Appendix C

Quality Assurance and Quality Control

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Appendix C

Quality Assurance and Quality Control

C. J. Thompson

This appendix presents fiscal year (FY) 2004 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* (RCRA) and the *Atomic Energy Act of 1954* (AEA). Long-term monitoring also includes monitoring performed at *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) sites with no active groundwater remediation. Pacific Northwest National Laboratory (PNNL) manages long-term monitoring via the Groundwater Performance Assessment Project (groundwater project). Interim action monitoring encompasses monitoring at sites with active groundwater remediation under CERCLA. Fluor Hanford, Inc. provided oversight for interim action groundwater monitoring during FY 2004. For both categories of groundwater monitoring, PNNL managed sample scheduling, sample collection, analytical work, and entry of associated information into the Hanford Environmental Information System (HEIS) database (HEIS 1994).

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) (EPA 1986a [OSWER-9950.1] and 1986b [SW 846]). U.S. Department of Energy (DOE) Orders and internal requirements provide the guidance for the collection and analysis of samples for other long-term monitoring. The QA/QC practices for the groundwater project are described in the project-specific QA plan (PNNL-15014). Guidance for interim action monitoring QA/QC practices is provided in project-specific documents (e.g., DOE/RL-90-08; DOE/RL-91-03; DOE/RL-91-46; DOE/RL-92-76; DOE/RL-96-07; DOE/RL-96-90; DOE/RL-97-36; DOE/RL-2002-10; DOE/RL-2002-17). A glossary of QA/QC terms is provided in PNNL-13080. Additional information about the QA/QC program and FY 2004 data (e.g., results of individual QC samples and/or associated groundwater samples) is available on request.

C.1 Sample Collection and Analysis

C. J. Thompson and D. L. Stewart

Duratek Federal Services, Inc. conducted groundwater sampling for FY 2004. Their tasks included bottle preparation, sample set coordination, field measurements, sample collection, sample shipping, well pumping, and coordination of purgewater containment and disposal. Duratek's statement of work[(a)] defines quality requirements for sampling activities. Groundwater project staff review all sampling procedures before the procedures are implemented.

Groundwater project staff periodically reviewed sample collection activities performed by nuclear chemical operators from Fluor Hanford, Inc. under the supervision of Duratek Federal Services, Inc. The purpose of the surveillances was to ensure that samples were collected and submitted to the laboratories in accordance with high-quality standards. Nine surveillances were conducted in the following areas: bottle preparation; sample packaging, shipping, and storage; measurement of groundwater levels; sample collection (two events); water-purification system maintenance;

(a) SOW-409744-A-B3. 2001. Statement of Work between Pacific Northwest National Laboratory and Duratek Federal Services, Inc., Richland, Washington.

decontamination of sampling equipment; training and associated documentation; and quality records management and storage. A few minor procedural deviations were identified. Corrective actions for all of these surveillances have been received and accepted. Three surveillances remain open pending completion of the corrective actions.

During FY 2004, Severn Trent Laboratories, Incorporated, St. Louis, Missouri (STL St. Louis), performed most of the routine analyses of Hanford groundwater samples for hazardous and non-hazardous chemicals. Lionville Laboratory, Incorporated, Lionville, Pennsylvania (Lionville Laboratory), served as a secondary laboratory for chemical analyses of split samples and blind standards.

Severn Trent Laboratories, Incorporated, Richland, Washington (STL Richland) performed the majority of radiological analyses on Hanford groundwater samples. Eberline Services, Richmond, California, also analyzed samples for radiological constituents.

Standard methods from EPA and American Society for Testing and Materials (ASTM) were used for the analysis of chemical constituents. Methods employed for radiological constituents were developed by the analyzing laboratories and are recognized as acceptable within the radiochemical industry. Descriptions of the analytical methods used are provided in PNNL-13080.

C.2 Data Completeness

C. J. Thompson

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. During FY 2004, 87% of the groundwater data (both long-term and interim action monitoring) were considered complete. The percentages of potentially invalid data were 1.4% for field QC problems, 1.9% for exceeded holding times, 0.0% for rejected results, 0.2% for suspect values, and 9.1% for laboratory blank contamination. These values are similar to the percentages observed in FY 2003.

C.3 Field Quality Control Samples

D. S. Sklarew, S. J. Trent, and C. J. Thompson

Field QC samples include field duplicates, split samples, and three types of field blanks. The three types of field blanks are full trip, field transfer, and equipment blanks. Field duplicates are used to assess sampling and measurement precision. Split samples are used to confirm out-of-trend results and for interlaboratory comparisons. Field blanks provide an overall measure of contamination introduced during the sampling and analysis process.

C.3.1 Long-Term Monitoring (Groundwater Performance Assessment Project)

The groundwater project's criteria for evaluating the analytical results of field QC samples are as follows:

- 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.
- split samples – Results must have a relative percent difference <20%. Only those results that are greater than five times the method detection limit or minimum detectable activity at both laboratories are evaluated.
- field 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. Results for metals are flagged if they exceed two times the instrument detection limit. For radiological data, blank results are flagged if they are greater than two times the total minimum detectable activity.

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 (4,015/4136 = 97%) and duplicate (4383/4408 = 99%) results evaluated in FY 2004 were high, indicating little problem with contamination and good precision overall. A limited number of split samples were collected during the year; the analyzing laboratories demonstrated reasonable agreement.

Tables C.1 through C.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. A few constituents such as chloride, sodium, and sulfate had several quantifiable field blank results, but the concentrations were much lower than the levels of these constituents in almost all groundwater samples.

Compared to FY 2003, the number of field blank results for chloride and fluoride that exceeded the QC limits decreased significantly.

Twelve field blanks results for metals exceeded the QC limits, which is considerably fewer than last year. In general, the blank concentrations were similar to those from last year. Most of the unacceptable results were within a factor of 5 of the instrument detection limits. All of the metals with out-of-limit field blank results had one or more comparable method-blank results, suggesting that some of the elevated field blank values were caused by false detections or laboratory contamination.

Concentrations of eight volatile organic compounds exceeded the QC limits in one or more field blanks. Methylene chloride was the predominant volatile contaminant, accounting for 65% of the out-of-limit results. Levels of acetone were also out-of-limits in twelve field blanks. Laboratory contamination is the suspected source of these common contaminants, because similar concentrations also were measured in several method blanks. Trace levels of several other volatile organic compounds also were measured in field blanks (Tables C.1 through C.3). All these compounds had low frequencies of detection (i.e., <5%) in field blanks, and the overall impact on the data is minor.

Gross beta, tritium, and uranium were the only radiological constituents with out-of-limit field blank results. Although their field blank concentrations were low, they were greater than levels of these constituents in some of the associated groundwater samples. Tritium and uranium were measured in one or more laboratory method blanks at concentrations similar to the field blank values.

Duplicate results were flagged for all constituent classes except general chemistry parameters (Table C.4). Overall, the relative number of flagged duplicate results was very low (<1%), but the percentages of unacceptable results were high for several constituents based on the number of duplicates that met the evaluation criteria. Most of the associated samples in the radiological parameters category were unfiltered; thus, suspended solids in heterogeneous sample fractions may have caused some of the discrepancies in the results. The majority 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 C.5.2 and C.5.3). In several cases, the laboratory was asked to re-analyze 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 a pair of results for zinc (2.7 and 17.1 µg/L) and iodine-129 (16.2 and 26.8 pCi/L). Swapped samples or procedural deviations at the laboratory may have caused the unmatched results.

During the second quarter of FY 2004, four pairs of split samples were collected from well 299-W7-12 (RCRA Low-Level Waste Management Area 3) to investigate previous total organic carbon measurements that showed elevated concentrations. STL St. Louis and Lionville Laboratories analyzed the samples for total organic carbon. Although none

of the results was above five times the method detection limit, the laboratories demonstrated reasonable agreement. The average concentration was 525 µg/L for STL St. Louis and 653 µg/L for Lionville. The relative percent difference ranged from 3% to 51%. These results appear to confirm that the previous measurements, which were made when STL St. Louis was having problems with the analysis, were biased high.

C.3.2 Interim Action Monitoring

Trained staff collected samples in accordance with approved procedures. 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 FY 2004, 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 long-term monitoring program identified in Section C.3.1.

For field blank samples, >95% of all reviewed results were returned as non-detected. This is substantially better than FY 2003 results (90% non-detect). This may reflect an overall improvement in sample collection and laboratory performance. Organic compounds showed the greatest inclination to exceed the acceptable QC criteria. Fifty percent of the field blank QC exceedances were due to acetone and methylene chloride. These two compounds are well-known laboratory contaminants, and it is likely that most of the acetone and methylene chloride detections are associated with contamination introduced during analysis of the samples. (Note: The concentration of these organic compounds did not exceed 4 µg/L in any field blank sample.) Evaluation of field blank sample results showed no evidence of unexpected or excessive contamination of blanks in the field. The constituents and levels of contamination found should have no impact on decision making for interim action monitoring. Blank detects are summarized in Table C.5.

Field duplicate results showed ~5% exceeding the criteria used for evaluation. Field duplicate evaluations are summarized in Table C.6. Most of the exceedances (74%) are associated with duplicate results for organic compounds and radiological constituents. The reason for the reduced precision for radiological analytes is not readily apparent, although it might reflect differential entrainment of particulates during sampling or laboratory analytical problems. Exceedance of the criteria for organic analytes is mainly associated with very low-level detections (<1 µg/L) or very high detections where sample dilution was required. In general, field duplicate QC issues are minimal and do not indicate significant laboratory or sample collection problems.

Approximately 10% of split sample results were outside the acceptance limits. Table C.7 summarizes the out-of-limit results. Field analytical and laboratory split samples for hexavalent chromium and sulfate showed the most frequent exceedances of the QC criteria. In most cases, the differences in analyte concentrations are probably associated with differences in analytical protocol and methods between the laboratory and the field test kits. The criteria used to evaluate split samples 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). Evaluation of the split sample data show no significant quality problems exist with either the primary or split laboratories.

Overall, field QC results appear to be good. The evaluation indicates no significant issues between procedures and analyses performed by the laboratories providing services to Fluor Hanford, Inc. The general performance for FY 2004 is similar to or better than the previous year.

C.4 Holding Times

C. J. Thompson

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 alterations. 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 C.8. Radiological constituents do not have recommended maximum holding times because these constituents are not typically lost under ambient temperatures when appropriate preservatives are used. Results of radionuclide analysis are corrected for decay from sampling date to analysis date.

During FY 2004, recommended holding times were exceeded for 353 out of 7,412 (4.8%) non-radiological sample analysis requests (both long-term and interim action monitoring). A sample analysis request is defined as a sample that is submitted for analysis by a particular analytical method. In general, the missed holding times should not have a significant impact on the data. Results for samples with missed holding times are flagged with an H in the database. STL St. Louis exceeded the holding times for 339 out of 7,218 (4.7%) sample analysis requests, an increase over last year's 1.4%. The constituents with the most missed holding times were anions by EPA method 300.0 (206 samples), phenols (20 samples), total organic carbon (28 samples), and volatile organic compounds (44 samples). STL Richland exceeded holding times for 3 out of 81 hexavalent chromium analyses, but all 69 of the laboratory's coliform analyses were performed within the recommended 24-hour holding time. Lionville Laboratory missed holding times for 11 out of 44 sample analyses. Anions and total organic carbon were the affected constituents.

Several factors caused holding times to be exceeded during FY 2004, including sample shipping delays, re-analyses triggered by QC failures, the need to dilute some samples, and oversight by laboratory staff. Periodically, missed holding times were discussed with the laboratories to help identify areas where improvements are needed.

C.5 Laboratory Performance

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

Laboratory performance is measured by several indicators, including national 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 STL St. Louis and STL Richland. Brief summaries of performance measures for Lionville Laboratory and Eberline Services also are presented throughout this section. The majority of the laboratory's results were within the acceptance limits indicating good performance overall.

C.5.1 National Performance Evaluation Studies

During FY 2004, Environmental Resources Associates and DOE conducted national studies to evaluate laboratory performance for chemical and radiological constituents. STL St. Louis and Lionville Laboratory participated in the EPA sanctioned Water Pollution and Water Supply Performance Evaluation studies conducted by Environmental Resources Associates. STL Richland and Eberline Services took part in DOE's Quality Assessment Program until it ended this year. STL Richland participated in the Environmental Resources Associates' InterLaB RadCheM Proficiency Testing Program; Eberline began participation in this program towards the end of the year. All four laboratories took 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.

C.5.1.1 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. An accredited agency such as Environmental Resource Associates distributes standard water samples 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 accredited agency, which 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 the accredited agency found acceptable, independently verify the level of laboratory performance.

For the three water pollution studies in which STL St. Louis participated this year (ERA WP-109, 111, and 114), the percentage of acceptable results submitted to the groundwater project ranged from 67% to 92% (Table C.9). One of these studies (WP-111) had a limited number of analytes. Of the 40 different constituents with unacceptable results, total Kjeldahl nitrogen (TKN), total cyanide, and tetrachloroethene were out of limits in both studies in which they were analyzed; a number of volatile organic compounds and phenols were out of limits in one out of two studies. The laboratory provided information about possible causes for many of the unacceptable results and suggested corrective actions where appropriate. The constituents that were out of limits last year are mainly within limits this year, with the exception of TKN; however, TKN is not used for Hanford groundwater samples. Overall, the unacceptable results should not have a significant impact on Hanford groundwater samples.

