriately trained and available. Samplers collect samples in accordance with sampling documentation. Samplers also complete field logbooks, data forms, and chain-of-custody forms, including any shipping paperwork, and enable delivery of the samples to the analytical laboratory.

Pre-job briefings are conducted by FSO, in accordance with work management and work release requirements, to evaluate activities and associated hazards by considering the following factors:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazards
- Environment in which the job will be performed
- Facility where the job will be performed
- Equipment and material required

2.1.1.9 Quality Assurance

The QA point of contact provides independent oversight and is responsible for addressing QA issues on the project, overseeing implementation of the project QA requirements. Responsibilities include reviewing project documents including the QAPjP, and participating in QA assessments on sample collection and analysis activities, as appropriate.

2.1.1.10 Environmental Compliance Officer

The ECO provides technical oversight, direction, and acceptance of project and subcontracted environmental work and develops appropriate mitigation measures with the goal of minimizing adverse environmental impacts.

2.1.1.11 Health and Safety

The Health and Safety organization is responsible for coordinating industrial safety and health support within the project as carried out through health and safety plans, job hazard analyses, and other pertinent safety documents required by federal regulation or internal primary contractor work requirements.

2.1.1.12 Radiological Engineering

Radiological Engineering is responsible for the following:

- Radiological engineering and project health physics support
- Conducting as low as reasonably achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization
- Identifying radiological hazards and ensuring appropriate controls are implemented to maintain worker exposures to hazards at ALARA levels
- Interfacing with the project Health and Safety representative and other appropriate personnel, as needed, to plan and direct project radiological control technician support

2.1.1.13 Waste Management

Waste Management is responsible for identifying waste management sampling/characterization requirements to ensure regulatory compliance and for interpreting data to determine waste designations and profiles. Waste Management communicates policies and practices and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner.

2.1.1.14 Field Technical Support

The Field Technical Support organization is responsible for tracer injections and deployment and maintenance of in situ probes. The probes require periodic battery changes and response checks using field standards (FSs). Additionally, the data from the probes must be downloaded and evaluated at regular time intervals to check for the onset of tracer at the observation wells. The Field Technical Support organization interfaces with the Technical Leads, SMR, FSO, and the FWS to adjust the collection frequency of grab and charcoal samples at the observation wells.

2.1.1.15 Analytical Laboratories

The analytical laboratories analyze samples in accordance with established procedures and the requirements of this plan and provide necessary data packages containing analytical and QC results. Laboratories provide explanations of results to support data review and in response to resolution of analytical issues. Statements of work flow down quality requirements consistent with HASQARD (DOE/RL-98-68). The laboratories are evaluated under the DOE Consolidated Audit -Accreditation Program (DOE/CAP-AP) or its successor programs to DoD/DOE, 2019 Quality Systems Manual (QSM) requirements. HASQARD requirements, beyond those within the DoD/DOE QSM, are also evaluated under the DOECAP-AP. Laboratories are accredited by Ecology for the analyses performed under this SAP.

2.1.1.16 Field Work Supervisor

The FSO FWS is responsible for planning and coordinating resources for field measurements and sampling. The FWS ensures samplers are appropriately trained and available. Additional related responsibilities include ensuring the sampling design is understood and can be performed as specified, by directing training, performing mock-ups, and holding practice sessions with field personnel. The FWS directs the samplers, who are nuclear chemical operators. The nuclear chemical operator samplers collect groundwater samples; periodically deploy and collect charcoal samplers; collect field parameters; and prepare QC samples in accordance with the SAP, corresponding standard methods, and field and sample instructions. The samplers complete field logbook entries, chain-of-custody forms, and shipping paperwork, and ensure delivery of the samples to the analytical laboratory.

The FWS acts as a technical interface between the OU Project Manager and the field crew supervisors and ensures technical aspects of the field work will be met. The FWS reviews the SAP for field sample collection concerns, analytical requirements, and special sampling requirements. The FWS, in consultation with the OU Project Manager and the SMR organization, resolves issues arising from translation of technical requirements to field operations and coordinates resolution of sampling issues.

2.1.1.17 Well Drilling and Well Maintenance

The well drilling and maintenance and well coordination and planning managers are responsible for the following:

- Planning, coordinating, and executing drilling construction
- Well maintenance activities
- Coordinating with the OU Technical Lead about field constraints that could affect sampling design
- Coordinating well decommissioning with DOE-RL in accordance with the substantive standards of WAC 173-160, “Minimum Standards for Construction and Maintenance of Wells”

2.1.2 Quality Assurance Objectives and Criteria

The QA objective of this plan is to ensure the generation of analytical data of known and appropriate quality. Data quality is assessed by accuracy and precision, by evaluation against the identified DQOs, and by evaluation against the work activities identified in this SAP. The applicable QC guidelines, quantitative target limits, and levels of effort for assessing data quality are dictated by the intended use of the data and the nature of the analytical methodology, which are discussed in the following sections and summarized in Table 2-1.

2.1.2.1 Representativeness

Representativeness is a measure of how closely analytical results reflect the actual concentration and distribution of the constituents in the matrix sampled. Sampling plan design, sampling techniques, and sample handling protocols (e.g., storage, preservation, and transportation) are discussed in subsequent sections of this SAP. The required documentation will establish the protocols to be followed and will ensure appropriate sample identification and integrity.

2.1.2.2 Accuracy

Accuracy is an assessment of the closeness of the measured value to the true value. Accuracy is usually measured as a percent recovery. For the groundwater tracing described in this SAP, QC elements used to assess accuracy include standard recoveries, laboratory control samples, and spiked samples.
The acceptance criterion for these elements is 80% to 120%.

Table 2-1. Data Quality Indicators, Assessment, and Corrective Actions

Data Quality Indicator	Definition	Determination Methodologies	Corrective Actions
Precision	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the RPD.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity) • Request reanalysis or remeasurement • Qualify the data before use
Accuracy	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. QC analyses used to measure accuracy include standard recoveries, laboratory control samples, spiked samples, and surrogates.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: • Qualify the data before use • Request reanalysis or remeasurement
Representativeness	Sample representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. It is dependent on the proper design of the sampling program and will be satisfied by ensuring the approved plans were followed during sampling and analysis.	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	If results are not representative of the system sampled: • Identify the reason for them not being representative • Reject the data, or, if data are otherwise usable, qualify the data for limited use and define the portion of the system that the data represent • Redefine sampling and measurement requirements and protocols • Resample and reanalyze

Table 2-1. Data Quality Indicators, Assessment, and Corrective Actions

Data Quality Indicator	Definition	Determination Methodologies	Corrective Actions
Comparability	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and QA protocols.	If data are not comparable to other data sets: • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Qualify the data as appropriate • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future comparability
Completeness	Completeness is a measure of the amount of valid data collected compared to the amount planned. Measurements are considered to be valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (DQOs or performance/acceptance criteria).	If data set does not meet completeness objective: • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Qualify the data as appropriate • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future comparability

Table 2-1. Data Quality Indicators, Assessment, and Corrective Actions

Data Quality Indicator	Definition	Determination Methodologies	Corrective Actions
Bias	Bias is the systematic or persistent distortion of a measurement process that causes error in one direction (e.g., the sample measurement is consistently lower than the sample's true value). Bias can be introduced during sampling, analysis, and data evaluation. Analytical bias refers to deviation in one direction (i.e., high, low, or unknown) of the measured value from a known spiked amount.	Sampling bias may be revealed by analysis of replicate samples. Analytical bias may be assessed by comparing a measured value in a sample of known concentration to an accepted reference value or by determining the recovery of a known amount of contaminant spiked into a sample (matrix spike).	For sampling bias: • Properly select and use sampling tools • Institute correct sampling and subsampling procedures to limit preferential selection or loss of sample media • Use random sampling designs • Use sample handling procedures, including proper sample preservation, that limit the loss or gain of constituents to the sample media • Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias. • Laboratories that are known to generate biased data for a specific analyte are asked to correct their methods to remove the bias as best as practicable. Otherwise, samples are sent to other laboratories for analysis.
Sensitivity	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation is the lowest level which can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or remeasurement using methods or analytical conditions that will meet required detection or limit of quantitation • Qualify/reject the data before use

Source: SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, current update.

DQO = data quality objective
RPD = relative percent difference
QA = quality assurance
QC = quality control

2.1.2.3 Precision

Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates (DUPs). Analytical precision is estimated by duplicate/replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the relative percent difference (RPD).

2.1.2.4 Comparability

Comparability expresses the degree of confidence with which one data set can be compared to another. Data comparability is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.

2.1.2.5 Completeness

Completeness is a measure of the amount of data collected compared to the amount planned. Due to the uncertain nature of groundwater flow in the two test areas, specific numbers of samples and field measurements cannot be predetermined. Guidance for the frequencies of in situ measurements and sampling events is specified in Chapter 3 of this SAP.

2.1.2.6 Detection Limits

Detection limits are functions of the analytical method used to provide the data and the quantity of the sample available for analyses. For this project, the required PQLs for the tracers measured by in situ probes are 0.5 µg/L and 1 µg/L for fluorescein and rhodamine WT, respectively. The analogous required PQLs for laboratory measurements 0.05 µg/L and 0.1 µg/L.

