INTERIM CHANGE NOTICE (ICN)

A. Document No.: PNNL-13024 **Revision No: 0** **Document Title:** *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site.* **Document's Original Author:** DG Horton and SM Narbutovskih	**Implementation Date of ICN:** 03/30/2007 **Change Requested By:** S. Luttrell

B. Action:
Remove table of contents and summary and replace with the attached. Remove all of Section 4.0 (as modified by previous ICNs) and replace with the attached. Place page with additional references behind Section 5.0 of original document. Remove Appendix D and replace with the attached. Attach this ICN to the front of the document just before the title page.

C. Effect of Change:
This ICN updates the text and tables to include radionuclides and specific sampling frequencies in a standardized format, and removes outdated text (see Section D). An updated table of critical mean values is added. Appendix D was updated to reflect current practices for Quality Assurance Project Plans. Table of contents and summary are revised to reflect the other changes.

D. Reason for Change/Description of Change:

- Update constituents and sampling frequencies in Table 4.1.
- Bring the well/constituent table into the project's standard format.
- Add a critical means table based on data from new upgradient wells.
- Remove outdated information on network evaluation and MEMO model. This information supported installing new wells, which were completed in 2003
- Update other information as needed.
- Remove references to the project's QA plan and subcontractor procedure manual.

E. Document Management Decisions:
The original information release form is unavailable, thus we do not know who approved the original document. For this ICN, Stuart Luttrell and Anne Fix will sign approval.

The attached distribution list shows the current staff who will receive this ICN because it may vary from the distribution list of the original document.

F. Groundwater Monitoring Task Manager Approval Signatures
(Please Sign and Date)

Stuart Luttrell [signature] 3/28/2007

Project Quality Engineer Approval: NJ (Anne) Fix [signature] Date: 03.29.2007

Author Approval: ______ Date: ______

Other Approvals: ______ Date: ______

Summary

This document describes the groundwater monitoring plan for Waste Management Area (WMA) C located in the 200 East Area of the U.S. Department of Energy (DOE) Hanford Site. This plan is required under *Resource Conservation and Recovery Act of 1976* (RCRA). The regulatory requirements can be found in WAC 173-303-400, and by reference, in 40 CFR 265.90 through 265.94. The plan objectives are to document the groundwater monitoring network designed to detect the facility's impact on the quality of groundwater beneath the site. As yet, groundwater monitoring results have not directly indicated that dangerous waste contamination associated with the single-shell tanks (SSTs) in WMA C has reached the aquifer.

The original groundwater monitoring network contained four RCRA-compliant wells used to monitor the uppermost 6 m (20 ft) of the unconfined aquifer with an assumed flow direction of due west. In addition, one pre-RCRA well was included as an upgradient well. The gradient of the water table is nearly flat, which caused ambiguities in the flow direction when based on water levels alone. Direct flow measurements with the colloidal borescope indicate a southwesterly flow direction at the WMA C. Three downgradient wells and one upgradient well were installed in FY 2003 to provide more complete coverage. The addition of these wells completes the monitoring needs at this farm until the water level drops below the screen in the older RCRA wells. When this happens, some of these older wells may either need replacement or require deepening.

Groundwater samples are analyzed semiannually for indicator parameters (pH, specific conductance, total organic carbon, total organic halides) for statistical evaluation required under RCRA. Additional constituents are monitored quarterly: alkalinity, anions, cyanide, and metals. Phenols are analyzed annually as required under RCRA. Selected radionuclides are monitored quarterly to support tank waste retrieval activities and *Atomic Energy Act* monitoring: antimony-125, cesium-137, cobalt-60, gross alpha, gross beta, technetium-99, and uranium. Water levels are measured quarterly.

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4.0 Detection Monitoring Program

The detection monitoring program employed at WMA C was designed to detect the presence of dangerous waste constituents at the point of compliance (downgradient wells). This program currently in use is based on the waste inventory in the tanks and on knowledge of the local hydrogeology. Based on water level data, vertical correction of boreholes and in situ flow measurement, it has been determined that the flow direction is to the southwest.

The detection monitoring plan presented herein contains the:

- Design of the basic interim status RCRA-compliant monitoring well network along with as-built diagrams of both RCRA and non-RCRA groundwater monitoring wells available for monitoring
- Current methods employed to routinely determine rate and direction of flow
- Indicator parameters used to detect the presence of groundwater contamination
- Frequency of groundwater sampling

The following sections discuss monitoring objectives specific to WMA C and describe the current detection monitoring plan. A proposed assessment monitoring plan outline is contained as required in Appendix B and details of local well construction are given in Appendix C. An explanation of the statistical calculations along with the Field Sampling Plan and Quality Assurance Project Plan are provided in Appendix D.