Lionville Laboratory participated in three water supply and three water pollution studies this year (ERA WS-84, 90, and 96 and WP-102, 108, and 114). For the results submitted to the groundwater project, the percentage of Lionville's acceptable results ranged from 91% to 99% (Table C.10). Of the 26 different constituents with unacceptable results, only one was out of limits in more than one study, 1,4-dichlorobenzene was out of limits in two out of six studies. The laboratory provided information about possible causes for the unacceptable results and suggested corrective actions where appropriate. Overall, the unacceptable results should not have a significant impact on Hanford groundwater samples.

C.5.1.2 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. The EML provides blind standards that contain specific amounts of one or more radionuclides to participating laboratories. Constituents analyzed can include americium-241, cesium-134, cesium-137, cobalt-60, gross alpha, gross beta, plutonium-238, plutonium-239, strontium-90, tritium, uranium-234, uranium-238, and total uranium. After sample analysis, each participating laboratory forwards the results to the EML for comparison with known values and with results from other laboratories. The 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% (<5th percentile or >95th percentile) of historical data (EML-564).

For the two studies conducted this year, QAP59 and QAP60, the percentage of STL Richland's acceptable results ranged from 83% to 91% (Table C.11). The unacceptable results were for gross alpha, gross beta, and strontium-90. Three constituents (13%) had results that were evaluated as acceptable with warning (Table C.11).

The percentage of Eberline Services' results that was acceptable was 100% in both studies (Table C.12). Three constituents had results that were evaluated as acceptable with warning (Table C.12).

The Quality Assessment Program is being terminated by DOE because the mission of EML has been changed to support homeland security. QAP 60 is the last study in the program.

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.

Three studies were available for FY 2004 (MAPEP-02-W10, MAPEP-03-W11, and MAPEP-04-MaW12&GrW12). Four results were unacceptable for STL St. Louis, plutonium-239/240, tritium, 1,3-dichlorobenzene, and 1,4-dichlorobenzene; four other results were acceptable with warning (Table C.11). Four results were unacceptable for STL Richland, americium-241, nickel-63 (two studies), and strontium-90. All results for Eberline Services and Lionville Laboratory were acceptable, though one result for Lionville was acceptable with warning (Table C.12).

C.5.1.3 InterLaB RadCheM Proficiency Testing Program Studies

The purpose of the InterLaB RadCheM Proficiency Testing Program, conducted by Environmental Resources Associates, is to evaluate the performance of laboratories in analyzing selected radionuclides. The program provides blind standards that contain specific amounts of one or more radionuclides in a water matrix to participating laboratories. Environmental Resources Associates standards were prepared for the following radionuclides/parameters: barium-133, cesium-134, cesium-137, cobalt-60, gross alpha, gross beta, iodine-131, radium-226, radium-228, strontium-89, strontium-90, tritium, uranium, and zinc-65. After sample analysis, the results were forwarded to Environmental Resources Associates for comparison with known values and with results from other laboratories. Environmental Resources Associates bases its control limits on the EPA's National Standards for Water Proficiency Testing Studies Criteria Document (NERL-Ci-0045).

In the six studies in which STL Richland participated this year (RAD-53, 54, 55, 56, 57, and 58), 73 constituents were analyzed. Of these, 69 (95%) were acceptable (Table C.11). The unacceptable results were for iodine-131, strontium-89, strontium-90, and tritium.

In the one study in which Eberline Services participated this year (RAD-58), 13 constituents were analyzed. All were acceptable (Table C.12).

C.5.2 Double-Blind Standard Evaluation

The groundwater project forwarded blind QC standards to STL Richland and St. Louis, Lionville Laboratory, and Eberline Services during FY 2004. 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. Standards for specific conductance were commercially prepared in 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). After analysis, the laboratory's results were compared with the spiked concentrations, and a set of control limits were used to determine if the data were acceptable. Generally, if a result was out of limits, the data were reviewed for errors. In situations where several results for the same method were unacceptable, the results were discussed with the laboratory, potential problems were investigated, and corrective actions were taken if appropriate.

Tables C.13 and C.14 list the number and types of blind standards used in FY 2004 along with the control limits for each constituent. Overall, 90% of the blind spike determinations were acceptable. This is slightly higher than the percentage from FY 2003 (88%), although fewer constituents were evaluated this year. A total of 15 results were out of limits for STL Richland and St. Louis. Total organic halides, cyanide, fluoride, gross alpha, plutonium-239, and tritium were the constituents with out-of-limit results. Lionville Laboratory had nine unacceptable results for total organic carbon. All of Eberline Services' results for gross beta were within the acceptance limits.

Total organic halides results from STL St. Louis were improved over FY 2003, although four results were out of limits. One of the unacceptable results was for a standard spiked with 2,4,5-trichlorophenol. Since the standard was spiked at a low concentration (i.e., approximately five times the method detection limit), the laboratory's recovery of 132% was not unreasonable. All of the unacceptable results for the standards spiked with volatile organic compounds had low recoveries (47% to 62%). PNNL staff performed in-house analyses on splits of the volatile standards and confirmed that the standards were spiked at the proper concentrations. Consequently, 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 C.6).

STL St. Louis had one out-of-limit result for cyanide; the recovery was 9%. Loss of cyanide during the distillation step of the analysis is the suspected cause of the low result.

All of STL St. Louis' first quarter fluoride results were biased high, with recoveries of 130%. PNNL analysis of a duplicate standard suggested that the samples had been spiked at higher concentrations than anticipated. Based on the in-house concentration, STL St. Louis' results would have been acceptable. All of the STL St. Louis' fluoride results from the last three quarters were acceptable.

In general, STL Richland performed well on the analysis of radiological blind standards. Eight results were outside the QC limits. Three of the unacceptable results were for tritium, and all of the results were high by a factor of ~2.5. A calculation or procedural error at the laboratory may have caused the elevated values. Three gross alpha results from the fourth quarter were biased high, with recoveries ranging from 140% to 255%. Additionally, two plutonium-239 results had low out-of-limit recoveries. Reasons for these unacceptable results are unknown.

During December, some special blind standards were submitted to STL Richland to evaluate possible loss of iodine-129 in samples with relatively high levels of technetium-99. Such samples undergo pre-treatment to remove technetium by passing the sample through an extraction disc. The special blind standards were designed to assess whether iodine was also sorbing onto the extraction discs. Two sets of standards were prepared: the first contained ~76 pCi/L of iodine-129, and the second contained ~6,300 pCi/L of technetium-99 in addition to the 76 pCi/L of iodine-129. In both cases, the samples were filtered through the extraction discs prior to analysis. The results from the two groups of standards

were very similar, with iodine-129 recoveries ranging from 105% to 113%. Consequently, the data demonstrate that iodine-129 does not appreciably sorb onto the extraction discs.

Over half (i.e., nine out of sixteen) of Lionville Laboratory's total organic carbon results were outside the acceptance limits, and all of the results were biased high. STL St. Louis had acceptable recoveries on splits of these standards, indicating that the samples were spiked correctly. Inadequate removal of inorganic carbon during the analysis is the likely cause of the elevated results. The impact of the out-of-limit results is minimal, because Lionville Laboratory did not analyze many routine groundwater samples for total organic carbon during FY 2004.

Eberline Services analyzed 12 blind standards for gross beta, and all of the results were acceptable.

Fluor Hanford, Inc. sent no blind standards as part of interim action monitoring to the commercial laboratories in FY 2004. 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.

C.5.3 Laboratory Internal QA/QC Programs

STL Richland, STL St. Louis, Eberline Services, and Lionville Laboratory 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). This information provides a means to assess laboratory performance and the suitability of a method for a particular sample matrix. Laboratory QC data are not currently used for in-house validation of individual sample results unless the lab is experiencing unusual performance problems with an analytical method. An assessment of the laboratory QC data for FY 2004 is summarized in this section. STL data are discussed in detail first. Table C.15 provides a summary of the STL QC data by listing the percentage of QC results that were out of limits for each analyte category and QC parameter. Additional details are presented in Tables C.16 through C.19. Constituents not listed in these tables did not exceed STL's QC limits. A brief summary of Lionville Laboratory and Eberline Services data is presented at the end of the section.

Most of this year's laboratory QC results were within acceptance limits, suggesting that the analyses were in control and reliable data were generated. Nevertheless, a number of parameters had unacceptable results.

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 for chemical constituents and two times the total propagated error for radiochemistry parameters. 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 C.16 summarizes method blank results from STL Richland and St. Louis. The metals category had the greatest percentages of method blank results exceeding the QC limits. The following parameters had >10% of method blank results outside the QC limits: lithium, zinc, acetone, benzyl alcohol, and diethylphthalate. The out-of-limit method blank results for sodium are not a significant problem because the values are much lower than the levels measured in Hanford Site groundwater. Similarly, the highest method blank results for chloride (0.2 mg/L), sulfate (0.34 mg/L), calcium (1,230 μg/L), magnesium (605 μg/L), and elemental strontium (2.4 μg /L) are typically lower than the respective levels measured in Hanford groundwater. The percentage of out-of-limit method blanks for conductivity, bromide, chloride, fluoride, nitrogen in nitrate, sulfate, iron, lead, sodium, tin, vanadium, methylene chloride, 2,3,4,6-tetrachlorophenol, carbon-14, and uranium decreased significantly compared to last year, while the percentage for lithium, zinc, 1,4-dichlorobenzene, acetone, trichloroethene, benzyl alcohol, diethylphthalate, and strontium-90 increased.

Table C.17 summarizes results for the laboratory control samples from STL Richland and St. Louis. Only volatile organic compounds and semivolatile organic compounds had >2% of their measurements outside the QC limits. Specific compounds with >10% of out-of-limit laboratory control samples included 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, 4-nitrophenol, aldrin, alpha-BHC, beta-BHC, delta-BHC, dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, gamma-BHC, heptachlor, heptachlor epoxide, methoxychlor, uranium-234, and uranium-238. In all of these cases except nitrophenol, the number of QC samples analyzed was limited (<20). Most of these constituents are not routinely monitored in Hanford groundwater.

Table C.18 summarizes results for the matrix spikes and matrix spike duplicates from STL Richland and St. Louis. The semivolatile organic compounds, volatile organic compounds, ammonia and anions, and radiochemistry parameters categories had the greatest percentage of matrix spikes/spike duplicates exceeding the QC limits. This represents an increase compared to last year's results for the volatile organic compounds, semivolatile organic compounds and

radiochemistry parameters. Fewer than 2% of the matrix spikes or matrix spike duplicates for general chemistry parameters and metals were out of limits; this represents a decrease for the general chemistry parameters compared to FY 2003 results.

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. Table C.19 lists the constituents that exceeded the relative percent difference limits. The semivolatile organic compounds and volatile organic compounds categories had the greatest percentage of matrix duplicates exceeding the QC limits. This represents an increase compared to last year's results for both categories. All other categories had fewer than 2% of their measurements outside the QC limits.

Surrogate data that was out of limits included six compounds for volatile organics and eight for semivolatile organics. For volatile organic compounds, 4.5% of the surrogate results were outside of QC limits; the corresponding percentage for semivolatile organic surrogates was 6.3%.

QC data for Eberline Services and Lionville Laboratory were limited for FY 2004 because these laboratories did not analyze many samples for the groundwater project. Lionville Laboratory analyzed method blanks, laboratory control samples, matrix spikes, and matrix duplicates for total organic carbon, some anions (by ion chromatography) and some metals (by inductively coupled plasma emission spectroscopy). All of the QC data for total organic carbon and the anions were within limits. Method blanks for several metals (barium, calcium, chromium, iron, potassium, magnesium, manganese, sodium, nickel, strontium, zinc) were out of limits at least once. Duplicates for several metals (aluminum, chromium, copper, manganese, nickel, zinc) were also out of limits at least once. Eberline Services QC data were limited to gross alpha, gross beta, radionuclides by gamma spectroscopy, strontium-90, and tritium. All of the QC data except one duplicate for gross beta were within limits.

C.5.3.1 Issue Resolution

Issue resolution forms are documents used to record and resolve problems encountered with sample receipt, sample analysis, missed holding times, and data reporting (e.g., broken bottles or QC problems). The laboratories generate these forms and forward them to the groundwater project as soon as possible after a potential problem is identified. The forms provide a means for the project to give direction to the laboratory on resolution with the issues. The documentation is intended to identify occurrences, deficiencies, and/or issues that may potentially have an adverse effect on data integrity. During FY 2004, 108 issue resolution forms were submitted by STL Richland and St. Louis.

