Appendix B

Quality Assurance and Quality Control

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Appendix B

Quality Assurance and Quality Control

This appendix presents fiscal year 1999 quality assurance/quality control (QA/QC) information for long-term and interim action groundwater monitoring at the Hanford Site. The phrase "long-term monitoring" refers to monitoring performed to meet the requirements of the *Resource Conservation and Recovery Act of 1976* (RCRA) and the *Atomic Energy Act of 1954*. Long-term monitoring also includes monitoring performed at *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) sites with no groundwater remediation. Pacific Northwest National Laboratory (PNNL) manages long-term monitoring via the Hanford Groundwater Monitoring Project (groundwater project). Interim action monitoring encompasses monitoring at sites with active groundwater remediation under CERCLA. Bechtel Hanford, Inc. manages interim action groundwater monitoring.

The QA/QC practices used by the groundwater project assess and enhance the reliability and validity of field and laboratory measurements conducted to support these programs. Accuracy, precision, and detection are the primary parameters used to assess data quality (Mitchell et al. 1985). Representativeness, completeness, and comparability may also be evaluated for overall quality. These parameters are evaluated through laboratory QC checks (e.g., matrix spikes, laboratory blanks), replicate sampling and analysis, analysis of blind standards and blanks, and interlaboratory comparisons. Acceptance criteria have been established for each of these parameters. When a parameter is outside the criteria, corrective actions are taken to prevent a future occurrence.

The QA/QC practices for RCRA samples are based on guidance from the U.S. Environmental Protection Agency (EPA) (OSWER-9950.1; SW-846). U.S. Department of Energy (DOE) orders and internal requirements provide the guidance for the collection and analysis of samples for long-term monitoring. The QA/QC practices for the groundwater project are described in the project-specific QA plan. Guidance for interim action monitoring QA/QC practices is provided in project-specific documents (e.g., DOE/RL-88-36; DOE/RL-90-08; DOE/RL-90-21; DOE/RL-91-46; DOE/RL-91-53; Section 1.5 in DOE/RL-92-03; DOE/RL-96-07; DOE/RL-96-90, Draft A).

A glossary of QA/QC terms is provided in PNNL-13080.

B.1 Sample Collection and Analysis

C. J. Thompson

B.1.1 Sample Collection

Waste Management Federal Services, Inc., Northwest Operations conducted groundwater sampling for fiscal year 1999. Their tasks included bottle preparation, sample set coordination, field measurements, sample collection, sample shipping, well pumping, and coordination of purgewater containment and disposal. Waste Management's statement of work defines quality requirements for sampling activities. Groundwater project staff review all sampling procedures before the procedures are implemented.

B.1.2 Sample Analysis

Quanterra Incorporated, St. Louis, Missouri (Quanterra, St. Louis) performed most routine analyses of hazardous and non-hazardous chemicals for the groundwater project. Recra Environmental, Inc.,

Lionville, Pennsylvania (Recra) served as the project's secondary laboratory for chemical analyses of split samples and blind standards. In contrast, Recra performed the majority of chemical analyses for interim action groundwater monitoring. Quanterra, St. Louis also analyzed samples from sites with active groundwater remediation.

Quanterra Incorporated, Richland, Washington (Quanterra, Richland) served as the primary radiological laboratory for the groundwater project. Thermo NUtech, Richmond, California also performed radiological analyses on long-term monitoring samples. The roles of these laboratories were reversed for interim action groundwater monitoring (i.e., Thermo NUtech served as the primary laboratory, while Quanterra, Richland was used as a backup laboratory).

B.2 Field Quality Control Samples

C. J. Thompson, R. W. Weiss

Field QC samples include field duplicates and three types of field blanks. Field duplicates are used to assess sampling and measurement precision, while field blanks provide an overall measure of contamination introduced during the sampling and analysis process.

B.2.1 Long-Term Monitoring (Hanford Groundwater Monitoring Project)

The groundwater project considers analytical results of field QC samples acceptable if the following evaluation criteria are met:

- field duplicates – Results of field duplicates must have precision within 20%, as measured by the relative percent difference. Only those field duplicates with at least one result greater than five times the method detection limit or minimum detectable activity are evaluated.
- field blanks – Three kinds of blanks are used to check for contamination that may result from field activities and/or bottle preparation: full trip, field transfer, and equipment blanks. For most chemical constituents, results above two times the method detection limit are identified as suspected contamination. However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the limit is five times the method detection limit. For radiological data, blank results are flagged if they are greater than two times the total propagated analytical uncertainty.

If a field blank does not meet the established criteria, it is assumed that there are potential problems with the data for all associated samples. For full-trip and field-transfer blanks, an associated sample is one that was collected on the same day and analyzed by the same method as a full-trip or field-transfer blank. For equipment blanks, an associated sample is one that has all of the following in common with an equipment blank:

- collection date
- collection method/sampling equipment
- analysis method.

Data associated with out-of-limit field blanks are flagged with a Q in the database to indicate a potential contamination problem. A Q is also applied to both duplicate results when their precision exceeds the QC limits.

The percentages of acceptable field blank (92%) and duplicate (98%) results evaluated in fiscal year 1999 were very high, indicating little problem with contamination and good precision overall. Tables B.1 through B.4 summarize the field blank and field duplicate results that exceeded QC limits. To assist with their evaluation, the tables are divided into the following categories, where applicable: general chemical parameters, ammonia and anions, metals, volatile organic compounds, semivolatile organic compounds, and radiological parameters. Constituents not listed in the tables had 100% acceptable field blanks and/or field duplicates.

With the exception of semivolatile organic compounds, all classes of constituents had results that were

flagged as potentially contaminated because of out-of-limit field blank results. Generally, the out-of-limit blank results were less than five times the method detection limit (i.e., below quantifiable limits). However, the majority of the flagged blank results for volatile organics were more than five times greater than the method detection limits, resulting in quantifiable contamination of 2-butanone, carbon disulfide, carbon tetrachloride, chloroform, methylene chloride, and tetrahydrofuran. In general, these compounds had low frequencies of detection (i.e., less than 10%) in field blanks, and the impact on the data is minor. Chloroform and methylene chloride had relatively high percentages of unacceptable field-transfer blanks results (25% and 41%, respectively). Chloroform may have been present in the water used to prepare the field blanks because of incomplete removal by the water-purification system. Methylene chloride is a common laboratory contaminant that was also detected at similar concentrations in several laboratory method blanks. Thus, laboratory contamination is the suspected source of the methylene chloride.

Near the end of fiscal year 1998 and early in fiscal year 1999, PNNL staff observed that the field blank results for total organic carbon were slightly higher than had been observed previously. Twenty-seven percent of the fiscal year 1999 field blank results for total organic carbon were out of limits, though none of the results exceeded the method detection limit by more than a factor of four. Based on this finding, it was postulated that the elevated results were caused by degraded performance of the water-purification system used to prepare reagent water for the field blanks. To test this hypothesis, seven replicate samples of certified, organic-free water, along with seven samples of water from the sampler's water-purification system, were collected throughout the second quarter of fiscal year 1999 and submitted in blind fashion to Quanterra, St. Louis. The samplers also collected additional samples by filling sample bottles with the certified water at the site where full-trip blanks are normally prepared. The purpose of these latter samples was to determine whether field blanks were being contaminated as a result of conditions at the preparation site. The results from this study were somewhat inconclusive, because the total organic carbon values for each sample type were highly variable and the laboratory changed total organic carbon analyzers approximately midway through the study. However, the data suggest that the water from the water-purification system was not significantly different from the certified, organic-free water. Although the cause of the elevated readings has not been discovered, total organic carbon concentrations in field blanks from the latter half of the year were ~15% lower than values from the first half. Moreover, the number of field blanks with detectable total organic carbon dropped from 65% in the first half of the year to 37% in the second half.

Equipment-blank and full-trip blank results were similar. This suggests that the use of non-dedicated sampling equipment at some wells did not have a significant impact on data quality. However, equipment blanks had higher percentages of out-of-limit results than full-trip blanks for anions and most metals.

The chemical class with the greatest number of out-of-limit field blank results was metals. Most of the unacceptable results were within a factor of two of the QC limits. Many of the out-of-limit values were probably false detections, resulting from the use of the instrument detection limit as a reporting limit for metals. Instrument detection limits do not take into account sample-matrix effects, which can have a negative impact on analyte detection.

Duplicate results were flagged for oil and grease, seven metals, six volatile organic compounds, and two radiological parameters. Overall, the total number of flagged duplicate results was very low, but the percentages of unacceptable results were high for several metals and volatile organic compounds based on the number of duplicates that met the evaluation criteria. Most of the out-of-limit duplicate results appear to be anomalous instances of poor precision based on other QC indicators such as the results from the blind standards and laboratory duplicates (discussed in Sections B.4.2 and B.4.3). In several cases, the laboratory was asked to reanalyze or investigate duplicate results with a very

high relative percent difference, but the checks did not reveal the source of the problem. Especially poor agreement was observed between one or more pairs of results for the following: 25,900 and 2,380 µg/L oil and grease; non-detection and 11.7 µg/L copper; 2,150 and 5,880 µg/L; 1,010 and 350 µg/L iron; and non-detection and 2 µg/L; 0.2 and 4 µg/L chloroform. Mislabeled samples or procedural deviations at the laboratory may have caused the unmatched results.

B.2.2 Interim Action Monitoring

Trained staff collected samples in accordance with approved procedures. Field QC samples were collected and evaluated according to site-specific requirements (e.g., BHI-00038, Rev. 2; DOE/RL-90-08; DOE/RL-91-03; DOE/RL-91-46; DOE/RL-92-76; DOE/RL-96-07; DOE/RL-96-90, Draft A; DOE/RL-97-36, Rev. 2). In general, field QC samples consisted of field duplicates, splits, equipment blanks, and trip blanks. Field QC data are evaluated as necessary to make decisions that may modify or terminate a remedial action. In fiscal year 1999, no evaluations were necessary for decision-making purposes.

Field QC data were examined to monitor laboratory operations and to identify potential problem areas where improvements were necessary. Evaluation criteria were essentially the same as those used for the groundwater project, with the following exceptions:

- The 20% relative percent difference criterion for field duplicate and split sample results was relaxed for sample analytical results near (i.e., typically within five times) the method detection limits.
- Bechtel Hanford, Inc. sent no blind standards as part of interim action monitoring to the commercial laboratories in fiscal year 1999. The great similarity of matrices between the long-term and interim action monitoring samples and common use of the same laboratories make additional analysis of blind standards redundant.

For field blank samples, ~84% of all results were returned as non-detected. Greater than 80% of the reported detected blank results were common metals (e.g., calcium, iron, manganese, sodium) measured by the inductively coupled plasma method (ICP) at levels close to analysis procedure detection limits. All detected organic constituents (i.e., ~10% of all reported detected results) were common laboratory contaminants seen at very low levels (1 to 4 µg/L). Minimal radioactive contamination was reported, and the results for all detected constituents except tritium were very near analysis detection limits. Two of seven tritium results were above detection limits (values of ~600 and 6,000 pCi/L). Tritium is a known contaminant in some water sources used for preparation of blanks. However, the elevated result of 6,000 pCi/L was probably the result of a swapped sample. Evaluation of other field blank sample results shows no evidence of unexpected or excessive contamination of blanks in the field or by the laboratory. The constituents and levels of contamination found should have no impact on decision making for interim action monitoring. No changes were noted from evaluation of the previous year's blank samples.

Field duplicate and split results showed ~8.5% exceeding the criteria used for evaluation. It should be noted that the criteria used are likely more restrictive than necessary because they are based on similar criteria for laboratory replicate evaluation (i.e., analysis of multiple aliquots from the same sample container by the same laboratory in the same analytical batch). Over one-half of the high relative percent difference results were from iron and vanadium analyses performed by the commercial laboratories. Poor agreement was noted for iron in both interlaboratory and intralaboratory comparisons. Most of the comparisons are at low levels (less than 50 µg/L), and all of the greater concentration samples were on unfiltered samples. Unfiltered samples would be expected to show greater variability because of suspended solids. The vanadium differences were all intralaboratory split samples and were manifested in all but one sample. All results reported were less than 30 µg/L, but in every case, results reported by Quanterra, St. Louis were greater than the split laboratory (Recra). Slightly different analytical technology is being used by the

commercial laboratories (i.e., traditional ICP spectroscopy at Quanterra, St. Louis versus super trace [low detection limits] ICP at Recra). If vanadium analysis at low concentrations becomes of interest, the differences between analytical technology should be investigated. The other differences between the laboratories appear to be essentially random (i.e., the high or low laboratories often switch places for the same analysis on different samples), with the following exception: field volatile organic analysis consistently showed slightly higher results than reported by the commercial laboratories. Most of the results met the criteria, and it would be expected that field analysis, typically performed much closer to the time of sampling, show less loss of volatile components.

Overall evaluation indicates no significant issues between procedures and analyses performed by the laboratories providing services to Bechtel Hanford, Inc. The overall performance for fiscal year 1999 appeared essentially unchanged from the previous year.

B.3 Holding Times

D. S. Sklarew

Holding time is the elapsed time period between sample collection and analysis. Samples should be analyzed within recommended holding times to minimize the possibility of changes in constituent concentrations caused by volatilization, decomposition, or other chemical changes. Samples are also refrigerated to slow potential chemical reactions within the sample matrix. Maximum recommended holding times for constituents frequently analyzed for the groundwater project are listed in Table B.5. Radiological constituents do not have recommended maximum holding times because these constituents do not typically change chemically under ambient temperatures when appropriate preservatives are used. Results of radionuclide analysis are corrected for decay from sampling date to analysis date.

Of the 4,065 non-radiological samples analyzed by Quanterra, St. Louis in fiscal year 1999 for the groundwater project, holding times were exceeded for 137 samples (3%). The constituents with the most missed holding times were 136 phenols, 118 anions, 37 alkalinity, 25 total dissolved solids, 16 total organic halides, 12 coliform, and 11 total organic carbon. This information was discussed with Quanterra, St. Louis to help the laboratory identify areas where improvements are needed. Recra did not exceed holding times for any of the samples that they analyzed for the groundwater project.