4.1 Objectives

In accordance with 40 CFR 265 by reference of WAC 173-303-400 (3), which describes requirements for a detection monitoring program, the general objectives of the WMA C groundwater monitoring plan are to:

- Monitor to detect indicator parameters, hazardous waste constituents, and reaction products that provide a reliable indication of the presence of dangerous constituents in the uppermost aquifer underlying WMA C. This includes the SSTs, diversion boxes, and the 244-CR Vault.
- Operate a groundwater monitoring system at the compliance point, i.e., at the downgradient wells, to detect dangerous waste constituents that may degrade groundwater quality. Provide evidence of leaks occurring at or near the surface to allow mitigation of groundwater pollution from WMA C.

- Monitor selected radionuclides[1] for the objectives of tank waste retrieval (e.g., RPP-22393) and the *Atomic Energy Act*, and to facilitate source delineation of dangerous waste constituents, if detected.

- Collect groundwater samples at the optimal time interval specifically determined for WMA C to detect dangerous waste constituents and/or indicator parameters to facilitate early detection.

The manner in which these general goals are achieved at WMA C is, to some extent, dependent on the site characteristics. For example, WMA C is not surrounded by operating facilities or past-practice, liquid waste, or disposal facilities as are the other tank farms in the 200 East Area. The 216-C-8 french drain is southeast of the WMA C, but there is little potential that waste from this facility could impact the groundwater under WMA C.

Although there are a few operating and past-practice facilities adjacent to WMA C, there are regional plumes beneath the WMA that must be differentiated from waste originating from WMA C. Since the RCRA groundwater-monitoring plan is designed to identify wastes emanating from WMA C, the upgradient monitoring wells are used to identify dangerous waste constituents entering the groundwater outside the area.

4.2 Groundwater Monitoring Plan

This section describes the interim-status groundwater-monitoring network and sampling parameters. It was designed in accordance with RCRA, as presented in 40 CFR 265, Subpart F.

4.2.1 Monitoring Network

The present groundwater-monitoring network consists of eight RCRA standard wells and one older carbon-steel well (Figure 1.2). Two are upgradient, five are downgradient, and two are cross-gradient (Table 4.1). As can be seen from Figure 1.2, all of the downgradient monitoring wells in the WMA C network are close to the WMA boundary.

Eight of the nine wells (all except 299-E27-7) meet requirements for resource protection wells under WAC 173-160, *Minimum Standards for Construction and Maintenance of Wells*. A 4-in. (10-cm) inner diameter, stainless steel casing was set to within about 5 ft (1.5 m) above the water table. The wells are equipped with 10-slot, stainless steel screens. Screens are 20 ft (6.1 m) long in the wells installed in 1989 and ~35 ft (10.7 m) long in the wells installed in 2003. The longer screens are designed to lengthen the lives of the wells as the water table declines. The open portion of the screen in the unsaturated zone provided for any rises in groundwater over time.

[1] Groundwater monitoring objectives of RCRA, CERCLA, and the AEA often differ slightly and the contaminants monitored are not always the same. For RCRA regulated units, monitoring focuses on nonradioactive dangerous waste constituents. Radionuclides (source, special nuclear and by-product materials) may be monitored in some RCRA unit wells to support objectives of monitoring under the AEA and/or CERCLA. Please note that pursuant to RCRA, the source, special nuclear and by-product material component of radioactive mixed waste are not regulated under RCRA and are regulated by DOE acting pursuant to its AEA authority. Therefore, while this report may be used to satisfy RCRA reporting requirements, the inclusion of information on radionuclides in such a context is for information only and may not be used to create conditions or other restrictions set forth in any RCRA permit.