2.1.3 Special Training/Certification

A graded approach is used to ensure that workers receive a level of training commensurate with responsibilities and in compliance with applicable DOE orders and government regulations. The FWS, in coordination with line management, will ensure special training requirements for field personnel are met. Training requirements or qualification programs have been instituted by the CHPRC management team to satisfy multiple training drivers imposed by the applicable *Code of Federal Regulations* and *Washington Administrative Code* requirements. The environmental, safety, and health training program provides workers with the knowledge and skills necessary to safely execute assigned duties. The following training for field personnel will be applied, as appropriate, for specific elements of work (details of training required for types of work and locations will be specified in the field site health and safety plan):

- Occupational Safety and Health Administration 40-Hour Hazardous Waste Worker Training and supervised 24-hour hazardous waste site experience
- 8-Hour Hazardous Waste Worker Refresher Training (as required)
- Hanford General Employee Radiation Training
- Hanford General Employee Training
- Radiological Worker Training

In addition, pre-job briefings will be performed in accordance with work management and work release documents to evaluate an activity and associated hazards by considering various factors, including the following:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazards
- Environment in which the job will be performed
- Facility where the job will be performed
- Equipment and material required
- Safety protocols applicable to the job
- Training requirements for individuals assigned to perform the work
- Level of management control
- Proximity of emergency contacts

Training records are maintained for each individual employee in an electronic training record database. The contractor's training organization maintains the training records system. Line management will be used to confirm that an individual employee's training is appropriate and up to date prior to performing any field work.

2.1.4 Documents and Records

The OU Project Manager is responsible for ensuring the current version of the SAP is being used and for providing any updates to field personnel. Version control is maintained by the administrative document control process. Changes to the sampling document are handled consistent with HASQARD (DOE/RL-96-68) and the Tri-Party Agreement Action Plan (Ecology et al., 1989b). Table 2-2 defines the type of changes that may impact sampling and the associated approvals, notifications, and documentation requirements.

Table 2-2. Change Control for Sampling Projects

Type of Change [a]	Action	Documentation
Minor Field Change. Changes that have no adverse effect on the technical adequacy of the job or the work schedule.	The field personnel recognizing the need for a field change will consult with the OU Project Manager (or designee) prior to implementing the field change.	Minor field changes will be documented in the field logbook. The logbook entry will include the field change, the reason for the field change, and the names and titles of those approving the field change.
Minor Change. Changes to approved plans that do not affect the overall intent of the plan or schedule.	The OU Project Manager will inform the DOE-RL Project Manager and the Regulatory Lead of the change. The lead regulatory agency determines there is no need to revise the document.	Documentation of this change approval would be in the Project Manager's Meeting minutes or comparable Tri-Party Agreement Change Notice. [b]

Table 2-2. Change Control for Sampling Projects

Type of Change [a]	Action	Documentation
Revision Necessary. Lead regulatory agency determines changes to approved plans require revision to the document.	If it is anticipated that a revision is necessary, the OU Project Manager will inform DOE-RL and the Regulatory Lead. The lead regulatory agency determines the change requires a revision to the document.	Formal revision of the sampling document.

References: DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents*.

Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*.

Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*.

a. Consistent with DOE/RL-96-68 and Sections 9.3 and 12.4 of Ecology, et al., 1989b.

b. The Tri-Party Agreement Action Plan, Section 9.3, defines the minimum elements of a change notice.

DOE-RL = U.S. Department of Energy, Richland Operations Office

OU = operable unit

Tri-Party Agreement = Hanford Federal Facility Agreement and Consent Order

The OU Project Manager is responsible for tracking all changes and obtaining appropriate reviews by contractor staff. The OU Project Manager will discuss the change with DOE-RL. DOE-RL will then discuss with the lead regulatory agency significant and fundamental changes, as described in Section 9.3 and Section 12.4 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b). Appropriate documentation will follow, in accordance with the requirements for the type of change.

Logbooks and data forms are required for field activities. The logbook must be identified with a unique project name and number. Only authorized individuals may make entries into the logbooks. Logbooks will be controlled in accordance with internal work requirements and processes.

The SMR organization, the FWS, and the appropriate Buyer's Technical Representative (BTR) are responsible for ensuring that the field instructions are maintained and aligned with any revisions or approved changes to the SAP. The SMR organization will ensure that any deviations from the SAP are reflected in revised paperwork, as applicable for the samplers and the analytical laboratory. The FWS or appropriate BTR will ensure that deviations from the SAP or problems encountered in the field are documented appropriately (e.g., in the field logbook or on nonconformance report forms), in accordance with internal corrective action protocols.

The OU Project Manager, FWS, or designee is responsible for communicating field corrective action requirements and ensuring immediate corrective actions are applied to field activities. The OU Project Manager is responsible for ensuring that a project file is properly maintained. The project file will contain the records or references to their storage locations. The project file will include the following, as appropriate:

- Operational records and logbooks
- Data forms
- Inspection or assessment reports and corrective action reports
- Interim progress reports
- Final reports

The following records are managed and maintained by SMR personnel:

- Field sampling logbooks
- Field sample reports
- In situ sensor data
- Chain-of-custody forms
- Sample receipt records
- Laboratory data packages
- Analytical data "case file purges" (i.e., raw data purged from laboratory files) provided by offsite analytical laboratories

The laboratory is responsible for maintaining, and having available upon request, as contracted, the following:

- Analytical logbooks
- Raw data and QC sample records
- Standard reference material and/or proficiency test sample data
- Instrument calibration information
- Training records for employees, as they relate to analytical methods.

Records may be stored in either electronic or hardcopy format. Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes to ensure the accuracy and accessibility of stored records. Records required by the Tri-Party Agreement (Ecology et al., 1989a) will be managed in accordance with the requirements of the agreement.

2.2 Data Generation and Acquisition

The following sections present the requirements for analytical methods, measurement and analysis, data collection or generation, data handling, and field and laboratory QC. The requirements for instrument calibration and maintenance, supply inspections, and data management are also addressed. The sampling design is presented in the field methods and procedures (Chapter 3) of this SAP.

2.2.1 Analytical Methods

The selected tracer dyes, fluorescein and rhodamine WT, are the primary analytical parameters that will be measured in this test. Three sampling/measurement approaches will be used to help ensure that the dyes are successfully detected at the observation wells. First, in situ fluorescence probes will be deployed in the observation wells. The probes are commercially available and will be interfaced with a datalogger system for frequent, automated measurements. Since the probes are designed to measure a single dye, separate probes are required for fluorescein and rhodamine WT. Second, groundwater samples (i.e., grab samples) will be periodically collected and submitted to a laboratory for fluorometric analysis. Third, charcoal samplers will be deployed at the observation wells. The samplers consist of a porous bag with activated charcoal that readily adsorbs fluorescent dyes such as fluorescein and rhodamine WT from water. By suspending a sampler inside a well, the charcoal can accumulate tracer over a prescribed time interval. After the exposure period has elapsed, the samplers will be retrieved, and the charcoal samples will be submitted to the laboratory. The charcoal samples are processed by passing an eluent solution containing isopropyl alcohol, water, and ammonia through the charcoal to desorb the dye, and the solution containing any desorbed dye is analyzed by fluorimetry.

Analytical performance requirements are specified in Table 2-3. There are no standard methods for measuring fluorescein or rhodamine WT in groundwater. However, the dye-concentration data generated during the tracer tests will not be used for risk analysis or remedy decision-making purposes. Approval of this SAP by a regulatory agency constitutes approval of the nonstandard approaches listed in the table and described in this section. Pacific Northwest National Laboratory (PNNL) will develop the methodology and conduct the laboratory measurements. Satisfactory laboratory measurements, performance must be demonstrated with validation data to confirm that the analytical approaches are adequate for the intended use of the data. This includes information such as the determination of detection limits, quantitation limits, and analytical precision and bias. The PNNL shall develop written test instructions for analyzing groundwater and charcoal samples. For the latter, a test must be conducted to help relate adsorbed dye quantities to actual groundwater concentrations. This would involve exposing separate charcoal samplers to different concentrations of dye solutions for fixed time periods, extracting the adsorbed dye from each sampler, and then determining the amount of dye adsorbed at each aqueous concentration. The concentrations of the aqueous solutions and the exposure periods should be representative of conditions that would be anticipated in the actual field tests. For the in situ probes, the manufacturer's specifications must meet or exceed the values in the table. Probe operation will be based on the manufacturer's instructions. Additional details about measurement frequencies and probe maintenance are provided in Chapter 3.

Deviations from the analytical methods in Table 2-3 must be approved in accordance with the change control requirements presented in Table 2-2. Deviations from the analytical methods noted in Table 2-3 will be properly approved. Issues that may affect analytical results are to be resolved by the OU Project Manager in coordination with the SMR organization.

Table 2-3. Analytical Performance Requirements

Sample Type	Analyte	Analytical Method	Dynamic Range (µg/L)	PQL (µg/L)	Precision (%)	Accuracy (%)
In situ probe	Fluorescein	N/A; probe operation will be based on manufacturer's instructions	0.1 – 500	N/A	N/A	N/A
Grab sample		Laboratory specific, based on USGS, 1986	0.05 – 100	0.05	≤20	80 – 120
Charcoal		Laboratory specific, based on Aley and Beeman, 2015, and USGS, 1986				
In situ probe	Rhodamine WT	N/A; probe operation will be based on manufacturer's instructions	0.2 – 1,000	N/A	N/A	N/A
Grab sample		Laboratory specific, based on USGS, 1986	0.10 – 100	0.10	≤20	80 – 120
Charcoal		Laboratory specific, based on Aley and Beeman (2015) and USGS, 1986				

References: Aley and Beeman, 2015, *Procedures and Criteria Analysis of Fluorescent Dyes in Water and Charcoal Samplers: Fluorescein, Eosine, Rhodamine WT, and Sulforhodamine B Dyes*.

