Characterization and Monitoring of 300 Area Facility Liquid Waste Streams: 1994 Annual Report

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April 1995

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**Pacific Northwest Laboratory
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Richland, Washington 99352

Abstract

The Effluent Monitoring Program characterizes and monitors liquid waste streams from 300 Area buildings owned by the U.S. Department of Energy and managed by the Pacific Northwest Laboratory.^(a) This program is managed by the Pacific Northwest Laboratory. This report summarizes the results of characterizing and monitoring the following sources during calendar year 1994 (the first year of the program): liquid waste streams from Buildings 306, 320, 324, 326, 331, and 3720; treated and untreated Columbia River water (influent); and water at the confluence of the waste streams (that is, end-of-pipe). Data were collected from March to December before the sampling system installation was completed. Data from this initial part of the program are considered tentative.

Samples collected were analyzed for chemicals, radioactivity, and general parameters. In general, the concentrations of chemical and radiological constituents and parameters in building wastewaters which were sampled and analyzed during CY 1994 were similar to historical data. Exceptions were the occasional observances of high concentrations of chloride, nitrate, and sodium that are believed to be associated with excursions that were occurring when the samples were collected. Occasional observances of high concentrations of a few solvents also appeared to be associated with infrequent building releases.

During calendar year 1994, nitrate, aluminum, copper, lead, zinc, bis(2-ethylhexyl)-phthalate, and gross beta exceeded U.S. Environmental Protection Agency maximum contaminant levels or the Treated Effluent Disposal Facility's National Pollution Discharge Elimination System permit limits on a frequent or occasional bases at end-of-pipe. Phthalates are suspected to be artifacts of sampling. The metals are also suspected to be a result of artifacts introduced during the sample collection and analysis process and/or leaching of residuals associated with the aged building and sewer piping systems.

Concentrations and clearance times for contaminants at end-of-pipe depended strongly on the source concentration at the building release point, waste stream flow rates, dispersion, and the mechanical action of sumps. When present, the action of sumps had the greatest impact on contaminant clearance times. In the absence of sump activity, dispersion and flow rate were the controlling factors.

Initial field evaluations of a transportable gas chromatograph/mass spectrometer, adsorptive stripping voltametry, solid phase extraction, and continuous monitoring of pH, flow, and conductivity were favorable. Future plans call for integrating the gas chromatographic capabilities with continuous monitoring of pH, conductivity, and flow to allow greater clarification of building waste stream chemistry during excursions.

(a) The Pacific Northwest Laboratory is operated by the Battelle Memorial Institute under Contract DE-AC06-76RLO 1830.

Executive Summary

Liquid effluent streams from six U.S. Department of Energy-owned and Pacific Northwest Laboratory-operated buildings (306, 320, 324, 326, 331, and 3720), end-of-pipe, and influent in the 300 Area of the Hanford Site were monitored for six general classes of parameters. Conclusions were drawn from the data generated from the analysis of mostly 24-hr composite samples collected one to two times a month from waste streams. However, at the most, this sampling practice leads to monitoring less than 3 to 6% of the effluent discharged from a building over the course of 1 month. Also, this was the initial sampling performed on sampling systems that were being installed in the facilities. Sampling system installations were not completed until 1995 and the data presented in this report are considered tentative.

Elevated concentrations of general chemical parameters, ammonia and anions, and volatile organic compounds appeared more frequently in the waste streams of Buildings 326, 331, and 3720 than in the waste streams of other buildings (i.e., 306, 320, and 324). Occasional elevated levels of sodium, chloride, phosphate, and pH were observed at end-of-pipe.

Chlorination of influent (Columbia River water) introduces volatile byproducts (i.e., chloroform, bromoform, bromodichloromethane, and dibromochloromethane) into building source water at levels slightly higher than those observed in the building effluents. Observed concentrations ranged from 0.5 to 40 $\mu\text{g/L}$ in building waste streams and 0.9 to 20 $\mu\text{g/L}$ at end-of-pipe. The observed concentration range for all four trihalomethanes at end-of-pipe was below the U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 100 $\mu\text{g/L}$.

Six other volatile halogenated hydrocarbons (i.e., 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,2-dichloroethylene, trichloroethene, tetrachloroethene, and trichlorofluoromethane) were detected infrequently in building waste streams and end-of-pipe at trace levels (0.6 to 2 $\mu\text{g/L}$). None of the observed levels of these compounds exceeded EPA MCLs or National Pollutant Discharge Elimination System (NPDES) permit limits for the Treated Effluent Disposal Facility.

Elevated levels (24 to 40,800 $\mu\text{g/L}$) of volatile organic solvents (i.e., acetone, acetonitrile, tetrahydrofuran, toluene, 2-butanone, hexone, ethanol, and isopropanol) were occasionally observed in waste streams from Buildings 320, 326, 331, and 3720 and at end-of-pipe. It is postulated that these observances are associated with infrequent building releases.

In general, metals were detected at trace levels (generally from 0.1 to 10 $\mu\text{g/L}$). Their presence is suspected to be the result of artifacts introduced during the sample collection and analysis process and/or leaching of residuals associated with the aged buildings and sewer piping systems.

Pesticides were found in the effluents of Buildings 326 and 331 but for the most part were detected at extremely trace levels (i.e., <20 ng/L). Phthalates were also detected in several building effluents (i.e., 326, 331, 3720). Bis(2-ethylhexyl)phthalate was detected at end-of-pipe at levels above the EPA MCL of 6 μ g/L. Phthalates are suspected to be a largely unavoidable artifact of sampling.