Table 4.1. Wells, Constituents, and Sampling Frequency for WMA C

Well ID	Well Name	Completion Date	Purpose	WAC Compliant	Indicator Parameters				Site-Specific and Supporting Parameters									
					pH[(a)]	Specific Conductance[(a)]	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions[(b)]	Cyanide	Gamma[(c)]	Gross alpha/beta	Metals , filtered[(d)]	Phenols	Technetuim-99	Uranium	Water Level[(e)]
C4125	299-E27-4	2003	Downgradient	C	Q4	Q4	S4	S4	Q	Q	Q	Q	Q	Q	A	Q	Q	--
A4816	299-E27-7	1982	Upgradient	N	Q4	Q4	S4	S4	Q	Q	Q	Q	Q	Q	A	Q	Q	Q
A4810	299-E27-12	1989	Cross-gradient	C	Q4	Q4	S4	S4	Q	Q	Q	Q	Q	Q	A	Q	Q	Q
A4811	299-E27-13	1989	Downgradient	C	Q4	Q4	S4	S4	Q	Q	Q	Q	Q	Q	A	Q	Q	Q
A4812	299-E27-14	1989	Downgradient	C	Q4	Q4	S4	S4	Q	Q	Q	Q	Q	Q	A	Q	Q	Q
A4813	299-E27-15	1989	Cross-gradient	C	Q4	Q4	S4	S4	Q	Q	Q	Q	Q	Q	A	Q	Q	Q
C4127	299-E27-21	2003	Downgradient	C	Q4	Q4	S4	S4	Q	Q	Q	Q	Q	Q	A	Q	Q	--
C4124	299-E27-22	2003	Upgradient	C	Q4	Q4	S4	S4	Q	Q	Q	Q	Q	Q	A	Q	Q	--
C4190	299-E27-23	2003	Downgradient	C	Q4	Q4	S4	S4	Q	Q	Q	Q	Q	Q	A	Q	Q	--

(a) Field measurement.
(b) Anions include but not limited to chloride, nitrate, nitrite, and sulfate.
(c) Gamma scan includes but not limited to antimony-125, cesium-137, and cobalt-60.
(d) Metals include but not limited to calcium, chromium, iron, potassium, magnesium, manganese, and sodium.
(e) Water levels are measured in all wells before sampling. Additional, quarterly measurements made in wells indicated.
A = Annually.
C = Well is constructed as a WAC 173-160 resource protection well.
N = Well constructed before requirements of WAC 173-160 applied.
Q = Quarterly
S = Semiannually
4 = Quadruplicate samples.

Silica sand pack was placed above and around the screens. An annular seal of bentonite was put above the silica sand to within 18 to 20 ft (5.2 to 6.1 m) below the ground surface. Surface casing was set and sealed with cement above the bentonite seal up to ground level. The wells were finished with a cement pad and 4 posts for well protection. The annular seals assure that no vertical contaminant moves along the outside of the casing. Dedicated pumps are installed in each well. The wells are capped and locked when not in use.

Well 299-E27-7 was completed in 1982. The well has a 40 ft (12 m) long, 6 in. (15 cm) stainless steel screen with a 5 ft (1.2 m) section of blank casing welded to the top. A 6 in. (15 cm) carbon steel casing extends from 240 ft (73 m) depth to 1.3 ft (0.4 m) above ground surface. There is also an 8 in. (20 cm) stainless steel casing from 150 ft (46 m) depth to ground surface. The 8 in. (20 cm) casing is perforated from 150 to 25 ft (46 to 6.1 m) below ground surface. The space between the two casings is filled with cement grout, as is the space outside. Details concerning well construction, well location, surveyed elevation, total depth, and general lithology for all the wells in the WMA C monitoring network are given in Appendix C.

Screened intervals below the water table ranged from 6 to 45 ft (1.8 to 13.6 m) in length, based on water levels measured in late 2006. The shortest saturated intervals are in the four wells installed in 1989. The current rate of water-level decline is ~7 cm/year (PNNL-16346).

4.2.2 Groundwater Flow Determination

Quarterly water-level measurements are made separately from the sampling events in five of the wells. These water-level measurements are made over a short time period to eliminate daily earth tide effects and to reduce barometric effects caused by changing atmospheric pressure.

The current water table is nearly flat throughout the 200 East Area. The low gradient is primarily due to the high aquifer permeability in the 200 East Area compared to upgradient regions to the west where permeability is considerably less. As evidenced by the large tritium plume from waste disposed to the PUREX cribs, the effective flow from the southeast corner of the 200 East Area is to the east and southeast.

When considering the flow for sites with small areas such as WMA C, knowledge of the local flow is required to ensure proper placement of downgradient wells with respect to the waste storage units and ancillary equipment. The objective of interim detection monitoring is not to discern where contamination is moving across the Hanford Site but to discern if waste from the WMA is entering the groundwater. Consequently, the regional flow directions and plume trends, as evidenced over miles, can be misleading when determining the local flow across a site that is only 500 ft wide (152 m).

Across the 200 East Area, the differences in water elevation between wells are small, on the order of a few inches. The combined errors from water level measurements, survey elevations and borehole deviations from vertical are enough to cause uncertainties in local flow direction anywhere in the 200 East Area. As reported in Hartman et al. (2000), water-level data alone are insufficient to determine flow direction in this area. Direct flow measurements using a colloidal borescope were made in four wells at WMA C to help determine flow direction. The direction of flow at WMA C appears to be southwest.