Specific evaluation of adherence to analytical holding times for interim action monitoring was not performed for this report. Analytical holding times are monitored as part of ongoing sample and data management activities throughout the year. No remediation decisions were affected by missed holding times in fiscal year 1999.

B.4 Laboratory Performance

D. S. Sklarew, D. L. Stewart, C. J. Thompson

Laboratory performance is measured by several indicators, including nationally based performance evaluation studies, double-blind standard analyses, laboratory audits, and internal laboratory QA/QC programs. This section provides a detailed discussion of the performance indicators for Quanterra, St. Louis and Richland. Brief summaries of performance measures for Recra and Thermo NUtech are also presented throughout this section.

B.4.1 Nationally Based Performance Evaluation Studies

During fiscal year 1999, EPA, Environmental Resources Associates, and DOE conducted nationally based studies to evaluate laboratory performance for chemical and radiological constituents. Quanterra, St. Louis and Recra participated in the EPA's Water Pollution and Water Supply Performance Evaluation Studies, which ended in December 1998. Environmental Resource Associates is currently conducting similar, EPA sanctioned water pollution and water

supply studies. Although fewer laboratories are participating, both Quanterra, St. Louis and Recra are among the participants. Quanterra, Richland and Thermo NUtech take part in DOE's Quality Assessment Program and EPA's National Exposure Research Laboratory Performance Evaluation Studies. The latter study ended in December 1998. Quanterra, Richland participates in the Environmental Resource Associates' InterLaB RadCheM Proficiency Testing Program, which has replaced the National Exposure Research Laboratory studies. All four laboratories take part in DOE's Mixed Analyte Performance Evaluation Program. Results of those studies related to groundwater monitoring at the Hanford Site are described in this section.

B.4.1.1 Water Pollution and Water Supply Studies

The purpose of water pollution and water supply studies is to evaluate the performance of laboratories in analyzing selected organic and inorganic compounds. Every month, standard water samples are distributed as blind standards to participating laboratories. These samples contain specific organic and inorganic analytes at concentrations unknown to the participating laboratories. After analysis, the laboratories submit results to the study's sponsor (i.e., EPA or Environmental Resources Associates). The sponsor uses regression equations to determine acceptance and warning limits for the study participants. The results of these studies, expressed in this report as a percentage of the results that EPA or Environmental Resources Associates found acceptable, independently verify the level of laboratory performance.

For the four studies in which Quanterra, St. Louis participated this year (WS030, WS035, WP040, WP050), the percentage of acceptable results ranged from 84% to 94% (Table B.6). Of the 30 constituents with unacceptable results, 7 were out of limits twice and 1 was out of limits 3 times. This discussion focuses on the results for the eight constituents that were out of limits more than once. Orthophosphate results were unacceptable in both water supply studies and one water pollution study; the latter was caused by a reporting error. The method required by the EPA for orthophosphate (i.e., Method 365.1, EPA-600/4-79-020, a colorimetric method) is not routinely used for analysis of Hanford Site groundwater samples, which are analyzed by an ion chromatography method. Because the two methods are very different, the unacceptable results should have no effect on the interpretation of data for Hanford Site samples. Alkalinity and Aroclor 1016 were unacceptable in two cases because of reporting errors. Mercury and two volatile organics were unacceptable because of analyst errors. Hardness results were probably unacceptable in one case because the sample was not freshly prepared for analysis and slight evaporation may have caused the high bias. The cause of the second unacceptable hardness result is not known. No reason has been found for the unacceptable kjeldahl nitrogen results; however, no kjeldahl nitrogen determinations were performed on Hanford Site groundwater samples during fiscal year 1999. The other 22 constituents were within limits three out of four times; thus, Quanterra, St. Louis has shown that it can achieve acceptable results for these constituents.

Recra participated in four water pollution and water supply studies this year, WS030, WS035, WP040, and WP048. The percentage of Recra's acceptable results ranged from 90% to 95% (Table B.7). Of the 26 constituents with unacceptable results, 4 were out of limits twice. Total organic carbon was unacceptable in one of the two cases because of a sample preparation error. Recra found no obvious causes for the two unacceptable results for dichlorodifluoromethane, pentachlorophenol, and 1,1-dichloroethylene.

B.4.1.2 DOE Quality Assessment and Mixed Analyte Performance Evaluation Programs

DOE's Quality Assessment Program evaluates how laboratories perform when they analyze radionuclides in water, air filter, soil, and vegetation samples. This discussion considers only water samples. The program is coordinated by the Environmental Measurements Laboratory (EML) in New York. EML provides blind

standards that contain specific amounts of one or more radionuclides to participating laboratories. Constituents analyzed can include americium-241, cesium-137, cobalt-60, gross alpha, gross beta, iron-55, manganese-54, nickel-63, plutonium-238, plutonium-239, strontium-90, tritium, uranium-234, uranium-238, and total uranium. After sample analysis, each participating laboratory forwards the results to EML for comparison with known values and with results from other laboratories. EML evaluates the accuracy of the results based on the historical analytical capabilities for the individual analyte/matrix pairs. Using a cumulative normalized distribution, acceptable performance yields results between the 15th and 85th percentiles. Acceptable with warning results are between the 5th and 15th percentile and between the 85th and 95th percentile. Not acceptable results include the outer 10% (less than 5th percentile or more than 95th percentile) of historical data (EML-600, EML-604).

For the two studies conducted this year, QAP49 and QAP50 (EML-600 and EML-604), the percentages of Quanterra, Richland's acceptable results were 100% and 92%, respectively (Table B.8). Uranium-238 was the only constituent that had a result that was not acceptable. However, one constituent (7%) in the first study and five constituents (38%) in the second study had results that were evaluated as acceptable with warning (Table B.8).

The percentages of Thermo NUtech's results that were acceptable for the two studies were 80% and 100%, respectively (Table B.9). Constituents with unacceptable results in the first study were cesium-137, cobalt-60, and manganese-54. Gross alpha results were acceptable with warning in this study.

DOE's Mixed Analyte Performance Evaluation Program examines laboratory performance in the analysis of soil and water samples containing metals, volatile and semivolatile organic compounds, and radionuclides. This report considers only water samples. The program is conducted at the Radiological and Environmental Sciences Laboratory in Idaho Falls, Idaho, and is similar in operation to DOE's Quality Assessment Program discussed above. DOE evaluates the accuracy of the Mixed Analyte Performance Evaluation Program results for radiological and inorganic samples by determining if they fall within a 30% bias of the reference value.

All fiscal year 1999 results (MAPEP-98-W6) for Quanterra, Richland and St. Louis were acceptable (Table B.8). All results for Thermo NUtech were also acceptable, but plutonium-239/240 was acceptable with warning. Two results (8%) were not acceptable for Recra: acenaphthylene and 2,6-dinitrotoluene (see Table B.9).

B.4.1.3 National Exposure Research Laboratory and InterLaB RadCheM Proficiency Testing Program Studies

As of January 1, 1999, the InterLaB RadCheM Proficiency Testing Program study, conducted by the Environmental Resources Associates, replaced the EPA's National Exposure Research Laboratory performance evaluation studies, which were conducted at the National Exposure Research Laboratory, Las Vegas, Nevada. Thus, fiscal year 1999 samples were evaluated under either the EPA or the Environmental Resource Associates program. The purpose of the studies was and is to evaluate the performance of laboratories in analyzing selected radionuclides. Both programs provide blind standards that contain specific amounts of one or more radionuclides in a water matrix to participating laboratories. National Exposure Research Laboratory standards and Environmental Resources Associates standards were prepared for the following radionuclides/parameters: barium-133, cesium-134, cesium-137, cobalt-60, gross alpha, gross beta, radium-226, radium-228, strontium-89, strontium-90, tritium, uranium, and zinc-65. In addition, National Exposure Research Laboratory standards were prepared for iodine-131 and plutonium. After sample analysis, the results were forwarded to EPA or Environmental Resources Associates for comparison with known values and with results from other laboratories. EPA evaluated the accuracy of the results by determining if they fell within ±3 standard deviations of the mean of all

results reported in the intercomparison study (EPA-600/4-81-004). Environmental Resources Associates bases its control limits on the EPA's National Standards for Water Proficiency Testing Studies Criteria Document (NERL-Ci-0045).

All National Exposure Research Laboratory results submitted by Quanterra Richland this year (see Table B.8) were acceptable (95%) with the exception of cesium-134 in one study. However, cesium-134 was below the control limit for 43% of the laboratories reporting for this study. All Environmental Resources Associates results from Quanterra, Richland except one set of data for natural uranium, were within the control limits (94%). Four constituents (24%) in the Environmental Resources Associates study had results that were evaluated as acceptable with warning (see Table B.8).

All National Exposure Research Laboratory results from Thermo NUtech this year were acceptable see Table B.9). Thermo NUtech does not participate in the Environmental Resources Associates program.

B.4.2 Double-Blind Standard Evaluation

The groundwater project forwarded blind QC standards to Quanterra, Richland and St. Louis, Recra, and Thermo NUtech during fiscal year 1999. Blind spiked standards were generally prepared in triplicate and submitted to the laboratories to check the accuracy and precision of analyses. For most constituents, the standards were prepared in a groundwater matrix from a background well. Cyanide standards and one set of volatile organic compound standards in the first quarter of fiscal year 1999 were prepared in organic free, deionized water. In all cases, the standards were submitted to the laboratories in double-blind fashion (i.e., the standards were disguised as regular groundwater samples).

Tables B.10 and B.11 list the number and types of blind standards along with the control limits used in fiscal year 1999. Overall, 84% of the blind spike determinations were acceptable. For Quanterra, 90% of the results were within the control limits, which represents an improvement over fiscal year 1998 (i.e., 80% were within limits in fiscal year 1998). This improvement is significant, considering that the fiscal year 1999 blind standard program was more focused on those constituents that have had poor results in the past. Fiscal year 1999 was the first year that the groundwater project submitted a complete set of blind standards to Recra and Thermo NUtech. This was done to provide performance information for the project's secondary laboratories.

Quanterra's blind standard results are listed in more detail in Table B.12. One or more results were unacceptably high for gross alpha, gross beta, plutonium-239, total organic carbon, and tritium. Similarly, one or more results were biased low for carbon tetrachloride, cyanide, total organic halides, trichloroethylene, and tritium. Three constituents, carbon tetrachloride, plutonium-239, and trichloroethylene, were out of limits only once; the anomalous results appear to reflect isolated instances of poor analytical precision. Two tritium results were out-of-limits. One was a non-detection result for a standard that had allegedly been spiked at 211,600 pCi/L. Since a re-analysis of the standard confirmed the original result, it is believed that the sample was either mislabeled or was not spiked with tritium. Quanterra, St. Louis' most problematic constituents were gross alpha, gross beta, total organic carbon, and total organic halides. Results for these constituents are discussed below.

Three of sixteen of Quanterra, St. Louis total organic carbon results were out of limits, but most of the total organic carbon results were biased high. The out-of-limit results were from the third and fourth quarters of the fiscal year, and the out-of-limit recoveries ranged from 127% to 133%. The laboratory performed data rechecks on the results and reanalyses on the samples but was unable to identify a reason for the discrepancies. Unlike other blind standard constituents, all of the total organic carbon standards were prepared at concentrations near the laboratory's practical quantitation limit (1,000 μg/L), so a small percentage of out-of-limit results is not unexpected. In the future, the groundwater project will continue to closely monitor Quanterra's performance for this important analysis.

An additional backup laboratory for total organic carbon will also be evaluated if necessary.

Half of Quanterra's total organic halide results were out of limits for the standards that were spiked with volatile organic compounds. Individual out-of-limit recoveries for these standards ranged from 55% to 71%. The groundwater project performed in-house analyses on splits of the standards and confirmed that the standards were spiked at the proper concentrations. Because all of the results for the 2,4,6-trichlorophenol standards were acceptable, the reason for the low bias appears to be volatilization or weak retention of the volatile analytes on the charcoal cartridges used in the analysis. The laboratory investigated the out-of-limit results but was unable to determine the source of error. Low-biased total organic halide results are of concern because of the potential for not detecting halogenated organics at RCRA sites. However, even with a 50% negative bias, detection should occur at concentrations well below the limit of quantitation (discussed in Section B.5).

Quanterra's gross alpha results were acceptable for all but the third quarter. Similarly, all of the gross beta results were within limits except for the second quarter results. For both parameters, the blind standards may have been spiked incorrectly. Splits of the beta standards had similar results at Thermo NUtech, while reanalysis of the gross alpha standards by Quanterra, Richland confirmed two out of three of the results. In general, the results for both parameters exhibited relatively poor precision, but the average results tended to be close to the expected concentrations.

Table B.13 provides a detailed summary of Recra and Thermo NUtech's blind standard results. Seventy-one percent of the results for these laboratories were within control limits, representing good performance overall. However, several high-biased results were reported for total organic carbon, total organic halides, and gross beta. In addition, the labs had two or more unacceptably low results for cyanide and iodine-129. Cyanide results were consistently low for Recra and Quanterra, St. Louis; the problem is believed to be associated with the standards because both laboratories have had acceptable water supply and water pollution performance-evaluation results for cyanide. The low iodine-129 results were non-detections that were caused by an error at the laboratory. Subsequent iodine-129 standards in the second quarter were spiked at lower concentrations, and all of Thermo NUtech's results were acceptable. Recra's total organic halide results were acceptable, except for the third quarter results that were biased high, and one of the fourth quarter results that was a non-detection. The reasons for these abnormal results are unknown. All of Recra's total organic carbon results were biased high and two-thirds were out of limits. Recra re-analyzed all of the standards with unacceptable results; the re-analysis results were also out of limits. Due to the large number of out-of-limit results, the groundwater project does not plan to submit additional samples to Recra for total organic carbon analyses. Finally, half of Thermo NUtech's gross beta results were unacceptably high. The second quarter results are believed to be high because of incorrectly spiked standards, but the high bias in the first quarter results appears to be a laboratory problem. Quanterra, Richland analyzed splits of the standards and achieved acceptable results.