Building 3720 effluent had gross alpha radiation levels consistently in the range of 4 to 45 pCi/L while other buildings and end-of-pipe had much lower levels (1 to 4 pCi/L). For all locations, the average gross beta activity was in the range of 3.5 to 7.4 pCi/L. Tritium was frequently detected in the effluent from Buildings 306, 324 (process and retention process sewer), 326, and 331 in the range of 118 to 687 pCi/L. Tritium was also detected once at end-of-pipe at an activity level of 227 pCi/L.

On occasion, gross alpha and/or gross beta radiological activity in samples slightly exceeded EPA MCL at Buildings 306, 324, 331, and 3720.

In general, concentrations of chemical and radiological constituents and parameters in wastewaters sampled and analyzed during calendar year (CY) 1994 were similar to historical data. Exceptions were the occasional observances of high concentrations of chloride, nitrate, and sodium that are believed to be associated with excursions that were occurring at the time that samples were being collected.

During CY 1994, nitrate, aluminum, copper, lead, zinc, bis(2-ethylhexyl)phthalate, and gross beta exceeded EPA MCLs or Treated Effluent Disposal Facility NPDES permit limits on a frequent or occasional basis at end-of-pipe.

Concentrations and clearance times at end-of-pipe were highly dependent on waste stream flow rates, dispersion, and the mechanical action of sumps. When present, the sumps had the greatest impact on clearance times. In the absence of sump activity, dispersion and flow rate were the controlling factors.

Initial evaluations of field transportable gas chromatography/mass spectrometry, adsorptive stripping voltametry, solid phase extraction, and continuous monitoring of flow, pH, and conductivity were favorable. These technologies illustrated the highly variable nature of the effluent streams and the potential to improve current characterization practices.

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Acronym and Abbreviation List

ASV	adsorptive stripping voltametry
CY	calendar year
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FEMP	Facility Effluent Monitoring Program
FMCS	Facilities Management Control System
GC/MS	gas chromatograph/mass spectrometer
MCL	maximum contaminant level
NPDES	National Pollutant Discharge Elimination System
PCB	polychlorinated biphenyl
PNL	Pacific Northwest Laboratory
QA	quality assurance
SPE	solid phase extraction
SVOC	semivolatile organic compound
TEDF	Treated Effluent Disposal Facility
VOC	volatile organic compound
WHC	Westinghouse Hanford Company

Trademarks Used

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1.0 Introduction

Physical, chemical, and radiological data are being gathered by the Pacific Northwest Laboratory (PNL) on the liquid waste streams (i.e., process and retention process sewer effluents) from 300 Area U.S. Department of Energy (DOE)-owned and PNL-operated buildings where radioactive and/or hazardous materials are used (Figure 1.1). Samples were collected and analyzed to meet the requirements of DOE Order 5400.1 (DOE 1988). The 300 Area is located on the Hanford Site, a National Environmental Research Park, in southeastern Washington State. Activities within these buildings involve basic and applied research and the evaluation and deployment of technology in support of environmental restoration and waste management activities across the DOE complex.

For calendar year (CY) 1994, liquid samples were collected from the following six buildings:

- Building 306
- Building 320
- Building 324
- Building 326
- Building 331
- Building 3720.

PNL is also monitoring end-of-pipe, which is where effluents from all of the 300 Area buildings come together before discharging to process trenches (previous to December 29, 1994) or the Treated Effluent Disposal Facility (TEDF) (Figure 1.1) (after December 29, 1994). The effluents at end-of-pipe include building process sewer and retention process sewer effluents. Before the streams are combined, the retention process sewer effluents are sent to 307 Basins where the streams are

monitored by WHC for gross alpha and beta radioactivity. After screening, waste water with acceptably low radiation levels is discharged to the process sewer which is routed to the TEDF. This facility, which is managed by Westinghouse Hanford Company (WHC), is fulfilling a milestone in the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989). Building effluents routed to TEDF are treated and discharged to the Columbia River according to the requirements of a National Pollutant Discharge Elimination System (NPDES) permit WA-0025917 (EPA 1994a).

Columbia River water is the source water for the buildings. This water is treated by filtration and chlorination at Building 315 before being routed as influent to the buildings. Treated and untreated influent is also being monitored as part of this program to provide background information on water coming into the buildings. Building 315 is operated by WHC.

Three more buildings are scheduled for baseline characterization and monitoring as sampling stations come online during CY 1995. The three additional buildings are

- Building 325
- Building 327
- Building 329.

1.1 Purpose

This report summarizes the results from 1) characterization and monitoring of effluent and influent performed during CY 1994 (March to December), 2) waste stream dynamics tests, and 3) technology

sampling and analyses processes and capabilities (Appendix C), quality control information for sample blanks and duplicate samples (Appendix D), detailed information on the chemical composition of influent (Appendix E), and tables with detailed information on the parameters and constituents detected at the buildings and end-of-pipe (Appendix F), and the glossary (Appendix G).

1.2 Objective

The objective of this report is to provide technical information for the purpose of responsible management of building effluents. This includes controlling effluents to support TEDF in meeting regulatory requirements and regularly assessing PNL administrative controls used to manage discharges to end-of-pipe from 300 Area PNL-operated buildings.

2.0 Background

Operation of facilities in the 300 Area began in February 1943 when the Hanford Site was created to produce plutonium for the first atomic bombs. Activities in the 300 Area have included fabricating reactor fuel and evaluating pilot-scale separations processes and the conduct of basic and applied research for industrial and governmental agencies.