4.2.3 Groundwater Sampling Parameters

It is required under 40 CFR 265.94(a)(2) and WAC 173-313-400 that indicator parameters (i.e., pH, conductivity, total organic carbon, total organic halogen) be monitored to provide a reliable indication of the presence of dangerous constituents in groundwater. The site-specific constituents for WMA C were determined based on:

- types and concentrations of waste constituents in the stored wastes
- mobility, stability, and persistence of waste constituents in the unsaturated zone beneath WMA C
- detectability of waste constituents in the groundwater
- concentrations or values of the monitoring parameters or constituents in the groundwater background chemistry
- supporting parameters that aid interpretation (e.g., general chemistry)

Groundwater sampling parameters for WMA C are presented in Table 4.1. The sampling and analysis plan (SAP), consisting of the field sampling plan (FSP) and the quality assurance project plan (QAPP), are provided in Appendix D.

The analysis for anions captures the values for nitrate, nitrite, sulfate, and chloride, which are the main mobile anionic species found in these tanks. The metals analysis provides, at a minimum, sodium, calcium, iron, chromium, and potassium, the main mobile cations found in tank waste. Alkalinity and magnesium are included because they are useful (along with the other major ions) in charge balance calculations to check data quality. The organics listed in tank waste with the greatest concentrations are glycolate, DBP, EDTA, HEDTA, and butanol. The analysis for total organic carbon is performed in quadruplicates as an indicator of these organics. Cyanide is included in the constituent list because it was in the waste streams routed to 241-C Tank Farm that resulted from in-tank scavenging conducted in the 244-CR vault. The pH, conductivity, total organic carbon and total organic halides are indicator parameters required by regulations. Phenols, which are not significant constituents of tank waste, will be analyzed annually as required by 40 CFR 265.93(b).

Radionuclides are excluded from regulation under RCRA. However, as discussed above, this plan includes selected radionuclides for the objectives of tank waste retrieval (e.g., RPP-22393) and the *Atomic Energy Act*, and to facilitate source delineation of dangerous waste constituents, if detected. Analyses include technetium-99, total uranium, and gamma scan (which includes antimony-125, cesium-137, and cobalt-60).

According to 40 CFR 265.92, and by reference WAC 173-303-400(3), the owner/operator of an interim-status hazardous waste facility must establish initial background concentrations for the contamination indicator parameters of pH, conductivity, total organic carbon, and total organic halogens. Background values for WMA C were determined first in 1992 and updated as needed to reflect current site conditions. The averaged replicate t-test is the statistical method used to determine whether significant differences occur in the concentration of indicator parameters from downgradient wells compared to the background concentrations from upgradient wells.

Details of the statistical method are given in Appendix D. A table of critical mean values and related information is presented in Table 4.2 in conformance with 40 CFR Part 265, Subpart F. Critical mean values may be updated annually and published in annual groundwater monitoring reports (e.g., PNNL-16346). Limits of quantitation for total organic carbon and total organic halides are calculated quarterly, based on results of analyses of quality control blank samples.

Table 4.2. Critical Means for Waste Management Area C For FY 2007 Comparisons[(a)]

Constituent, units	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	11	10	4.8087	605.8	66.8	941	941
Field pH	11	10	5.2810	8.12	0.143	[7.34, 8.91]	[7.34, 8.91]
Total organic carbon[(b)], µg/L	8	7	5.7282	667.2	298.4	2,480	2,480[(c)]
Total organic halides[(b)], µg/L	7[(d)]	6	6.3510	8.98	4.75	41.2	41.2[(c)]

(a) Based on quarterly/semiannual sampling events from December 2004 to June 2006 for upgradient wells 299-E27-22 and 299-E27-7. Critical mean values may be revised annually. Statistical evaluations will be conducted semi-annually during the quarters where samples for total organic carbon and total organic halides are collected and analyzed.
(b) For values reported below laboratory's specified method detection limit, one half of the method detection limit is used in the critical means calculation.
(c) Upgradient/downgradient value is the larger of the calculated critical mean or the limit of quantitation (updated quarterly).
(d) Excluded suspected values on samples collected in June 2005.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 28 comparisons.

4.2.4 Data Management, Interpretation, and Reporting

The manner in which the data are received, handled, and stored is described in this section along with information pertaining to data interpretation and reporting of the project results to DOE/RL and Washington State Department of Ecology.