B.4.3 Laboratory Internal QA/QC Programs

Quanterra, Richland and St. Louis, Thermo NUtech, and Recra maintain internal QA/QC programs that generate data on analytical performance by analyzing method blanks, laboratory control samples, matrix spikes and matrix spike duplicates, matrix duplicates, and surrogates (see PNNL-13080 for definitions of these terms). An assessment of the laboratory QC data for fiscal year 1999 is summarized in this section. Quanterra data are discussed in detail first and presented in Tables B.14 through B.17. Constituents not listed in these tables did not exceed Quanterra's QC limits. A brief summary of Recra and Thermo NUtech data is presented at the end of the section.

Evaluation of results for method blanks was based on the frequency of detection above the blank QC

limits. In general, these limits are two times the method detection limit or instrument detection limit for chemical constituents and two times the total propagated error for radiological components. For common laboratory contaminants such as 2-butanone, acetone, methylene chloride, phthalate esters, and toluene, the QC limit is five times the method detection limit. Table B.14 summarizes Quanterra's method blank results. The general chemical parameters, ammonia and anions, and metals categories had the greatest percentage of method blank results exceeding the QC limits. For the general chemical parameters, only specific conductance showed high method blank results, with 100% above the method detection limit. These high method blanks for conductance do not appear to be a significant problem because 94% of groundwater samples have conductance values that are at least 100 times higher than the highest blank value. For ammonia and anions, only chloride had greater than 10% of the method blanks outside the QC limits. The highest method blank for chloride was 0.194 mg/L, or 2.8 times the QC limit. For metals, the laboratory's instrument detection limits for Method 6010 (the ICP method SW-846) are believed to be unrealistically low, which resulted in the large number of method blanks that exceeded the limits for this method. For volatile organic compounds, only acetone and methylene chloride had greater than 10% of method blanks outside the QC limits. Fewer than 4% of the method blanks for acetone and 1% for methylene chloride exceeded three times the QC limits. Acetone and methylene chloride show frequent blank problems because of low-level background contamination in the laboratories.

To assess the laboratory control samples, QC limits for general chemical parameters, ammonia and anions, and metals were between 80% and 120%; those for radiological parameters were between 70% and 130%. Table B.15 summarizes Quanterra's results for the laboratory control samples. For constituents with 10 or more measurements, none had greater than 10% of laboratory control samples outside of QC limits. Fewer than 3% of the volatile or semivolatile organics were out of limits based on the QC limits that were effective in July. Previous limits were similar but were not used for statistical data evaluation because the limits were not reported electronically by the laboratory until July.

Table B.16 summarizes Quanterra's results for the matrix spikes and matrix spike duplicates. Matrix spike and matrix spike duplicate QC limits were between 75% and 125% for general chemical parameters, ammonia and anions, and metals. Matrix spike QC limits were between 70% and 130% for radiological parameters. These limits are based on those incorporated into the database starting in July 1999. For the volatile and semivolatile organic compounds, the QC limits that were effective in July were used to evaluate the results, as described above. Fewer than 5% of the volatile or semivolatile organic matrix spikes and matrix spike duplicates were out of limits.

Matrix duplicates were evaluated by comparing the relative percent difference to the QC limit for results that were five times greater than the method detection limit or the minimum detectable activity for general chemical parameters, ammonia and anions, and radiological parameters. The QC limit was 20% for all three categories. Table B.17 lists the constituents that exceeded the relative percent difference limits. Matrix duplicates were not analyzed for volatile organic compounds, semivolatile organic compounds, or metals.

Surrogate data included seven compounds for volatile organics and two for semivolatile organics. Applying the QC limits electronically available from Quanterra as of July 1999, none of the volatile organic surrogate compounds and 16% of the semivolatile organic compounds were outside the QC limits.

QC data for Thermo NUtech and Recra were limited for fiscal year 1999 because these laboratories did not analyze many samples for the groundwater project. Recra analyzed method blanks, laboratory control samples, matrix spikes, and matrix duplicates for total organic carbon, total organic halides, selected anions, metals, and selected volatile organic compounds. Most results were within QC limits. However, the following data were outside limits: one total organic halide laboratory control sample, one trichloroethylene

matrix spike, one silicon matrix spike, one boron and one molybdenum matrix duplicate, and five metal method blanks (barium, calcium, magnesium, sodium, and silicon). Thermo NUtech analyzed method blanks, laboratory control samples, matrix spikes, and matrix duplicates for gross alpha, gross beta, and iodine-129. One iodine-129 matrix duplicate was outside limits.

B.4.3.1 Issue Resolution

Issue resolution forms are documents for recording and resolving problems encountered with sample receipt, sample analysis, and data reporting. The forms are generated by the laboratory and forwarded to the groundwater project as soon as possible after a potential problem is identified. The forms indicate if direction on the part of the project is required. The documentation is intended to identify occurrences, deficiencies, and/or issues that may potentially have an adverse effect on data integrity. Table B.18 indicates the specific issues identified during fiscal year 1999 and the number of times these occurred.

B.4.3.2 Laboratory Audits/Assessments

Laboratory activities are regularly assessed by surveillance and auditing processes to ensure that quality problems are prevented and/or detected. Regular assessment supports continuous process improvement.

Assessments of Quanterra, Richland and St. Louis were conducted December 7 to 10, 1998 and May 6 to 8, 1999, respectively. The Hanford Site's Integrated Contractor Assessment Team, consisting of representatives from Bechtel Hanford, Inc. and Waste Management Federal Services of Hanford, Inc. conducted the audits. The purpose of the assessments was to evaluate the continued readiness of both Quanterra laboratories to analyze and process samples for the Hanford Site. Specific work requirements for the laboratories are specified in the statement of work between Waste Management Federal Services of Hanford, Inc. and Quanterra (RFSH-SOW-93-003, Rev. 5).

The assessment scope for these audits was based on the analytical and QA requirements for both groundwater and multi-media samples as specified in the statement of work. The primary focus of the Quanterra, Richland audit was personnel training, procedure compliance, sample receipt and tracking, instrument operation and calibration, equipment maintenance, instrumentation records and logbooks, and the implementation of Quanterra's QA management plan. For Quanterra, St. Louis, the focus was on the implementation of their QA program, compliance to their technical operating procedures, and verification of the corrective actions initiated in response to the previous audit (May 1998). The specific areas reviewed included sample preparation, instrument calibration, QC sample data and acceptance criteria, logbook review, and preventive maintenance.

Seven findings and five observations were noted in the assessment of Quanterra, Richland, and ten findings and five observations were identified during the assessment of Quanterra, St. Louis. These findings and observations related to deficiencies in four specific programmatic areas: document control, quality improvement, work processes, and calibration. Corrective-action responses to the assessment findings and observations have been evaluated. The laboratories have addressed all findings and observations, and the audits have been closed.

The Hanford Integrated Contractor Assessment Team conducted an assessment of Quanterra, Richland's sample disposal practices on May 13, 1999. This targeted system assessment was part of the continuing assessments required by the DOE, Richland Operations Office Waste Programs division as a condition of continuance of the commercial laboratory disposal program. General waste handling processes were reviewed, as well as sample handling, personnel qualifications, records, and requirements for waste. Results of the audit indicated that the commercial laboratory has systems in place for processing and managing waste streams. Laboratory staff were knowledgeable and well trained.

Assessments of Thermo NUtech and its subcontractor laboratory, Recra, were conducted by an assessment team consisting of representatives from Bechtel

Hanford, Inc., PNNL, and Waste Management Federal Services of Hanford, Inc., March 18 to 20, 1999 and June 22 to 24, 1999. The scope of these audits focused on the analytical and QA requirements for sample analyses as specified in the contract with the laboratories.

Four findings and eight observations were identified during the audit conducted at Thermo NUtech. The findings and observations were related to lack of procedures, use of instruments past the calibration dates, incomplete training records, and incomplete followup to previous corrective-action responses for past audits. All corrective-action responses have been accepted, and the findings have been closed.

Five findings and ten observations were noted for Recra. These findings and observations were related to procedural non-compliance, lack of procedures, incomplete training records, and reporting and software deficiencies. Closure of this audit is still pending.

Continued assessments of the laboratories are planned for the upcoming year to further evaluate performance and to ensure those corrective actions for the past findings and observations have been implemented.

B.4.3.3 Sample Collection Contractor Surveillances

Groundwater project staff regularly reviewed sample collection activities performed by the sampling subcontractor, Waste Management Technical Services. The purpose of the reviews was to ensure that samples were collected and submitted to the laboratories in accordance with high-quality standards. Monthly surveillances were conducted in the following areas: sample delivery and shipping, bottle preparation, sample collection, calibration of instruments, standard certifications, procedure implementation, training, and paperwork processing. All issues identified during the surveillances have been corrected.

B.4.4 Data Completeness and Comparability

Data judged to be complete are data that are not suspect, rejected, associated with a missed holding time, out-of-limit field duplicate or field blank, or qualified to indicate laboratory blank contamination. For fiscal year 1999, 85% of the groundwater project data were considered complete. Potentially invalid data was flagged in the database. The percentages of data flagged were 2.7% for field QC problems, 0.6% for exceeded holding times, 0.2% for rejected results, 0.3% for support values, and 13% for laboratory blank contamination.

For comparability, samples are split in the field (i.e., collected in duplicate) and forwarded to two or more laboratories when problems arise that require confirmation of analytical results. During fiscal year 1999, 10 samples were split for one or more analyses of alkalinity, anions, iodine-129, metals, strontium-90, total dissolved solids, and tritium (27 constituents total). Samples were analyzed for hazardous and non-hazardous chemicals by Quanterra, St. Louis and Recra. Radiological analyses were performed by Quanterra, Richland and Thermo NUtech. None of the split sample results had a relative percent difference greater than 20% for concentrations that were more than five times greater than the analyzing laboratories' detection limits. Thus, the laboratories showed excellent agreement for constituents at mutually quantifiable concentrations, and the split samples were useful for confirming out-of-trend results.

Specific evaluation of completeness and comparability issues for interim action groundwater monitoring was not performed for this report. Completeness and comparability issues are primarily assessed as part of site-specific validation activities. No validation activities were performed on interim action groundwater monitoring data in fiscal year 1999.

B.5 Limit of Detection, Limit of Quantitation, and Method Detection Limit

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Detection and quantitation limits are essential for evaluating data quality and usefulness because they

provide the limits of a method's measurement. The detection limit is the lower limit at which a measurement can be differentiated from background. The quantitation limit is the lower limit where a measurement becomes quantifiably meaningful. The limit of detection, limit of quantitation, and method detection limit are useful for evaluating groundwater data.

The limit of detection is defined as the lowest concentration level statistically different from a blank (Currie 1988). The concentration at which an analyte can be detected depends on the variability of the blank response. For the purpose of this discussion, the blank is taken to be a method blank.

In general, the limit of detection is calculated as the mean concentration in the blank plus three standard deviations of that concentration (EPA/540/P-87/001, OSWER 9355.0-14). The blank-corrected limit of detection is simply three times the blank standard deviation. At three standard deviations from the blank mean, the false-positive and the false-negative error rates are each ~7% (Miller and Miller 1988). A false-positive error is an instance when an analyte is declared to be present but is, in fact, absent. A false-negative error is an instance when an analyte is declared to be absent but is, in fact, present.

The limit of detection for a radionuclide is typically computed from the counting error associated with each reported result (e.g., EPA 520/1-80-012) and represents instrumental or background conditions at the time of analysis. In contrast, the limit of detection and limit of quantitation for the radionuclides shown in Table B.19 are based on variabilities that result from both counting errors and uncertainties introduced by sample handling. In the latter case, distilled water, submitted as a sample, is processed as if it were an actual sample. Thus, any random cross-contamination of the blank during sample processing will be included in the overall error, and the values shown in Table B.17 are most useful for assessing long-term variability in the overall process.

The limit of quantitation is defined as the level above which quantitative results may be obtained with a specified degree of confidence (Keith 1991). The limit of quantitation is calculated as the blank mean plus 10 standard deviations of the blank (EPA/540/P-87/001, OSWER 9355.014). The blank-corrected limit of quantitation is simply 10 times the blank standard deviation. The limit of quantitation is most useful for defining the lower limit of the useful range of concentration measurement technology. When the analyte signal is 10 times larger than the standard deviation of the blank measurements, there is a 95% probability that the true concentration of the analyte is within ±25% of the measured concentration.

The method detection limit is defined as the minimum concentration of a substance that can be measured and reported with a 99% confidence that the analyte concentration is greater than zero. The method detection limit is determined from analysis of a sample in a given matrix containing the analyte (Currie 1988). The method detection limit is 3.14 times the standard deviation of the results of 7 replicates of a low-level standard. Note that the method detection limit, as defined above, is based on the variability of the response of low-level standards rather than on the variability of the blank response.

For this report, total organic carbon, total organic halides, and radionuclide field blank data are available for limit of detection and limit of quantitation determinations. The field blanks are QC samples that are introduced into a process to monitor the performance of the system. The use of field blanks to calculate the limit of detection and the limit of quantitation is preferred over the use of laboratory blanks because field blanks include error contributions from sample preparation and handling, in addition to analytical uncertainties. Methods to calculate the limit of detection and the limit of quantitation are described in detail in Appendix A of DOE/RL-91-03. The results of the limit of detection and limit of quantitation determinations are listed in Table B.17.

Because of the lack of blank data for other constituents of concern, it was necessary to calculate approximate limit of detection and limit of quantitation values

by using variability information obtained from low-level standards. The data from the low-level standards are obtained from laboratory method detection limit studies. If low-level standards are used, the variability of the difference between the sample and blank response is increased by a factor of √2 (Currie 1988, p. 84). The formulas are summarized below:

$$MDL = 3.14 \times s$$

$$LOD = 3 \times \left(\sqrt{2} \times s\right) = 4.24 \times s$$

$$LOQ = 10 \times \left(\sqrt{2} \times 2\right) = 14.14 \times s$$

where s = standard deviation from the seven replicates of the low-level standard.

The results of limit of detection, limit of quantitation, and method detection limit calculations for most non-radiological constituents of concern (besides total organic carbon and total organic halides) are listed in Table B.20. The values in the table apply to Quanterra, St. Louis only.