For over five decades, chemically and radiologically contaminated waste waters from these activities were discharged to ponds, trenches, and cribs in the 300 Area (Riley and Zachara 1992). The waste waters were discharged using an intricate system of sewer lines linking facilities to waste disposal areas. The sewer system consisted of independently

functioning sanitary and process components. Detailed information describing the sewer system (past, present, and future) and 300 Area liquid waste disposal practices can be found in *Past Practices Technical Characterization Study-300 Area-Hanford Site* (Gerber 1992). Information from that report is summarized in Appendix A with an emphasis on the process and retention process sewer systems because the sanitary sewer and radioactive liquid waste systems are not monitored by the effluent program. Preliminary information on the characterization and monitoring of 300 Area facility waste streams conducted by the Effluent Monitoring Program can be found in Riley et al. (1994).

3.0 1994 Liquid Waste Stream Characterization and Monitoring

This section summarizes information about the samples collected during CY 1994 (such as types, location, and dates). The sampling process is described in Appendix C. Also, this section summarizes quality control and background information that is used to clarify the interpretation of waste stream data presented in Sections 4.0 through 10.0. Guidance on how to interpret the figures is provided. Sampling and analytical data limitations are also discussed.

3.1 Sample Types and Dates of Collection

Effluents in the 300 Area were routinely collected and analyzed from six PNL-operated buildings equipped with automated, refrigerated samplers, and periodic sampling was done at two buildings using portable samplers. A total of 11 locations were sampled in CY 1994; 6 process (chemical) sewers, 1 retention (radiological) process sewer, end-of-pipe, and 3 influent sites (Figure 3.1). The influent was sampled and analyzed to provide a baseline from which the chemical and radiological composition of building effluents could be assessed. Source water locations that were sampled included untreated influent (originating from the Columbia River), treated influent (after Columbia River water was treated at Building 315), and an alternate influent originating from the city of Richland. Alternate influent was used on occasions when the primary treated influent was not available.

Samples for CY 1994 were collected from March 22, 1994, through December 20, 1994. Buildings were sampled

during business hours on a weekly basis from March through September and on a biweekly basis from October through December. Untreated and treated influent samples were collected from May 11, 1994, through July 8, 1994. Alternate influent was sampled on August 4, 1994. Grab samples of influent and effluent were collected from May 11, 1994, through September 27, 1994, for volatile organic compound (VOC) analysis using a U.S. Environmental Protection Agency (EPA) standard protocol. In addition, liquid effluent from buildings was sampled biweekly during nonbusiness days (e.g., weekends and holidays) from May 23, 1994, through August 15, 1994. No restriction was placed on building activities during these latter sampling activities. Therefore, the analytical data obtained from the analyses of nonbusiness day samples could be nonrepresentative of the actual building background composition. See Appendix C for detailed information on all samples collected (i.e., descriptions of sample type, analyses requested, and deviations from the sample collection and analyses process).

3.2 Analytical Data Presentation and Quality

This section describes information that will assist the reader in understanding the data presented in Sections 4.0 through 10.0. Interpretation of figures is discussed. Normalization of analytical data, taking into account quality control (i.e., data from blanks and duplicate samples) and background data (i.e., data on influents), is presented. Limitations of the sampling and analytical data are also discussed.

Figure 3.1. Location of Facility Sampling Stations, Source Water, and End-of-Pipe

3.2.1 Understanding the Figures

The format for presenting analytical data is shown in Figure 3.2. This format was chosen to enable rapid interpretation of monitoring results. Detected analytes are listed along the abscissa (x-axis or horizontal axis) in order of increasing concentration (from left to right). The primary ordinate (left y-axis or left vertical axis) corresponds to concentration. The height of each column depicts an analyte's average concentration, and the superimposed range bars represent the corresponding minimum and maximum detected concentrations. For example, in Figure 3.2, the average concentration of compound X is 25 $\mu\text{g/L}$, and the associated range is approximately 10 to 50 $\mu\text{g/L}$. When concentrations are too low to discern from the graph, the results are listed in the figure caption. The secondary ordinate (right y-axis or right vertical axis) displays the frequency of detection, which is defined as the number of times a constituent was detected divided by the number of samples that were analyzed. For an individual analyte, the frequency of detection is indicated by the height of a small circle positioned above the analyte's name. In Figure 3.2, compound X was detected only 10% of the time, while compound Y was detected in every sample analyzed.

A few caveats should be kept in mind when viewing the figures. A high frequency of detection could be the result of a small number of sample analyses, as is the case with some of the nonbusiness day results. The absence or apparent absence of a range bar on some figures could indicate that an analyte was detected only once, or that an analyte had a very narrow concentration range. In addition, the figures only list analytes that were detected. For a complete listing of the analyses which were performed, see Appendix C. Additional

Figure 3.2. Example Figure Showing the Frequencies of Detection and the Average, Minimum, and Maximum Concentrations of Detected Parameters and Constituents

information (i.e., numerical averages, ranges, standard deviations, and the number of analyses performed) can be found in Appendix F.

Conclusions drawn from analytical data must be made with care because of the potential for qualitative and quantitative errors. Both the sampling and analysis processes can introduce bias, errors, and contamination. Thus, sometimes, several interpretations of the data are possible. Interpretations made in the text note these concerns when appropriate.

3.2.2 Quality Assurance and Quality Control

The Quality Assurance (QA) program for the 300 Area Effluent Monitoring Program is based on the following documentation:

- 10 CFR 830.120, "Quality Assurance for DOE Nuclear Facilities"

- DOE Order 5400.1, "General Environmental Protection Program"
- DOE Order 5700.6C, "Quality Assurance"
- EPA QAMS-005/80, "Interim Guidelines for Preparing Quality Assurance Project Plans"
- PNL QA manual and associated implementing procedures
- SW-846, "USEPA Methods for Evaluating Solids Waste, Physical/Chemical Methods" (EPA 1986).