The contract laboratories provide analytical results in written reports and digital media. The results are then loaded into the Hanford Environmental Information System (HEIS) database. Field-measured parameters such as field conductivity, pH, temperature, and turbidity are entered manually or through electronic transfer from the sampling staff. Data from HEIS can be downloaded to smaller databases, such spreadsheets for easier handling and manipulation. The printed analytical data reports and original field records are the official record copies (equivalent, approved, electronic records may be used in place of printed copies). If questions arise concerning the validity of a data value, the official record copies are used for initial verification.

The data undergo a validation/verification process according to documented procedures. As periodic reviews of the data are completed, a copy of each review is kept in project files. Beginning with FY 1996, the annual groundwater monitoring report contains a digital disk of all chemical and water-level data collected for the year (Hartman 1999).

Once the laboratory data are available on HEIS, a qualitative check is performed to assure that data are reasonable with respect to historic trends for each specific constituent of concern. If changes occur from one sampling interval to the next that are unusual, trend comparisons may be made with an appropriate co-contaminant to verify the change. If the value continues to appear anomalous, the results are returned to the laboratory for further checking and possible reanalysis.

After data are validated and verified, the accepted data are used to interpret groundwater conditions at the site. Interpretive techniques include but are not limited to:

- hydrographs: the water elevations are plotted versus time to determine fluctuations in groundwater levels and any changes in flow direction.

- water-table maps: normally water-table elevations are mapped from multiple wells to construct contour maps to estimate flow directions. Groundwater flow is assumed to be perpendicular to lines of equal potential for the local region proximal to a WMA.

- surface trend analysis: flow direction can be estimated by fitting the water elevations for the same day from three or more wells to a planer surface and calculating the direction of the maximum gradient.

- flow rate determination: estimates of saturated hydraulic conductivity, porosity, and water table gradients are used to estimate flow rates.

- in situ direct flow rate/direction measurements: data from the colloidal borescope may allow direct observation of flow direction with a better understanding of relative flow rates.

- historic trend plots: concentrations and activities of chemical and/or radiological constituents are plotted versus time to determine increases, decreases, and fluctuations in groundwater chemistry. These plots may be used in tandem with hydrographs and/or water-table maps to determine if concentrations relate to changes in water-level or in groundwater flow directions.

- plume maps: distributions of chemical concentrations or radiological activities are mapped across the local WMA to determine the extent of contamination. Changes in plume distribution where noticeable movement occurs over time aid in determining movement of plumes and the direction of flow.

- contaminant ratios are used to distinguish between different sources of contamination.

- conductivity and charge balances are used to check the quality of anionic data.

A summary of the reporting requirements for compliance with 40 CFR 265, Subpart F are listed in Table 4.3.

Occasionally, circumstances such as field conditions or equipment malfunctions may cause a sampling event to be missed. Broken bottles or scheduling errors may lead to missed analyses. This type of omission will be reported to Ecology via the routine quarterly reports. Sampling events that are delayed beyond the end of the scheduling quarter also will be listed in quarterly reports.

Table 4.3. Reports Required for Compliance with 40 CFR 265, Subpart F, for Groundwater Monitoring

Submittal	Submittal Period	Reporting Vehicle	Regulatory Requirement
First year of sampling: concentrations of interim primary drinking water constituents, identifying those that exceed limits	Quarterly	Complete[a]	40 CFR 265.94(a)(2)(i)
Concentration and statistical analyses of groundwater contamination indicator parameters, noting significant differences in upgradient wells	Annually, by March 1 of following year	Annual groundwater monitoring report (e.g., Hartman 1999)	40 CFR 265.94(a)(2)(ii)
Results of groundwater surface elevation evaluation and description of response if appropriate	Annually, by March 1 of following year	Annual groundwater monitoring report (e.g., Hartman 1999)	40 CFR 265.94(a)(2)(iii)
Outline for groundwater quality assessment program	Within one year after effective date of regulations	Appendix B of this document	40 CFR 265.93(a)
Notification of statistical exceedance[b]	Within 7 days of verification	Letter to Ecology	40 CFR 265.93(c)
Assessment Plan[b]	Within 15 days of notification	Plan submitted to Ecology	40 CFR 265.93(d)
Determinations under assessment program[b]	As soon as technically feasible; annually thereafter	Report, letter, or annual groundwater monitoring report	40 CFR 265.93(d)(5) and 265.94(b)

(a) Requirement was fulfilled during first year of sampling via published reports. Quarterly submittal of data continues via HEIS.
(b) Required if exceedance occurs and is verified.

5.0 References

(The following references were added to support the revised Section 4.0 of ICN-5.)