Table C.20 indicates the specific issues identified this year and the number of analytical requests that were impacted. The number of analytical requests impacted was small compared to the total number of analytical requests submitted (~13,300, consisting of ~22,900 bottles). Relative to FY 2003, the frequencies of the individual issues increased or remained the same in most categories prior to receipt at the laboratory. Similarly, the frequencies of issues after receipt at the laboratory remained the same with one exception: laboratory QC out of limits. The number of holding time issues was primarily related to delays caused by the need for radiological screens prior to shipment. A small percentage of the holding time issues were related to shipping delays. The QC out of limits were due to analytical problems that occurred with phenols and low level tritium analyses.

C.5.3.2 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. Seven assessments of the commercial analytical laboratories were performed. Four of these audits were conducted by the Department of Energy Consolidated Assessment Program (DOECAP), two audits were conducted by Bechtel Hanford, Inc. (BHI), and one audit was conducted by joint team of BHI and PNNL representatives.

The goal of the DOECAP is to design and implement a program to consolidate site audits of commercial and DOE environmental laboratories providing services to DOE Environmental Management. The specific audit objectives of the DOECAP were to assess the ability of the laboratories to produce data of acceptable and documented quality through analytical operations that follow approved methods and the handling of DOE samples and associated waste in a manner that protects human health and the environment.

The four DOECAP audits were performed at the following laboratories: STL St. Louis, March 30 to April 1, 2004; Eberline Services, May 18 to 20, 2004; Lionville Laboratory, May 4 to 6, 2004; and STL Richland, August 3 to 5, 2004.

The assessment scope of the DOECAP audits included the following specific functional areas: (1) QA management systems and general laboratory practices, (2) data quality for organic analyses, (3) data quality for inorganic and wet chemistry analyses, (4) data quality for radiochemistry analysis, (5) hazardous and radioactive materials management, and (6) verification of corrective-action implementation from previous audit findings.

The purpose of the joint BHI and PNNL assessment (conducted on August 10 to 12, 2004) and the BHI audits (conducted on March 8 and August 15, 2004) was to evaluate the continued support of analytical services to Hanford Site contractors as specified in the statement of work between Fluor Hanford, Inc. and STL and Eberline Services.[b] The audit was based on the analytical and QA requirements for both groundwater and multi-media samples as specified in the statement of work. The primary areas of focus were personnel training, procedure compliance, sample receipt and tracking, instrument operation and calibration, equipment maintenance, instrumentation records and logbooks, implementation of STL's QA Management Plan in accordance with Hanford Analytical Services Quality Assurance Document (HASQARD, Volumes 1 and 4, DOE/RL-96-68), and the implementation of corrective actions for deficiencies identified in previous audits.

A total of 26 findings and 41 observations were noted for the 4 DOECAP audits, 11 findings and 6 observations were identified in the joint BHI and PNNL audit, and 5 findings and 19 observations were identified by the BHI only audits. Results of each of these audits are summarized in Table C.21. Corrective actions have been accepted for all audits, and verification of the corrective actions will be performed in future audits. All laboratories have been qualified to continue to provide analytical services for samples generated at DOE sites.

In addition to many of the past audit findings being closed, several proficiencies for all of the laboratories were noted in each audit this year, indicating that the laboratories are improving their processes and continuing to provide quality analytical services. 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.

C.5.4 Concerns about Aluminum Results

In July, PNNL staff observed an increase in the frequency of detection and the concentrations of aluminum at several wells across the Hanford Site. For example, wells such as 299-E27-4 that previously had a history of non-detected results began having detected results in the range of 70 to 120 µg/L. The problem appeared to begin with samples collected in May and continued through the end of the fiscal year. Although aluminum is not a primary constituent of concern, the results were considered significant because many of the detected values exceeded the lower end of the secondary drinking water standard (50 to 200 µg/L). The questionable data were discussed with the analyzing laboratory (STL St. Louis), and the laboratory was asked if they were aware of any procedural or instrument changes that might be responsible for the data trends. Laboratory staff were not aware of any factors that might explain the anomalous values. Review of the laboratory QC results showed that while aluminum was detected in several method blanks (21%), there did not appear to be an obvious correlation with the elevated sample results. Other laboratory QC parameters such as laboratory control samples and matrix spikes were almost always within the acceptance limits. Moreover, field blank results for aluminum were generally acceptable during the second half of the year, although one from June had a result of 81 µg/L, and one from August had a result of 114 µg/L. In response to PNNL's concerns, the laboratory has performed an extensive cleaning of the laboratory used to prepare samples for metals analysis, and they have replaced overhead ventilation ductwork to reduce the possibility of sample contamination. PNNL has flagged many of the suspect data points in HEIS. In addition, special blind standards and several split samples are planned for FY 2005 to help identify and correct the source of the elevated results.

(b) RFSH-SOW-93-0003, Rev. 6. 1999. *Environmental and Waste Characterization of Analytical Services*. Statement of Work between Fluor Daniel Hanford, Inc. and Severn Trent Laboratories, Richland, Washington, and Eberline Services, Richmond, California.

C.6 Limit of Detection, Limit of Quantitation, and Method Detection Limit

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Detection and quantitation limits are essential to evaluate 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 present but is, in fact, absent. A false-negative error is an instance when an analyte is declared 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 C.22 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 C.22 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 9355.0-14). 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 seven 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 C.23.

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:

$$\mathrm{MDL} = 3.14 \cdot s$$

$$\begin{aligned}\mathrm{LOD} &= 3\left(\sqrt{2} \cdot s\right) \\ &= 4.24 \cdot s\end{aligned}$$

$$\begin{aligned}\mathrm{LOQ} &= 10\left(\sqrt{2} \cdot s\right) \\ &= 14.14 \cdot s\end{aligned}$$

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 C.23. The values in the table apply to STL St. Louis only.

Specific evaluation of detection-limit issues for the interim action groundwater monitoring 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 FY 2004.

C.6.1 Iodine-129 Detection Issues

Iodine-129 is a challenging radionuclide to monitor due to the need for especially low detection limits. The drinking water standard for iodine-129 is 1 pCi/L, which is the lowest of any radionuclide. STL Richland performed all of the iodine-129 measurements during FY 2004, and in most cases, the laboratory was able to achieve a minimum detectable activity of 1 pCi/L or less. However, ~16% of the results were reported as non-detected at levels up to 7 pCi/L. In FY 2003, the problem was worse, with non-detected values as high as 36 pCi/L. The highest non-detected values were associated with locations having elevated levels of technetium-99 (e.g., wells 299-W14-13 and 299-W14-15). Due to high screening results for these samples (resulting from the technetium-99 concentrations), the laboratory was using a smaller volume for iodine-129 analyses, resulting in a higher effective detection limit. PNNL discussed this problem with the laboratory, and the laboratory has implemented a special preparation step for samples that contain high levels of technetium-99. Such samples are filtered through an extraction disc that removes the technetium, and the filtrate is re-screened and processed for iodine-129 using the full sample volume. Limited data are available since this procedural modification has been employed, and the results have been variable (see Section C.5.2 for an investigation of possible sorption of iodine onto the extraction disc). Obtaining the desired 1-pCi/L detection limit is challenging even for ideal sample matrices, and it is anticipated that detection at these levels will be a continued problem until methodologies improve. PNNL is planning to explore the use of inductively coupled plasma/mass spectroscopy for low-level detection of iodine-129 during FY 2005.

C.7 Conclusions

Overall, assessments of FY 2004 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. Mismatched results for key constituents are identified during data review and flagged when appropriate.

- Several indicator parameters, anions, metals, volatile organic compounds, and radiological parameters were detected at low levels in field and/or laboratory method blanks. The most significant contaminants were 1,4-dichlorobenzene, acetone, aluminum, copper, iron, gross beta, methylene chloride, tritium, and zinc.
- Maximum recommended holding times were exceeded for ~1.4% of groundwater project samples that were analyzed by non-radiological methods. Anions were primarily affected, though the data impacts are considered minor.
- Laboratory performance on blind standards was very good overall: 90% of the results were acceptable. Constituents with out-of-limit results were cyanide (STL St. Louis), fluoride (STL St. Louis), gross alpha (STL Richland), plutonium-239 (STL Richland), total organic carbon (Lionville Laboratory), total organic halides (STL St. Louis), and tritium (STL Richland).

C.8 References

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Table C.1. Long-Term Monitoring 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	39	2.6	2,400 µg/L	6,000 µg/L
Total organic carbon	4	88	4.6	780 µg/L	790 - 1,000 µg/L
Total organic halides	4	81	4.9	4.4 µg/L	4.6 - 5.8 µg/L
Ammonia and Anions					
Chloride	4	49	8.2	86 - 90 µg/L	98 - 140 µg/L
Nitrogen in nitrate	3	49	6.1	8 - 22 µg/L	13 - 36 µg/L
Sulfate	9	57	15.8	74 - 108 µg/L	260 - 570 µg/L
Metals					
Aluminum	2	43	4.7	68.4 - 191.6 µg/L	81.4 - 114 µg/L
Copper	2	43	4.7	4.8 - 6.4 µg/L	7.4 - 9.7 µg/L
Iron	1	43	2.3	13.8 - 109 µg/L	16.6 µg/L
Sodium	1	43	2.3	163.6 - 324 µg/L	568 µg/L
Zinc	6	43	14.0	3 - 7 µg/L	3.5 - 20.8 µg/L
Volatile Organic Compounds					
1,4-dichlorobenzene	1	13	7.7	0.22 µg/L	0.41 µg/L
Acetone	2	13	15.4	1.05 - 3.3 µg/L	1.6 - 1.9 µg/L
Methylene chloride	3	13	23.1	0.6 - 1.5 µg/L	1.8 - 25 µg/L
Radiological Parameters					
Gross beta	1	28	3.6	3.34 - 5.42 pCi/L[b]	9.81 pCi/L
Tritium	2	36	5.6	10.7 - 674 pCi/L[b]	16.4 - 28.6 pCi/L
Uranium	5	24	20.8	0.00978 µg/L	0.026 - 0.0531 µg/L

(a) Because method detection limits may change throughout the year, some 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.
QC = Quality control.

Table C.2. Long-Term Monitoring 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)
1,4-Dichlorobenzene	1	93	1.1	0.58	15
4-Methyl-2-pentanone	2	93	2.2	0.38 - 1.8	1.9 - 3.5
Acetone	14	93	15.1	1.05 - 6.5	1.1 - 21
Carbon tetrachloride	3	93	3.2	0.2 - 0.3	0.27 - 1.2
Chloroform	2	93	2.2	0.14 - 0.24	0.26 - 33
cis-1,2-Dichloroethene	1	93	1.1	0.12 - 0.4	0.22
Methylene chloride	49	93	52.7	0.6 - 13	0.87 - 16
Trichloroethene	5	93	5.4	0.12 - 0.32	0.24 - 0.91

(a) Because method detection limits may change throughout the year, some 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.
QC = Quality control.

Table C.3. Long-Term Monitoring Equipment Blanks Exceeding Quality Control Limits

Constituent	Number Out of Limits	Number of Analyses	Percent Out of Limits	QC Limits (µg/L)	Out-of-Limit Results (µg/L)
Ammonia and Anions					
Chloride	1	1	100	43	780
Nitrogen in nitrate	1	1	100	4	16
Metals					
Zinc	1	1	100	1.5	8
Volatile Organic Compounds					
Chloromethane	1	1	100	0.09	0.3

QC = Quality control.

Table C.4. Long-Term Monitoring 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)]
Ammonia and Anions					
Chloride	57	57	1	1.8	22.5
Cyanide	18	6	2	33.3	31.8 - 44.0
Fluoride	57	55	2	3.6	24.5 - 34.7
Metals					
Arsenic	18	4	1	25.0	27.7
Vanadium	51	22	2	9.1	21.6 - 22.1
Zinc	51	5	1	20.0	145.5
Volatile Organic Compounds					
Acetone	18	2	2	100.0	28.6 - 162.0
Methylene chloride	54	3	1	33.3	136.8
Tetrachloroethene	54	6	2	33.3	24.0 - 35.6
TPH-Gasoline	6	1	1	100.0	42.4
Trichloroethene	72	16	1	6.3	27.2
Semivolatile Organic Compounds					
TPH-Diesel	6	2	1	50.0	85.7
Radiological Parameters					
Gross beta	87	36	2	5.6	21.9 - 25.8
Iodine-129	24	8	3	37.5	47.6 - 54.0
Tritium	43	29	1	3.4	67.3

(a) Duplicates with both results <5 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 C.5. Interim Action Monitoring Field Blank Detections

Constituent	Number of Detects	Number of Analyses[a]	Percent Out of Limits	Range of QC Limits[a] (µg/L or pCi/L)	Range of Out-of-Limit Results (µg/L or pCi/L)
Anions					
Chloride	1	5	20	43	160
Nitrate	1	5	20	17.7	88.5
Sulfate	1	5	20	0.037	300
Metals					
Aluminum	1	12	8	45.5	117
Beryllium	3	12	25	0.3 - 0.4	0.59 - 1.0
Calcium	1	12	8	111	286
Sodium	1	12	8	94.3	371
Volatile Organic Compounds					
4-Methyl-2-pentanone	1	43	2	0.38	2.4
Acetone	4	43	9	0.21	1.4 - 2.3
Carbon tetrachloride	5	43	12	0.1 - 0.2	0.5 - 0.8
Methylene chloride	13	43	30	0.2 - 0.3	0.4 - 3.6
Radiological Parameters					
Uranium	1	1	100	0.01	0.0235
Tritium	1	5	20	252	276
Field Analyses					
Hexavalent chromium	3	9	33	5	6 - 9
Sulfate	1	7	14	8.3	1,000

(a) Because method detection limits may change throughout the year, some limits are presented as a range.