The program has a draft QA plan which addresses the applicable requirements delineated in the above documents. Future project work activity (liquid effluent sampling and monitoring system operations, associated analytical services, and data validation and reduction) will be conducted in accordance with this QA plan. Although the QA plan is still under development, many of its components have been addressed during CY 1994 characterization and monitoring activities.

- Sampling procedures were developed and implemented.
- Appropriate training was given and documented.
- Sample chain-of-custody was maintained and documented.
- Analyses were performed in accordance with PNL-approved statements of work and procedures.
- Quality control sampling and analyses were performed as described in Section 3.2.3

3.2.3 Quality Control Data

Quality control consisted of making analytical measurements on five types of sample blanks (bottle blanks, equipment blanks, field-transfer blanks, full-trip blanks, and daily-trip blanks) which were prepared and submitted to the laboratories for analysis. In addition, 1 laboratory reagent blank was analyzed for every 20 samples. Definitions of the various blank types can be found in the glossary.

Duplicate samples were prepared and analyzed to determine analytical laboratory reproducibility. A detailed summary of data generated from duplicate samples and sample blanks can be found in Appendixes D and F. A brief summary is provided in Sections 3.2.3.1 and 3.2.3.2.

3.2.3.1 Blanks

Table 3.1 summarizes the analysis results of the various blanks for the parameters and constituents of interest. This table lists only those analytes which were detected in the various blank analyses. A total of 21 parameters and constituents were identified with varying frequencies in one or more of the blank types. Aluminum, chromium, iron, lead, acetone, chloroform, methylene chloride, and tetrahydrofuran were the constituents observed in most (i.e., in three or more) of the blank types. Of these constituents, chromium, lead, and methylene chloride were observed at levels similar to the concentrations observed in actual samples of building effluent. Alkalinity, chemical oxygen demand, total carbon, nitrate, sodium, zinc, toluene, and tri-chloroethane were observed in only one to two blank types and at concentrations below levels observed in effluents. Sulfides, manganese, nickel, thallium, and vanadium were observed in only one to

Table 3.1. Quality Control Sample Summary

Parameter	Laboratory Reagent Blanks	Bottle Blanks	Equipment Blanks	Field Transfer Blanks	Trip Blanks
General Chemical Parameters					
Alkalinity	★				
Chemical Oxygen Demand			▼		
Total carbon	★				
Common Anions					
Nitrate			▼		
Sulfides		•			▼
Metals					
Aluminum	★	▼			•
Chromium		•	•		•
Iron	★	▼			•
Lead	★	•	•		•
Manganese			•		
Nickel					•
Sodium	★				
Thallium		•			
Vanadium			•		
Zinc	★	▼			
Volatile Organic Compounds					
Acetone		▼		•	▼
Chloroform		▼	▼		▼
Methylene chloride	★	•	•	•	▼
Tetrahydrofuran		▼	•		▼
Toluene		▼		▼	
Trichloroethene		▼			
★ = Detected in 10% or more of the laboratory reagent blanks. ▼ = Concentrations observed at levels below levels detected in effluent samples. • = Concentrations observed at levels similar to levels detected in one or more effluent samples.					

two blank types; however, they were observed at least once at levels similar to concentrations in building effluent samples.

Blank data were compared against building effluent and influent sample data; the impact of contamination resulting from the sampling and analysis process was noted. A more detailed discussion of the analysis of the blanks along with figures and tables is presented in Appendix D.

3.2.3.2 Duplicate Samples

Matching results for a total of 42 constituents were compared in up to six duplicate sample pairs. For most of these analytes, the analytical precision was fairly high (i.e., the results were within 25% of each other). A few metals, organic compounds, and radiological parameters exhibited poorer agreement. However, among these latter constituents, only iron, potassium, manganese, and carbon disulfide had average concentrations which were significantly above their method detection limits. Thus, for most constituents, these results illustrate that the measurement precision is lower for constituents measured at levels near the detection limit. Overall, these results suggest that the level of precision associated with CY 1994 analytical measurements on effluent samples should not have a significant impact on the data's interpretation. Additional caution should be applied when drawing conclusions from trace-level concentrations, which were typically reported for many metals, pesticides, and radiological parameters. Detailed information on the duplicate samples' results can be found in Appendix D.

3.2.4 Influent Chemistry (Untreated, Treated, Alternate)

Influent was sampled periodically before and after treatment (i.e., filtration and chlorination) at Building 315. Alternate influent (which was treated) was used in the buildings when the primary influent was not available. Because alternate influent sampling was performed only once, the results are considered tentative. Also, only limited data (five samples) on influent before and after treatment at Building 315 are available. Samples were taken from May to July 1994, and thus provide information for only one season. This data set has much less variability than most of the building data sets which were generated from a much larger number of samples.

Primary influent is pumped into the 300 Area directly from the Columbia River at the 312 Intake Pumphouse and treated at Building 315. Alternate influent is supplied at Building 382B and was used for a few weeks in CY 1994. All of these buildings are maintained and operated by WHC. Periodic, 24-hr time-proportional sampling was done at all three locations using a portable sampler. Concentrations of constituents in untreated, treated, and alternate influent were compared. Results are summarized in the following text. Detailed quantitative data (figures and tables) for the influent can be found in Appendix E.

General Chemical Parameters.