Specific evaluation of detection-limit issues for the interim action groundwater monitoring program was not performed for this report. Detection-limit issues are primarily assessed as part of site-specific validation activities. No validation activities were performed on interim action groundwater monitoring data in fiscal year 1999.

B.6 Conclusions

Overall, assessments of fiscal year 1999 QA/QC information indicate that groundwater monitoring data are reliable and defensible. Sampling was conducted in accordance with reviewed procedures. Few contamination or other sampling-related problems were encountered that affected data integrity. Likewise, laboratory performance was excellent in most respects, based on the large percentages of acceptable field and laboratory QC results. Satisfactory laboratory audits and generally acceptable results in nationally-based performance evaluation studies also demonstrated good laboratory performance. However, the following areas of concern were identified and should be considered when interpreting groundwater monitoring results:

- A few QC samples were probably swapped in the field or at the laboratory based on a small number of unusually high field-blank results and duplicate results with poor precision. The same problem likely occurred for a small number of groundwater samples.
- Several indicator parameters, metals, and volatile organic compounds were detected at low levels in field and/or laboratory method blanks. Some of these constituents were found at similar levels in groundwater samples.
- Maximum recommended holding times were exceeded for ~3% of groundwater project samples. Anions and phenols were the primary analyses affected, though the data impacts are considered minor.
- Quanterra, St. Louis' double-blind standard results for total organic carbon were typically biased ~15% high, while the results for total organic halides (volatiles only) were biased low by ~25%. On average, Recra's total organic carbon results were biased ~40% high.
- Quanterra, Richland's double-blind standard results for gross alpha and gross beta were inconsistent with biases ranging from 16% low to 88% high. Thermo NUtech's results for gross beta were biased high by up to 51%.

B.7 References

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Table B.1. Full-Trip Blanks Exceeding Quality Control Limits

Constituent	Number Out of Limits	Number of Analyses	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
General Chemical Parameters					
Alkalinity	1	27	3.7	598 - 4,460 µg/L	8,000 µg/L
Chemical oxygen demand	1	3	33.3	7,638 µg/L	34,000 µg/L
Specific conductance	42	45	93.3	0.09 µS/cm	0.571 - 13 µS/cm
Total carbon	2	3	66.7	512 - 1,416 µg/L	1,520 - 1,960 µg/L
Total dissolved solids	8	14	57.1	8,456 µg/L	9,000 - 31,000 µg/L
Total organic carbon	22	82	26.8	444.4 - 512 µg/L	446 - 1,030 µg/L
Total organic halides	3	74	4.1	4.76 - 8.54 µg/L	5.8 - 15.2 µg/L
Ammonia and Anions					
Chloride	12	47	26.5	69.2 - 70 µg/L	70 - 167 µg/L
Nitrogen in nitrate	4	47	8.5	4 - 21.2 µg/L	22 - 124 µg/L
Sulfate	3	47	6.4	194 - 216 µg/L	239 - 329 µg/L
Metals					
Antimony	1	38	2.6	39.4 - 54.6 µg/L	63.3 µg/L
Beryllium	2	38	5.3	0.4 - 1.4 µg/L	0.52 - 1.4 µg/L
Calcium	11	38	28.9	130.6 - 249 µg/L	250 - 833 µg/L
Copper	4	38	10.5	4.6 - 8 µg/L	4.6 - 9.2 µg/L
Iron	3	38	7.9	60.6 - 71.2 µg/L	78.2 - 528 µg/L
Magnesium	16	38	42.1	68.2 - 201.4 µg/L	73.1 - 1,080 µg/L
Manganese	17	38	44.7	1 - 1.4 µg/L	1.1 - 8.1 µg/L
Potassium	1	38	2.6	1,152 - 3,355.2 µg/L	2,690 µg/L
Sodium	27	38	71.1	88.4 - 239.6 µg/L	245 - 1,120 µg/L
Strontium (elemental)	4	38	10.5	0.8 - 1.4 µg/L	3.2 - 4.9 µg/L
Vanadium	9	38	23.7	7.4 - 9.4 µg/L	8.1 - 25 µg/L
Zinc	13	38	34.2	8.2 - 8.4 µg/L	8.8 - 45.6 µg/L
Volatile Organic Compounds					
Carbon tetrachloride	1	14	7.1	0.05 - 0.904 µg/L	0.4 µg/L
Radiological Parameters					
Gross beta	4	39	10.3	2.2 - 6.36 pCi/L[b]	3.15 - 22.7 pCi/L
Tritium	3	41	7.3	30 - 602 pCi/L[b]	129 - 1,280 pCi/L

(a) Because method detection limits may change throughout the year, the limits are presented as a range. However, each result was evaluated according to the method detection limit in effect at the time the sample was analyzed.
(b) The limit for radiological analyses is determined by the sample-specific total propagated uncertainty.

Table B.2. Field Transfer Blanks Exceeding Quality Control Limits

Constituent	Number Out of Limits	Number of Analyses	Percent Out of Limits	Range of QC Limits[a] (µg/L)	Range of Out-of-Limit Results (µg/L)
2-Butanone	1	79	1.3	0.84 - 1.78	4
Carbon disulfide	1	79	1.3	0.26 - 0.296	0.4
Carbon tetrachloride	5	88	5.7	0.284 - 0.904	0.4 - 1
Chloroform	22	88	25.0	0.18 - 0.572	0.2 - 4
Methylene chloride	36	88	40.9	1.425 - 3.8	3 - 38
Tetrahydrofuran	1	75	1.3	3.14 - 3.92	17

(a) Because method detection limits may change throughout the year, the limits are presented as a range. However, each result was evaluated according to the method detection limit in effect at the time the sample was analyzed.

Table B.3. Equipment Blanks Exceeding Quality Control Limits

Constituent	Number Out of Limits	Number of Analyses	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
General Chemical Parameters					
Specific conductance	18	20	90.0	0.09 µS/cm	0.865 - 11.7 µS/cm
Total dissolved solids	3	4	75.0	8,456 µg/L	10,000 - 23,000 µg/L
Total organic carbon	6	20	30.0	444.4 - 512 µg/L	460 - 815 µg/L
Total organic halides	2	16	12.5	4.76 - 8.54 µg/L	4.8 - 15.2 µg/L
Ammonia and Anions					
Chloride	11	20	55.0	69.2 - 70 µg/L	71 - 276 µg/L
Fluoride	3	20	15.0	20.8 - 24 µg/L	61 - 86 µg/L
Nitrogen in nitrate	6	20	30.0	4 - 21.2 µg/L	13 - 150 µg/L
Sulfate	2	20	10.0	194 - 216 µg/L	215 - 220 µg/L
Metals					
Barium	2	17	11.8	1.8 - 2.2 µg/L	5.6 - 5.9 µg/L
Calcium	7	17	41.2	130.6 - 249 µg/L	254 - 439 µg/L
Copper	5	17	29.4	4.6 - 8 µg/L	5.7 - 39.7 µg/L
Iron	1	17	5.9	60.6 - 71.2 µg/L	132 µg/L
Magnesium	7	17	41.2	68.2 - 201.4 µg/L	195 - 588 µg/L
Manganese	10	17	58.8	1 - 1.4 µg/L	1.7 - 5.4 µg/L
Nickel	1	17	5.9	20 - 28.6 µg/L	103 µg/L
Sodium	14	17	82.4	88.4 - 239.6 µg/L	234 - 838 µg/L
Strontium (elemental)	1	17	5.9	0.8 - 1.4 µg/L	3.3 µg/L
Vanadium	7	17	41.2	7.4 - 9.4 µg/L	9.7 - 35.6 µg/L
Zinc	7	17	41.2	8.2 - 8.4 µg/L	8.3 - 14.5 µg/L
Volatile Organic Compounds					
Acetone	1	3	33.3	1.65 - 9.7 µg/L	2 µg/L
Carbon disulfide	1	3	33.3	0.26 - 0.296 µg/L	1 µg/L
Chloroform	1	3	33.3	0.18 - 0.344 µg/L	11 µg/L
Radiological Parameters					
Tritium	2	15	13.3	34.8 - 432 pCi/L[b]	142 - 147 pCi/L

(a) Because method detection limits may change throughout the year, the limits are presented as a range. However, each result was evaluated according to the method detection limit in effect at the time the sample was analyzed.
(b) The limit for radiological analyses is determined by the sample-specific total propagated uncertainty.

Table B.4. Field Duplicates Exceeding Quality Control Limits

Constituent	Total Number of Duplicates	Number of Duplicates Evaluated[a]	Number Out of Limits	Percent Out of Limits	Range of Relative Percent Differences[b]
General Chemical Parameters					
Oil and grease	1	1	1	100.0	166.3
Metals					
Chromium	61	27	2	7.4	22.2 - 41.4
Copper	55	1	1	100.0	100
Iron	55	11	6	54.6	37.2 - 97.1
Manganese	55	32	7	21.9	22.8 - 68.9
Potassium	55	17	3	17.7	20.4 - 26.2
Vanadium	55	33	2	6.1	27.4 - 32.8
Zinc	55	14	4	28.6	43.6 - 95.6
Volatile Organic Compounds					
1,1,1-Trichloroethane	17	2	1	50.0	22.2
Acetone	14	1	1	100.0	162
Carbon tetrachloride	17	4	1	25.0	107.7
Chloroform	17	4	2	50.0	181
cis-1,2-Dichloroethylene	17	2	2	100.0	40
Methylene chloride	17	1	1	100.0	28.6
Radiological Parameters					
Gross alpha	42	9	3	33.3	20.2 - 28.5
Technetium-99	17	10	2	20.0	24.3 - 50.0

(a) Duplicates with both results less than five times the method detection limit or minimum detectable activity were excluded from the evaluation.
(b) In cases where a non-detected result was compared with a measured value, the method detection limit or minimum detectable activity was used for the non-detected concentration.

Table B.5. Hanford Groundwater Monitoring Project Maximum Recommended Holding Times

Methods	Constituents	Holding Times
8010/8020/8260 (SW-846)	Volatile organics	14 days
8270 (SW-846)	Semivolatile organics	7 days before extraction; 40 days after extraction
8080 (SW-846)	Pesticides	7 days before extraction; 40 days after extraction
8080 (SW-846)	Polychlorinated biphenyls	7 days before extraction; 40 days after extraction
8040 (SW-846)	Phenols	7 days before extraction; 40 days after extraction
6010 (SW-846)	Inductively coupled-plasma metals	6 months
7060 (SW-846)	Arsenic	6 months
7421 (SW-846)	Lead	6 months
7470 (SW-846)	Mercury	28 days
7740 (SW-846)	Selenium	6 months
7841 (SW-846)	Thallium	6 months
9012 (SW-846)	Cyanide	14 days
9020 (SW-846)	Total organic halides	28 days
9060 (SW-846)	Total organic carbon	28 days
300.0 (EPA-600/4-81-004)	Bromide	28 days
300.0 (EPA-600/4-81-004)	Chloride	28 days
300.0 (EPA-600/4-81-004)	Fluoride	28 days
300.0 (EPA-600/4-81-004)	Nitrate	72 hours
300.0 (EPA-600/4-81-004)	Nitrite	72 hours
300.0 (EPA-600/4-81-004)	Phosphate	72 hours
300.0 (EPA-600/4-81-004)	Sulfate	28 days
310.1 (EPA-600/4-81-004)	Alkalinity	14 days
410.4 (EPA-600/4-81-004)	Chemical oxygen demand	28 days

Table B.6. Results of U.S. Environmental Protection Agency Water Pollution (WP) and Water Supply (WS) Performance Evaluation Studies

Laboratory	WP030 February 1999 Percent Acceptable	WS035 August 1999 Percent Acceptable	WP040 November 1998 Percent Acceptable	WS050 May 1999 Percent Acceptable
Quanterra Incorporated, St. Louis, Missouri	84[a]	94[b]	85[c]	91[d]

(a) Unacceptable results were for alkalinity, orthophosphate, hardness, turbidity, boron, fluoride, nitrate, nitrite, 2,4,5-T, 2,4-D, 2,4-DB, chlorobenzene, 1,2-dichloroethane, and 1,1,2-trichloroethane.
(b) Unacceptable results were for orthophosphate, mercury, carbon tetrachloride, 1,1,1,2-tetrachloroethane, and 1,2,3-trichloropropane.
(c) Unacceptable results were for alkalinity, kjeldahl-nitrogen, Aroclor 1016/1242 in oil, Aroclor 1254 in oil, benzene, ethylbenzene, toluene, three dichlorobenzenes, and total phenolics.
(d) Unacceptable results were for hardness, orthophosphate, mercury, Aroclor 1016, kjeldahl nitrogen, 1,2-dichlorobenzene, 1,3-dichlorobenzene, tetrachloroethylene, and total suspended solids.

Table B.7. Results of Water Pollution (WP) and Water Supply (WS) Performance Evaluation Studies for Recra Environmental, Inc.

Laboratory	WP040 November 1998 Percent Acceptable	WS030 February 1999 Percent Acceptable	WP048 March 1999 Percent Acceptable	WS035 August 1999 Percent Acceptable
Recra LabNet, Philadelphia	95[(a)]	94[(b)]	93[(c)]	90[(d)]

(a) Unacceptable results were for silver, total organic carbon, chemical oxygen demand, and Aroclor 1016/1242 in oil.
(b) Unacceptable results were for hardness, bis-(2-ethylhexyl)adipate, dichlorodifluoromethane, 1,1,1,2-perchloroethylene, 1,2,3-trichlorobenzene, 1,1-dichloroethylene, methyl-t-butyl ether, dinoseb, pentachlorophenol, 2,4-D, and dicamba.
(c) Unacceptable results were for cyanide, conductivity, and total organic carbon.
(d) Unacceptable results were for aluminum, chloride, fluoride, carbon tetrachloride, 1,2-dichlorobenzene, 1,1-dichloroethylene, 1,1,2,2-tetrachloroethane, chloroform, toxaphene, pentachlorophenol, and dichlorodifluoromethane.