Table C.6. Interim Action Monitoring 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
General Chemical Parameters					
Alkalinity	1	1	0	0	2.2
Ammonia and Anions					
Chloride	24	24	1	4	0 - 21
Cyanide	3	1	1	100	134
Fluoride	24	23	0	0	0 - 19
Nitrate	24	24	0	0	0 - 11
Sulfate	24	24	0	0	0 - 17
Metals					
Aluminum	28	1	0	0	9
Barium	28	18	0	0	0 - 6
Calcium	28	26	0	0	1 - 5
Chromium	28	9	0	0	1 - 8
Cobalt	28	1	0	0	5
Iron	28	2	2	100	22 - 32
Magnesium	28	25	0	0	0 - 4
Manganese	28	6	0	0	1 - 4
Nickel	28	1	0	0	1
Potassium	28	3	0	0	0 - 2
Sodium	28	28	0	0	0 - 4
Strontium	28	28	0	0	0 - 6
Vanadium	28	4	0	0	1 - 10
Zinc	28	5	1	20	2 - 44
Volatile Organic Parameters					
Acetone	12	5	1	25	0 - 153
Carbon disulfide	12	2	2	100	29 - 107
Carbon tetrachloride	12	12	3	25	0 - 65
Chloroform	12	11	0	0	0 - 19
Methylene chloride	12	1	0	0	1
Tetrachloroethene	12	3	3	100	32 - 63
Trichloroethene	12	10	0	0	0 - 15
Radiological Parameters					
Gross beta	10	4	1	25	1 - 24
Iodine-129	9	1	1	100	23
Strontium-90	11	5	1	20	2 - 27
Technetium-99	10	8	1	13	0 - 217
Tritium	21	15	0	0	0 - 12
Uranium	11	11	1	9	0 - 172
Field Analyses					
Hexavalent chromium	48	47	1	4	0 - 43
Sulfate	19	19	0	0	0 - 17

(a) Duplicates with both results <5 times the method detection limit or minimum detectable activity were excluded from the evaluation.

Table C.7. Interim Action Monitoring Interlaboratory Splits Exceeding Quality Control Limits

Constituent	Total Number of Splits	Number of Splits Evaluated[(a)]	Number Out of Limits	Percent Out of Limits	Range of Relative Percent Differences
		Anions			
Chloride	7	6	0	0	4 - 14
Fluoride	7	1	0	0	16
Sulfate	7	7	0	0	0 - 9
		Metals			
Barium	11	9	0	0	0 - 12
Calcium	11	11	0	0	2 - 14
Chromium	11	5	1	20	2 - 22
Magnesium	11	11	0	0	1 - 13
Sodium	11	11	0	0	1 - 8
Strontium	11	11	0	0	1 - 14
Zinc	11	5	1	20	3 - 52
		Radiological Parameters			
Gross beta	7	4	0	0	3 - 17
Total beta radiostrontium	6	3	0	0	4 - 11
Tritium	8	6	2	33	12 - 32
		Fixed Laboratory-Field Analyses			
Hexavalent chromium	45	44	8	18	0 - 200
Sulfate	11	11	2	18	3 - 30

(a) Split sample pairs with both results <5 times the method detection limit or minimum detectable activity were excluded from the evaluation.

Table C.8. Groundwater Performance Assessment Project Maximum Recommended Holding Times

Method	Constituent	Holding Time
8260 (SW-846)	Volatile organics	14 days
8270 (SW-846)	Semivolatile organics	7 days before extraction; 40 days after extraction
8081 (SW-846)	Pesticides	7 days before extraction; 40 days after extraction
8082 (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
7131 (SW-846)	Cadmium	6 months
7191 (SW-846)	Chromium	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
9131 (SW-846)	Coliform	1 day
120.1 (EPA-600/4-81-004)	Conductivity	28 days
160.1 (EPA-600/4-81-004)	Total dissolved solids	7 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	48 hours
300.0 (EPA-600/4-81-004)	Nitrite	48 hours
300.0 (EPA-600/4-81-004)	Phosphate	48 hours
300.0 (EPA-600/4-81-004)	Sulfate	28 days
310.1 (EPA-600/4-81-004)	Alkalinity	14 days
350.1 (EPA-600/4-81-004)	Ammonia	28 days
410.4 (EPA-600/4-81-004)	Chemical oxygen demand	28 days

Table C.9. Summary of Severn Trent St. Louis Water Pollution (WP) Performance Evaluation Studies

Accreditation Laboratory	WP-109 April 2004 Acceptable Results/Total	WP-111 June 2004 Acceptable Results/Total	WP-114 September 2004 Acceptable Results/Total
Environmental Resource Associates	241/262[(a)]	6/9[(b)]	240/268[(c)]

(a) Unacceptable results were for total suspended solids, ammonia as N, total Kjeldahl nitrogen, total phosphorus as P, total cyanide, total residual chlorine, total dissolved solids, total solids at 105°C, tetrachloroethene, acenaphthene, 4-chloro-3-methylphenol, 2-chlorophenol, 2,4-dichlorophenol, 2-nitrophenol, pentachlorophenol, 2,4,5-trichlorophenol, and 2,4,6-trichlorophenol.
(b) Unacceptable results were for acidity as CaCO3, volatile solids, and sulfide.
(c) Unacceptable results were for orthophosphate as P, total Kjeldahl nitrogen, total cyanide, fluoride, sodium, chlorobenzene, 2-chloroethylvinylether, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, ethylbenzene, tetrachloroethene, toluene, 1,1,1-trichloroethane, trichloroethene, 2,4,5-T, 2,4,5-TP, naphthalene, boron, and 1,2,4-trichlorobenzene.

Table C.10. Summary of Lionville Laboratory Water Pollution (WP) and Water Supply (WS) Performance Evaluation Studies

Accreditation Laboratory	WS-84 September 2003 Acceptable Results/Total	WS-90 March 2004 Acceptable Results/ Total	WS-96 September 2004 Acceptable Results/Total	WP-102 September 2003 Acceptable Results/Total	WP-108 March 2004 Acceptable Results/Total	WP-114 September 2004 Acceptable Results/Total
Environmental Resource Associates	71/75[(a)]	63/69[(b)]	68/69[(c)]	249/271[(d)]	437/451[(e)]	455/471[(f)]

(a) Unacceptable results were for chlorobenzene, 1,4-dichlorobenzene, 1,1,2-trichloroethane, and total xylenes.
(b) Unacceptable results were for nitrate + nitrite as N, 1,2,4-trichlorobenzene, vinyl chloride, chloroethane, chloromethane, and 2,2-dichloropropane.
(c) Unacceptable result was for 1,4-dichlorobenzene.
(d) Unacceptable results were for total hardness ($CaCO_3$), grease and oil (gravimetric), alkalinity as $CaCO_3$; chloride, tetrachloroethene, Aroclor 260, and total organic halides.
(e) Unacceptable results were for fluoride (three results), acenaphthene (two results), bis(2-chloroethoxy)methane (two results), 2,6-dichlorophenol (two results), and benzo(g,h,i)perylene.
(f) Un

Table C.11. Summary of Severn Trent Interlaboratory Performance, FY 2004

Radionuclides	Number of Results Reported for Each	Number Within Acceptable Control Limits
DOE Quality Assessment Program (QAP59, 60) Environmental Measurements Laboratory		
Americium-241, cesium-137, cobalt-60, plutonium-238, plutonium-239, tritium, uranium-234, uranium-238, uranium	2[a]	2[b,c]
Strontium-90	2[a]	1[b]
Cesium-134	1[a]	1[b]
Gross alpha, gross beta	1[a]	0[b]
DOE Mixed Analyte Performance Evaluation Program (MAPEP-02-W10, MAPEP-03-W11, MAPEP-04-MaW12&GrW12) Radiological and Environmental Sciences Laboratory		
Americium-241, cesium-134, cesium-137, cobalt-57, cobalt-60, manganese-54, plutonium-238, plutonium-239/240, strontium-90, technetium-99, uranium-234/233, uranium-238, zinc-65	6[a,d]	6
Americium-241, plutonium-239/240, strontium-90	6[a,d]	5[e,f]
Iron-55	5[a,d]	5
Nickel-63	5[a,d]	3[e]
Tritium	4[a,d]	3[f]
Gross alpha, gross beta	2[a,d]	2
Antimony, arsenic, barium, beryllium, cadmium, copper, lead, nickel, selenium, thallium, vanadium, zinc	3[d]	3
Chromium	2[d]	2
1,2-Dichlorobenzene, 2,4-dimethylphenol, 1,2,4-trichlorobenzene, naphthalene, 4-chloro-3-methylphenol, 2-methylphenol, 2,6-dichlorophenol, 2,6-dinitrotoluene, 2,4-dinitrotoluene, diethylphthalate, phenanthrene, anthracene, pyrene, benzo(a)anthracene, heptachlor, dieldrin	2[d]	2[g]
Nitrobenzene, 2,4-dichlorophenol, hexachlorobutadiene, fluorene, 4-nitrophenol, 1,2,4,5-tetrachlorobenzene, 1,3-dinitrobenzene, benzo(a)pyrene, chrysene, 4,4'-DDT	1[d]	1[g]
1,3-Dichlorobenzene	2[d]	1[f]
1,4-Dichlorobenzene	1[d]	0[f]
ERA InterLaB RadCheM Proficiency Testing Program (RAD 53, 54, 55, 56, 57, 58) Environmental Resource Associates		
Gross alpha	7[a,h]	7[i]
Cesium-134, cesium-137, cobalt-60, gross beta, radium-228	6[a,h]	6[i]
Radium-226, uranium	5[a,h]	5[i]
Strontium-89, strontium-90	5[a]	4[i]

Table C.11. (contd)

Radionuclides	Number of Results Reported for Each	Number Within Acceptable Control Limits
Zinc-65	4[a]	4[i]
Tritium	4[a]	3[i]
Barium-133	3[a]	3[i]
Iodine-131	3[a]	2[i]

(a) Results from STL Richland.
(b) Control limits from EML-564.
(c) One result each for americium-241, uranium-234, and uranium was acceptable but outside warning limits.
(d) Results from STL St. Louis.
(e) Result(s) from STL Richland were not acceptable.
(f) Result(s) from STL St. Louis were not acceptable.
(g) One result each for 2,4-dichlorophenol, 4-chloro-3-methylphenol, benzo(a)anthracene, and chrysene was acceptable but outside warning limits.
(h) Some constituents were analyzed more than once in a given study.
(i) Control limits from NERL-Ci-0045.

Table C.12. Summary of Eberline Services and Lionville Laboratory Interlaboratory Performance, FY 2004

Radionuclides	Number of Results Reported for Each	Number Within Acceptable Control Limits
DOE Quality Assessment Program (QAP59, 60) Environmental Measurements Laboratory		
Americium-241, cesium-137, cobalt-60, gross alpha, gross beta, plutonium-238, plutonium-239, strontium-90, tritium, uranium-234, uranium-238, uranium	2[a]	2[b,c]
Cesium-134	2[a]	1[b]
DOE Mixed Analyte Performance Evaluation Program (MAPEP-02-W10, MAPEP-03-W11, MAPEP-04-MaW12&GrW12) Radiological and Environmental Sciences Laboratory		
Americium-241, cesium-134, cesium-137, cobalt-57, cobalt-60, iron-55, manganese-54, nickel-63, plutonium-238, plutonium-239/240, strontium-90, technetium-99, uranium-234/233, uranium-238, zinc-65	3[a]	3
Tritium	2[a]	2
Gross alpha, gross beta	1[a]	1
Antimony, arsenic, barium, beryllium, cadmium, copper, lead, nickel, selenium, thallium, vanadium, zinc	3[d]	3
Chromium	2[d]	2
Silver	1[d]	1
1,3-Dichlorobenzene, 1,2-dichlorobenzene, 2,4-dimethylphenol, 1,2,4-trichlorobenzene, naphthalene, 4-chloro-3-methylphenol, 2-methylphenol, 2,6-dichlorophenol, 2,6-dinitrotoluene, 2,4-dinitrotoluene, diethylphthalate, phenanthrene, anthracene, pyrene, benzo(a)anthracene	2[d]	2[e]
Nitrobenzene, 2,4-dichlorophenol, hexachlorobutadiene, 4-nitrophenol, fluorene, 1,2,4,5-tetrachlorobenzene, benzo(a)pyrene, chrysene	1[d]	1
ERA InterLaB RadCheM Proficiency Testing Program (RAD 58) Environmental Resource Associates		
Barium-133, cesium-134, cesium-137, cobalt-60, gross alpha, gross beta, radium-226, radium-228, strontium-89, strontium-90, tritium, uranium, zinc-65	1[a]	1[f]

(a) Results from Eberline Services.
(b) Control limits from EML-564.
(c) One result each for gross beta, tritium, and uranium was acceptable but outside warning limits.
(d) Results from Lionville Laboratory.
(e) One result for diethylphthalate was acceptable but outside warning limits.
(f) Control limits from NERL-Ci-0045.