PNNL-16346. 2007. *Hanford Site Groundwater Monitoring for Fiscal Year 2006*. MJ Hartman, LF Morasch, and WD Webber (eds.), Pacific Northwest National Laboratory, Richland, Washington.

Martinez CR. 2003. *Calendar Year 2003 RCRA Groundwater Monitoring Well Summary Report*. WMP-18472, Fluor Hanford, Inc., Richland, Washington.

RPP-22393, Rev. 2B. 2005. *241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan*. JS Schofield, CH2M HILL Hanford Group, Inc., Richland, Washington.

Williams BA and SM Narbutovskih. 2004. *Borehole Data Package for Four CY 2003 RCRA Wells 299-E27-4, 299-E27-21, 299-E27-22, and 299-E27-23 at Single-Shell Tank, Waste Management Area C, Hanford Site, Washington*. PNNL-14656, Pacific Northwest National Laboratory, Richland, Washington.

Appendix D

Sampling and Analysis Plan

This appendix consists of a description of the statistical method used for data evaluation, the field sampling plan (FSP), and the quality assurance project plan (QAPP). The t-test required to calculate the critical means in Table 4.2 is provided. The FSP specifies the procedures guiding sample and field data collection. The QAPP includes the procedures and project management controls intended to ensure the analyzed data and associated measurement errors meet the quantitative and qualitative needs of the groundwater monitoring program at WMA C. Together the FSP and QAPP form the Sampling and Analysis Plan (SAP). The SAP is used as a principal controlling document for conducting the work identified in Section 4.2.3.

D.1 Statistical Methods

The goal of RCRA detection monitoring is to determine if WMA C has affected groundwater quality. This is determined based on the results of a statistical test. According to 40 CFR 265.92 (and by reference of WAC 173-303-400[3]) the owner/operator of an interim-status hazardous waste facility must establish initial background concentrations for the contamination indicator parameters: specific conductance, pH, total organic carbon, and total organic halogen. This has been done for WMA C by obtaining at least four replicate measurements for each parameter from each well quarterly for one year. Data from the upgradient wells were used to determine the background arithmetic mean and variance.

Monitoring data collected after the first year are compared with the background data to determine if there is an indication that contamination may have occurred. A t-test is required to make this determination (40 CFR 265.93[b]). A recommended method is the averaged replicate t-test method described in Appendix B of the *RCRA Groundwater Monitoring Technical Enforcement Guidance Document* (OSWER 9950.1). The averaged replicate t-test method for each contamination indicator parameter is calculated as:

$$t = \left(\bar{x}_i - \bar{x}_b\right) / S_b * \sqrt{1 + 1/n_b} \qquad \text{(D.1)}$$

Where
$t =$ test statistic
$\bar{x}_i =$ average of replicates from the ith monitoring well
$\bar{x}_b =$ background average
$S_b =$ background standard deviation
$n_b =$ number of background replicate averages.

A test statistic larger than the Bonferroni critical value, tc, (i.e., $t > t_c$) indicates a statistically significant probability of contamination. These Bonferroni critical values depend on the overall false positive rate required for each sampling period (i.e., 1% for interim status), the total number of wells in the monitoring network, and the number of degrees of freedom (n_b - 1) associated with the background standard deviation. Because of the nature of the test statistic in the above equation, results to be compared to background do not contribute to the estimate of the variance. The test can be reformulated, without prior knowledge of the results of the sample to be compared to background (i.e., $\bar{x}_i$), in such a way that a critical mean, CM, can be obtained:

$$CM = \bar{x}_b + t_c * S_b * \sqrt{(1+1/n_b)} \quad \text{(D.2)}$$

$$CM = \bar{x}_b \pm t_c * S_b * \sqrt{(1+1/n_b)} \quad \text{(D.3)}$$

If downgradient data exceed the CM, they are determined to be statistically different from background. For pH, a two-tailed CM (or critical range; equation D.3) is calculated and downgradient data beyond the range are considered to be statistically different from background. If a statistical exceedance is detected, the well will be resampled to determine if the originally detected increase (or pH decrease) was a result of laboratory or measurement error (verification sampling). If verification sampling confirms the exceedance, the owner/operator must notify Ecology within 7 days and submit a groundwater quality assessment plan within 15 days following the notification (40 CFR 265.93[d]). The goal of the assessment monitoring program is to determine if dangerous waste or dangerous waste constituents from the facility have entered the groundwater and, if so, to determine their concentration and the rate and extent of migration in groundwater (40 CFR 265.93[d]). Critical mean values for WMA C are presented in Table 4.2 in Section 4.2.