Treated influent contained 10 to 20% less total carbon and total organic carbon compared to untreated influent. Values for chemical oxygen demand, alkalinity, and total dissolved solids were similar for untreated and treated influents. Alternate

influent contained approximately 50% less total organic carbon, slightly less total carbon, and no detectable chemical oxygen demand. Alkalinity and total dissolved solids were slightly higher in the alternate influent compared to untreated and treated influent.

Ammonia and Anions. Concentrations of selected anions were significantly higher in the treated influent than in the untreated influent. Chloride was approximately four times higher; fluoride and sulfate were approximately twice as high. Ammonia was detected in the alternate influent but not in the untreated or treated influent.

Metals. Aluminum, arsenic, chromium, iron, manganese, and tin were detected in untreated and treated influent but not in the alternate influent. The concentrations of the alkali and alkaline earth metals (sodium, potassium, calcium, and magnesium) were similar among all the influents.

Volatile Organic Compounds. Although 10 to 20% of total carbon and total organic carbon appear to be removed from untreated influent during the chlorination process, trihalomethanes (e.g., chloroform and bromodichloromethane) are introduced, increasing their concentrations above background levels. Chloroform, the most common chlorination byproduct, was always found at concentrations 2 to 7 times higher in the treated influent when compared to the untreated influent. The highest value was greater than 1.5 times the TEDF waste acceptance criteria of $26 \mu\text{g/L}$, but the concentration was below the trihalomethane drinking water standard of $100 \mu\text{g/L}$. Bromodichloromethane was also frequently detected in the treated influent.

A number of the VOCs identified in the three influents are probably artifacts of the sampling and analysis process. For example, methylene chloride and tetrahydrofuran were also detected in sample blanks, and benzene and toluene were reported at near method detection limit concentrations. Chlorobenzene's low frequency of detection requires that its presence be considered suspect.

Semivolatile Organic Compounds. Trace levels of di-n-butylphthalate ($\sim 2 \mu\text{g/L}$) and low nanogram per liter concentrations of delta-BHC (a pesticide) were also found in the treated influent.

Radiological Parameters. No radiological analyses were performed on influent samples.

3.2.5 Data Limitations

Ideally, building effluents should be monitored continuously, providing information on the concentrations of parameters and constituents in a real-time mode. In this way, decisions can be made on the control of effluent discharges from the building and end-of-pipe. However, limitations on task financial resources and on characterization technologies restricted the frequency in which building effluents were monitored. During CY 1994, sampling of building effluents consisted of collecting a 24-hr composite sample one to four times a month for chemical and radiological analyses. A simple calculation shows that such a sampling practice at the most is sampling 3 to 13% of the effluent discharged from a building over the course of 1 month. Some limited information on continuous monitoring of pH, conductivity, and flow suggest that discharge events do occur in building

effluents and that these events, in most cases, do not correspond to the limited time in which composite sampling is performed. Thus, with finite composite sampling, the uncertainty of understanding the effluent composition at any given time during the year is high.

When considering the influent, the small number of samples collected at the source water locations results in an uncertainty associated with this data that is higher than that calculated for effluent samples.

In most cases, more samples were taken of the effluent than the influent.

Also, effluent sampling covered a much larger time frame than influent sampling. Thus, some of the differences noted between the effluent and influent may simply be the cause of better effluent characterization. These uncertainties should be taken into account when reading the information and conclusions provided in Sections 4.0 through 10.0 on building effluent chemistry. A plan is under development to deploy over time new characterization tools to reduce characterization and monitoring uncertainty of 300 Area building effluents.

4.0 Building 306 (Process Sewer)

4.1 Background and Description

Building 306 is located in the north-east corner of the 300 Area. Here, PNL and WHC staff conduct metallurgical research and development. The facility is equipped for metal working, heat treating, and finishing equipment activities. General activities include the development, demonstration, and testing of pilot-phase fabrication processes and new material concepts.

4.2 Routine Sampling

At Building 306, seven 24-hr composite sampling events occurred. However, seven analyses do not necessarily exist for each constituent because additional grab samples may have been taken, additional analyses may have been requested for specific constituents, or inadequate samples may have been collected for the analyses desired. Table C.2 lists the analyses performed on the samples from Building 306. Samples were collected with a portable 24-hour, time-proportional sampler. Summary data supporting the constituent class discussions in Sections 4.2.1 through 4.2.6 are shown in the accompanying figures. Comparisons to influent chemistry are based on the data in Appendix E. Tables with detailed building effluent information can be found in Appendix F.

4.2.1 General Chemical Parameters

Except for chemical oxygen demand and total organic carbon, the concentrations of general chemical parameters were slightly elevated over treated influent levels. Both alkalinity and total dissolved solids were approximately 70% higher; total carbon was nearly 50%

higher. Chemical oxygen demand and total organic carbon levels were slightly less than (i.e., 10 to 20% lower than) treated influent concentrations (Figure 4.1). None of the general chemical parameters that were investigated have regulatory standards of comparison except total dissolved solids. The maximum total dissolved solid value observed for Building 306 was 180 mg/L, which is much less than the National Secondary Drinking Water Standard of 500 mg/L.

Figure 4.1. Building 306 General Chemical Parameters

4.2.2 Ammonia and Anions

Ammonia and sulfides were detected in 50% of the samples. Although the ammonia concentrations were low, they were likely valid because ammonia was not detected in any blank samples (bottle,

trip, or reagent). However, the effluent's sulfide concentration and detection frequency were comparable to those found in the bottle blanks. In addition, the sulfides concentration was near the method detection limit ($210 \mu\text{g/L}$). Concentrations of fluoride in the Building 306 effluent were 40% lower than in the treated influent. Nitrate concentrations fluctuated substantially and were approximately 15 times greater than treated influent levels. Chloride concentrations were nearly 60% higher than levels found in treated influent. Sulfate concentrations were 10% higher than treated influent levels but varied over a larger range ($13,400$ to $22,600 \mu\text{g/L}$) (Figure 4.2).