Table C.13. Summary of Severn Trent Laboratories Double-Blind Spike Determinations

Constituent	Laboratory	Sample Frequency	Number of Results Reported[a]	Number of Results Outside QC Limits[b]	Control Limits[c] (%)
		General Chemical Parameters			
Specific conductance	St. Louis	Quarterly	12	0	±25
Total organic carbon (potassium hydrogen phthalate spike)	St. Louis	Quarterly	16	1	±25
Total organic halides (2,4,5-trichlorophenol spike)	St. Louis	Quarterly	14	1	±25
Total organic halides (carbon tetrachloride, chloroform, and trichloroethene spike)	St. Louis	Quarterly	13	4	±25
		Ammonia and Anions			
Cyanide	St. Louis	Quarterly	12	1	±25
Fluoride	St. Louis	Quarterly	12	3	±25
Nitrate as N	St. Louis	Quarterly	12	0	±25
		Metals			
Chromium	St. Louis	Annually	3	0	±20
		Volatile Organic Compounds			
Carbon tetrachloride	St. Louis	Quarterly	12	0	±25
Chloroform	St. Louis	Quarterly	12	0	±25
Trichloroethene	St. Louis	Quarterly	12	0	±25
		Radiological Parameters			
Gross alpha (plutonium-239 spike)	Richland	Quarterly	12	3	±30
Gross beta (strontium-90 spike)	Richland	Quarterly	12	0	±30
Cesium-137	Richland	Annually	3	0	±30
Cobalt-60	Richland	Annually	3	0	±30
Iodine-129	Richland	Semiannually	10	0	±30
Plutonium-239	Richland	Quarterly	12	2	±30
Strontium-90	Richland	Semiannually	6	0	±30
Technetium-99	Richland	Quarterly	12	0	±30
Tritium	Richland	Annually	3	3	±30
Tritium (low level)	Richland	Semiannually	6	0	±30
Uranium-238	Richland	Quarterly	12	0	±30

(a) Blind standards were generally submitted in duplicate, triplicate, or quadruplicate.
(b) Quality control limits are given in PNNL-15014.
(c) Each result must be within the specified percentage of the known value to be acceptable.

Table C.14. Summary of Lionville Laboratory, Inc. and Eberline Services 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				
Total organic carbon (potassium hydrogen phthalate spike)	Quarterly	16	9	±25
Radiological Parameters				
Gross beta (strontium-90 spike)	Quarterly	12	0	±30

(a) Blind standards were submitted in triplicate or quadruplicate.
(b) Quality control limits are given in PNNL-15014.
(c) Each result must be within the specified percentage of the known value to be acceptable.
QC = Quality control.

Table C.15. Percentage of Out-of-Limit Quality Control Results by Category, Severn Trent Laboratories (Richland and St. Louis)

Quality Control Parameter	General Chemistry Parameters	Ammonia and Anions	Metals	Volatile Organic Compounds	Semivolatile Organic Compounds	Radiological Parameters	Total
Method blanks	0	1.7	2.7	1.2	0.3	0.9	1.3
Laboratory control samples	0	0.2	0.2	2.2	4.0	1.9	1.6
Matrix spikes	1.8	8.6	0.3	8.8	9.3	7.5	5.2
Matrix duplicates	0.2	0.2	0	5.5	21.2	1.2	4.5
Surrogates	--	--	--	4.5	6.3	--	4.9

Table C.16. Method Blank Results, Severn Trent Laboratories (Richland and St. Louis)

Constituent	Percent Out of Limit[a]	Number of Analyses	Concentration Range of Out-of-Limit Results
General Chemistry Parameters			
Total general chemistry parameters	0	339	--
Ammonia and Anions			
Total ammonia and anions	1.7	1,133	--
Chloride	2.9	206	0.092 - 0.2 mg /L
Nitrogen in nitrate	0.5	205	0.036 mg /L
Nitrogen in nitrite	0.5	205	0.018 mg/L
Sulfate	5.3	207	0.1 - 0.34 mg/L
Metals			
Total metals	2.7	1,900	--
Aluminum	8.4	95	61.3 - 297 µg/L
Beryllium	9.5	95	0.79 - 2.0 µg/L
Calcium	1.1	95	1,230 µg/L
Copper	3.2	95	6.5 - 11.9 µg/L
Iron	4.2	95	14.7 - 32.5 µg/L
Lithium	20.0	5	38.1 µg /L
Magnesium	1.1	95	605 µg/L
Manganese	4.2	96	2.4 - 37.6 µg/L
Nickel	1.1	95	28.7 µg/L
Silver	1.1	95	6.3 µg /L
Sodium	2.1	95	359 - 383 µg/L
Strontium	2.1	95	1.8 - 2.4 µg/L
Vanadium	1.1	95	15.4 µg/L
Zinc	14.7	95	3.1 - 13.1 µg/L
Volatile Organic Compounds			
Total volatile organic compounds	1.2	4,047	--
1,2-Dichloroethane	0.7	148	0.67 µg/L
1,2-Dichloroethene (total)	7.7	13	0.36 µg/L
1,4-Dichlorobenzene	5.1	158	0.27 - 0.37 µg/L
1-Butanol	0.7	136	30 µg/L
Acetone[b]	14.9	148	1.1 - 4.4 µg/L
Benzene	0.7	147	0.17 µg/L
Bromomethane	7.7	13	0.74 µg/L
Chloroform	0.7	148	0.16 µg/L
Chloromethane	7.7	13	0.26 µg/L
cis-1,2-Dichloroethene	0.7	149	0.14 µg/L
Methylene chloride[b]	4.7	148	0.78 - 2.2 µg/L
Tetrachloroethene	0.7	148	0.19 µg/L
trans-1,2-Dichloroethene	0.7	147	0.22 µg/L
Trichloroethene	2.0	148	0.2 - 0.44 µg/L
Semivolatile Organic Compounds			
Total semivolatile organic compounds	0.3	1,935	--
4-Nitrophenol	2.1	48	12 µg/L
Benzyl alcohol	28.6	7	7.7 - 7.7 µg/L
Diethylphthalate[b]	28.6	7	2 - 2.1 µg/L

Table C.16. (contd)

Constituent	Percent Out of Limit[a]	Number of Analyses	Concentration Range of Out-of-Limit Results
	Radiochemistry Parameters		
Total radiochemistry parameters	0.9	1,794	--
Strontium-90	7.1	84	0.724 - 1.25 pCi/L
Tritium	2.5	275	13.5 - 28.0 pCi/L
Uranium	4.2	96	0.0249 - 0.0514 µg/L

(a) Quality control limits are twice the method detection limit.
(b) Quality control limits are 5 times the method detection limit.

Table C.17. Laboratory Control Samples, Severn Trent Laboratories (Richland and St. Louis)

Constituent	Percent Out of Limit	Number of Analyses
General Chemistry Parameters		
Total general chemistry parameters	0.0	344
Ammonia and Anions		
Total ammonia and anions	0.2	1,132
Nitrogen in nitrate	0.5	205
Nitrogen in nitrite	0.5	205
Metals		
Total metals	0.2	1,882
Aluminum	3.2	94
Volatile Organic Compounds		
Total volatile organic compounds	2.2	2,849
1,1,1-Trichloroethane	2.0	148
1,1,2-Trichloroethane	6.8	147
1,1-Dichloroethane	2.0	148
1,2-Dichloroethane	4.7	148
1,2-Dichloroethene (total)	7.7	13
1,4-Dichlorobenzene	2.1	143
2-Butanone	0.7	147
4-Methyl-2-pentanone	0.7	147
Acetone	6.8	147
Bromomethane	7.7	13
Carbon tetrachloride	1.9	162
Chloroform	2.7	148
Methylene chloride	1.4	147
Tetrachloroethene	2.7	148
Trichloroethene	4.7	148
Vinyl chloride	2.0	147
Semivolatile Organic Compounds		
Total semivolatile organic compounds	4.0	1,303
2,4-Dinitrophenol	2.2	46
2-Methylphenol	3.7	54
3-+4-Methylphenol	2.0	49
4,4'-DDD	20.0	10
4,4'-DDE	20.0	10
4,4'-DDT	20.0	10
4,6-Dinitro-2-methylphenol	4.3	46
4-Chloro-3-methylphenol	2.2	46
4-Nitrophenol	10.9	46
Aldrin	20.0	10
alpha-BHC	20.0	10
beta-BHC	20.0	10
delta-BHC	20.0	10
Dieldrin	20.0	10
Endosulfan I	40.0	10
Endosulfan II	20.0	10
Endosulfan sulfate	20.0	10
Endrin	30.0	10
Endrin aldehyde	20.0	10
gamma-BHC (lindane)	20.0	10
Heptachlor	20.0	10
Heptachlor epoxide	20.0	10
Methoxychlor	20.0	10
Pentachlorophenol	1.9	54
Phenol	3.4	59

Table C.17. (contd)

Constituent	Percent Out of Limit	Number of Analyses
	Radiochemistry Parameters	
Total radiochemistry parameters	1.9	1,299
Cesium-137	5.3	75
Cobalt-60	1.3	75
Europium-152	1.4	74
Gross alpha	4.3	92
Gross beta	1.0	98
Hexavalent chromium	2.1	48
Iodine-129	2.2	93
Neptunium-237	8.3	12
Technetium-99	1.9	107
Tritium	0.7	275
Uranium	1.1	189
Uranium-234	15.4	13
Uranium-238	15.4	13

Table C.18. Matrix Spikes and Matrix Spike Duplicates, Severn Trent Laboratories (Richland and St. Louis)

Constituent	Percent Out of Limit	Number of Analyses
General Chemistry Parameters		
Total general chemistry parameters	1.8	165
Total organic carbon	1.3	80
Total organic halides	2.7	74
Ammonia and Anions		
Total ammonia and anions	8.6	560
Chloride	3.1	96
Cyanide	3.4	29
Fluoride	6.3	95
Nitrogen in ammonia	15.4	26
Nitrogen in nitrate	10.3	97
Nitrogen in nitrite	22.1	95
Sulfate	3.0	100
Metals		
Total metals	0.3	4,234
Arsenic	2.3	88
Cadmium	1.4	216
Calcium	1.9	210
Chromium	1.4	214
Potassium	0.5	210
Volatile Organic Compounds		
Total volatile organic compounds	8.8	2,947
1,1,1-Trichloroethane	6.0	150
1,1,2,2-Tetrachloroethane	12.5	16
1,1,2-Trichloroethane	9.3	150
1,1-Dichloroethane	12.7	150
1,1-Dichloroethene	7.1	28
1,2-Dichloroethane	7.9	151
1,2-Dichloroethene (total)	18.8	16
1,2-Dichloropropane	12.5	16
1,4-Dichlorobenzene	8.5	142
2-Butanone	4.7	150
2-Hexanone	12.5	16
4-Methyl-2-pentanone	4.7	150
Acetone	8.7	150
Benzene	5.3	150
Bromodichloromethane	12.5	16
Bromoform	12.5	16
Carbon disulfide	5.3	150
Carbon tetrachloride	28.0	150
Chlorobenzene	18.8	16
Chloroethane	25.0	16
Chloroform	8.0	150
Chloromethane	12.5	16
cis-1,3-Dichloropropene	12.5	16
Dibromochloromethane	12.5	16
Ethylbenzene	9.7	113
Methylene chloride	15.3	150
Styrene	12.5	16
Tetrachloroethene	4.0	150
Toluene	6.0	151
TPH Gasoline	8.8	34
trans-1,3-Dichloropropene	18.8	16
Trichloroethene	2.0	150
Vinyl chloride	5.3	150

Table C.18. (contd)

Constituent	Percent Out of Limit	Number of Analyses
Semivolatile Organic Compounds		
Total semivolatile organic compounds	9.3	2,057
2-(2,4-Dichlorophenoxy)propionic acid	25.0	16
2,3,4,6-Tetrachlorophenol	4.9	61
2,4,5-TP (silvex)	18.8	16
2,4,5-Trichlorophenol	10.1	69
2,4,6-Trichlorophenol	11.6	69
2,4-D	43.8	16
2,4-Dichlorophenol	12.5	80
2,4-Dimethylphenol	10.1	69
2,4-Dinitrophenol	10.1	69
2,6-Dichlorophenol	9.8	61
2-Chlorophenol	11.6	69
2-Methylphenol	11.3	80
2-Nitrophenol	12.5	80
2-secButyl-4,6-dinitrophenol	6.5	77
3+4-Methylphenol	8.3	72
4-(2,4-Dichlorophenoxy)butyric acid	37.5	16
4,4'-DDD	12.5	16
4,4'-DDE	6.3	16
4,4'-DDT	6.3	16
4,6-Dinitro-2-methylphenol	10.1	69
4-Chloro-3-methylphenol	8.7	69
4-Nitrophenol	7.2	69
Aldrin	6.3	16
alpha-BHC	12.5	16
Aroclor 1016	25.0	8
beta-BHC	12.5	16
delta-BHC	6.3	16
Dieldrin	12.5	16
Endosulfan I	12.5	16
Endosulfan II	6.3	16
Endosulfan sulfate	12.5	16
Endrin	12.5	16
Endrin aldehyde	12.5	16
gamma-BHC (lindane)	12.5	16
Heptachlor	6.3	16
Heptachlor epoxide	43.8	16
Methoxychlor	6.3	16
Naphthalene	5.3	19
Oil and grease	9.1	11
Pentachlorophenol	11.3	80
Phenol	18.4	87
TPH Diesel	23.3	30
Radiochemistry Parameters		
Total radiochemistry parameters	7.5	305
Hexavalent chromium	10.8	102
Technetium-99	9.3	108
Uranium	2.2	93