USGS, 1986, *Techniques of Water-Resources Investigations*.

N/A = not applicable

PQL = practical quantitation limit

2.2.2 Quality Control

The QC requirements specified in this SAP must be followed in the field and analytical laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and provide information pertinent to field sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects of the analytical data. Field and laboratory QC sample requirements are summarized in Table 2-4.

The impact of a failed QC measure may be determined and evaluated during data review and data usability assessment (DUA) processes.

Table 2-4. Project Quality Control Requirements

Sample Type	Frequency	Characteristics Evaluated
Field Quality Control		
Field duplicates [a]	1 for every 20 samples [b]	Precision, including sampling and analytical variability
Equipment blanks [c]	As needed. If only disposable equipment is used or equipment is dedicated to a particular well, then an equipment blank is not required. Otherwise, 1 for every 20 samples for each type of media (groundwater/charcoal)	Adequacy of sampling equipment decontamination and contamination from nondedicated equipment
Trip blanks [d]	1 for every 20 samples	Monitor contamination from containers, sampling media, or transportation
Field standards [e]	Monthly	Stability/accuracy of in situ probes
Laboratory Quality Control		
Method blanks	One per analytical batch	Laboratory contamination, false-positive detection
Laboratory duplicates [f]	One per analytical batch	Laboratory precision
Laboratory control samples	One per analytical batch	Laboratory accuracy

a. Applies to groundwater grab samples only.

b. If possible, field duplicates should be collected at an observation well when the tracer concentration is high enough to be measurable by the in situ probe at that well.

c. Applies to grab and charcoal samples only.

d. Applies to charcoal samples only.

e. Applies to in situ probes only.

f. For charcoal samplers, the laboratory duplicate is a replicate sample of the charcoal sampler eluate.

2.2.2.1 Field QC Samples

Field QC samples will be collected to evaluate the potential for cross-contamination and provide information pertinent to field sampling/measurement variability and laboratory performance to help

ensure that reliable data are obtained. Field QC samples include DUPs, equipment blanks (EBs), and FSs. The QC samples and the required frequency for collection are described in this section.

Field Duplicates. DUPs are independent groundwater samples collected as close as possible to the same time and same location and are intended to be identical. Field duplicates do not apply to charcoal samplers. DUPs are placed in separate sample containers and analyzed independently. The DUPs are collected at a frequency of 1 in 20 samples and should be scheduled at an observation well to coincide with a timeframe when a detectable quantity of dye is present at that well (i.e., based on in situ probe measurements).

DUPs must agree within 20%, as measured by the RPD, to be acceptable. Only those DUPs with at least one result >5 times the appropriate detection limit are evaluated. Large RPDs can indicate potential laboratory performance problems, field sampling problems, or sample heterogeneity, and should be investigated. DUP results not satisfying evaluation criteria will be qualified and flagged in the data record, as appropriate.

Equipment Blanks. EBs consist of reagent water within the same sampling equipment, as identified on the project sampling authorization form. The EB sample bottles will be placed in the same storage containers with the samples from the associated sampling event. EB samples will be analyzed using the same method protocols as the other samples from the associated sampling event.

EBs are collected from reusable sampling devices on a 1-in-20 basis and are not required for disposable sampling equipment. Results >2 times the MDL are identified as containing suspected contamination.

Trip Blanks (TBs). TBs consist of a charcoal sampler that has not been exposed to groundwater, but otherwise has been treated identically to charcoal samplers exposed to groundwater, as identified on the project sampling authorization form. The TB samples will be placed in the same storage containers with the samples from the associated sampling event. TB samples will be analyzed using the same method protocols as the other samples from the associated sampling event. TBs are collected on a 1-in-20 basis. Results >2 times the MDL are identified as containing suspected contamination.

Field Standards. FSs are standards containing a known concentration of the tracer and are used to check the accuracy and stability of the in situ probes. The standards can help identify sensor drift due to changes in environmental conditions or biofilm formation on the sensor's active surfaces. FS recoveries must agree within 80% to 120% to be acceptable. Unacceptable results will be qualified and flagged in the data record. Moreover, field probe results immediately preceding the unacceptable FS results will be investigated (e.g., for baseline drift) in an attempt to determine the extent of data affected. After checking the performance of the in situ probes, FSs may also be used to periodically standardize their output.

2.2.2.2 Laboratory QC Samples

Laboratory QC samples (method blanks, laboratory duplicates, and laboratory control samples) must be prescribed in the laboratory's written test instructions. The laboratory must establish acceptance criteria for each QC sample type.

Method Blanks. Method blanks are samples of reagent water that are subjected to the same processing as the samples, including all reagent additions. These samples are used to evaluate contamination associated with sample processing. They can also provide indications of false-positive detections.

Laboratory Duplicates. Laboratory duplicates are two aliquots of the same sample that are taken through the entire sample preparation and analytical process. These samples are used to assess the precision of the preparation and analysis process in a client-specific matrix. For charcoal samplers, the laboratory duplicate is a duplicate sample of the charcoal sampler eluate.

Laboratory Control Samples. Laboratory control samples consist of a standard reference material (e.g., standard solution of dye). They are used to evaluate method accuracy.

Laboratory QC sample results that are outside the control limits will be noted in the narrative of the analytical report and during the DUA, if performed.

2.2.3 Measurement Equipment

Each user of measuring equipment is responsible for ensuring that the equipment is functioning as expected, properly handled, and properly calibrated at required frequencies in accordance with methods governing control of the measuring equipment. Onsite environmental instrument testing, inspection, calibration, and maintenance shall be recorded in accordance with approved methods. Field screening instruments will be used, maintained, and calibrated in accordance with the manufacturer's specifications and other approved methods.

2.2.4 Instrument and Equipment Testing, Inspection, and Maintenance

Collection, measurement, and testing equipment should meet applicable standards (e.g., American Society for Testing and Materials) or have been evaluated as acceptable and valid in accordance with the approved methods, requirements, and specifications. Software applications will be acceptance tested prior to use in the field.

Measuring and testing equipment used in the field or in the laboratory and directly affecting the quality of analytical data will be subject to preventive maintenance measures to ensure minimization of measurement system downtime. Laboratories and onsite measurement organizations must maintain and calibrate their equipment. Maintenance requirements (e.g., documentation of routine maintenance) will be included in the individual laboratory and onsite organization's QA plan or operating protocols, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with maintenance requirements specified in HASQARD (DOE/RL-96-68).

2.2.5 Instrument/Equipment Calibration and Frequency

Specific field equipment calibration information is provided in Section 3.6. Analytical laboratory instruments and measuring equipment are calibrated in accordance with the laboratory's test instructions and QA plan.

2.2.6 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, requirements and will be appropriate for their use. Supplies and consumables used in support of sampling and analysis activities are procured in accordance with internal work requirements and processes. Responsibilities and interfaces necessary to ensure that items procured/acquired for the contractor meet the specific technical and quality requirements must be in place. The procurement system ensures purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

2.2.7 Data Management

Environmental data will be managed to ensure that the integrity and quality of the data are preserved. Data processing activities will be controlled to ensure that the introduction of errors is minimized while environmental data are being collected, transferred, stored, analyzed, and reviewed. The Field Technical Support and SMR organizations, in coordination with the OU Project Manager, are responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with the applicable

programmatic requirements governing data management methods. Data processing practices will include some or all of the following controls to avoid errors during data handling and manipulation.

- Perform periodic checks/reviews to ensure data are not lost or incorrectly transcribed when transferred from one format to another.
- Minimize the number of data transfer steps and the number of personnel handling the data.
- Institute access control and accountability measures to protect hardcopy and electronic database files.

Electronic data access, when appropriate, will be through a Hanford Site database (e.g., the Hanford Environmental Information System) or a project-specific database, whichever is applicable for the data being stored. Where electronic data are not available, hardcopies will be provided in accordance with Section 9.6 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b).

Laboratory errors are reported routinely to the SMR organization. For reported laboratory errors, a sample issue resolution form will be initiated in accordance with applicable methods. This process is used to document analytical errors and to establish their resolution with the OU Project Manager. The sample issue resolution forms become a permanent part of the analytical data package for future reference and for records management.

Further details on documentation of field activities are provided in Section 3.5 and shall be prepared, reviewed, approved, and maintained according to prescribed processes.

2.2.8 Nondirect Measurements

Data obtained from sources such as computer databases, programs, literature files, and historical databases will be technically reviewed to the same extent as data generated as part of any sampling and analysis QA/QC effort. Data used in evaluations will be identified by source.

2.3 Assessment and Oversight

The elements in assessment and oversight address the activities for assessing the effectiveness of project implementation and associated QA/QC activities. The purpose of assessment is to ensure that the QAPjP is implemented as prescribed.

2.3.1 Assessments and Response Actions

Random surveillances and assessments verify compliance with the requirements outlined in this SAP, project field instructions, the project quality management plan, methods, and regulatory requirements. Assessments include but are not limited to surveillances, management systems reviews, readiness reviews, technical systems audits, performance evaluations, audits of data quality, and DUAs. Assessment processes, roles, and responsibilities will be in accordance with existing QA program methods and as directed jointly by the OU Project Manager and the QA point of contact. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project's line management chain coordinates the resolution of corrective actions/deficiencies in accordance with the QA program, the corrective action management program, and associated methods implementing these programs. When appropriate, corrective actions will be taken by the OU Project Manager (or designee).