Table B.8. Summary of Quanterra Incorporated Interlaboratory Performance, Fiscal Year 1999

Radionulclides	Number of Results Reported for Each	Number Within Acceptable Control Limits
DOE Quality Assessment Program (EML-600, EML-604) Environmental Measurements Laboratory		
Americium-241, cobalt-60, cesium-137, gross alpha, gross beta, plutonium-238, plutonium-239, strontium-90, tritium, uranium-234, uranium	2	2[a,b]
Uranium-238	2	1[a]
Manganese-54, nickel-63	1	1[a]
DOE Mixed Analyte Performance Evaluation Program (MAPEP-98-W6) Radiological and Environmental Sciences Laboratory		
Americium-241, cesium-137, cobalt-57, manganese-54, nickel-63, plutonium-238, plutonium-239/240, strontium-90, uranium-234/233, uranium-235, uranium-238, zinc-65	1	1[c]
Anthracene, antimony, barium, beryllium, chromium, copper, 1,3-dichlorobenzene, 2,4-dichlorophenol, diethylphthalate, 2,4-dimethylphenol, 2,4-dinitrotoluene, 2,6-dinitrotoluene, fluoranthene, fluorene, lead, 2-methylphenol, naphthalene, 4-nitrophenol, phenanthrene, phenol, selenium, thallium, zinc	1	1[d]
EPA Laboratory Intercomparison Studies National Exposure Research Laboratory		
Cesium-137, cobalt-60, gross alpha, gross beta, radium-226, radium-228, uranium	2	2[e]
Cesium-134	2	1[e]
Barium-133, iodine-131, strontium-89, strontium-90, tritium, zinc-65	1	1[e]
EPA InterLaB RadCheM Proficiency Testing Program Environmental Resource Associates		
Gross alpha, gross beta, radium-226, radium-228, strontium-90	2	2[f,g]
Uranium	2	1[f]
Cesium-134, cesium-137, cobalt-60, strontium-89, tritium	1	1[f,g]

(a) Control limits from EML-600 and EML-604.
(b) One result each for americium-241, cesium-137, cobalt-60, gross alpha, gross beta, and plutonium-238 was acceptable but outside warning limits.
(c) Results from Quanterra, Richland.
(d) Results from Quanterra, St. Louis.
(e) Control limits from EPA-600/4-81-004.
(f) Control limits from National Standards for Water Proficiency Testing Studies Criteria Document.
(g) One result each for cesium-137, cobalt-60, gross beta, and strontium-89 was acceptable but outside warning limits.

Table B.9. Summary of Recra Environmental, Inc. and Thermo NUtech Interlaboratory Performance, Fiscal Year 1999

Radionulclides	Number of Results Reported for Each	Number Within Acceptable Control Limits
DOE Quality Assessment Program (EML-600, EML-604) Environmental Measurements Laboratory		
Americium-241, gross alpha, gross beta, iron-55, nickel-63, plutonium-238, plutonium-239, strontium-90, tritium, uranium-234, uranium-238, uranium	2	2[a,b]
Cobalt-60, cesium-137	2	1[a]
Manganese-54	1	0[a]
DOE Mixed Analyte Performance Evaluation Program (MAPEP-98-W6) Radiological and Environmental Sciences Laboratory		
Americium-241, cesium-137, cobalt-57, cobalt-60, iron-55, manganese-54, nickel-63, plutonium-238, plutonium-239/240, strontium-90, uranium-234/233, uranium-238, zinc-65	1	1[c,d]
Anthracene, antimony, barium, beryllium, chromium, copper, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 2,4-dichlorophenol, diethylphthalate, 2,4-dimethylphenol, 2,4-dinitrotoluene, fluoranthene, fluorene, lead, 2-methylphenol, 4-nitrophenol, phenanthrene, phenol, selenium, thallium, zinc	1	1[e]
Acenaphthylene	1	0[e]
EPA Laboratory Intercomparison Studies National Exposure Research Laboratory		
Cesium-134, cesium-137, cobalt-60, gross alpha, gross beta, strontium-89, strontium-90	2	2[f]
Barium-133, iodine-131, radium-226, radium-228, uranium, zinc-65	1	1[f]

(a) Results from Thermo NUtech, Richmond, California. Control limits from EML-600 and EML-604.
(b) One result each for gross alpha was acceptable but outside warning limits.
(c) Results from Thermo NUtech, Richmond, California.
(d) One result for plutonium-239/240 was acceptable but outside warning limits.
(e) Results from Recra LabNet, Philadelphia.
(f) Results from Thermo NUtech, Richmond, California. Control limits from EPA-600/4-81-004.

Table B.10. Summary of Quanterra Incorporated Double-Blind Spike Determinations

Constituent	Sample Frequency	Number of Results Reported[a]	Number of Results Outside QC Limits[b]	Control Limits[c] (%)
General Chemical Parameters				
Specific conductance	Annually	3	0	±25
Total organic carbon (potassium hydrogen phthalate spike)	Quarterly	16	3	±25
Total organic halides (2,4,6-trichlorophenol spike)	Quarterly	14	0	±25
Total organic halides (carbon tetrachloride, chloroform, and trichloroethene spike)	Quarterly	14	7	±25
Anions				
Cyanide	Quarterly	14	3	±25
Fluoride	Quarterly	12	0	±25
Nitrate	Semiannually	6	0	±25
Metals				
Chromium	Semiannually	6	0	±20
Volatile Organic Compounds				
Carbon tetrachloride	Quarterly	16	1	±25
Chloroform	Quarterly	16	0	±25
Trichlorethylene	Quarterly	16	1	±25
Radiological Parameters				
Gross alpha (plutonium-239 spike)	Quarterly	16	3	±25
Gross beta (strontium-90 spike)	Quarterly	16	3	±25
Cesium-137	Semiannually	6	0	±30
Cobalt-60	Semiannually	6	0	±30
Iodine-129	Semiannually	6	0	±30
Plutonium-239	Quarterly	16	1	±30
Strontium-90	Semiannually	6	0	±30
Technetium-99	Quarterly	16	0	±30
Tritium	Quarterly	9	2	±30
Uranium-238	Quarterly	16	0	±30

(a) Blind standards were submitted in triplicate or quadruplicate.
(b) Quality control limits are given in the Hanford Groundwater Monitoring Project's QA plan.
(c) Each result must be within the specified percentage of the known value to be acceptable.

Table B.11. Summary of Recra Environmental, Inc. and Thermo NUtech Double-Blind Spike Determinations

Constituent	Sampling Frequency	Number of Results Reported[a,b]	Number of Results Outside QC Limits[c]	Control Limits[d] (%)
General Chemical Parameters				
Total organic carbon (potassium hydrogen phthalate spike)	Quarterly	15	10	±25
Total organic halides (2,4,6-trichlorophenol spike)	Quarterly	10	4	±25
Total organic halides (carbon tetrachloride, chloroform, and trichlorethylene spike)	Quarterly	11	4	±25
Anions				
Cyanide	Semiannually	6	4	±25
Fluoride	Annually	3	0	±25
Metals				
Chromium	Annually	3	0	±20
Volatile Organic Compounds				
Carbon tetrachloride	Annually	3	0	±25
Chloroform	Annually	3	0	±25
Trichlorethylene	Annually	3	0	±25
Radiological Parameters				
Gross alpha (plutonium-239 spike)	Semiannually	6	0	±25
Gross beta (strontium-90 spike)	Quarterly	12	6	±25
Cesium-137	Annually	3	0	±30
Cobalt-60	Annually	3	0	±30
Iodine-129	Semiannually	6	2	±30
Plutonium-239	Annually	3	0	±30
Strontium-90	Annually	3	0	±30
Technetium-99	Annually	3	0	±30
Tritium	Annually	3	0	±30
Uranium-238	Annually	3	0	±30

(a) Blind standards were submitted in triplicate or quadruplicate.
(b) Recra Environmental, Inc. performed chemical analyses, and Thermo NUtech performed radiological analyses.
(c) Control limits are given in the Hanford Groundwater Monitoring Project's QA plan.
(d) Each result must be within the specified percentage of the known value to be acceptable.

Table B.12. Quanterra Incorporated Blind Standard Results

Constituent	Fiscal Year Quarter	Spike Amount	Average Result	Average Recovery (%)	Relative Standard Deviation (%)
		General Chemical Parameters (µg/L)			
Specific conductance	Fourth	445	425	96	1
Total organic carbon[a]	First	805	808	100	19
	Second	1,002	1,155	115	5
	Third	1,500	1,930	129	4
	Fourth	1,998	2,440	122	4
Total organic halides[b] (phenol)	First	1,02.3	86.3	84	0
	Second	1,052	1,023	97	19
	Third	12.9	14.7	114	3
	Fourth	130	113	87	6
Total organic halides[c] (volatile organic mixture)	First	103.5	64.3	62	11
	Second	1,088	752.8	69	11
	Third	13.2	12.1	91	13
	Fourth	130	94.7	73	4
		Anions (µg/L)			
Cyanide	First	100	70.6	71	1
	Second	100	77.6	78	1
	Third	300	237	79	2
	Fourth	400	307	77	1
Fluoride	First	1,000	1,237	124	1
	Second	1,000	1,190	119	1
	Third	5,000	5,283	106	2
	Fourth	2,000	2,353	118	2
Nitrate	First	10,166	10,220	101	2
	Second	10,166	10,600	104	1
		Metals (µg/L)			
Chromium	First	300	288	96	1
	Second	300	296	99	1
		Volatile Organic Compounds (µg/L)			
Carbon tetrachloride	First	9.8	9.0	92	11
	Second	414	387	93	6
	Third	5.1	4.3	85	13
	Fourth	51	42.7	84	16
Chloroform	First	98.9	96.7	98	1
	Second	435	460	106	9
	Third	5.1	4.3	85	13
	Fourth	50	47.3	95	1
Trichloroethylene	First	7.9	7.3	93	8
	Second	394	383	97	8
	Third	5	5.3	107	11
	Fourth	50	40.3	81	10

Table B.12. (contd)

Constituent	Fiscal Year Quarter	Spike Amount	Average Result	Average Recovery (%)	Relative Standard Deviation (%)
		Radiological Parameters (pCi/L)			
Gross alpha (plutonium-239)	First	21.22	20.8	98	23
	Second	292.22	272	93	6
	Third	6.98	13.1	188	14
	Fourth	101.45	107	106	13
Gross beta (strontium-90)[d]	First	13.08	10.9	84	13
	Second	21.29	37.8	178	5
	Third	58.86	64.9	110	24
	Fourth	105.85	121.0	114	4
Cesium-137	First	614.8	643.7	105	6
	Second	197.8	201.0	102	6
Cobalt-60	First	200.46	201.3	100	3
	Second	398.95	399.0	100	1
Iodine-129	First	30.49	29.9	98	14
	Second	24.59	18.8	76	5
Plutonium-239	First	21.224	24.0	113	5
	Second	1.482	1.81	122	18
	Third	6.978	7.02	101	4
	Fourth	1.939	2.38	123	5
Strontium-90	First	7.98	8.99	113	12
	Second	20.15	21.3	106	6
Technetium-99	First	471.5	393.7	83	5
	Second	910.1	880.7	97	7
	Third	202.1	211.3	105	8
	Fourth	97.1	103.4	107	5
Tritium	Second	38,080	36,867	97	1
	Third	211,600	134,310	63	87
	Fourth	199	246	124	18
Uranium-238	First	61.881	61.4	99	5
	Second	144.48	144.0	100	2
	Third	915.726	908.3	99	1
	Fourth	318.21	330.0	104	2

(a) Total organic carbon standards were submitted in quadruplicate each quarter.
(b) Total organic halide (phenol) standards were submitted in quadruplicate during the first and fourth quarters. The standards were submitted in triplicate in the second and third quarters.
(c) Total organic halide (volatile) standards were submitted in triplicate during the first and fourth quarters. The standards were submitted in quadruplicate in the second and third quarters.
(d) Assuming strontium-90 and yttrium-90 are in equilibrium, spike amount is strontium-90 + yttrium-90.

Table B.13. Recra Environmental, Inc. and Thermo NUtech Blind Standard Results

Constituent	Fiscal Year Quarter	Spike Amount	Average Result[a]	Average Recovery (%)	Relative Standard Deviation (%)
		General Chemical Parameters (µg/L)			
Total organic carbon[b]	First	805	978	121	3
	Second	1,002	1,600	160	7
	Third	1,500	1,933	129	13
	Fourth	1,998	2,975	149	8
Total organic halides[c] (phenol)	Second	1,052	1,150	109	8
	Third	12.9	21.9	170	10
	Fourth	130	88.8	68	59
Total organic halides[d] (volatile organic mixture)	Second	1,088	1,063	98	8
	Third	13.2	21.4	162	19
	Fourth	130	102	78	4
		Anions (µg/L)			
Cyanide	Second	100	74.0	74	5
	Fourth	400	277	69	17
Fluoride	Second	1,000	1,100	110	0
		Metals (µg/L)			
Chromium	Second	300	302	101	2
		Volatile Organic Compounds (µg/L)			
Carbon tetrachloride	Second	414	383	93	6
Chloroform	Second	435	410	94	2
Trichlorethylene	Second	394	333	85	2
		Radiological Parameters (pCi/L)			
Gross alpha (plutonium-239)	Second	292.22	278.3	95	8
	Fourth	101.45	94.6	93	15
Gross beta (strontium-90)[e]	First	13.08	19.8	151	8
	Second	21.29	30.5	143	8
	Third	58.86	68.9	117	1
	Fourth	104.52	114.7	110	4
Cesium-137	Second	197.8	193.7	98	3
Cobalt-60	Second	398.95	361.0	90	5
Iodine-129	First	30.49	14.8	49	73
	Second	24.59	24.6	100	13
Plutonium-239	Second	1.482	1.26	85	7
Strontium-90	Second	20.15	19.8	98	5
Technetium-99	Second	910.1	998.7	110	2
Tritium	Second	38,080	39,030	103	1
Uranium-238	Second	144.48	167.0	116	1

(a) Recra Environmental, Inc. performed chemical analyses, and Thermo NUtech performed radiological analyses.
(b) Total organic carbon standards were submitted in quadruplicate each quarter.
(c) Total organic halide (phenol) standards were submitted in triplicate during the second and third quarters and in quadruplicate during the fourth quarter.
(d) Total organic halide (volatile) standards were submitted in quadruplicate during the second and third quarters and in triplicate during the fourth quarter.
(e) Assuming strontium-90 and yttrium-90 are in equilibrium, spike amount is strontium-90 + yttrium-90.