D.2 Field Sampling Plan

Groundwater monitoring follows a quality assurance plan that meets *Requirements for Quality Assurance Project Plans,* EPA/240/B-01/003 (EPA QA/R-5, March 2001, as revised). The work follows documented procedures for sample collection and chain-of-custody.

Field personnel measure water levels in each well before sampling, and then purge stagnant water from the well. Samples generally are collected after three casing volumes of water have been purged from the well or after field parameters (pH, temperature, specific conductance, and turbidity) have stabilized (i.e., after two consecutive measurements are within 0.2 units pH, 0.2°C for temperature, 10% for specific conductance, and turbidity <5 nephelometric turbidity units [NTUs]). If a well is purged to dryness, it is allowed to recover and then sampled.

In most cases, field parameters are measured in a flow-through chamber. When circumstances make a flow-through chamber impractical, samplers measure field parameters in an open container.

Unless the site-specific monitoring plan directs otherwise, samples for metals analyses are filtered in the field with 0.45 micrometer, in-line, disposable filters to ensure results represent dissolved metals and do not include particulates (40 CFR 136.3).[1]

Deviations from standard sampling procedures are allowed when circumstances warrant. For instance, some wells have large volumes of water in the casing and would require excessive time to purge three casing volumes. In that case, the wells are generally purged for one hour and until field parameters

[1]Note to Table 1B, note 4 states "…Dissolved metals are defined as those constituents which will pass through a 0.45 micron membrane filter."

stabilize. A number of wells are subject to high turbidity so the <5 NTU requirement cannot be met. The samples for additional constituents from those wells may be filtered at the direction of scientific staff. Deviations from standard sampling procedures are documented on field records.

Sample preservation techniques will follow EPA approved procedures (e.g., SW-846, Table 11-1). For routine groundwater samples from monitoring wells, preservatives are added to the collection bottles, if necessary, before their use in the field. A chemical preservative label is affixed to the sample container listing the specific preservative. The preservative's brand name, lot number, concentration, and date opened are recorded. A calibrated dispenser or pipette is used to dispense preservatives. Appropriate measures are taken to eliminate any potential for cross contamination.

Sample packaging and transfer/shipping are done in accordance with documented procedures. Samples are labeled and sealed with evidence tape, wrapped with bubble wrap, and placed in a Department of Transportation approved container with coolant, if required. Hazardous samples have packaging parameters determined by associated hazards. Samples for offsite laboratories are shipped according to Department of Transportation regulations. A chain of custody form accompanies all samples.

Groundwater samplers use chain-of-custody forms to document the integrity of groundwater samples from the time of collection through data reporting. The forms are generated during scheduling and managed through a documented procedure. Samplers enter required information on the forms, for example:

- Sampler's name
- Method of shipment and destination
- Collection date and time
- Sample identification numbers
- Analysis methods
- Preservation methods

When samples are transferred from one custodian to another (e.g., from sampler to shipper or shipper to analytical laboratory), the receiving custodian inspects the form and samples and notes any deficiencies. Each transfer of custody is documented by the printed names and signatures of the custodian relinquishing the samples and the custodian receiving the samples, and the time and date of transfer.

Procedures for measuring water levels were developed in accordance with the techniques described in American Society for Testing and Materials (1988), Garber and Koopman (1968), OSWER 9950.1, and U.S. Geological Survey (1977). Water levels are measured primarily with laminated steel electrical sounding tapes, although graduated steel tapes are used occasionally.

Water levels are measured before each well is sampled, unless that is impossible (e.g., no access for steel tape; use as a pumping well). Additional measurements are made quarterly in selected wells for WMA C.

D.3 Quality Assurance Project Plan

The quality assurance program employed for this project meets the requirements specified in Article XXXI of the *Tri-Party Agreement*. It is based on the quality assurance requirements of *EPA Requirements for Quality Assurance Project Plans*, EPA/240/B-01/003 (EPA QA/R-5, March 2001, as revised), DOE Order 414.1C, *Quality Assurance*, and 10 CFR 830, Subpart A, "Quality Assurance Requirements." Additional requirements applicable to the quality assurance of the sampling and analysis are described in the *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD, DOE/RL-96-68). The level of QA/QC for the collection, preservation, transportation, and analysis of each sample shall be dependent upon the data quality objectives for the sample.