The OU Project Manager will determine whether a DUA will be performed for the activities identified in this SAP. The DUA process, if performed, is discussed in Section 2.4.2. The results of the DUA will be provided to the OU Project Manager. No assessments have been planned. If circumstances arise in the field dictating the need for assessment activities, then assessments will be performed.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with the laboratories' QA plans. The contractor oversees offsite analytical laboratories and verifies that the laboratories are qualified for performing Hanford Site analytical work.

2.3.2 Reports to Management

Management will be made aware of deficiencies identified by self-assessments, corrective actions from ECOs, and findings from QA assessments and surveillances. Issues reported by laboratories are communicated to the SMR organization, which then initiates a sample issue resolution form. This process is used to document analytical or sample issues and to establish resolution with the OU Project Manager.

2.4 Data Review and Usability

This section addresses the QA activities that occur after the data collection phase of the project is completed. Implementation of these activities determines whether the data conform to the specified criteria, thus satisfying the project objectives.

2.4.1 Data Review and Verification

Data review and verification are performed to confirm that sampling and chain-of-custody documentation are complete. This review shall include linking sample numbers to specific sampling locations, reviewing sample collection dates and sample preparation and analysis dates to assess whether holding times have been met, and reviewing QC data to determine whether analyses have met the data quality requirements specified in this SAP.

The criteria for verification include but are not limited to review for contractual compliance (samples were analyzed as requested), use of the correct analytical method, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors.

Errors identified by the laboratories are reported to the SMR organization's project coordinator, who initiates a sample issue resolution form. This process is used to document analytical errors and to establish resolution with the OU Project Manager.

Field QA/QC results will be reviewed to ensure that field screening results are usable.

2.4.2 Reconciliation with User Requirements

The purpose of reconciliation with user requirements is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet the project data needs. The DUA process is the scientific and statistical evaluation of previously verified and validated data to determine if information obtained from environmental data operations are of the right type, quality, and quantity to support their intended use (usability). The DUA process uses the entirety of the collected data to determine usability for decision making. If a statistical sampling design was utilized during field sampling activities, then the DUA will be performed following guidance in EPA/240/B-06/003, *Data Quality Assessment: Statistical Methods for Practitioners*, EPA QA/G-9S. When judgmental (focused) sampling designs are implemented in the field, data quality indicators (DQIs) such as precision, accuracy, representativeness, comparability, completeness, and sensitivity for the specific data sets (individual data packages) will be evaluated in accordance with EPA/240/R-02/004, *Guidance on Environmental Data Verification and Data Validation*, EPA QA/G-8. Data verification and data validation are integral to both the statistical DUA data evaluation process and the DQI evaluation process. Results of the DUA or DQI processes generated by the SMR group will be used by the contractor OU Project Manager to interpret the data and determine if the DQOs for this activity have been met. Potential corrective actions for the DQI review are shown in Table 2-1.

3 Field Sampling Plan

This chapter describes the methods that will be used to inject and monitor the fluorescent dye tracer in Central Plateau groundwater. The field methods and procedures are based on the sampling design that was documented in the DQO process (SGW-60511 and Section 1.3). Elements described in this chapter include injection protocols, the number of sampling and monitoring locations, sampling frequencies, field documentation, field equipment calibration, and sample handling requirements.

3.1 Injection and Observation Wells

Two locations have been identified for the tracer tests: Phase IIa will be conducted at the B Complex removal action, and Phase IIb will be conducted at the operating groundwater uranium remedial action in the 200-UP-1 OU.

Prior to conducting the tests, wellbore camera surveys will be performed in the injection and observation wells to identify nonideal wellbore conditions (e.g., biofouling) and confirm the depths of the screened or perforated intervals. If necessary, the wells will be repaired or cleaned to remove biofouling or other unwanted material.

Well completion information for tracer test injection and observation wells is provided in Table 3-1.

3.1.1 Phase IIa: 200-BP-5 OU

The B Complex groundwater extraction removal action currently uses extraction well 299-E33-360. Figure 3-1 shows the simulated capture zone when pumping the extraction well at 568 L/min (150 gal/min) and assuming homogenous aquifer properties. Arrowhead marks on the flow lines indicate an estimated duration of 1 year between marks. Groundwater tracing will be performed using two sequential tracer injections to help ensure successful detection and quantitative measurement of tracer at downgradient TOWs.

In the first injection, a fluorescein solution will be pumped into an existing upgradient well (299-E33-341) located approximately 340 m (1,115 ft) to the northwest (Figure 3-2). Flow simulations suggest that it will take approximately 5 months for the tracer to travel from the injection well to the extraction well. Four to five additional existing wells (299-E33-38, 299-E33-1A, 299-E33-342, 299-E33-44, and 299-E33-16) are projected within the flow path and will be used as TOWs (Figure 3-2).

A second tracer injection will be made after one of the following conditions have been met: the fluorescein plume's arrival and effective capture at the extraction well is successfully observed, or a minimum of 7 months have passed since the first injection. If the plume is successfully detected at the extraction well, capture will not be considered complete (and the second injection will not be initiated) until repeated fluorescence measurements at the extraction well return to background levels (i.e., nondetections). These conditions will help ensure the two tracer plumes are separated from each other and hydrologic perturbations are minimized. For the second injection, a single dose of rhodamine WT will be added to well 299-E33-44, one of the TOWs utilized after the first tracer injection. Since this well is located along the flow path for the first injection and is much closer to the extraction well (approximately 109 m to the northwest), the likelihood of successful tracer capture and detection at the extraction well is expected to be higher for the second injection. The estimated time for rhodamine WT to reach the extraction well is 51 days (1.7 months).

Table 3-1. Tracer Test Well Information

Well Name	Well Function for Tracer Study	Screen Type	Screen Length (m)	Top of Screen Elevation [a] (m)	Bottom of Screen Elevation [a] (m)	Water Table Elevation [b] (m)	Water Table Elevation Date	Screened Interval Formation
200-BP-5 OU – First Injection								
299-E33-341	Tracer injection	stainless wire wrap	3	123.3	120.3	121.65	5/6/2019	CCU HSU 3
299-E33-38	Tracer observation	stainless wire wrap	6.4	126.4	120	121.626	6/28/2019	CCU HSU 3
299-E33-1A	Tracer observation	perforated casing	6.1	127.4	121.3	121.726	10/8/2017	CCU HSU 3
299-E33-342	Tracer observation	stainless wire wrap	3	123.2	120.2	121.626	6/28/2019	CCU HSU 3
299-E33-44	Tracer observation	stainless wire wrap	4.6	123.5	118.9	121.63	6/28/2019	CCU HSU 3
299-E33-16	Tracer observation	perforated casing	4.6	125.3	120.7	121.692	10/29/2017	CCU HSU 3
299-E33-360	Groundwater extraction	stainless wire wrap	6.1	122.2	116.1	121.725	12/29/2015	CCU HSU 3
200-UP-1 OU								
299-W19-36	Tracer injection	stainless wire wrap	6.1	132.701	126.601	128.703	6/25/2019	Rwie HSU 5
299-W19-34A	Tracer observation (optional)	stainless wire wrap	4.7	115.708	111.008	127.68	6/25/2019	Rwie HSU 5
299-W19-113	Groundwater extraction	stainless wire wrap	6.1	110.637	104.537	128.37	5/13/2015	Rwie HSU 5

Table 3-1. Tracer Test Well Information

Well Name	Well Function for Tracer Study	Screen Type	Screen Length (m)	Top of Screen Elevation [a] (m)	Bottom of Screen Elevation [a] (m)	Water Table Elevation [b] (m)	Water Table Elevation Date	Screened Interval Formation

a. Elevation is above mean sea level (amsl) from the NAVD88, *North American Vertical Datum of 1988*from the NAVD 88 datum.

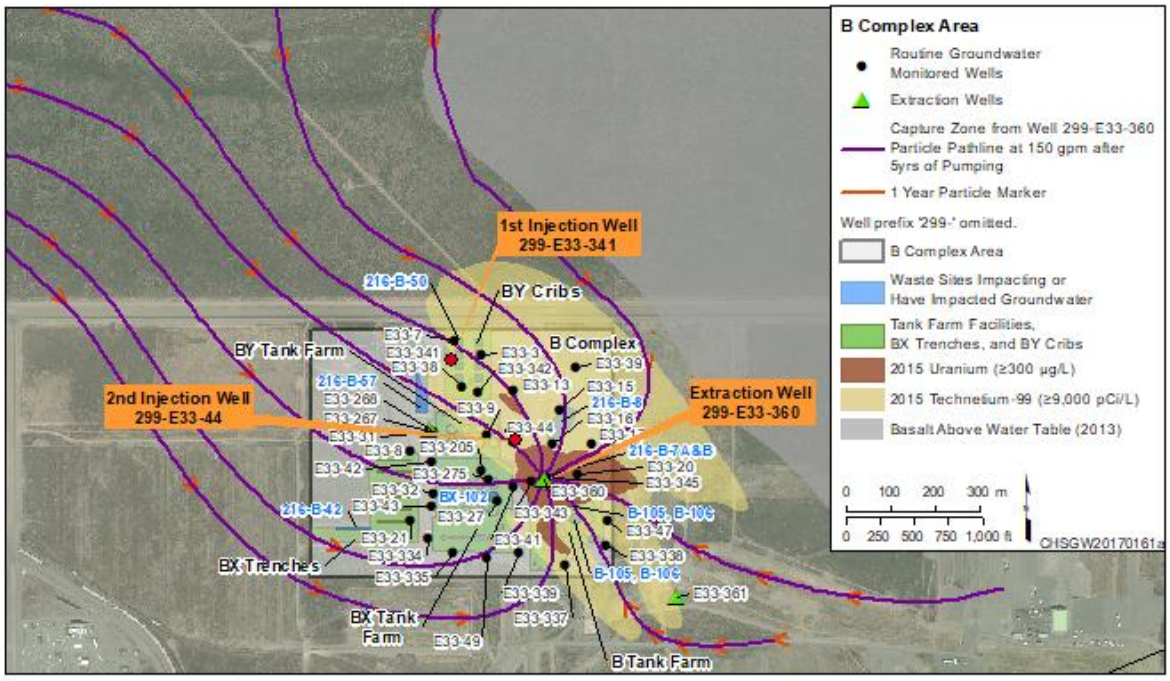
b. Elevation is above mean sea level (amsl) from the NGVD 29, *National Geodetic Vertical Datum of 1929*.

amsl = above mean sea level

CCU = Cold Creek unit

HSU = hydrostratigraphic unit

Rwie = Ringold Formation member of Wooded Island – unit E datum.