Table B.14. Quanterra Incorporated Method Blank Results

Constituent	Percent Out of Limit	Number of Analyses	Concentration Range of Out-of-Limit Results
General Chemical Parameters			
Total general chemical parameters	15.6	688	--
Alkalinity	0.9	112	5.6 mg/L
Specific conductance	100	105	0.317 - 1.04 µS/cm
Total dissolved solids	1.4	74	39 mg/L
Ammonia and Anions			
Total ammonia and anions	5.7	1,104	--
Chloride	26.2	210	0.07 - 0.194 mg/L
Fluoride	2.0	204	0.037 - 0.063 mg/L
Sulfate	1.9	213	0.234 - 0.277 mg/L
Metals			
Total metals	14.4	2,028	--
Aluminum	55.9	102	39 - 161 mg/L
Calcium	51.0	102	27.1 - 492 mg/L
Chromium	0.9	106	7.1 mg/L
Copper	11.8	102	5.9 - 11.7 mg/L
Iron	89.2	102	12.8 - 91.8 mg/L
Magnesium	11.8	102	123 - 276 mg/L
Manganese	5.9	102	1.1 - 2.5 mg/L
Sodium	24.5	102	59.4 - 241 mg/L
Vanadium	5.9	102	6.1 - 14.3 mg/L
Zinc	29.4	102	3.2 - 17 mg/L
Volatile Organic Compounds			
Total volatile organic compounds	2.0	2,696	--
Acetone	33.0[(b)]	106	2 - 19 mg/L
2-Butanone	0.9[(b)]	106	4 mg/L
1,4-Dichlorobenzene	0.8	123	0.4 mg/L
Methylene chloride	12.6[(b)]	119	2 - 15 mg/L
Vinyl chloride	1.7	119	0.3 mg/L
Semivolatile Organic Compounds			
Total semivolatile organic compounds	0	832	--
Radiological Parameters			
Total radiological parameters	0.2	1,076	--
Technetium-99	1.4	70	54.9 pCi/L
Tritium	1.2	82	23.6 pCi/L

(a) Control limits are twice the method detection limit.
(b) Control limits for footnoted compounds are five times the method detection limit.

Table B.15. Quanterra Incorporated Laboratory Control Samples

Constituent	Percent Out of Limit[a]	Number of Analyses
General Chemical Parameters		
Total general chemical parameters	0	706
Ammonia and Anions		
Total ammonia and anions	0	1,101
Metals		
Total metals	0.1	2,030
Silver	2.0	102
Radiological Parameters		
Total radiological parameters	2.1	708
Cesium-137	1.8	56
Cobalt-60	1.8	57
Gross alpha	6.8	73
Technetium-99	5.7	70
Tritium	0.9	109
Uranium	1.6	61
Uranium-235	28.6	7

(a) QC limits are 80% to 120% for general chemical parameters, ammonia and anions, and metals; 70% to 130% for radiological parameters.

Table B.16. Quanterra Incorporated Matrix Spikes and Matrix Spike Duplicates

Constituent	Percent Out of Limit[a]	Number of Analyses
General Chemical Parameters		
Total general chemical parameters	4.2	212
Total carbon	83.3	6
Total organic carbon	0.9	115
Total organic halides	3.3	91
Ammonia and Anions		
Total ammonia and anions	16.2	468
Chloride	10.8	83
Cyanide	6.9	29
Fluoride	12.0	83
Nitrogen in nitrate	33.7	83
Nitrogen in nitrite	18.1	83
Sulfate	12.6	87
Sulfide	100	1
Metals		
Total metals	0.5	3,147
Cadmium	0.6	161
Chromium	1.2	163
Copper	1.3	157
Iron	1.3	157
Lead	11.1	54
Selenium	50.0	4
Sodium	0.6	157
Zinc	0.6	157
Radiological Parameters		
Total radiological parameters	15.6	122
Technetium-99	6.3	64
Uranium	25.9	58

(a) Control limits are 75% to 125% for general chemical parameters, ammonia and anions, and metals; 70% to 130% for radiological parameters.

Table B.17. Quanterra Incorporated Matrix Duplicates

Constituent	Percent Out of Limit[a]	Number of Analyses
General Chemical Parameters		
Total general chemical parameters	0.5	400
Specific conductance	1.3	75
Total carbon	16.7	6
Total organic halides	1.1	91
Ammonia and Anions		
Total ammonia and anions	0.6	459
Fluoride	1.2	81
Nitrogen in nitrate	1.2	81
Sulfate	1.2	85
Radiological Parameters		
Total radiological parameters	0.9	1,128
Gross alpha	1.4	70
Gross beta	1.4	71
Iodine-129	5.9	34
Plutonium-239/240	8.3	12
Strontium-90	1.8	56
Technetium-99	1.5	68
Uranium-234	14.3	7
Uranium-235	14.3	7
Uranium-238	14.3	7

(a) For values five times greater than the method detection limit, control limits for relative percent difference are 20% for general chemical parameters, ammonia and anions, and radiological parameters.

Table B.18. Summary of Issue Resolution Forms Received for Fiscal Year 1999

Issue	Number of Occurrences
Hold time missed	34
Broken bottles[a]	11
Missing samples[a]	6
Temperature deviation[a]	7
pH variance[a]	3
Bottle size/type (insufficient volume)	4
Chain of custody forms incomplete[a]	16
Laboratory QC out of limits	29
Analytical preparation deviations	5
Method failures/discontinued analyses	7

(a) Issue always originated before samples were received at the laboratory.

Table B.19. Summary of Quanterra Incorporated Detection/Quantitation Limits Determined from Field Blanks Data

Period	Number of Samples	Mean	Standard Deviation	Limit of Detection	Limit of Quantitation
Constituent: Total Organic Carbon (µg/L)					
10/01/98 - 12/29/98	22[a]	225.89	121.44	590[b]	1,440[b]
01/19/99 - 02/23/99	8[a]	325.47	80.80	568	1,133
02/24/99 - 03/18/99	12[a]	141.21	166.36	499[c]	1,664[c]
04/19/99 - 06/28/99	14[a]	163.03	156.78	470	1,568
07/14/99 - 08/24/99	13	122.89	115.37	346	1,154
Summary	69	190.55	165.93	400	1,334
Constituent: Total Organic Halides (µg/L)					
10/01/98 - 12/29/98	25	0.18	2.24	6.7[c]	22.4[c]
01/19/99 - 03/18/99	25[a]	1.37	1.40	4.2	14.0
04/19/99 - 06/28/99	16	-0.38	1.62	4.8	16.2
07/14/99 - 08/24/99	13	0.66	1.79	5.4	17.9
Summary	79	0.52	1.81	5.4	18.1
Constituent: Antimony-125 (pCi/L)					
10/13/98 - 12/16/98	6	-1.52	3.43	10.28[c]	34.26[c]
04/01/99 - 06/02/99	6	0.47	5.10	15.29	50.98
07/13/99 - 08/16/99	3	1.59	3.96	11.88	39.62
Summary	15	-0.10	4.28	12.8	42.8
Constituent: Cesium-134 (pCi/L)					
10/13/98 - 12/16/98	6	-1.61	0.91	2.74[c]	9.14[c]
04/01/99 - 06/02/99	6	-0.29	0.81	2.43	8.09
07/13/99 - 08/16/99	3	-2.15	2.40	7.20	23.99
Summary	15	-1.19	1.26	3.77	12.57
Constituent: Cesium-137 (pCi/L)					
10/13/98 - 12/16/98	6	0.92	0.54	1.62[c]	5.40[c]
04/01/99 - 06/02/99	6	0.01	1.33	3.98	13.28
07/13/99 - 08/16/99	3	-0.54	1.06	3.19	10.63
Summary	15	0.26	1.02	3.07	10.22
Constituent: Cobalt-60 (pCi/L)					
10/13/98 - 12/16/98	6	0.00	0.45	1.34[c]	4.46[c]
04/01/99 - 06/02/99	6	0.59	1.52	4.56	15.2
07/13/99 - 08/16/99	3	-0.23	1.09	3.27	10.89
Summary	15	0.19	1.11	3.34	11.5
Constituent: Europium-154 (pCi/L)					
10/13/98 - 12/16/98	6	0.13	3.23	9.69[c]	32.30[c]
04/01/99 - 06/02/99	6	1.14	2.64	7.91	26.37
07/13/99 - 08/16/99	3	-2.36	3.97	11.90	39.66
Summary	15	0.03	3.14	9.42	31.41
Constituent: Gross Alpha (pCi/L)					
10/01/98 - 12/29/98	15	0.143	0.233	0.70[c]	2.33[c]
01/06/99 - 03/16/99	11	0.065	0.164	0.49	1.64
04/12/99 - 06/28/99	11	0.051	0.168	0.5	1.68
07/13/99 - 08/19/99	6	0.061	0.168	0.5	1.68
Summary	43	0.088	0.193	0.58	1.93

Table B.19. (contd)

Period	Number of Samples	Mean	Standard Deviation	Limit of Detection	Limit of Quantitation
		Constituent: Gross Beta (pCi/L)			
10/01/98 - 12/29/98	14[a]	0.79	0.83	2.50[c]	8.34[c]
01/06/99 - 03/31/99	11	0.96	0.84	2.51	8.36
04/07/99 - 06/28/99	12[a]	1.00	0.87	2.61	8.72
07/13/99 - 08/24/99	7	0.93	1.05	3.16	10.53
Summary	44	0.91	0.88	2.64	8.81
		Constituent: Iodine-129 (pCi/L)			
10/13/98 - 11/19/98	5	0.028	0.167	0.50[c]	1.67[c]
01/06/99 - 03/16/99	3	0.045	0.097	0.29	0.97
04/12/99 - 06/23/99	5	0.001	0.056	0.17	0.56
07/13/99 - 07/14/99	2	0.059	0.022	0.07	0.22
Summary	15	0.026	0.114	0.34	1.14
		Constituent: Strontium-90 (pCi/L)			
10/13/98 - 12/16/98	6	0.096	0.145	0.43[c]	1.45[c]
01/06/99 - 02/01/99	3	-0.005	0.058	0.17	0.58
04/12/99 - 05/25/99	2	0.137	0.001	0.00	0.01
08/11/99 - 08/24/99	2	0.129	0.010	0.03	0.10
Summary	13	0.084	0.111	0.33	1.11
		Constituent: Technetium-99 (pCi/L)			
10/01/98 - 12/29/98	8	3.01	3.41	10.23[c]	34.12[c]
02/01/99 - 03/31/99	3	11.60	7.81	23.43	78.09
04/07/99 - 06/23/99	7	1.67	4.32	12.95	43.16
07/13/99 - 08/24/99	5	-2.85	6.49	19.47	64.90
Summary	23	2.45	5.05	15.14	50.50
		Constituent: Tritium (pCi/L)			
10/13/98 - 12/29/98	15	188.4	162.2	486.5[c]	1,621.8[c]
01/06/99 - 03/16/99	13[a]	169.4	71.5	214.4	714.7
04/01/99 - 06/23/99	12	76.4	83.8	251.5	838.3
07/13/99 - 08/24/99	7	146.9	153.8	461.4	1,538.1
Summary	47	148.4	122.8	368.5	1,228.3
		Constituent: Uranium (µg/L)			
10/01/98 - 12/29/98	6	0.0137	0.0141	0.056[b]	0.155[b]
01/14/99 - 03/31/99	5	0.0104	0.0117	0.045	0.127
04/07/99 - 06/09/99	4	0.0079	0.0055	0.024	0.063
08/16/99 - 08/24/99	2	0.0030	0.0006	0.005	0.009
Summary	17	0.010	0.011	0.044	0.122

(a) Excluded outliers.
(b) Limit of detection equals the mean blank concentration plus 3 standard deviations; limit of quantitation equals the mean blank concentration plus 10 standard deviations.
(c) Limit of detection (blank corrected) equals 3 times the blank standard deviation; limit of quantitation (blank corrected) equals 10 times the blank standard deviation.