Table C.19. Matrix Duplicates, Severn Trent Laboratories (Richland and St. Louis)

Constituent	Percent Out of Limit	Number of Analyses
General Chemistry Parameters		
Total general chemistry parameters	0.2	469
Total organic carbon	0.7	151
Ammonia and Anions		
Total ammonia and anions	0.2	1,669
Chloride	0.3	301
Fluoride	0.3	300
Nitrogen in nitrate	0.7	301
Metals		
Total metals	0.0	2,117
Volatile Organic Compounds		
Total volatile organic compounds	5.5	2,271
1,1,1-Trichloroethane	2.6	116
1,1,2,2-Tetrachloroethane	16.7	12
1,1,2-Trichloroethane	3.4	116
1,1-Dichloroethane	1.7	116
1,1-Dichloroethene	8.6	23
1,2-Dichloroethane	3.4	116
1,2-Dichloroethene (total)	16.7	12
1,2-Dichloropropane	16.7	12
1,4-Dichlorobenzene	2.7	111
2-Butanone	6.0	116
2-Hexanone	25.0	12
4-Methyl-2-pentanone	5.2	116
Acetone	19.8	116
Benzene	1.7	116
Bromodichloromethane	16.7	12
Bromoform	25.0	12
Bromomethane	25.0	12
Carbon disulfide	3.4	116
Carbon tetrachloride	4.9	123
Chlorobenzene	16.7	12
Chloroethane	16.7	12
Chloroform	2.6	117
Chloromethane	16.7	12
cis-1,3-Dichloropropene	25.0	12
Dibromochloromethane	16.7	12
Ethylbenzene	3.5	86
Methylene chloride	4.3	116
Styrene	25.0	12
Tetrachloroethene	2.6	116
Toluene	2.6	116
TPH Gasoline	5.6	18
trans-1,3-Dichloropropene	25.0	12
Trichloroethene	1.7	116
Vinyl chloride	3.4	116
Semivolatile Organic Compounds		
Total semivolatile organic compounds	21.2	1,346
2-(2,4-Dichlorophenoxy)propionic acid	12.5	8
2,2-Dichloropropionic acid	25.0	8
2,3,4,6-Tetrachlorophenol	31.7	41
2,4,5-T	50.0	8
2,4,5-TP (silvex)	12.5	8
2,4,5-Trichlorophenol	23.9	46
2,4,6-Trichlorophenol	23.9	46
2,4-D	37.5	8
2,4-Dichlorophenol	26.4	53

Table C.19. (contd)

Constituent	Percent Out of Limit	Number of Analyses
2,4-Dimethylphenol	23.9	46
2,4-Dinitrophenol	23.9	46
2,6-Dichlorophenol	22.0	41
2-Chlorophenol	26.1	46
2-Methylphenol	28.3	53
2-Nitrophenol	24.5	53
2-secButyl-4,6-dinitrophenol	28.6	49
3,3'-Dichlorobenzidine	20.0	5
3-+4-Methylphenol	29.2	48
4-(2,4-Dichlorophenoxy)butyric acid	25.0	8
4,4'-DDD	18.2	11
4,4'-DDE	18.2	11
4.4'-DDT	18.2	11
4,6-Dinitro-2-methylphenol	23.9	46
4-Chloro-3-methylphenol	23.9	46
4-Chloroaniline	20.0	5
4-Nitrophenol	39.1	46
Aldrin	18.2	11
alpha-BHC	18.2	11
Aroclor 1016	40.0	5
Aroclor 1260	20.0	5
beta-BHC	18.2	11
bis(2-Ethylhexyl)phthalate	8.3	12
delta-BHC	18.2	11
Dicamba	25.0	8
Dieldrin	18.2	11
Endosulfan I	18.2	11
Endosulfan II	18.2	11
Endosulfan sulfate	18.2	11
Endrin	18.2	11
Endrin aldehyde	18.2	11
gamma-BHC (lindane)	18.2	11
Heptachlor	27.3	11
Heptachlor epoxide	18.2	11
Hexachlorocyclopentadiene	40.0	5
Methoxychlor	18.2	11
Naphthalene	16.7	12
Oil and grease	4.8	21
Pentachlorophenol	22.6	53
Phenol	41.1	56
TPH Diesel	6.3	16
Radiochemistry Parameters		
Total radiochemistry parameters	1.2	1,707
Americium-241	12.5	8
Cobalt-60	1.3	77
Gross beta	3.0	99
Iodine-129	6.5	92
Strontium-90	1.2	84
Technetium-99	0.9	108
Tritium	1.3	150
Uranium	2.1	95
Uranium-234	7.1	14
Uranium-235	13.3	15
Uranium-238	6.7	15

Table C.20. Summary of Issue Resolution Forms Received from Severn Trent Laboratories (Richland and St. Louis) for FY 2004

Issue Category	Number of Analyses Impacted	
	Prior to Receipt at the Laboratory	After Receipt at the Laboratory
Hold time missed	283	98
Broken bottles	20	
Missing samples	4	
Temperature deviation	3	
pH variance	39	
Bottle size/type (insufficient volume)	6	
Chain of custody forms incomplete	1	
Laboratory QC out of limits	--	220
Analytical preparation deviations	--	17
Method failures/discontinued analyses	--	32

QC = Quality control.

Table C.21. Results of Laboratory Assessments

Laboratory	Audit Team	Findings	Observations	Summary of Results
Severn Trent, Inc. St. Louis, MO	DOECAP	13	19	Findings related to insufficient documentation for proficiency testing, lack of procedures or incomplete procedures or non-compliance with SW-846 methods, inconsistent implementation of procedures, inadequate traceability of acids use for preservation, no separation of rad standards or reference materials from samples, insufficient security for some of the calibration factors used in the LIMS. Observations related to inconsistent general laboratory practices, such are daily recording and monitoring of equipment.
Eberline Services-Richmond, CA	DOECAP	4	8	Findings related to current copies of some procedures not available in the appropriate areas, use of expired flame-sealed check source and background sources, calibration and performance checks not being performed on each day of analyses, waste container being held past the allowable accumulation limits. Observations related to QA management systems and general laboratory practices (i.e., procedures has not been updated to reflect laboratory practice, re-verification of standard solutions, incomplete documentation).
Lionville Laboratory, Inc., Lionville, PA	DOECAP	9	7	Findings related to unclear chain of custody until final disposition of sample, review of control charts not done in a timely manner, personnel qualifications and training requirements not established, overdue method detection limit studies, use of expired standards, inconsistent implementation of procedures and data review, and insufficient preventative maintenance checks and documentation. Observations related to incomplete procedures, lack of procedures, and inconsistent general practices within the laboratory.
Severn Trent, Inc.-Richland, WA	DOECAP	0	7	Six observations related general safety practices used in the laboratory for handling waste and samples and one related to the lack of review of the laboratory policy on "Minimum Detectable Concentration Determination."

Table C.21. (contd)

Laboratory	Audit Team	Findings	Observations	Summary of Results
Severn Trent, Inc.-St. Louis, MO	PNNL/BHI Joint Team	11	6	Findings related to inadequate compliance to STL procedures and Quality Manual (annual determination of method detection limits, internal chain of custody, preventative maintenance), incomplete training documentation, insufficient verification of software changes, insufficient standard operating procedures and document control, ineffective corrective action system, inadequate implementation of the HASQARD requirements in the STL QA Program. Observations related mostly to inconsistent general laboratory practices.
Severn Trent, Inc.-Richland, WA	BHI	3	10	Findings related to lack of verification of corrective actions, lack of employee certification in job descriptions, and non-compliance to procedural deviation quality control acceptance criteria. Observations related to missing information on forms, incomplete training files, incomplete corrective actions, and inconsistent general laboratory practices.
Eberline Services,-Richmond, CA	BHI	2	9	Findings related to lack of documentation for calculation checks and non-compliance to HASQARD requirement for procedures pertaining to functional responsibilities. Observations related to incomplete tracking of samples through sample disposal, not clear roles and responsibilities related to records management, lack of training or assessment documentation, inconsistent general laboratory practices.

BHI = Bechtel Hanford, Inc.
DOECAP = Department of Energy Consolidated Assessment Program.
HASQARD = Hanford Analytical Services Quality Assurance Document (DOE/RL-96-68).
LIMS = Laboratory Information Management System.
PNNL = Pacific Northwest National Laboratory.
QA = Quality assurance.
STL = Severn Trent Laboratories, Incorporated.

Table C.22. Summary of Analytical Laboratory Detection/Quantitation Limits Determined from Field Blanks Data, Severn Trent Laboratories (Richland and St. Louis)

Period[a]	Number of Samples	Mean	Standard Deviation	Limit of Detection	Limit of Quantitation
		Constituent: Total Organic Carbon (µg/L)			
11/19/02 - 12/17/03	83[b]	112.4	141.6	420[c]	1,420[c]
04/02/03 - 03/11/04	72[b]	174.1	137.0	410	1,370
07/10/03 - 06/08/04	74[b]	199.4	151.9	460	1,520
10/07/03 - 09/27/04	68[b]	207.3	151.2	450	1,510
Summary	68[b]	207.3	151.2	450	1,510
		Constituent: Total Organic Halides (µg/L)			
12/16/02 - 12/17/03	67	0.70	1.54	4.6[c]	15.4[c]
04/02/03 - 03/11/04	65	0.81	1.40	4.2	14.0
07/10/03 - 06/08/04	77	0.92	1.54	4.6	15.4
10/07/03 - 09/27/04	77	0.78	1.27	3.8	12.7
Summary	77	0.78	1.27	3.8	12.7
		Constituent: Cesium-137 (pCi/L)			
12/15/03 - 12/17/03	2	0.04	0.18	0.54[c]	1.81[c]
01/15/04 - 03/11/04	4	0.23	0.87	2.60	8.66
06/01/04 - 06/07/04	4	-0.37	0.48	1.45	4.83
08/02/04 - 09/16/04	3	-0.61	0.28	0.85	2.83
Summary	13	-0.18	0.59	1.77	5.91
		Constituent: Cobalt-60 (pCi/L)			
12/15/03 - 12/17/03	2	1.07	2.25	6.75[c]	22.51[c]
01/15/04 - 03/11/04	4	-0.93	0.53	1.60	5.32
06/01/04 - 06/07/04	4	0.12	0.69	2.06	6.88
08/02/04 - 09/16/04	3	-0.27	1.27	3.81	12.69
Summary	13	-0.15	1.08	3.25	10.83
		Constituent: Europium-152 (pCi/L)			
12/15/03 - 03/11/04	5	-0.52	3.07	9.22[c]	30.73[c]
06/01/04 - 06/07/04	4	-0.15	4.55	13.64	45.46
08/02/04 - 09/16/04	3	1.14	1.10	3.31	11.03
Summary	12	0.02	3.37	10.11	33.70
		Constituent: Europium-154 (pCi/L)			
12/15/03 - 12/17/03	2	3.22	0.40	1.21[c]	4.03[c]
01/15/04 - 03/11/04	4	-2.10	2.58	7.73	25.75
06/01/04 - 06/07/04	4	-1.25	4.27	12.82	42.74
08/02/04 - 09/16/04	3	0.91	4.06	12.17	40.55
Summary	13	-0.33	3.46	10.38	34.60
		Constituent: Europium-155 (pCi/L)			
12/15/03 - 12/17/03	2	-2.53	0.87	2.61[c]	8.70[c]
01/15/04 - 03/11/04	4	0.56	3.26	9.78	32.60
06/01/04 - 06/07/04	4	0.19	2.28	6.83	22.76
08/02/04 - 09/16/04	3	0.74	1.84	5.51	18.35
Summary	13	0.01	2.47	7.41	24.70
		Constituent: Gross Alpha (pCi/L)			
10/01/03 - 12/18/03	12	0.05	0.20	0.60[c]	2.01[c]
01/20/04 - 02/20/04	4	0.08	0.11	0.34	1.15
04/12/04 - 06/08/04	5	0.12	0.06	0.18	0.61
07/08/04 - 09/16/04	6	-0.04	0.10	0.29	0.95
Summary	27	0.05	0.15	0.46	1.54