Source: Modified from Figure 10, DOE/RL-2017-11, *Removal Action Work Plan for the 200-BP-5 Operable Unit Groundwater Extraction*.

Figure 3-1. Simulated Groundwater Capture Zone for Extraction Well 299-E33-360

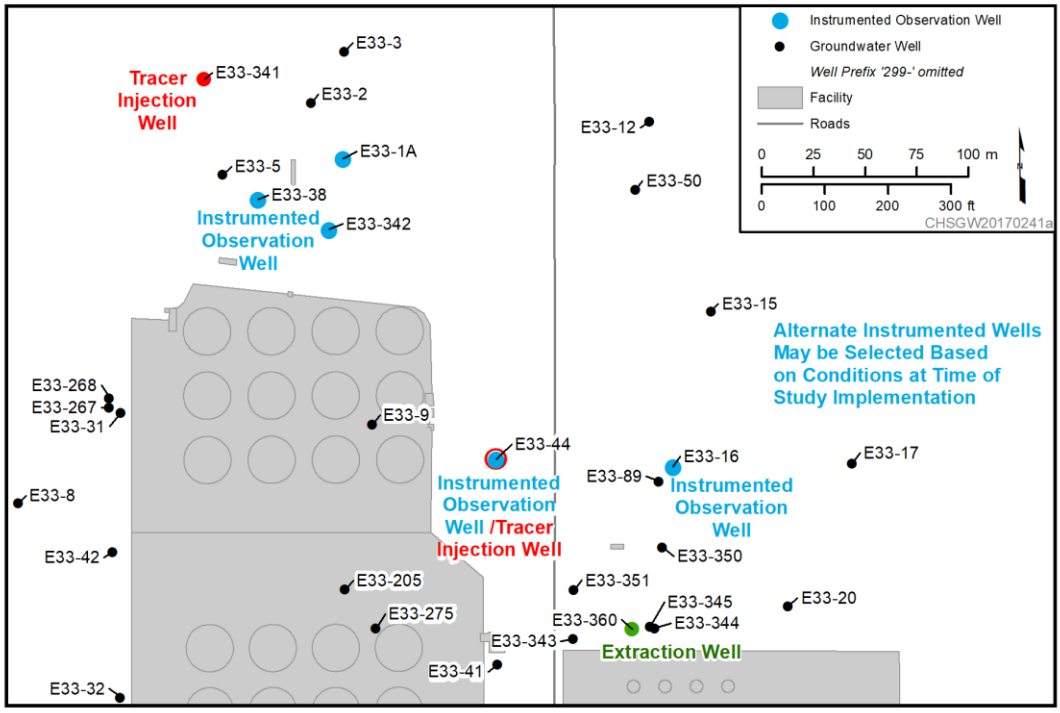


Figure 3-2. Location of Tracer Injection, Tracer Observation, and Extraction Wells in the B Complex Removal Action Area

Table 3-2 lists the radial distances from the injection well and the estimated travel times to each TOW for the two tracer injections based on a capture simulation. In situ monitoring, combined with confirmatory sampling and analysis, will be conducted at the TOWs and the extraction well as described in Sections 3.3 and 3.4.

Table 3-2. Wells Selected for Tracer Injection, Observation, and Groundwater Extraction for Both Study Areas

Well Name	Well Function for Tracer Study	Radial Distance from Injection Well (m [ft])	Estimated Travel Time in Days from Injection Well (Based on Capture Simulation)
200-BP-5 OU – First Injection			
299-E33-341	Tracer injection	0	0
299-E33-38*	Tracer observation	63 [207]	27
299-E33-1A*		77 [253]	33
299-E33-342	Tracer observation	90 [295]	37
299-E33-44		231 [758]	96
299-E33-16		293 [961]	122
299-E33-360	Groundwater extraction	340 [1,115]	147
200-BP-5 OU – Second Injection			
299-E33-44	Tracer injection	0	0
299-E33-360	Groundwater extraction	109	51
200-UP-1 OU			
299-W19-36	Tracer injection	0	0
299-W19-34A	Tracer observation (optional)	39 [128]	128
299-W19-113	Groundwater extraction	55 [180]	180

*These wells may be sampled if they have adequate water in screened/perforated intervals. Well 299-E33-1A is located in an area of subsidence and access is currently restricted. The access issue must be resolved (e.g., site stabilized) prior to sampling.

OU = operable unit

3.1.2 Phase IIb: 200-UP-1 OU

The 200-UP-1 OU groundwater uranium plume remedial action currently uses three extraction wells in the vicinity of U Plant in the 200 West Area. Figure 3-3 shows the current well locations, inferred water table elevation contours, and simulated extraction well capture zone. The estimated groundwater flow velocity in this study area is substantially slower than in the 200-BP-5 OU removal action area in the 200 East Area, reflecting relatively lower aquifer transmissivity. As a result, tracer injection and observation wells must be relatively close to the extraction wells to complete the study within about 1 year of the tracer injection.

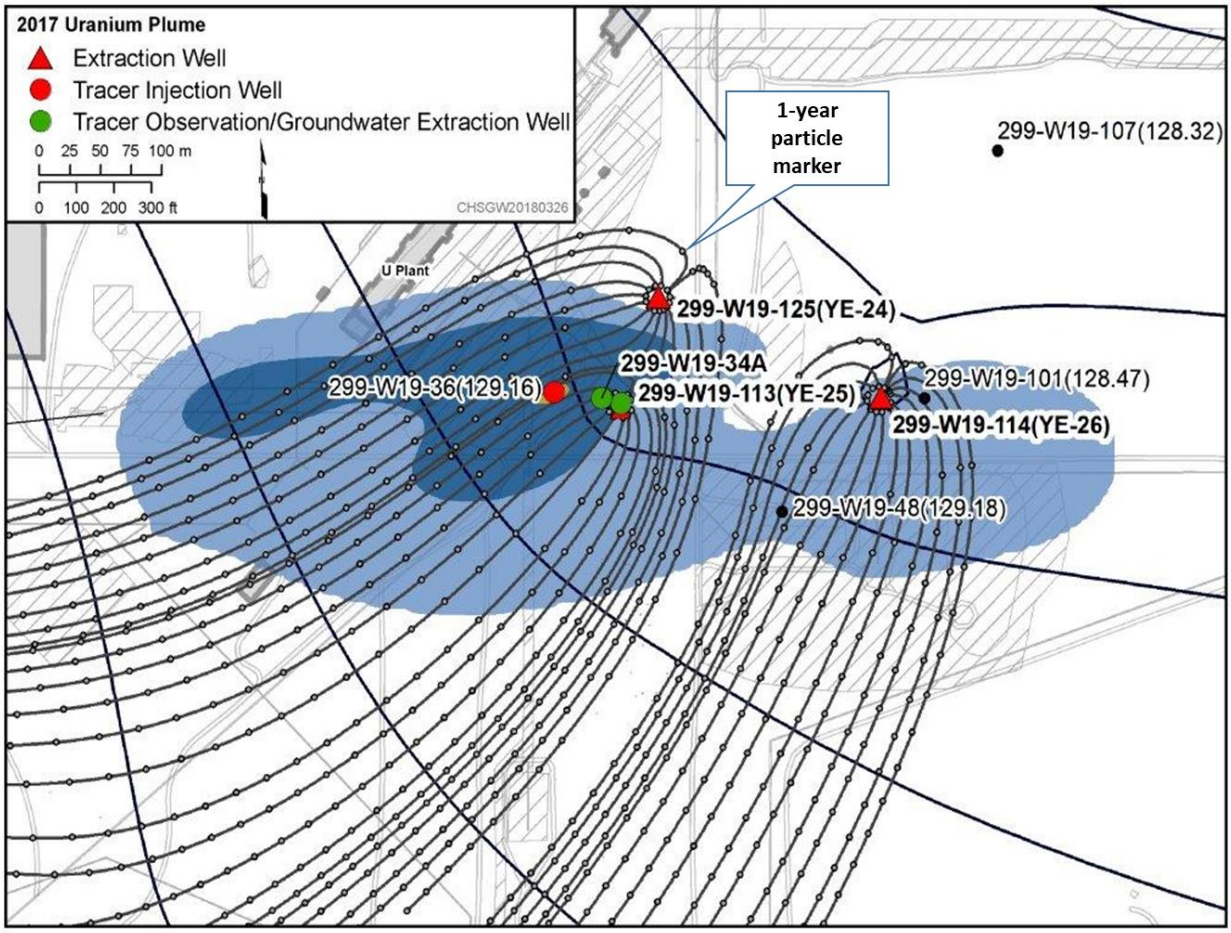


Figure 3-3. 200-UP-1 OU Groundwater Remedial Action Inferred Capture Area and Groundwater Elevation Contours for 2015 (Injection Well = 299-W19-36, Extraction Well = 299-W19-113)

In this location, anticipated travel times between most wells are >1 year, so the selected study wells include an injection well (299-W19-36) near an existing 200 West Area P&T system extraction well (299-W19-113) where the anticipated travel time is 6 months. This extraction well will also serve as the primary observation well. If resources allow, an additional existing well (299-W19-34A) will also be used as a TOW. This latter well is located between the TIW and the extraction well (approximately 39 m [128 ft] east of the TIW) and could be outfitted with an in situ probe. All three wells are screened in the upper portion of the unconfined aquifer. The TIW is about 55 m (180 ft) upgradient and to the west of extraction well 299-W19-113, along a groundwater stream line. A single dose of fluorescein will be added to the TIW in this test. Similar to the Phase IIa test, a combination of in situ monitoring and confirmatory sampling and analysis will be conducted at the TOW and the extraction well.