For reference only (building effluent is not meant to be drinking water and is treated by the TEDF before being discharged to the river), concentrations of ammonia and anions were compared to the National Drinking Water Standards, which exist for four of the constituents detected (chloride, fluoride, nitrate, and sulfate). Only the nitrate standard of 10 mg/L was exceeded with a maximum observed concentration of 13.5 mg/L in the effluent (this was true of almost all of the building waste streams). The TEDF waste acceptance criteria exist for only one of the constituents detected; ammonia was measured at a small fraction ($< 6\%$) of the waste acceptance criteria.

Figure 4.2. Building 306 Ammonia and Anions (Ammonia Average $60 \mu\text{g/L}$, Range 40 to $100 \mu\text{g/L}$; Sulfides $273 \mu\text{g/L}$, Range 220 to $300 \mu\text{g/L}$)

4.2.3 Metals

The validity of the metals results detected below $10 \mu\text{g/L}$ is questionable because of their low frequencies of occurrence and because their concentrations are comparable to the method detection limits (Figure 4.3a and b). The detection of many of the heavy metals in the blanks and the treated influent samples demonstrates the high potential for finding these constituents when monitoring at trace levels. The concentration of manganese was twice as high in the effluent ($14 \mu\text{g/L}$) compared to the untreated influent, while levels of aluminum, barium, and copper were similar to those found at influent sampling points. The source of aluminum and copper at these locations may be attributable to leaching of these constituents from a corroded local water delivery system (piping and plumbing), given the low levels of copper found in the treated influent and previously reported river values (Dirkes et al. 1993). Zinc ($105 \mu\text{g/L}$) and iron ($285 \mu\text{g/L}$) concentrations were several times higher than the

influent (9 to 44 $\mu\text{g/L}$ zinc; 46 to 160 $\mu\text{g/L}$ iron), but their presence may also be a result of leaching of corroded facility plumbing and sewer systems. Other metals were found at higher concentrations that ranged from 40% (sodium) to 65% (potassium, magnesium, calcium) above treated influent levels (Figure 4.3c).

The TEF has waste acceptance criteria for 10 of the metals detected: aluminum, arsenic, copper, iron, lead,

manganese, mercury, selenium, silver, and zinc. One of the seven zinc measurements at Building 306 was above the waste acceptance criteria of 210 $\mu\text{g/L}$; zinc is believed to be present in steam condensate. None of the other waste acceptance criteria were exceeded. Note that even though the waste acceptance criteria for zinc (210 $\mu\text{g/L}$) was exceeded, the National Drinking Water Standards for zinc (5,000 $\mu\text{g/L}$) was not.

Figure 4.3. Building 306 Metals (a) Concentrations Less than 8 $\mu\text{g/L}$, (Mercury Average 0.08 $\mu\text{g/L}$, Range N/A) (b) Concentrations Between 10 and 900 $\mu\text{g/L}$, (c) Concentrations Greater than 900 $\mu\text{g/L}$

4.2.4 Volatile Organic Compounds

Two trihalomethanes, chloroform and bromoform, were detected at low concentrations. The average for chloroform (1.4 $\mu\text{g/L}$) was approximately 16 times lower than the treated influent level (22.4 $\mu\text{g/L}$). Both compounds are common byproducts of water disinfection. Acetone and methylene chloride were also detected at low concentrations (i.e., 15 $\mu\text{g/L}$ or less) (Figure 4.4), but the blank results suggest that methylene chloride probably resulted from sample contamination. None of the TEDF waste acceptance criteria or National Drinking Water Standards were exceeded for these constituents.

Figure 4.4. Building 306 Volatile Organic Compounds

4.2.5 Semivolatile Organic Compounds

No target semivolatile organic compounds (SVOCs) were detected in the Building 306 effluent.

4.2.6 Radiological Parameters

Low levels of gross alpha (3.7 pCi/L), gross beta (7.4 pCi/L), and tritium (326.2 pCi/L) were detected in most samples (Figure 4.5). All three parameters exhibited a wide range of concentrations; the average gross beta concentration was the highest found at any monitoring location, but was still less than half the TEDF waste acceptance criteria of 50 pCi/L. None of the TEDF waste acceptance criteria were exceeded.

Figure 4.5. Building 306 Radiological Parameters (Tritium Average 326.2 pCi/L, Range 155.0 to 687.0 pCi/L)

5.0 Building 320 (Process Sewer)

5.1 Background and Description

Building 320 is located in the southwest end of the 300 Area and supports a variety of trace analysis research.

5.2 Routine and Nonbusiness Day Sampling

At Building 320, 32 routine and 7 nonbusiness day 24-hr composite sampling events and 21 routine and 6 nonbusiness day grab sampling events occurred. However, the full number of analyses do not necessarily exist for each constituent because additional grab samples may have been taken, additional analyses may have been requested for specific constituents, or inadequate samples may have been collected for the analyses desired. Table C.2 lists the analyses performed for the sampling events from Building 320. Summary data supporting the constituent class discussions in Sections 5.2.1 through 5.2.6 are shown in the accompanying figures. Comparisons to influent chemistry are based on the data in Appendix E. Tables with detailed building effluent information can be found in Appendix F.