Table B.20. Summary of Quanterra Incorporated, St. Louis Detection and Quantitation Limits

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
				General Chemical Parameters				
EPA-600/4-81-004, 160.1	Total dissolved solids	4,228	5,713	19,042				
EPA-600/4-81-004, 310.1	Alkalinity	299	404	1,347	11/16/98	2230	3013	10044
EPA-600/4-81-004, 410.4	Chemical oxygen demand	3,819	5,160	17,200				
EPA-600/4-81-004, 413.1	Oil and grease	699	944	3,148				
				Ammonia and Anions				
EPA-600/4-81-004, 300.0	Bromide	15	20.3	67.6	12/22/98	17.4	23.5	78.4
EPA-600/4-81-004, 300.0	Chloride	35	47.3	157.6	12/22/98	34.6	46.8	155.8
EPA-600/4-81-004, 300.0	Fluoride	12	16.2	54.0	12/22/98	10.4	14.1	46.8
EPA-600/4-81-004, 300.0	Nitrogen in nitrate	2	2.7	9.0	12/22/98	10.6	14.3	47.7
EPA-600/4-81-004, 300.0	Nitrogen in nitrite	17	23.0	76.6	12/22/98	7.4	10.0	33.3
EPA-600/4-81-004, 300.0	Phosphate	42	56.7	189	12/22/98	34.8	47.0	157
EPA-600/4-81-004, 300.0	Sulfate	97	131	437	12/22/98	108	146	486
EPA-600/4-81-004, 350.1	Nitrogen in ammonia	8.76	11.8	39.5	12/10/98	30.1	40.67	135.6
SW-846, 9012	Cyanide	1.33	1.80	5.99	12/7/98	1.59	2.15	7.16
				Metals				
SW-846, 6010	Aluminum	38	51.3	171	7/25/99	26.5	35.8	119
SW-846, 6010	Antimony	27.3	36.9	123	7/25/99	19.7	26.6	88.7
SW-846, 6010	Barium	1.1	1.5	5.0	7/25/99	0.9	1.2	4.1
SW-846, 6010	Beryllium	0.7	0.9	3.2	7/25/99	0.2	0.3	0.9
SW-846, 6010	Cadmium	2.2	3.0	9.9	7/25/99	2	2.7	9.0
SW-846, 6010	Calcium	124.5	168.2	560.7	7/25/99	65.3	88.2	294
SW-846, 6010	Chromium	2.7	3.6	12.2	7/25/99	2.7	3.6	12.2
SW-846, 6010	Cobalt	2.3	3.1	10.4	7/25/99	2.5	3.4	11.3
SW-846, 6010	Copper	2.3	3.1	10.4	7/25/99	4	5.4	18.0
SW-846, 6010	Iron	35.6	48.1	160	7/25/99	30.3	40.9	137
SW-846, 6010	Lead	37.3	50.4	168	7/25/99	9	12.2	40.5
SW-846, 6010	Magnesium	34.1	46.1	154	7/25/99	100.7	136.1	453.5
SW-846, 6010	Manganese	0.7	0.9	3.2	7/25/99	0.5	0.7	2.3
SW-846, 6010	Nickel	14.3	19.3	64.4	7/25/99	10	13.5	45.0
SW-846, 6010	Potassium	1,677.6	2,266.7	7,555.7	7/25/99	576	778	2,594
SW-846, 6010	Silver	3.8	5.1	17.1	7/25/99	8	10.8	36.0
SW-846, 6010	Sodium	119.8	161.9	539.6	7/25/99	44.2	59.7	199
SW-846, 6010	Strontium (elemental)	0.7	0.9	3.2	7/25/99	0.4	0.5	1.8
SW-846, 6010	Tin	70	94.6	315	7/25/99	27	36.5	122
SW-846, 6010	Vanadium	3.7	5.0	16.7	7/25/99	4.7	6.4	21.2
SW-846, 6010	Zinc	4.1	5.5	18.5	7/25/99	4.2	5.7	18.9

Table B.20. (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 7060	Arsenic	2	2.70	9.01				
SW-846, 7131	Cadmium	0.2	0.27	0.90				
SW-846, 7191	Chromium	0.3	0.41	1.35				
SW-846, 7421	Lead	0.8	1.08	3.60				
SW-846, 7470	Mercury	0.011	0.015	0.050				
SW-846, 7740	Selenium	0.9	1.22	4.05				
SW-846, 7841	Thallium	0.6	0.81	2.70				
			Volatile Organic Compounds					
SW-846, 8010	1,1,1-Trichloroethane	0.028	0.038	0.126				
SW-846, 8010	1,1,2-Trichloroethane	0.036	0.049	0.162				
SW-846, 8010	1,1-Dichloroethane	0.024	0.032	0.108				
SW-846, 8010	1,2-Dichloroethane	0.018	0.024	0.081				
SW-846, 8010	1,4-Dichlorobenzene	0.026	0.035	0.117				
SW-846, 8010	Carbon tetrachloride	0.025	0.034	0.113				
SW-846, 8010	Chloroform	0.028	0.038	0.126				
SW-846, 8010	cis-1,2-Dichloroethylene	0.025	0.034	0.113				
SW-846, 8010	Methylene chloride	0.207	0.280	0.932				
SW-846, 8010	Tetrachloroethylene	0.031	0.042	0.140				
SW-846, 8010	trans-1,2-Dichloroethylene	0.031	0.042	0.140				
SW-846, 8010	Trichloroethylene	0.028	0.038	0.126				
SW-846, 8010	Vinyl chloride	0.294	0.397	1.324				
SW-846, 8020	1,4-Dichlorobenzene	0.028	0.038	0.126	11/16/98	0.52	0.703	2.342
SW-846, 8020	Benzene	0.042	0.057	0.189	11/16/98	0.26	0.351	1.171
SW-846, 8020	Ethylbenzene	0.033	0.045	0.149	11/16/98	0.31	0.419	1.396
SW-846, 8020	Toluene	0.089	0.120	0.401	11/16/98	0.81	1.094	3.648
SW-846, 8020	Xylenes (total)	0.065	0.088	0.293	11/16/98	0.59	0.797	2.657
SW-846, 8260	1,1,1,2-Tetrachloroethane	0.1134	0.153	0.511	1/27/99	0.2	0.270	0.901
SW-846, 8260	1,1,1-Trichloroethane	0.178	0.241	0.802	1/27/99	0.14	0.189	0.631
SW-846, 8260	1,1,2,2-Tetrachloroethane	0.3	0.405	1.351	1/27/99	0.13	0.176	0.586
SW-846, 8260	1,1,2-Trichloroethane	0.1	0.135	0.450	1/27/99	0.23	0.311	1.036
SW-846, 8260	1,1-Dichloroethane	0.2	0.270	0.901	1/27/99	0.13	0.176	0.586
SW-846, 8260	1,1-Dichloroethylene	0.194	0.262	0.874	1/27/99	0.15	0.203	0.676
SW-846, 8260	1,2,3-Trichloropropane	0.1546	0.209	0.696	1/27/99	0.24	0.324	1.081
SW-846, 8260	1,2-Dibromo-3-chloropropane	0.24	0.324	1.081	1/27/99	0.32	0.432	1.441
SW-846, 8260	1,2-Dibromoethane	0.068	0.092	0.306	1/27/99	0.13	0.176	0.586
SW-846, 8260	1,2-Dichloroethane	0.144	0.195	0.649	1/27/99	0.14	0.189	0.631
SW-846, 8260	1,2-Dichloroethylene (total)	0.1028	0.139	0.463	1/27/99	0.24	0.324	1.081
SW-846, 8260	1,2-Dichloropropane	0.2	0.270	0.901	1/27/99	0.1	0.135	0.450

Table B.20. (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 8260	1,4-Dichlorobenzene	0.184	0.249	0.829	1/27/99	0.17	0.230	0.766
SW-846, 8260	1-Butanol	2.52	3.405	11.35	1/27/99	7	9.458	31.53
SW-846, 8260	2-Butanone	0.42	0.567	1.892	1/27/99	0.89	1.203	4.008
SW-846, 8260	2-Hexanone	0.36	0.486	1.621	1/27/99	0.44	0.595	1.982
SW-846, 8260	4-Methyl-2-pentanone	0.19	0.257	0.856	1/27/99	0.15	0.203	0.676
SW-846, 8260	Acetone	1.94	2.621	8.737	1/27/99	0.33	0.446	1.486
SW-846, 8260	Acetonitrile	4.7	6.350	21.17	1/27/99	4.4	5.945	19.82
SW-846, 8260	Acrolein	4.28	5.783	19.28	1/27/99	5.07	6.850	22.83
SW-846, 8260	Acrylonitrile	1.7	2.297	7.66	1/27/99	1.01	1.365	4.55
SW-846, 8260	Benzene	0.168	0.227	0.757	1/27/99	0.13	0.176	0.586
SW-846, 8260	Bromodichloromethane	0.0998	0.135	0.449	1/27/99	0.08	0.108	0.360
SW-846, 8260	Bromoform	0.072	0.097	0.324	1/27/99	0.14	0.189	0.631
SW-846, 8260	Bromomethane	0.28	0.378	1.261	1/27/99	0.11	0.149	0.495
SW-846, 8260	Carbon disulfide	0.148	0.200	0.667	1/27/99	0.13	0.176	0.586
SW-846, 8260	Carbon tetrachloride	0.142	0.192	0.640	1/27/99	0.15	0.203	0.676
SW-846, 8260	Chlorobenzene	0.15	0.203	0.676	1/27/99	0.25	0.338	1.126
SW-846, 8260	Chloroethane	0.2	0.270	0.901	1/27/99	0.23	0.311	1.036
SW-846, 8260	Chloroform	0.172	0.232	0.775	1/27/99	0.09	0.122	0.405
SW-846, 8260	Chloromethane	0.66	0.892	2.973	1/27/99	0.03	0.041	0.135
SW-846, 8260	cis-1,2-Dichloroethylene	0.1	0.135	0.450	1/27/99	0.15	0.203	0.676
SW-846, 8260	cis-1,3-Dichloropropene	0.102	0.138	0.459	1/27/99	0.07	0.095	0.315
SW-846, 8260	Dibromochloromethane	0.066	0.089	0.297	1/27/99	0.16	0.216	0.721
SW-846, 8260	Dichlorodifluoromethane	0.4626	0.625	2.083	1/27/99	0.21	0.284	0.946
SW-846, 8260	Ethyl cyanide	0.96	1.297	4.324	1/27/99	1.47	1.986	6.621
SW-846, 8260	Ethylbenzene	0.26	0.351	1.171	1/27/99	0.23	0.311	1.036
SW-846, 8260	Methylene chloride	0.76	1.027	3.423	1/27/99	0.41	0.554	1.847
SW-846, 8260	Styrene	0.128	0.173	0.576	1/27/99	0.17	0.230	0.766
SW-846, 8260	Tetrachloroethylene	0.184	0.249	0.829	1/27/99	0.29	0.392	1.306
SW-846, 8260	Tetrahydrofuran	1.96	2.648	8.828	1/27/99	1.57	2.121	7.071
SW-846, 8260	Toluene	0.158	0.213	0.712	1/27/99	0.26	0.351	1.171
SW-846, 8260	trans-1,2-Dichloroethylene	0.13	0.176	0.586	1/27/99	0.11	0.149	0.495
SW-846, 8260	trans-1,3-Dichloropropene	0.058	0.078	0.261	1/27/99	0.2	0.270	0.901
SW-846, 8260	Trichloroethylene	0.4	0.540	1.802	1/27/99	0.16	0.216	0.721
SW-846, 8260	Trichloromonofluoromethane	0.406	0.549	1.829	1/27/99	0.13	0.176	0.586
SW-846, 8260	Vinyl acetate	0.72	0.973	3.243	1/27/99	0.17	0.230	0.766
SW-846, 8260	Vinyl chloride	0.68	0.919	3.063	1/27/99	0.1	0.135	0.450
SW-846, 8260	Xylenes (total)	0.142	0.192	0.640	1/27/99	0.79	1.067	3.558

Table B.20. (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
			Semivolatile Organic Compounds					
SW-846, 8040	2,3,4,6-Tetrachlorophenol	1.43	1.93	6.44	11/12/98	2.09	2.82	9.41
SW-846, 8040	2,4,5-Trichlorophenol	1.81	2.44	8.14	11/12/98	4.7	6.35	21.2
SW-846, 8040	2,4,6-Trichlorophenol	2.42	3.27	10.9	11/12/98	4.96	6.70	22.3
SW-846, 8040	2,4-Dichlorophenol	1.93	2.60	8.67	11/12/98	1.23	1.66	5.54
SW-846, 8040	2,4-Dimethylphenol	1.82	2.46	8.18	11/12/98	2.87	3.88	12.9
SW-846, 8040	2,4-Dinitrophenol	0.53	0.72	2.39	11/12/98	1.82	2.46	8.20
SW-846, 8040	2,6-Dichlorophenol	1.90	2.57	8.57	11/12/98	1.1	1.49	4.95
SW-846, 8040	2-Chlorophenol	1.94	2.62	8.75	11/12/98	2.13	2.88	9.59
SW-846, 8040	2-Methylphenol (cresol, o-)	1.79	2.42	8.06	11/12/98	2.43	3.28	10.9
SW-846, 8040	2-Nitrophenol	1.51	2.04	6.80	11/12/98	1.92	2.59	8.65
SW-846, 8040	2-secButyl-4,6-dinitrophenol (DNBP)	0.52	0.71	2.35	11/12/98	2	2.70	9.01
SW-846, 8040	3,4 methyl phenol	3.54	4.79	15.96				
SW-846, 8040	4,6-Dinitro-2-methylphenol	0.46	0.63	2.09	11/12/98	1.36	1.84	6.13
SW-846, 8040	4-Chloro-3-methylphenol	2.03	2.75	9.15	11/12/98	1.01	1.37	4.55
SW-846, 8040	4-Nitrophenol	0.70	0.94	3.14	11/12/98	0.92	1.24	4.14
SW-846, 8040	Pentachlorophenol	2.16	2.92	9.72	11/12/98	1.5	2.03	6.76
SW-846, 8040	Phenol	0.94	1.28	4.25	11/12/98	0.54	0.73	2.43
SW-846, 8080	4,4'-DDD	0.007	0.009	0.032				
SW-846, 8080	4,4'-DDE	0.005	0.007	0.023				
SW-846, 8080	4,4'-DDT	0.01	0.014	0.045				
SW-846, 8080	Aldrin	0.011	0.015	0.050				
SW-846, 8080	Alpha-BHC	0.006	0.008	0.027				
SW-846, 8080	Aroclor-1016	0.08	0.108	0.360				
SW-846, 8080	Aroclor-1221	0.08	0.108	0.360				
SW-846, 8080	Aroclor-1232	0.08	0.108	0.360				
SW-846, 8080	Aroclor-1242	0.08	0.108	0.360				
SW-846, 8080	Aroclor-1248	0.08	0.108	0.360				
SW-846, 8080	Aroclor-1254	0.03	0.041	0.135				
SW-846, 8080	Aroclor-1260	0.03	0.041	0.135				
SW-846, 8080	Beta-BHC	0.019	0.026	0.086				
SW-846, 8080	Chlordane	0.098	0.132	0.441				
SW-846, 8080	Delta-BHC	0.004	0.005	0.018				
SW-846, 8080	Dieldrin	0.008	0.011	0.036				
SW-846, 8080	Endosulfan I	0.007	0.009	0.032				
SW-846, 8080	Endosulfan II	0.009	0.012	0.041				
SW-846, 8080	Endosulfan sulfate	0.039	0.053	0.176				