3.2 Tracer Injections

A single, large-volume injection of fluorescent dye will be made at each of the TIWs as described in Section 3.2.1. This approach has four potential advantages over the alternative approach of injecting a small volume of a highly concentrated solution. First, the tracer solution should not exhibit density flow effects (e.g., sinking and abnormal dispersion) that would likely occur with highly concentrated solutions. For reference, a 40% solution of fluorescein in water has a density of 1.28 g/mL, based on product information from Turner Designs (www.turnerdesigns.com). Second, by introducing a large volume of

dye solution (i.e., creating a broad plume near the injection site), there will be a greater chance of the plume being observed at periphery observation wells. Third, the concentration of the tracer can be tailored to be within or near the upper limit of the working range of the in situ probes as described in Section 3.2.1, resulting in fewer off-scale readings as the dye plume migrates past the observation wells located closer to the injection well. Finally, cleanup of the injection wells and equipment will likely be easier and more complete with more dilute dye solutions. The primary disadvantage of a large-volume injection is the need for a large supply of make-up water and the associated equipment to inject and monitor the solution over hours to days as described below. An additional drawback to this approach is that the dye peaks will be broad and possibly less defined at the observation wells. In spite of these drawbacks, the improved flow dynamics, greater potential for in situ detection at all TOWs, and easier cleanup of test components make a large-volume injection the preferred strategy for meeting the study objectives.

3.2.1 Dye Quantities and Injection Volumes

The quantities of dye and the injection volumes that will be used at each location are listed in Table 3-3. The relatively large volume is intended to produce a broader initial tracer plume that will increase the likelihood of being intercepted by the down gradient observation well(s). Concentration of injected tracer solution will be measured and monitored during the emplacement process. The estimated tracer concentrations were evaluated over a range of values that were determined to fall within the measurement capability of both the in situ monitoring devices and the laboratory measurement techniques. Dye amounts are listed as a range to allow for potential dye attenuation (e.g., sorption of minor quantities onto aquifer sediments). The injection volumes were calculated based on the pore volume of an idealized aquifer cylinder as follows:

$$V = \pi r^2 b\theta \qquad \textbf{(Eq. 3-1)}$$

where:

r = the target plume radius

b = height equivalent to the saturated well screen length (1.8 m [6.0 ft] for well 299-E33-341 and 13.7 m [44.9 ft] for well 299-W19-36)

θ = media porosity (0.2).

For the first injection of Phase IIa, the target plume radius was chosen as halfway between the injection well (299-E33-341) and the nearest of the originally selected observation wells, 299-E33-342. For the second injection of Phase IIa (well 299-E33-44), the target plume radius was calculated to be proportionately smaller (14.4 m) based on the closer distance to the extraction well. For Phase IIb (200-UP-1 OU), there is only one optional observation well between the injection and extraction wells, and the target plume radius for well 299-W19-36 was chosen to be much smaller due to the shorter travel distance and the estimated capture area of the extraction well (299-W19-113).

Table 3-3. Quantities of Dye and Injection Volumes

Well/Tracer	Target Injection Plume Radius (m [ft])	Injection Volume (L [gal])	Injection Solution Concentration (mg/L)	Total Mass of Dye Required (kg [lb])
200-BP-5 OU				
299-E33-341/Fluorescein	45.0 [147.6]	2,328,028 [615,000]	0.500 – 5.00	1.16 – 11.6 [2.5 – 25.5]
299-E33-44/Rhodamine WT	14.4 [47]	237,762 [62,900]	1.00 – 10.0	0.238 – 2.38 [0.60 – 6.0]
200-UP-1 OU				
299-W19-36/Fluorescein	3.05 [10.0]	79,493 [21,100]	0.500 – 2.00	0.039 – 0.160 [0.85 – 0.35]

OU = operable unit

Impacts from the injected volume of dye solution on aquifer flow conditions are expected to be minimal over the study area, particularly for the B Complex area aquifer, which consists of open framework gravels with a high hydraulic conductivity, as discussed in Section 1.2.1. Impacts (e.g., mounding) are expected to be localized in the vicinity of the injection well and short-lived. However, water levels will be tracked during the testing using downhole sensors as discussed in Section 3.3.

3.2.2 Water Supply

Due to the mix of contaminants of concern that are present in groundwater from the study areas, a preferred water source for the dye injection solutions is raw water (i.e., river water) from the Hanford Site's fire-suppression system. For the Phase IIa test (B Complex), the closest source for raw water is approximately 1,400 m (4,593 ft) to the south of the first injection well (299-E33-341) (near the corner of Baltimore Ave. and 7th St.). For the Phase IIb test, fire-suppression water will be used; an active water hydrant is located approximately 250 m (820 ft) west of the injection well. Make-up water for both test locations will be routed from the applicable source to the injection locations using appropriately sized hose or pipe in a temporary installation.

3.2.3 Injection Equipment

A representative schematic of the equipment that will be used to mix and inject the tracer is shown in Figure 3-4. Concentrated dye solution (e.g., up to 40 w/v %), also known as the stock tracer solution, will be procured or prepared and stored in a large carboy that is shielded from light (fluorescein and rhodamine WT decompose when exposed to sunlight). A chemical metering pump will be used to feed the concentrated dye solution into a mixing manifold that will be supplied with makeup water. The manifold will be outfitted with inlet and outlet valves, and in-line flow meters interfaced to data loggers that will be used to monitor the flow rates of the supply water, stock tracer solution, and the output (injection) solution. A sampling valve near the outlet end of the manifold will enable periodic collection of samples to monitor the concentration of the injection solution. Hose or piping of appropriate diameter to handle the flow will be used to route the solution to a length of 5 cm (2 in.) diameter pipe that will be suspended in the injection well. The lower section of the pipe will be perforated with approximately 0.6 cm (0.5 in.) diameter outlet holes over the length corresponding to the screen interval of the injection well, and the bottom end of the pipe will be capped.

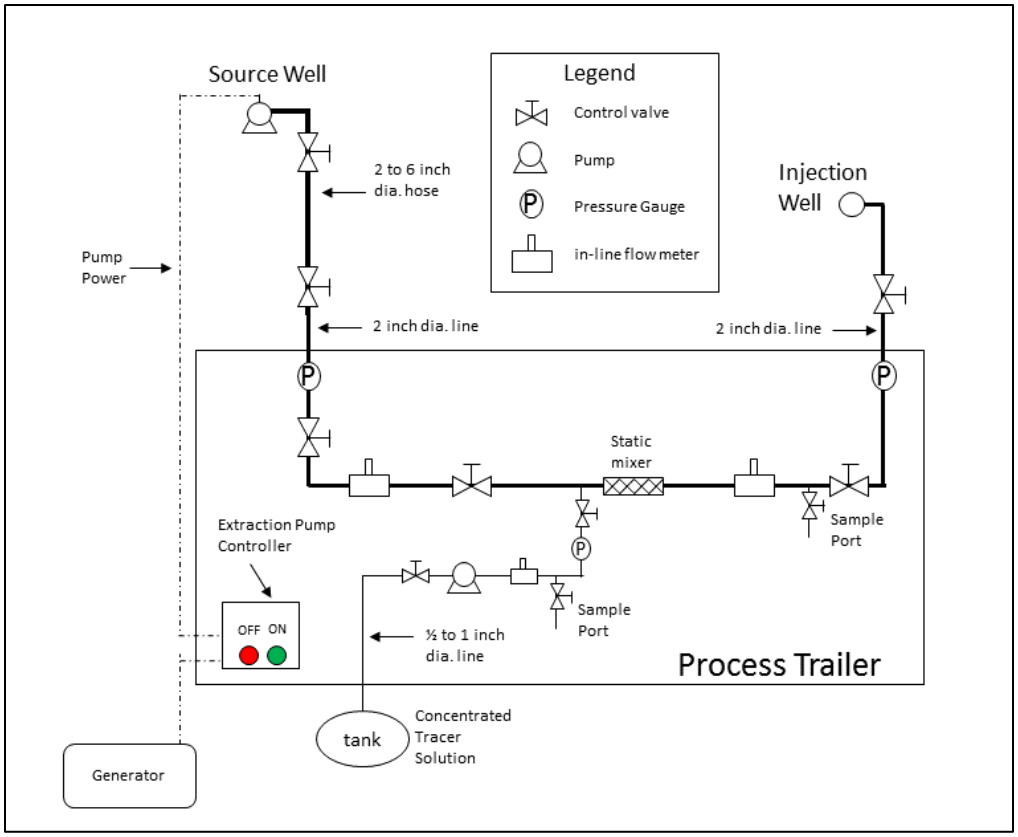


Figure 3-4. Tracer Mixing and Injection System

3.2.4 Injection Rate and Duration

Anticipated injection flow rates are 189 to 379 L/min (50 to 100 gal/min). Previous drawdown and hydraulic test data for the injection wells suggest that the wells should be able to accommodate injection rates in this range. Using the volumes in Table 3-3 and these flow rates, the time required to make the injections for Phase IIa is estimated to range from 4 to 9 days at well 299-E33-341, and 21 to 42 hours at well 299-E33-44, assuming a continuous injection process. For Phase IIb, the corresponding estimated injection time is 4 to 7 hours at 299-W19-36.