5.2.1 General Chemical Parameters

The concentrations of general chemical parameters in Building 320 effluent reveal a mixture of trends when compared to treated influent levels. Routine monitoring of alkalinity and total dissolved solids showed approximately 20 to 25% higher concentrations than treated influent, while chemical oxygen demand was nearly 25% lower, and total organic carbon was about 55% lower (Figure 5.1a and b). Total carbon was observed at concentrations similar to (i.e., within 3%) treated influent levels.

The maximum concentrations of alkalinity, total carbon, and total dissolved solids in routine samples were almost twice as high as the maximum concentrations in nonbusiness day samples. However, this disparity may be caused, in part, by the relatively small number of nonbusiness day samples collected (Figure 5.1b). Both routine and nonbusiness day samples showed average concentrations for total organic carbon of approximately 1,700 $\mu\text{g/L}$.

None of the general chemical parameters that were investigated have standards of comparison except total dissolved solids. The maximum total dissolved solid value observed for Building 320 was 210 mg/L, which is much less than the National Secondary Drinking Water Standard of 500 mg/L.

Figure 5.1. Building 320 General Chemical Parameters: (a) Routine Sampling (Total Organic Carbon Average 1,781 $\mu\text{g/L}$, Range 1,000 to 3,000 $\mu\text{g/L}$)

Figure 5.1 (contd). Building 320 General Chemical Parameters: (b) Nonbusiness Day Sampling

5.2.2 Ammonia and Anions

Ammonia was detected three times at very low levels in routine and nonbusiness day samples from Building 320 effluent, but the low concentrations and low frequency of detection suggest its actual presence is questionable (Figures 5.2a and b). Sulfide concentrations and frequency of detection were comparable to those found in the bottle blanks. Moreover, the concentration of sulfides was near the method detection limit (210 µg/L). Fluoride concentrations (average = 571 µg/L) were comparable to influent levels and were similar for both sample types. The concentration of nitrate (100 to 15,600 µg/L) fluctuated considerably in the routine samples (from levels comparable to influent to 30 times greater than influent concentrations); nitrate levels were much more constant in the nonbusiness day samples (200 to 1,700 µg/L) and averaged less than twice

influent levels. Chloride (1,800 to 11,800 µg/L) and sulfate (8,500 to 23,500 µg/L) concentrations were comparable among both sample types and were similar to the influent levels. However, routine samples had 50 to 100% greater levels of chloride and sulfate than nonbusiness day samples (Figures 5.2b and c).

For reference only (building effluent is not meant to be drinking water and is treated by the TEDF before being discharged to the river), concentrations of ammonia and anions were compared to the National Drinking Water Standards, which exist for four of the constituents detected (chloride, fluoride, nitrate, and sulfate). Only the nitrate standard of 10 mg/L was exceeded with a maximum observed concentration of 15.6 mg/L in the effluent. The TEDF waste acceptance criteria exist for only one of the constituents detected; ammonia was measured at a small fraction (< 3%) of the waste acceptance criteria.

Figure 5.2. Building 320 Ammonia and Anions: (a) Routine Sampling (Ammonia Average 30 µg/L, Range N/A; Sulfides Average 296 µg/L, Range 220 to 400 µg/L)

Figure 5.2 (contd). Building 320 Ammonia and Anions: (b) Nonbusiness Day Sampling Concentrations Less than 1,000 µg/L, (c) Nonbusiness Day Sampling Concentrations Greater than 1,000 µg/L

5.2.3 Metals

The concentrations of heavy metals found in Building 320 effluent were generally similar to levels found in the blank and influent samples. A few exceptions should be noted. Low levels of mercury were detected with similar frequencies (20%) in the routine and nonbusiness day samples; 50 to 100% higher concentrations of mercury and lead

were evident in the routine samples. Zinc (29 µg/L routine; 35 µg/L nonbusiness day) and aluminum (65 µg/L routine; 35 µg/L nonbusiness day) concentrations were similar for the two sample types. Zinc levels were approximately three times greater than influent levels. Common cations (potassium, sodium, magnesium, calcium) were 20 to 30% higher in routine samples than nonbusiness day samples and were more variable in the routine samples. Nonbusiness day sample concentrations of the common cations were very similar to influent levels in all respects, including the narrow concentration ranges (Figures 5.3a through e).

The TEDF has waste acceptance criteria for 12 of the metals detected: aluminum, arsenic, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, and zinc. None of the metals exceeded the waste acceptance criteria.

Figure 5.3. Building 320 Metals: (a) Routine Sampling Concentrations Less than 16 µg/L (Mercury Average 0.15 µg/L, Range 0.05 to 0.46 µg/L)

Figure 5.3 (contd). Building 320 Metals: (b) Routine Sampling Concentrations Between 16 and 140 µg/L, (c) Routine Sampling Concentrations Greater than 140 µg/L, (d) Nonbusiness Day Sampling Concentrations Less than 180 µg/L (Mercury Average 0.15 µg/L, Range N/A; Lead Average 0.9 µg/L, Range 0.6 to 1.2 µg/L; Manganese Average 1.3 µg/L, Range 1.2 to 1.6 µg/L), (e) Nonbusiness Day Sampling Concentrations Greater than 180 µg/L

5.2.4 Volatile Organic Compounds

A variety of VOCs were detected in routine and nonbusiness day samples (Figures 5.4a and b). 1,1,1-trichloroethane and toluene were detected at or just slightly above the method detection limits. Therefore, the presence of these compounds in the effluent is somewhat questionable. Similarly, the frequent detection of methylene chloride should be considered suspect based on the high detection frequency of this compound in the reagent blanks.