Table C.22. (contd)

Period	Number of Samples	Mean	Standard Deviation	Limit of Detection	Limit of Quantitation
		Constituent: Gross Beta (pCi/L)			
10/01/03 - 12/18/03	11[b]	0.48	0.55	1.65[c]	5.50[c]
01/15/04 - 03/08/04	6	0.85	1.03	3.10	10.33
04/12/04 - 06/08/04	7	0.58	0.79	2.36	7.86
07/08/04 - 09/16/04	7	0.76	0.57	1.72	5.72
Summary	31	0.64	0.72	2.16	7.21
		Constituent: Iodine-129 (pCi/L)			
10/01/03 - 12/18/03	7	0.00	0.05	0.14[c]	0.46[c]
01/15/04 - 02/20/04	3	0.05	0.06	0.19	0.64
04/12/04 - 06/01/04	3	0.05	0.03	0.09	0.30
07/08/04 - 09/13/04	5	-0.01	0.04	0.11	0.37
Summary	18	0.02	0.04	0.13	0.45
		Constituent: Strontium-90 (pCi/L)			
10/01/03 - 12/15/03	4	0.32	0.27	0.80[c]	2.66[c]
01/15/04 - 03/11/04	3	0.16	0.21	0.63	2.09
04/16/04 - 06/07/04	4	0.27	0.24	0.72	2.39
07/08/04 - 08/11/04	2	0.25	0.10	0.31	1.04
Summary	13	0.26	0.23	0.70	2.32
		Constituent: Technetium-99 (pCi/L)			
10/07/03 - 12/17/03	4[b]	1.50	3.95	11.8[c]	39.5[c]
01/15/04 - 03/18/04	8	-0.32	2.99	9.0	29.9
04/12/04 - 06/24/04	6	-0.32	1.89	5.7	18.9
07/21/04 - 09/13/04	6	-0.81	2.90	8.7	29.0
Summary	24	-0.14	2.91	8.7	29.1
		Constituent: Tritium (pCi/L)			
10/01/03 - 12/22/03	14	163.4	76.4	229[c]	764[b]
01/15/04 - 03/11/04	8	72.7	52.7	158	527
04/12/04 - 06/24/04	7	33.3	86.9	261	869
07/08/04 - 09/16/04	8	58.7	116.7	350	1,167
Summary	37	96.5	84.5	254	845
		Constituent: Tritium – Low-Level Method (pCi/L)			
04/16/04 - 09/16/04	5	10.79	11.54	35[c]	115[c]
		Constituent: Uranium (µg/L)			
10/07/03 - 12/18/03	7	0.017	0.018	0.071[d]	0.197[d]
01/15/04 - 03/01/04	5	0.012	0.018	0.065	0.189
04/12/04 - 06/29/04	7	0.007	0.013	0.046	0.138
07/14/04 - 09/16/04	6	0.008	0.015	0.053	0.157
Summary	25	0.011	0.016	0.059	0.171

(a) Time period covered for total organic carbon and total organic halides is a moving average of four quarters.
(b) Excluded outliers.
(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. Numbers are rounded.
(d) Limit of detection equals the mean blank concentration plus 3 standard deviations; limit of quantitation equals the mean blank concentration plus 10 standard deviations. Numbers are rounded.

Table C.23. Summary of Detection and Quantitation Limits, Severn Trent Laboratory (St. Louis)

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, 120.1	Conductivity[b]	0.49	0.662	2.207				
EPA-600/4-81-004, 160.1	Total dissolved solids	3,500	4,726	15,761				
EPA-600/4-81-004, 310.1	Alkalinity	1,200	1,620	5,404				
EPA-600/4-81-004, 410.4	Chemical Oxygen Demand[c]	3,600	4,861	16,211	09/01/2004	7,100	9,587	31,973
EPA-600/4-81-004, 413.1	Oil and grease	920	1,242	4,143	07/14/2004	5,000	6,752	22,516
			Ammonia and Anions					
EPA-600/4-81-004, 300.0	Bromide	42	57	189	04/13/2004	20	27	90
EPA-600/4-81-004, 300.0	Chloride	45	61	203	04/09/2004	43	58	194
EPA-600/4-81-004, 300.0	Fluoride[d]	40	54	180	06/16/2004	10	14	45
EPA-600/4-81-004, 300.0	Nitrogen in Nitrate	11	15	50	04/09/2004	4	5	18
EPA-600/4-81-004, 300.0	Nitrogen in Nitrite[d]	7.4	10.0	33.3	06/16/2004	4	5	18
EPA-600/4-81-004, 300.0	Phosphate	260	351	1171	04/13/2004	23	31	104
EPA-600/4-81-004, 300.0	Sulfate	54	73	243	04/09/2004	37	50	167
EPA-600/4-81-004, 350.1	Nitrogen in ammonia	21.6	29.2	97.3				
SW-846, 9012	Cyanide	4.7	6.3	21.2	3/8/2004	2.5	3.4	11.3
			Metals					
SW-846, 6010	Aluminum[d]	20.3	27.4	91.4	02/09/2004	16.6	22.4	74.8
SW-846, 6010	Antimony[e]	16	22	72	02/09/2004	32.0	43.2	144.1
SW-846, 6010	Barium[e]	6.5	8.8	29.3	02/09/2004	0.754	1.02	3.40
SW-846, 6010	Beryllium[e]	0.17	0.23	0.77	02/09/2004	0.659	0.89	2.97
SW-846, 6010	Cadmium[e]	2	3	9				
SW-846, 6010	Calcium[e]	148	200	666	02/09/2004	20	27	90
SW-846, 6010	Chromium[e]	2	3	9	02/09/2004	7.38	9.97	33.23
SW-846, 6010	Cobalt[e]	4	5	18				
SW-846, 6010	Copper[e]	7.7	10.4	34.7	02/09/2004	4.27	5.77	19.23
SW-846, 6010	Iron[e]	14.5	19.6	65.3	02/09/2004	12.0	16.2	54.0
SW-846, 6010	Lead[e]	9	12	41				
SW-846, 6010	Magnesium[e]	138	186	621	02/09/2004	137.0	185.0	616.9
SW-846, 6010	Manganese[e]	0.79	1.1	3.6	02/09/2004	2	3	9
SW-846, 6010	Nickel[e]	12	16	54	02/09/2004	18.9	25.5	85.1
SW-846, 6010	Potassium[e]	1,330	1,796	5,989	02/09/2004	1,492	2,015	6,719
SW-846, 6010	Silver[e]	6	8	27	02/09/2004	2.2	3.0	9.9
SW-846, 6010	Sodium[e]	140	189	630	02/09/2004	66.4	89.7	299.0
SW-846, 6010	Strontium (elemental)[e]	1.5	2.0	6.8	02/09/2004	0.659	0.89	2.97
SW-846, 6010	Tin[e]	19.8	26.7	89.2				
SW-846, 6010	Vanadium[e]	2.3	3.1	10.4	02/09/2004	7.63	10.30	34.36
SW-846, 6010	Zinc[e]	1.3	1.8	5.9	02/09/2004	2.29	3.09	10.31
SW-846, 7060	Arsenic	1.053	1.42	4.74				
SW-846, 7131	Cadmium	0.078	0.11	0.35				
SW-846, 7191	Chromium	0.364	0.49	1.64				

Table C.23. (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, 7421	Lead	0.622	0.84	2.80				
SW-846, 7470	Mercury	0.1	0.1	0.5				
SW-846, 7740	Selenium	1.652	2.23	7.44				
SW-846, 7841	Thallium	1.298	1.75	5.85				
	Volatile Organic Compounds							
SW-846, 8260	1,1,1,2-Tetrachloroethane[f]	0.04	0.05	0.18	08/12/2004	0.17	0.23	0.77
SW-846, 8260	1,1,1-Trichloroethane[f]	0.17	0.23	0.77	07/06/2004	0.07	0.1	0.3
SW-846, 8260	1,1,2,2-Tetrachloroethane[f]	0.17	0.23	0.77	05/19/2004	0.3	0.4	1.4
SW-846, 8260	1,1,2-Trichloroethane[f]	0.05	0.07	0.23	07/06/2004	0.21	0.28	0.95
SW-846, 8260	1,1-Dichloroethane[g]	0.2	0.3	0.9	07/06/2004	0.12	0.16	0.54
SW-846, 8260	1,1-Dichloroethene[g]	0.16	0.22	0.72	07/10/2004	0.07	0.1	0.3
SW-846, 8260	1,2,3-Trichloropropane[f]	0.15	0.20	0.68	08/12/2004	0.41	0.55	1.85
SW-846, 8260	1,2-Dibromomethane[f]	0.06	0.08	0.27	05/19/2004	0.2	0.3	0.9
SW-846, 8260	1,2-Dichloroethane[g]	0.08	0.1	0.4	07/06/2004	0.21	0.28	0.95
SW-846, 8260	1,2-Dichloroethene (total)[f]	0.17	0.23	0.77	08/12/2004	0.18	0.24	0.81
SW-846, 8260	1,2-Dichloropropane[f]	0.24	0.32	1.08	08/12/2004	0.17	0.23	0.77
SW-846, 8260	1,4-Dichlorobenzene	0.11	0.15	0.50	01/02/2004	0.39	0.53	1.76
SW-846, 8260	1,4-Dioxane	11.1	15.0	50.0	01/02/2004	19	26	86
SW-846, 8260	1-Butanol	4.57	6.17	20.58	01/02/2004	33	45	149
SW-846, 8260	2-Butanone[f]	0.29	0.39	1.31	07/06/2004	0.1	0.1	0.5
SW-846, 8260	2-Hexanone[f]	0.14	0.19	0.63	08/12/2004	0.14	0.19	0.63
SW-846, 8260	4-Methyl-2-pentanone[f]	0.35	0.47	1.58	07/06/2004	0.19	0.26	0.86
SW-846, 8260	Acetone[f]	0.66	0.89	2.97	04/30/2004	0.21	0.28	0.95
SW-846, 8260	Acetonitrile[f]	2.7	3.6	12.2	05/19/2004	0.21	0.28	0.95
SW-846, 8260	Acrolein[f]	2.1	2.8	9.5	05/19/2004	2.8	3.8	12.6
SW-846, 8260	Benzene	0.07	0.09	0.32	12/29/2003	0.11	0.15	0.50
SW-846, 8260	Bromodichloromethane[f]	0.2	0.27	0.90	08/12/2004	0.3	0.4	1.4
SW-846, 8260	Bromoform[f]	0.2	0.3	0.9	08/12/2004	0.3	0.4	1.4
SW-846, 8260	Bromomethane[g]	0.61	0.82	2.75	08/12/2004	0.1	0.1	0.5
SW-846, 8260	Carbon disulfide[g]	0.43	0.58	1.94	07/06/2004	0.06	0.1	0.3
SW-846, 8260	Carbon tetrachloride[f]	0.15	0.20	0.68	07/06/2004	0.1	0.1	0.5
SW-846, 8260	Chlorobenzene[g]	0.08	0.1	0.4	08/12/2004	0.16	0.22	0.72
SW-846, 8260	Chloroethane[g]	0.32	0.43	1.44	08/12/2004	0.1	0.1	0.5
SW-846, 8260	Chloroform[f]	0.07	0.09	0.32	07/06/2004	0.11	0.15	0.50
SW-846, 8260	Chloromethane[f]	0.2	0.3	0.9	05/19/2004	0.09	0.1	0.4
SW-846, 8260	cis-1,2-Dichloroethene[g]	0.06	0.08	0.27	07/6/2004	0.1	0.1	0.5
SW-846, 8260	cis-1,3-Dichloropropene[g]	0.24	0.32	1.08	08/12/2004	0.13	0.18	0.59
SW-846, 8260	Dichlorodifluoromethane[g]	0.32	0.43	1.44	08/12/2004	0.05	0.1	0.2
SW-846, 8260	Ethyl cyanide	1.3	1.8	5.9	01/2/2004	3.6	4.9	16.2
SW-846, 8260	Ethylbenzene[f]	0.14	0.19	0.63	07/12/2004	0.1	0.1	0.5
SW-846, 8260	Methylenechloride[g]	0.3	0.4	1.4	07/06/2004	0.17	0.23	0.77
SW-846, 8260	Styrene[f]	0.07	0.09	0.32	05/19/2004	0.13	0.18	0.59
SW-846, 8260	Tetrachloroethene[f]	0.17	0.23	0.77	07/06/2004	0.08	0.1	0.4