Table B.20. (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 8080	Endrin	0.005	0.007	0.023				
SW-846, 8080	Endrin aldehyde	0.01	0.014	0.045				
SW-846, 8080	Gamma-BHC (Lindane)	0.009	0.012	0.041				
SW-846, 8080	Heptachlor	0.011	0.015	0.050				
SW-846, 8080	Heptachlor epoxide	0.005	0.007	0.023				
SW-846, 8080	Methoxychlor	0.017	0.023	0.077				
SW-846, 8080	Toxaphene	0.136	0.184	0.613				
SW-846, 8150	2,4,5-T	0.257	0.347	1.157				
SW-846, 8150	2,4,5-TP	0.064	0.086	0.288				
SW-846, 8150	2,4-Dichlorophenoxyacetic acid	3.98	5.38	17.9				
SW-846, 8150	2-secButyl-4,6-dinitrophenol (DNBP)	0.095	0.128	0.428				
SW-846, 8270	1,2,4,5-Tetrachlorobenzene	4.9	6.62	22.1	11/17/98	1.03	1.39	4.64
SW-846, 8270	1,2,4-Trichlorobenzene	1.13	1.53	5.09	11/17/98	0.97	1.31	4.37
SW-846, 8270	1,2-Dichlorobenzene	1.07	1.45	4.82	11/17/98	0.89	1.20	4.01
SW-846, 8270	1,3-Dichlorobenzene	1.51	2.04	6.80	11/17/98	0.9	1.22	4.05
SW-846, 8270	1,4-Dichlorobenzene	0.959	1.30	4.32	11/17/98	0.93	1.26	4.19
SW-846, 8270	1,4-Naphthoquinone	1.9	2.57	8.56				
SW-846, 8270	1-Naphthylamine	4.4	5.95	19.8				
SW-846, 8270	2,2'-Oxybis(1-chloropropane)	1.59	2.15	7.16	11/17/98	1.18	1.59	5.31
SW-846, 8270	2,3,4,6-Tetrachlorophenol	3.7	5.00	16.7				
SW-846, 8270	2,4,5-Trichlorophenol	1.15	1.55	5.18	11/17/98	0.78	1.05	3.51
SW-846, 8270	2,4,6-Trichlorophenol	1.55	2.09	6.98	11/17/98	0.66	0.89	2.97
SW-846, 8270	2,4-Dichlorophenol	1.53	2.07	6.89	11/17/98	1	1.35	4.50
SW-846, 8270	2,4-Dimethylphenol	1.36	1.84	6.13	11/17/98	0.97	1.31	4.37
SW-846, 8270	2,4-Dinitrophenol	1.15	1.55	5.18	11/17/98	0.97	1.31	4.37
SW-846, 8270	2,4-Dinitrotoluene	0.949	1.28	4.27	11/17/98	0.68	0.92	3.06
SW-846, 8270	2,6-Dichlorophenol	5	6.76	22.5				
SW-846, 8270	2,6-Dinitrotoluene	0.968	1.31	4.36	11/17/98	0.71	0.96	3.20
SW-846, 8270	2-Acetylaminofluorene	4.3	5.81	19.4				
SW-846, 8270	2-Chloronaphthalene	1.65	2.23	7.43	11/17/98	0.98	1.32	4.41
SW-846, 8270	2-Chlorophenol	1.07	1.45	4.82	11/17/98	1.12	1.51	5.04
SW-846, 8270	2-Methylnaphthalene	1.25	1.69	5.63	11/17/98	1	1.35	4.50
SW-846, 8270	2-Methylphenol (cresol, o-)	0.854	1.15	3.85	11/17/98	1	1.35	4.50
SW-846, 8270	2-Naphthylamine	4.4	5.95	19.8				
SW-846, 8270	2-Nitroaniline	1.07	1.45	4.82	11/17/98	0.59	0.80	2.66
SW-846, 8270	2-Nitrophenol	1.22	1.65	5.49	11/17/98	1.18	1.59	5.31
SW-846, 8270	2-Picoline	5.7	7.70	25.7				

Table B.20. (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 8270	2-secButyl-4,6-dinitrophenol (DNBP)	4.2	5.67	18.9				
SW-846, 8270	3,3'-Dichlorobenzidine	1.046	1.41	4.71	11/17/98	0.55	0.74	2.48
SW-846, 8270	3-Methylcholanthrene	17	23.0	76.6				
SW-846, 8270	3-Nitroaniline	0.998	1.35	4.49	11/17/98	0.5	0.68	2.25
SW-846, 8270	4,6-Dinitro-2-methylphenol	0.459	0.62	2.07	11/17/98	1.74	2.35	7.84
SW-846, 8270	4-Aminobiphenyl	3.7	5.00	16.7				
SW-846, 8270	4-Bromophenylphenyl ether	1.44	1.95	6.49	11/17/98	0.78	1.05	3.51
SW-846, 8270	4-Chloro-3-methylphenol	1.44	1.95	6.49	11/17/98	0.84	1.13	3.78
SW-846, 8270	4-Chloroaniline	1.37	1.85	6.17	11/17/98	0.88	1.19	3.96
SW-846, 8270	4-Chlorophenylphenyl ether	1.18	1.59	5.31	11/17/98	1.02	1.38	4.59
SW-846, 8270	4-Methylphenol (cresol, p-)	0.735	0.99	3.31	11/17/98	0.77	1.04	3.47
SW-846, 8270	4-Nitroaniline	0.532	0.72	2.40	11/17/98	0.87	1.18	3.92
SW-846, 8270	4-Nitrophenol	0.845	1.14	3.81	11/17/98	0.48	0.65	2.16
SW-846, 8270	4-Nitroquinoline-1-oxide	2.8	3.78	12.6				
SW-846, 8270	5-Nitro-o-toluidine	4.4	5.95	19.8				
SW-846, 8270	7,12-Dimethylbenz[a]anthracene	4.4	5.95	19.8				
SW-846, 8270	Acenaphthene	1.1	1.49	4.95	11/17/98	0.87	1.18	3.92
SW-846, 8270	Acenaphthylene	1.3	1.76	5.86	11/17/98	0.98	1.32	4.41
SW-846, 8270	Acetophenone	3.4	4.59	15.3				
SW-846, 8270	alpha,alpha-Dimethylphene-thylamine	50	67.6	225				
SW-846, 8270	Aniline	0.977	1.32	4.40	11/17/98	0.87	1.18	3.92
SW-846, 8270	Anthracene	0.929	1.26	4.18	11/17/98	0.48	0.65	2.16
SW-846, 8270	Azobenzene	0.736	0.99	3.31	11/17/98	0.45	0.61	2.03
SW-846, 8270	Benzidine	2.52	3.40	11.4	11/17/98	0.87	1.18	3.92
SW-846, 8270	Benzo(a)anthracene	0.258	0.35	1.16	11/17/98	0.58	0.78	2.61
SW-846, 8270	Benzo(a)pyrene	0.585	0.79	2.63	11/17/98	0.6	0.81	2.70
SW-846, 8270	Benzo(b)fluoranthene	0.462	0.62	2.08	11/17/98	0.88	1.19	3.96
SW-846, 8270	Benzo(ghi)perylene	0.938	1.27	4.22	11/17/98	0.95	1.28	4.28
SW-846, 8270	Benzo(k)fluoranthene	0.869	1.17	3.91	11/17/98	0.74	1.00	3.33
SW-846, 8270	Benzoic acid	28	37.8	126	11/17/98	0.96	1.30	4.32
SW-846, 8270	Benzyl alcohol	0.917	1.24	4.13	11/17/98	1.1	1.49	4.95
SW-846, 8270	Bis(2-Chloroethoxy)methane	1.2	1.62	5.40	11/17/98	1.14	1.54	5.13
SW-846, 8270	Bis(2-chloroethyl) ether	0.518	0.70	2.33	11/17/98	1.12	1.51	5.04
SW-846, 8270	Bis(2-ethylhexyl) phthalate	0.45	0.61	2.03	11/17/98	1.29	1.74	5.81
SW-846, 8270	Butylbenzylphthalate	0.484	0.65	2.18	11/17/98	0.72	0.97	3.24
SW-846, 8270	Carbazole	1.392	1.88	6.27				
SW-846, 8270	Chlorobenzilate	4.1	5.54	18.5				

Table B.20. (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 8270	Chrysene	0.229	0.31	1.03	11/17/98	0.42	0.57	1.89
SW-846, 8270	Di-n-butylphthalate	0.823	1.11	3.71	11/17/98	1.05	1.42	4.73
SW-846, 8270	Di-n-octylphthalate	0.426	0.58	1.92	11/17/98	1.35	1.82	6.08
SW-846, 8270	Diallate	7.3	9.86	32.9				
SW-846, 8270	Dibenz[a,h]anthracene	0.74	1.00	3.33	11/17/98	1.43	1.93	6.44
SW-846, 8270	Dibenzofuran	1.19	1.61	5.36	11/17/98	0.77	1.04	3.47
SW-846, 8270	Diethylphthalate	0.789	1.07	3.55	11/17/98	1.5	2.03	6.76
SW-846, 8270	Dimethoate	3.7	5.00	16.7				
SW-846, 8270	Dimethyl phthalate	0.98	1.32	4.41	11/17/98	3.04	4.11	13.7
SW-846, 8270	Disulfoton	3.3	4.46	14.9				
SW-846, 8270	Ethyl methanesulfonate	3.3	4.46	14.9				
SW-846, 8270	Famphur	49	66.21	221				
SW-846, 8270	Fluoranthene	0.135	0.18	0.61	11/17/98	0.6	0.81	2.70
SW-846, 8270	Fluorene	0.846	1.14	3.81	11/17/98	0.72	0.97	3.24
SW-846, 8270	Hexachlorobenzene	1.57	2.12	7.07	11/17/98	0.58	0.78	2.61
SW-846, 8270	Hexachlorobutadiene	1.98	2.68	8.92	11/17/98	0.91	1.23	4.10
SW-846, 8270	Hexachlorocyclopentadiene	1.66	2.24	7.48	11/17/98	0.91	1.23	4.10
SW-846, 8270	Hexachloroethane	1.42	1.92	6.40	11/17/98	0.86	1.16	3.87
SW-846, 8270	Hexachlorophene	100	135	450				
SW-846, 8270	Hexachloropropene	5.2	7.03	23.4				
SW-846, 8270	Indeno(1,2,3-cd)pyrene	0.841	1.14	3.79	11/17/98	0.61	0.82	2.75
SW-846, 8270	Isodrin	4.1	5.54	18.5				
SW-846, 8270	Isophorone	1.03	1.39	4.64	11/17/98	0.86	1.16	3.87
SW-846, 8270	Isosafrole	4.1	5.54	18.5				
SW-846, 8270	Kepone	30	40.5	135				
SW-846, 8270	m-Dinitrobenzene	3.8	5.13	17.1				
SW-846, 8270	Methapyrilene	26	35.1	117				
SW-846, 8270	Methyl methanesulfonate	1.5	2.03	6.76				
SW-846, 8270	Methyl parathion	3.5	4.73	15.8				
SW-846, 8270	N-Nitroso-di-n-dipropylamine	2.22	3.00	10.0	11/17/98	0.9	1.22	4.05
SW-846, 8270	N-Nitrosodi-n-butylamine	5.3	7.16	23.9				
SW-846, 8270	N-Nitrosodiethylamine	2.9	3.92	13.1				
SW-846, 8270	N-Nitrosodimethylamine	1.86	2.51	8.38	11/17/98	0.74	1.00	3.33
SW-846, 8270	N-Nitrosodiphenylamine	0.588	0.79	2.65	11/17/98	0.45	0.61	2.03
SW-846, 8270	N-Nitrosomethylethylamine	5.2	7.03	23.4				
SW-846, 8270	N-Nitrosomorpholine	2.9	3.92	13.1				
SW-846, 8270	N-Nitrosopiperidine	4.2	5.67	18.9				
SW-846, 8270	Naphthalene	1.59	2.15	7.16	11/17/98	1.09	1.47	4.91
SW-846, 8270	Nitrobenzene	1.19	1.61	5.36				

Table B.20. (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 8270	Nitrosopyrrolidine	3.2	4.32	14.4				
SW-846, 8270	O,O,O-Triethyl phosphorothioate	5	6.76	22.5				
SW-846, 8270	O,O-Diethyl O-2-pyrazinyl phosphorothioate	3.5	4.73	15.8				
SW-846, 8270	o-Toluidine	3.2	4.32	14.4				
SW-846, 8270	p-Dimethylaminoazobenzene	4.8	6.49	21.6				
SW-846, 8270	p-Phenylenediamine	100	135	450				
SW-846, 8270	Parathion	3.7	5.00	16.7				
SW-846, 8270	Pentachlorobenzene	3.4	4.59	15.3				
SW-846, 8270	Pentachloronitrobenzene (PCNB)	4	5.40	18.0				
SW-846, 8270	Pentachlorophenol	0.84	1.13	3.78	11/17/98	0.87	1.18	3.92
SW-846, 8270	Phenacetin	3.5	4.73	15.8				
SW-846, 8270	Phenanthrene	0.679	0.92	3.06	11/17/98	0.46	0.62	2.07
SW-846, 8270	Phenol	0.7	0.95	3.15	11/17/98	0.55	0.74	2.48
SW-846, 8270	Phorate	4.2	5.67	18.9				
SW-846, 8270	Pronamide	3.9	5.27	17.6				
SW-846, 8270	Pyrene	0.521	0.70	2.35	11/17/98	0.71	0.96	3.20
SW-846, 8270	Pyridine	0.96	1.30	4.32				
SW-846, 8270	Safrol	4.4	5.95	19.8				
SW-846, 8270	sym-Trinitrobenzene	22	29.7	99.1				
SW-846, 8270	Tetraethyl dithiopyrophosphate	4.6	6.22	20.7				
SW-846, 8270	Tributyl phosphate	21	28.4	94.6				

(a) MDLs for many constituents changed during the fiscal year. For these constituents, the initial MDL, LOD, and LOQ were in effect until the date the values were updated (ending values, effective date). In cases where the MDL did not change, no ending values are listed.

MDL = Method detection limit.
LOD = Limit of detection.
LOQ = Limit of quantitation.