3.3 Field Measurements

Field measurements will be made throughout the tests, but some of the monitoring locations and frequencies will change during and after the tracer injections. Table 3-4 lists the parameters, instruments, monitoring locations, and minimum measurement frequencies for the two stages of each test.

Table 3-4. Field Measurements

Parameter	Instrument	Monitoring/Sampling Location	Minimum Frequency
During Injection			
Flow rate	Flow meter	Inlet and outlet of injection manifold, tracer supply line	Every minute
Well water level	Submersible pressure sensor	Injection, observation, and extraction wells	Every hour
Water temperature	Thermistor or thermocouple	Sample valve on mixing manifold	Every 4 hours during daytime work shift
pH	pH electrode		
Fluorescence	Field-portable fluorometer or in situ probe*		
Post-Injection			
Water level	Pressure transducer	Injection, observation, and extraction wells	Every hour
Water temperature	Thermistor or thermocouple	Observation wells	When grab samples are collected
pH	pH electrode		
Fluorescence	In situ probe*		Every hour

*Separate in situ probes are required for fluorescein and rhodamine WT.

3.3.1 During the Injections

During the injections, it will be necessary to continuously monitor the flow rates of the feed dye solution, raw make-up water, and the tracer solution flowing into the well to quantify the volume injected and to help ensure the concentration of tracer is fairly uniform over the entire injection period. The flow meters used for these measurements will be interfaced to data loggers to facilitate frequent automated measurements.

Periodically, samples of the injection solution will be collected near the outlet of the mixing manifold. Samples shall be collected within 30 minutes after initiating each injection and at the following minimum intervals: twice per day during the Phase IIa 1st injection (well 299-E33-341), three times per day during the Phase IIa 2nd injection (well 299-E33-44), and every two hours during the Phase IIb injection (well 299-W19-36). These samples will be analyzed in the field for temperature, pH, and fluorescence. The purpose of the temperature and pH measurements is to enable corrections for slight variations in fluorescence intensity that occur with changes in temperature and pH. These corrections will allow for more accurate comparisons with laboratory measurements made on grab samples. Field fluorescence measurements will be performed with an in situ probe or a field-portable fluorimeter. Since the injection solution will be relatively concentrated, sample dilution may be required prior to analysis. The

approximate concentration of the injection solution will be known based on the concentration of the stock tracer solution and the measured flow rates of the supply water and the stock tracer solution.

Submersible pressure sensors will be installed in the injection, observation, and extraction wells to monitor water levels during the injection and provide head measurements for hydraulic gradient calculations. The sensors will be interfaced with data loggers to provide a detailed record of water levels throughout the test. Manual water-level measurements (i.e., using an e-tape) will also be performed to verify and convert the sensor pressure data into elevation values. Because the hydraulic gradient is very low in this vicinity, the pressure sensors will need to have a full-scale operating range ≤10 psig and an accuracy of at least ±0.1% full scale.

3.3.2 Post Injection

After each injection has been completed, field fluorescence measurements will be performed in the observation wells by in situ probes interfaced to data loggers. The fluorescent probes are designed to detect only one dye, so separate probes will be required for fluorescein and rhodamine WT. For the first injection portion of the Phase IIa test, while awaiting the initial arrival of the tracer at the early-detection observation wells (e.g., 299-E33-38, 299-E33-1A, and 299-E33-342), the sensor's data record will be reviewed and evaluated by field personnel (at least twice per week). Observation of a fluorescence signal that is >5 times the probe's detection limit after accounting for baseline drift will trigger the collection of grab samples (within 3 days) at that location, as described in the next section. When grab samples are collected, the water temperature and pH will be measured in the field. The data records for sensors in the other observation and extraction wells will be reviewed and evaluated at least once every 2 weeks. Detection of tracer at any of these other locations will trigger the weekly collection of grab samples with accompanying water temperature and pH measurements. As noted above, the criterion for detection is a fluorescence signal that is >5 times the probe's detection limit after accounting for baseline drift.
A similar field monitoring and sampling strategy will be followed for the second injection portion of the Phase IIa test and for the Phase IIb test. However, these activities will largely be focused at the associated extraction wells since these test areas include either zero or one optional observation well between the injection and extraction wells. If the optional observation well in the Phase IIb test is outfitted with an in situ probe, the probe's data will be used to trigger the collection of grab samples and the measurement of water temperature and pH as described above.

Water-level measurements will be made in the observation wells coincident with water sample collection until each test has concluded.

3.4 Sampling Methods

Groundwater grab samples will be collected from the observation and extraction wells for quantitative laboratory analyses of the tracer. Charcoal samplers will also be used as an additional detection approach.

Grab samples are discrete groundwater samples that will be collected using dedicated well pumps. In observation wells outfitted with in situ probes, the probes will be vertically positioned near the center of the saturated well screen interval, and the pumps will be set below the probes. Grab samples will be collected using standard Hanford Site groundwater sampling protocols and equipment. Low-flow bladder pumps will be used to collect the groundwater samples in observation wells to minimize impacts on the natural flow field from the sampling process. These pumps typically pump <1 L/min (0.26 gal/min).
A reduced purge volume (nominally one riser pipe volume) will be used to minimize drawing tracer into the well prematurely.

Charcoal samples consist of approximately 4.25 g (0.15 oz) of coarse activated charcoal housed in a 7.6 to 10.1 cm (3 to 4 in.) square porous bag. These charcoal "samplers" will be suspended in the screened

intervals of observation wells for prescribed time periods during which tracer will adsorb onto the charcoal. The samplers will then be collected, shipped to the laboratory, and processed to desorb and analyze the amount of dye that accumulated on the charcoal. Charcoal samplers will be suspended in the observation wells using stainless steel aircraft cable that has been measured and marked with appropriate well screen intervals. Up to three bags will be secured to the cable, each at a different depth interval. If multiple bags are deployed, their depths will span the saturated interval of the well screen. A 0.45 kg (1 lb) stainless steel weight will be attached to the bottom of the cable to make it easier to lower the samplers into the well.

Table 3-5 summarizes the sample types and a proposed sampling schedule for the two Phase II tests. In general, the strategy is to collect grab and charcoal samples during the time period bounded by when the tracer plume is expected to be approaching an observation well (Table 3-4) and when the dye has completely passed by that location. Complete passage of the tracer will be established when either in situ probe measurements return to continuous nondetections for at least 7 days or three consecutive grab sample measurements are nondetected. For Phase IIa, the early-detection observation wells will be sampled weekly beginning 2 weeks after the first tracer injection has been initiated. Sampling will commence at more downgradient locations at later dates based on the estimated arrival time at each well. Initially, these downgradient wells will be sampled at 2-week intervals, but the frequency will increase to weekly when the tracer is expected to arrive at a sampling location within 3 to 4 weeks. This sampling schedule will be adjusted, as appropriate, if the in situ probe measurements indicate the tracer is travelling faster or slower than the rates inferred from the capture simulation. For example, weekly sampling of an observation well will commence as soon as possible if the well's in situ probe detects the tracer ahead of schedule. Once the tracer has been detected by an in situ probe (or is expected to have arrived at a sampling location), weekly sampling will continue until the plume has passed (based on the criteria described above).

Since the charcoal samplers are a backup monitoring approach (i.e., in case the tracer is not detected by in situ probes or grab samples), continued deployment and analysis of charcoal samplers is not required once the tracer has been successfully detected by in situ probes and grab samples.

Table 3-5. Sample Locations, Types, and Frequencies

Well	Sample Type(s) [a]	Estimated Arrival Time (days) [b]	Time of First Sample (Elapsed Days) [c]	Initial Sampling Frequency	Expected Time to Switch to Weekly Sampling (Elapsed Days) [d]
Phase IIa (200-BP-5 OU) – First Injection (injection well 299-E33-341)					
299-E33-38	G, C	27	14	Weekly	—
299-E33-1A		33			
299-E33-342		37			
299-E33-44		96	60	Every 2 weeks	74
299-E33-16		122	90		104
299-E33-360	G	147			118
Phase IIa (200-BP-5 OU) – Second Injection (injection well 299-E33-44)					
299-E33-360	G	51	14	Weekly	—

Table 3-5. Sample Locations, Types, and Frequencies

Well	Sample Type(s) [a]	Estimated Arrival Time (days) [b]	Time of First Sample (Elapsed Days) [c]	Initial Sampling Frequency	Expected Time to Switch to Weekly Sampling (Elapsed Days) [d]
Phase IIb (200-UP-1 OU) (injection well 299-W19-36)					
299-W19-34 A (optional)	G, C	127	71	Every 2 weeks	99
299-W19-113	G	180	90		118

a. G = grab sample, C = charcoal sample.

b. Arrival times were estimated by interpolation using 1-year particle markers along flow lines shown in Figure 3-1 and 3-3.

c. Days after the injection is initiated. For wells with in situ probes, sampling could be triggered earlier if a probe indicates tracer arrival before these times.

d. Weekly monitoring may be instituted earlier based on in situ probe measurements and apparent travel times at upgradient monitoring locations.