Table C.23. (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	Tetrahydrofuran	1.74	2.35	7.84	01/02/2004	0.2	0.3	0.9
SW-846, 8260	Toluene[f]	0.12	0.16	0.54	04/29/2004	0.07	0.1	0.3
SW-846, 8260	trans-1,2-Dichloroethene[g]	0.17	0.23	0.77	07/06/2004	0.09	0.1	0.4
SW-846, 8260	trans-1,3-Dichloropropene[f]	0.05	0.07	0.23	05/19/2004	0.12	0.16	0.54
SW-846, 8260	Trichloroethene[f]	0.16	0.22	0.72	04/29/2004	0.09	0.1	0.4
SW-846, 8260	Vinyl acetate	0.2	0.3	0.9	03/27/2004	0.18	0.24	0.81
SW-846, 8260	Vinyl chloride[g]	0.25	0.34	1.13	07/06/2004	0.08	0.1	0.4
SW-846, 8260	Xylenes (total)	0.28	0.38	1.26	01/02/2004	0.82	1.11	3.69
SW-846, 8260	1,4-Dichlorobenzene	0.11	0.15	0.50	01/02/2004	0.39	0.53	1.76
WTPH_Gasoline	TPH, gasoline fraction[f]	0.06	0.08	0.27	07/19/2004	0.029	0.039	0.13
	Semivolatile Organic Compounds							
SW-846, 8015	TPH, diesel fraction[f]	60	81	270	4/20/2004	50	68	225
SW-846, 8040	2,3,4,6-Tetrachlorophenol	3.73	5.04	16.80	12/23/2004	4.8	6.5	21.6
SW-846, 8040	2,4,5-Trichlorophenol	2.91	3.93	13.10	12/23/2004	4.6	6.2	20.7
SW-846, 8040	2,4,6-Trichlorophenol	2.65	3.58	11.93	12/23/2004	4.1	5.5	18.5
SW-846, 8040	2,4-Dichlorophenol	2.9	3.92	13.06	12/23/2004	3	4.1	13.5
SW-846, 8040	2,4-Dimethylphenol	3.75	5.06	16.89	12/23/2004	2.8	3.8	12.6
SW-846, 8040	2,4-Dinitrophenol	3.45	4.66	15.54	12/23/2004	3.4	4.6	15.3
SW-846, 8040	2,6-Dichlorophenol	2.66	3.59	11.98	12/23/2004	3.3	4.5	14.9
SW-846, 8040	2-Chlorophenol	2.65	3.58	11.93	12/23/2004	3.2	4.3	14.4
SW-846, 8040	2-Methylphenol (cresol, o-)	2.79	3.77	12.56	12/23/2004	4	5.4	18.0
SW-846, 8040	2-Nitrophenol	2.65	3.58	11.93	12/23/2004	3.2	4.3	14.4
SW-846, 8040	2-secButyl-4,6-dinitrophenol(DNBP)	1.43	1.93	6.44	12/23/2004	4.2	5.7	18.9
SW-846, 8040	3,4 methyl phenol	3.54	4.78	15.94	12/23/2004	2.8	3.8	12.6
SW-846, 8040	4,6-Dinitro-2methyl phenol	4.02	5.43	18.10	12/23/2004	4	5.4	18.0
SW-846, 8040	4-Chloro-3-methylphenol	2.78	3.75	12.52	12/23/2004	2.8	3.8	12.6
SW-846, 8040	4-Nitrophenol	2.81	3.79	12.65	12/23/2004	2.8	3.8	12.6
SW-846, 8040	Pentachlorophenol	2.5	3.38	11.26	12/23/2004	4.3	5.8	19.4
SW-846, 8040	Phenol	3	4.1	13.5	12/23/2004	3	4.1	13.5
SW-846, 8082	Aroclor-1016	0.35	0.47	1.58	05/05/2004	0.22	0.30	0.99
SW-846, 8082	Aroclor-1221	0.35	0.47	1.58	05/05/2004	0.22	0.30	0.99
SW-846, 8082	Aroclor-1232	0.35	0.47	1.58	05/05/2004	0.49	0.66	2.21
SW-846, 8082	Aroclor-1242	0.35	0.47	1.58	05/05/2004	0.2	0.3	0.9
SW-846, 8082	Aroclor-1248	0.35	0.47	1.58	05/05/2004	0.14	0.19	0.63
SW-846, 8082	Aroclor-1254	0.35	0.47	1.58	05/05/2004	0.38	0.51	1.71
SW-846, 8082	Aroclor-1260	0.23	0.31	1.04	05/05/2004	0.19	0.26	0.86
SW-846, 8270	1,2,4,5-Tetrachlorobenzene	0.21	0.28	0.95	01/14/2004	0.4	0.5	1.8
SW-846, 8270	1,2,4-Trichlorobenzene	0.45	0.61	2.03	12/31/2003	0.91	1.23	4.10
SW-846, 8270	1,2-Dichlorobenzene	0.28	0.38	1.26	12/31/2004	1.9	2.57	8.56
SW-846, 8270	1,3-Dichlorobenzene	0.29	0.39	1.31	12/31/2004	1.9	2.57	8.56
SW-846, 8270	2,2'-Oxybis(1-chloropropane)	0.27	0.36	1.22	12/31/2003	1.1	1.49	4.95
SW-846, 8270	2,4,5-Trichlorophenol	0.64	0.86	2.88	12/31/2004	2.4	3.24	10.81
SW-846, 8270	2,4,6-Trichlorophenol	0.44	0.59	1.98	12/31/2004	2.4	3.24	10.81
SW-846, 8270	2,4-Dichlorophenol	0.27	0.36	1.22	12/31/2004	0.91	1.23	4.10

Table C.23. (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	2,4-Dimethylphenol	5.3	7.2	23.9	12/31/2004	1	1.4	4.5
SW-846, 8270	2,4-Dinitrophenol	1.7	2.3	7.7	12/31/2004	6.7	9.05	30.17
SW-846, 8270	2,4-Dinitrotoluene	0.62	0.84	2.79	12/31/2004	4	5.4	18.0
SW-846, 8270	2,6-Dinitrotoluene	0.68	0.92	3.06	12/31/2004	3	4.1	13.5
SW-846, 8270	2-Chloronaphthalene	0.28	0.38	1.26	12/31/2004	1	1.4	4.5
SW-846, 8270	2-Chlorophenol	0.25	0.34	1.13	12/31/2004	0.92	1.24	4.14
SW-846, 8270	2-Methylnaphthalene	0.37	0.50	1.67	12/31/2004	1.1	1.5	5.0
SW-846, 8270	2-Methylphenol (cresol, o-)	0.24	0.32	1.08	12/31/2004	0.93	1.26	4.19
SW-846, 8270	2-Nitroaniline	0.65	0.88	2.93	12/31/2004	0.71	0.96	3.20
SW-846, 8270	2-Nitrophenol	0.64	0.86	2.88	12/31/2004	1.9	2.6	8.6
SW-846, 8270	3,3'-Dichlorobenzidine	1.3	1.8	5.9	12/31/2004	2.6	3.5	11.7
SW-846, 8270	3-Nitroaniline	0.56	0.76	2.52	12/31/2004	0.85	1.15	3.83
SW-846, 8270	4,6-Dinitro-2methyl phenol	0.53	0.72	2.39	12/31/2004	4	5.4	18.0
SW-846, 8270	4-Bromophenylphenyl ether	0.42	0.57	1.89	12/31/2004	1	1.4	4.5
SW-846, 8270	4-Chloro-3-methylphenol	0.37	0.50	1.67	12/31/2004	0.87	1.17	3.92
SW-846, 8270	4-Chloroaniline	1.1	1.49	4.95	12/31/2004	1.3	1.8	5.9
SW-846, 8270	4-Chlorophenylphenyl ether	0.44	0.59	1.98	12/31/2004	1.1	1.5	5.0
SW-846, 8270	4-Methylphenol (cresol, p-)	7.1	9.6	32.0	12/31/2004	1.5	2.0	6.8
SW-846, 8270	4-Nitroaniline	1	1.4	4.5	12/31/2004	0.84	1.13	3.78
SW-846, 8270	4-Nitrophenol	0.81	1.09	3.65	12/31/2004	3.2	4.3	14.4
SW-846, 8270	Acenaphthene	0.35	0.47	1.58	12/31/2004	1.1	1.5	5.0
SW-846, 8270	Acenaphthylene	0.34	0.46	1.53	12/31/2004	0.99	1.34	4.46
SW-846, 8270	Aniline	0.29	0.39	1.31	12/31/2004	1.1	1.5	5.0
SW-846, 8270	Anthracene	0.39	0.53	1.76	12/31/2004	1.2	1.6	5.4
SW-846, 8270	Benzo(a)anthracene	0.47	0.63	2.12	12/31/2004	1.7	2.3	7.7
SW-846, 8270	Benzo(a)pyrene	1.1	1.5	5.0	12/31/2004	4	5.4	18.0
SW-846, 8270	Benzo(b)fluoranthene	0.83	1.12	3.74	12/31/2004	4.3	5.8	19.4
SW-846, 8270	Benzo(ghi)perylene	1.2	1.6	5.4	12/31/2004	3.1	4.2	14.0
SW-846, 8270	Benzo(k)fluoranthene	1.5	2.0	6.8	12/31/2004	4.8	6.5	21.6
SW-846, 8270	Benzyl alcohol	0.33	0.45	1.49	12/31/2004	1	1.4	4.5
SW-846, 8270	Bis(2-Chloroethoxy)methane	0.37	0.50	1.67	12/31/2004	1.2	1.6	5.4
SW-846, 8270	Bis(2-chloroethyl) ether	0.43	0.58	1.94	12/31/2004	1.1	1.5	5.0
SW-846, 8270	Bis(2-ethylhexyl) phthalate	2.7	3.6	12.2	12/31/2004	3.6	4.9	16.2
SW-846, 8270	Butylbenzylphthalate	0.55	0.74	2.48	12/31/2004	1.8	2.4	8.1
SW-846, 8270	Chrysene	0.6	0.81	2.70	12/31/2004	2	2.7	9.0
SW-846, 8270	Di-n-butylphthalate	0.47	0.63	2.12	12/31/2004	1.7	2.3	7.7
SW-846, 8270	Di-n-octylphthalate	5.1	6.9	23.0	12/31/2004	2.2	3.0	9.9
SW-846, 8270	Dibenz[a,h]anthracene	1.4	1.9	6.3	12/31/2004	2.7	3.6	12.2
SW-846, 8270	Dibenzofuran	0.36	0.49	1.62	12/31/2004	1.2	1.6	5.4
SW-846, 8270	Diethylphthalate	0.24	0.32	1.08	12/31/2004	3.6	4.9	16.2
SW-846, 8270	Dimethyl phthalate	0.68	0.92	3.06	12/31/2004	2.1	2.8	9.5
SW-846, 8270	Fluoranthene	0.44	0.59	1.98	12/31/2004	1.5	2.0	6.8
SW-846, 8270	Fluorene	0.38	0.51	1.71	12/31/2004	1.2	1.6	5.4
SW-846, 8270	Hexachlorobenzene	0.47	0.63	2.12	12/31/2004	1.2	1.6	5.4
SW-846, 8270	Hexachlorobutadiene	0.41	0.55	1.85	12/31/2004	0.91	1.2	4.1

Table C.23. (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	Hexachlorocyclopentadiene	2.4	3.2	10.8	12/31/2004	2.5	3.4	11.3
SW-846, 8270	Hexachloroethane	0.24	0.32	1.08	12/31/2004	0.8	1.1	3.6
SW-846, 8270	Indeno(1,2,3-cd)pyrene	1.2	1.6	5.4	12/31/2004	2.6	3.5	11.7
SW-846, 8270	Isophorone	0.23	0.31	1.04	12/31/2004	1.1	1.5	5.0
SW-846, 8270	N-Nitroso-di-n-propylamine	0.89	1.20	4.01	12/31/2004	2.4	3.2	10.8
SW-846, 8270	N-Nitrosodimethylamine	0.46	0.62	2.07	12/31/2004	0.73	0.99	3.29
SW-846, 8270	N-Nitrosodiphenylamine	0.45	0.61	2.03	12/31/2004	1.2	1.6	5.4
SW-846, 8270	Naphthalene	0.3	0.4	1.4	12/31/2004	1.1	1.5	5.0
SW-846, 8270	Pentachlorophenol	0.58	0.78	2.61	12/31/2004	3.8	5.1	17.1
SW-846, 8270	Phenanthrene	0.4	0.5	1.8	12/31/2004	1.4	1.9	6.3
SW-846, 8270	Phenol	0.26	0.35	1.17	12/31/2004	0.52	0.70	2.34
SW-846, 8270	Pyrene	0.46	0.62	2.07	12/31/2004	1.7	2.3	7.7

(a) MDLs for many constituents changed during the fiscal year. For th
date). In cases where the MDL did not change, no ending values are listed.
(b) µMhos/cm.
(c) Between 05/26/2004 and 09/01/2004, a third MDL (value not shown in table) was in effect for this compound.
(d) Between 04/09/2004 and 06/16/2004, a third MDL (value not shown in table) was in effect for this compound.
(e) Two instruments (standard and trace level) were used for samples analyzed by method 6010. MDL values for the standard instrument were included in this table. MDL values for the trace instrument were typically 2 to 10 times lower, but in s
(f) A third MDL (value not shown in table) was in effect for this compound for part of the fiscal year before the effective date of the ending value.
(g) Two additional MDLs (values not shown in table) were in effect for this compound for part of the fiscal year before the effective date of the ending value.
LOD = Limit of detection.
LOQ = Limit of quantitation.
MDL = Method detection limit.