If work is subcontracted, quality control requirements are discussed in a statement of work with the subcontractor. The subcontractor's quality assurance protocols also will meet *EPA Requirements for Quality Assurance Project Plans*, EPA/240/B-01/003 (EPA QA/R-5, March 2001, as revised). The quality control program is designed to assess and enhance the reliability and validity of groundwater data. This is accomplished through evaluating the results of quality control samples, conducting audits, and validating groundwater data. The quality control practices are based on EPA guidance cited in the *Tri-Party Agreement Action Plan* (Ecology et al. 1989, Section 6.5, as revised). Accuracy, precision, and detection are the primary parameters used to assess data quality (Mitchell et al. 1985). Data for these parameters are obtained from two categories of quality control samples: those that provide checks on field and laboratory activities (field quality control) and those that monitor laboratory performance (laboratory quality control).

D.3.1 Analytical Methods

Instruments for field measurements (e.g., pH, specific conductance, temperature, and turbidity) are calibrated using standard solutions before use and are operated according to the manufacturer's instructions. Each instrument is assigned a unique number that is tracked on field and calibration documentation.

Laboratory analytical methods are specified in contracts with the laboratories and are standard methods from *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA/SW-846, 1986 as revised) or *Methods for Chemical Analysis of Water and Wastes* (EPA-600/4-79-020, 1979, as revised). Radiological parameters are analyzed by EPA or laboratory-specific methods.

D.3.2 Quality Control

Limits for precision and accuracy for chemical analyses are based on criteria stipulated in the methods (e.g., EPA/SW-846, EPA 600 series). Method detection limits as low as one third the EPA drinking water standards are preferred, but not always achievable.

Quality control data are evaluated based on established acceptance criteria for each quality control sample type, as discussed in the quality control plan and summarized here. For field and method blanks, the acceptance limit is generally two times the instrument detection limit (metals), or method detection limit (other chemical parameters). However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, and phthalate esters, the limit is five times the method detection limit. Groundwater samples that are associated (i.e., collected on the same date and analyzed by the same method) with out-of-limit field blanks are flagged with a “Q” in the Hanford Environmental Information System (HEIS 1994) database to indicate a potential contamination problem.

Field duplicates must agree within 20%, as measured by the relative percent difference, to be acceptable. Only those field duplicates with at least one result greater than five times the appropriate detection limit are evaluated. Unacceptable field duplicate results are flagged with a “Q” in the database.

The acceptance criteria for laboratory duplicates, matrix spikes, matrix spike duplicates, surrogates, and laboratory control samples generally are derived from historical data at the laboratories in accordance with *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA/SW-846, 1986 as revised).

D.4 References

10 CFR 830.120. “Quality Assurance Requirements.” *U.S. Code of Federal Regulations*.

40 CFR 136.3. “Guidelines Establishing Test Procedures for the Analysis of Pollutants.” *U.S. Code of Federal Regulations*.

40 CFR 265. “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment Storage and Disposal Facilities.” *U.S. Code of Federal Regulations.*

DOE Order 414.1C. “Quality Assurance.” U.S. Department of Energy, Washington, D.C.

DOE/RL-96-68. 1996, as revised. *Hanford Analytical Services Quality Assurance Requirements Documents*. HASQARD, Volumes 1 through 4, U.S. Department of Energy, Richland, Washington.

Ecology – Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy. 1989. *Hanford Federal Facility Agreement and Consent Order*. Document No. 89-10, as amended (The Tri-Party Agreement), Olympia, Washington.

EPA/240/B-01/003 (QA/R-5). March 2001, as revised. *EPA Requirements for Quality Assurance Project Plans.* U.S. Environmental Protection Agency, Washington, D.C. Available online at http://www.epa.gov/QUALITY/qs-docs/r5-final.pdf

EPA. 1986, as revised. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, Third Edition*. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA-600/4-79-020. 1979. *Methods for Chemical Analysis of Water and Wastes*. U.S. Environmental Protection Agency, Washington, D.C.

HEIS. 1994. *Hanford Environmental Information System*. Environmental Information Systems Department, Fluor Hanford, Inc., Richland, Washington.

Mitchell, WJ, RC Rhodes, and FF McElroy. 1985. “Determination of Measurement Data Quality and Establishment of Achievable Goals for Environmental Measurements.” *Quality Assurance for Environmental Measurements*, ASTM STP 867.

OSWER-9950.1. 1986. *Resource Conservation and Recovery Act (RCRA) Groundwater Monitoring Technical Enforcement Guidance Document*. U.S. Environmental Protection Agency, Washington, D.C.

Resource Conservation and Recovery Act. 1976. Public Law 94-580, as amended, 90 Stat. 2795, 42 USC 6901 et seq.

WAC 173-303. "Dangerous Waste Regulations." *Washington Administrative Code*, Olympia, Washington (as amended).

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