OU = operable unit

3.4.1 Decontamination of Sampling Equipment

Where possible, dedicated equipment will be used at each sampling location. Due to the high sensitivity of fluorescence measurements, it will be especially important to avoid using equipment that comes into direct contact with raw injection solutions at downgradient monitoring locations unless the equipment has been thoroughly cleaned.

Special care should be taken to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting the equipment/sample bottle on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events

3.5 Documentation of Field Activities

Logbooks or data forms are required for field activities. A logbook must be identified with a unique project name and number. Only authorized persons may make entries in logbooks. Logbook entries will be reviewed by the FWS, cognizant scientist/engineer, or other responsible manager; the review will be documented with signature and date. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason. Entries will be made in indelible ink. Corrections will be made by marking through the erroneous data with a single line, entering the correct data, and initialing and dating the changes.

Data forms may be used to collect field information; however, the information recorded on data forms must follow the same requirements as those for logbooks. The data forms must be referenced in the logbooks.

A summary of information to be recorded in logbooks is as follows:

- Purpose of activity
- Day, date, time, and weather conditions
- Names, titles, and organizations of personnel present
- Deviations from the QAPjP
- All site activities, including field tests
- Materials quality documentation (e.g., certifications)
- Details of samples collected (e.g., preparation, splits, duplicates, matrix spikes, and blanks)
- Location and types of samples
- Chain-of-custody details and variances relating to chain of custody
- Field measurements
- Field calibrations testing, inspections, maintenance, and surveys, and equipment identification numbers, as applicable
- Equipment decontaminated, number of decontaminations, and variations to decontamination methods
- Equipment failures or breakdowns, and descriptions of any corrective actions
- Telephone calls relating to field activities

3.5.1 Corrective Actions and Deviations from Sampling Activities

The OU Project Manager, Field Technical Support personnel, FWS, and SMR personnel must document deviations from protocols, problems pertaining to sample collection, chain-of-custody forms, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected because of field conditions, changes in sample locations because of physical obstructions, or additions of sample depth(s).

As appropriate, such deviations or problems will be documented in the field logbook or on nonconformance report forms in accordance with internal corrective action methods. The OU Project Manager, Field Technical Support personnel, FWS, or SMR personnel will be responsible for communicating field corrective action requirements and for ensuring immediate corrective actions are applied to field activities.

3.6 Calibration of Field Equipment

Field Technical Support personnel or the FWS are responsible for ensuring that field equipment is calibrated appropriately. Onsite environmental instruments are calibrated in accordance with the manufacturer’s operating instructions, internal work requirements and processes, and/or field instructions that provide direction for equipment calibration or verification of accuracy by analytical methods.

The results from all instrument calibration activities will be recorded in accordance with HASQARD (DOE/RL-96-68).

Field instrumentation, calibration, and QA checks will be performed as follows:

- Prior to initial use of a field analytical measurement system
- At the frequency recommended by the manufacturer or methods
- Upon failure to meet specified QC criteria

3.7 Sample Containers and Handling

Table 3-6 lists the container types and storage requirements for grab and charcoal samples. For grab samples, the use of amber-colored sample containers is necessary because fluorescein and rhodamine WT degrade when exposed to sunlight. Samples shall be stored in the dark (e.g., in a closed cooler or refrigerator). Each charcoal sample shall be sealed in a resealable zipper bag that is sealed inside a second resealable zipper bag and then stored in the dark.

Collected samples will be delivered from the field and shipped to the laboratory (ideally within 24 hours of collection). If necessary, samples stored prior to delivery will be stored in a controlled environment, as required. Sample handling and transfer shall be in accordance with established methods to preclude loss of identity, damage, deterioration, and loss of sample. Custody seals or custody tape shall be used to verify that sample integrity has been maintained during sample transport. The custody seal will be inscribed with the sampler's initials and date.

Table 3-6. Sample Containers and Handling

Sample Type	Container Type	Preservation	Holding Time
Grab sample	250-mL glass amber bottle	Cool 4°C, store in the dark	N/A*
Charcoal sample	Double resealable zipper bags		

*Although maximum recommended holding times have not been established, it is recommended that samples be analyzed within 1 week of collection due to fluorescein's sensitivity to light.

N/A = not applicable

3.7.1 Container Labeling

Each sample container will be labeled with the following information on firmly affixed, water-resistant labels:

- Sample authorization form number
- Sampler's name
- Sample collection date and time
- Sample number
- Chain-of-custody number
- Laboratory performing the analyses

Sample records must include the following information:

- Analysis required
- Matrix (e.g., water or charcoal)
- Sample depth (charcoal samples only)

3.7.2 Sample Custody

Sample custody will be maintained in accordance with existing protocols to ensure the maintenance of sample integrity throughout the analytical process. Chain-of-custody protocols will be followed throughout sample collection, transfer, analysis, and disposal to ensure sample integrity is maintained. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory. Shipping requirements will determine how sample shipping containers are prepared for shipment. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Each time the responsibility changes for the custody of the sample, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and will transmit the copy to the SMR organization within 48 hours of shipping. The following information is required on a completed chain-of-custody form:

- Project name
- Printed name of sampler
- Unique sample number
- Date and time of collection
- Signatures of individuals involved in sample transfer
- Matrix
- Preservative
- Requested analyses
- Date and time of transfer

3.7.3 Sample Transportation

All packaging and transportation instructions shall be in compliance with applicable transportation regulations and DOE requirements. Regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the U.S. Department of Transportation (DOT) as described in 49 CFR 171, "Transportation," "General Information, Regulations, and Definitions," through 49 CFR 177, "Carriage by Public Highway." Carrier-specific requirements defined in the International Air Transportation Association (IATA) *Dangerous Goods Regulations* should also be considered when preparing sample shipments conveyed by air freight providers.

Samples containing hazardous constituents shall be considered hazardous material in transportation and transported according to DOT 49 CFR requirements. If the sample material is known or can be identified, then it shall be packaged, marked, labeled, and shipped according to the specific instructions for that material. Materials are classified by DOT as radioactive when the isotope-specific activity concentration and the exempt consignment limits described in 49 CFR 173, "Transportation," "Shippers—General Requirements for Shipments and Packagings," are exceeded. Samples shall be screened, or relevant historical data shall be used, to determine if these values are exceeded. When screening or historical data

indicate that samples are radioactive, they shall be properly classified, described, packaged, marked, labeled, and transported according to DOT requirements.

Prior to shipping radioactive samples to the laboratory, the organization responsible for shipping shall notify the laboratory of the approximate number and radiological levels of the samples. This notification is conducted through the SMR project coordinator. The laboratory is responsible for ensuring that the applicable license limits are not exceeded. The laboratory shall provide the SMR organization with written acceptance for samples with elevated radioactive contamination or dose.

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4 Management of Waste

Waste generated from sampling activities will be managed in accordance with DOE/RL-2017-64, *Post Remedial Investigation Waste Control Plan and Removal Action Waste Management Plan for the 200-BP-5 Groundwater Operable Unit* and DOE/RL-2016-13, *Waste Management Plan for the 200-UP-1 Groundwater Operable Unit*. The waste control plan establishes the requirements for management and disposal of generated waste. Investigation-derived waste from these sampling activities will be handled as CERCLA waste. Unused samples will be archived for potential later analysis. Laboratory waste will be dispositioned in accordance with the laboratory contract and agreements concerning return to the Hanford Site. In accordance with 40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off-Site Response Actions," approval from the Remedial Project Manager is required before unused samples or wastes are returned from offsite laboratories.

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5 Health and Safety

The hazardous waste operations safety and health program is implemented for employees involved in hazardous waste site activities. The program was developed to comply with the requirements of 29 CFR 1910.120, "Occupational Safety and Health Standards," "Hazardous Waste Operations and Emergency Response," and 10 CFR 835, "Occupational Radiation Protection," to ensure the safety and health of workers during hazardous waste operations.

The health and safety program was developed to define the chemical, radiological, and physical hazards and to specify the controls and requirements for day-to-day work activities on the overall Hanford Site. The program incorporates applicable core functions and guiding principles outlined in the Integrated Safety Management System and governs minimal personal training; control of industrial safety and radiological hazards; personal protective equipment; site control; and general emergency response to spills, fire, accidents, injury, and incident reporting. Workers at the Hanford Site have the right and responsibility to stop work if a threat to human health or the environment is identified or perceived.

Project field staff will be required to comply with the health and safety program at all times. Site visitors must have read the health and safety plan and be escorted by project team personnel before entering the work area. Escorted visitors are briefed on health and safety concerns and must be escorted by the Project Manager (or designee) at all times when they are in the work area.

During operations, emergency response will be covered by the health and safety program. The health and safety program specifies primary emergency response actions for site personnel, area alarms, implementation of the emergency action plan and emergency equipment at the task site, emergency coordinators, emergency response, and spill containment.

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6 References

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title10-vol4/xml/CFR-2010-title10-vol4-part835.xml.

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