Trihalomethanes were detected in routine and nonbusiness day samples (Figure 5.4a through c); the average concentrations of bromodichloromethane and chloroform were similar to the treated influent concentrations. Bromoform and dibromochloromethane were also detected infrequently at low concentrations (i.e., less than $2\text{ }\mu\text{g/L}$) in the routine samples.

Several common solvents, including acetone, acetonitrile, 2-butanone (methyl ethyl ketone), hexone (methyl isobutyl ketone), and tetrahydrofuran, were detected in 15% or less of the routine samples. The average concentrations of these constituents ranged from $26\text{ }\mu\text{g/L}$ (acetone and 2-butanone) to $170\text{ }\mu\text{g/L}$ (acetonitrile). Similar concentrations of acetone and approximately 50% lower concentrations of hexone were detected in nonbusiness day samples (Figure 5.4c).

Ethylbenzene and total xylenes were sporadically detected at low concentrations ($12\text{ }\mu\text{g/L}$ or less) in routine and nonbusiness day samples. The average concentrations of both constituents were about twice as high in the routine

samples as in the nonbusiness day samples (Figures 5.4a and c).

Specific waste acceptance criteria from the TEDF exist for five of the constituents detected: bromodichloromethane, chloroform, methylene chloride, toluene, and 1,1,1-trichloroethane. Of these, only chloroform measurements (up to $32\text{ }\mu\text{g/L}$) exceeded the waste acceptance criteria. Chloroform is produced from chlorination of influent in the treatment facility (Building 315) and was measured at Building 315 in concentrations up to $41\text{ }\mu\text{g/L}$. The two other constituents (ethylbenzene and xylenes) that were measured did not exceed the National Drinking Water Standards.

Figure 5.4. Building 320 Volatile Organic Compounds: (a) Routine Sampling Concentrations Less than $12\text{ }\mu\text{g/L}$ (Toluene Average $0.16\text{ }\mu\text{g/L}$, Range $0.14\text{ to }0.18\text{ }\mu\text{g/L}$)

Figure 5.4 (contd). Building 320 Volatile Organic Compounds: (b) Routine Sampling Concentrations Greater than 12 µg/L, (c) Nonbusiness Day Sampling (Toluene Average 0.2 µg/L, Range N/A)

5.2.5 Semivolatile Organic Compounds

Di-n-butylphthalate was found at trace levels in about 10% of the routine samples. Phthalates are commonly found

at trace levels in liquids that have contacted plastic materials. Thus, this constituent is likely an artifact of the sampling and analysis process and not a constituent being discharged as a result of building activities.

5.2.6 Radiological Parameters

No gross alpha or gross beta radiation was detected in the nonbusiness day samples. Although very low levels (i.e., less than 5 pCi/L) of both were measured in approximately 33% of the routine samples (Figure 5.5), the positive detects are suspect, because none of the results were greater than twice the background counting error. Tritium analyses were not performed on Building 320 samples. All measurements were less than the TEDF waste acceptance criteria.

Figure 5.5. Building 320 Radiological Parameters for Routine Sampling

6.0 Building 324 (Process Sewer and Retention Process Sewer)

6.1 Background and Description

Building 324 is located in approximately the middle of the 300 Area, just off of Locust Street. Staff in this building conduct research in the areas of waste characterization and immobilization, waste remediation and clean-up development, biomass research, spent fuel characterization, tritium development, and cesium chloride encapsulation.

6.2 Routine Sampling

At Building 324, two process sewer and three retention process sewer sampling events occurred. All the samples were 24-hr composites. Table C.2 shows the analyses performed for each sampling event. The small number of sampling events make the results for Building 324 tentative. Summary data supporting the constituent class discussions in Sections 6.2.1 through 6.2.6 are shown in the accompanying figures. Comparisons to influent chemistry are based on the data in Appendix E. Tables with detailed building effluent information can be found in Appendix F.

6.2.1 General Chemical Parameters

Most of the general chemical parameters were lower in the process sewer (Figure 6.1a) than in the retention process sewer (Figure 6.1b), but the levels in both were distinct from the influent. Chemical oxygen demand concentrations were approximately 30% (retention process sewer) to 50% (process sewer) lower than the concentration observed in the treated influent. Total organic carbon concentrations were 20% (retention

process sewer) to 25% (process sewer) as high as influent levels. Concentrations of alkalinity, total carbon, and total dissolved solids were approximately 35 to 45% higher in the retention process sewer than in the process sewer. Retention process sewer values for these three parameters were also roughly 25 to 55% greater than treated influent values.

None of the general chemical parameters that were investigated have regulatory standards of comparison except total dissolved solids. The maximum total dissolved solids value observed for Building 324 was 200 mg/L, which is much less than the National Secondary Drinking Water Standard of 500 mg/L.

Figure 6.1. Building 324 General Chemical Parameters: (a) Process Sewer (Total Organic Carbon Average 1,000 µg/L, Range N/A)

Figure 6.1 (contd). Building 324 General Chemical Parameters: (b) Retention Process Sewer (Total Organic Carbon Average 767 µg/L, Range 600 to 1,000 µg/L)

6.2.2 Ammonia and Anions

Ammonia was detected once in the retention process sewer, and sulfides were detected in both the process sewer (300 µg/L) and retention process sewer (350 µg/L) (Figures 6.2a and b). The average concentration of nitrate in the retention process sewer (5,748 µg/L) was 17 times higher than the concentration observed in the treated influent and nearly 7 times higher than the process sewer level. The concentration of chloride was twice as high in the retention process sewer (6,427 µg/L) compared to the process sewer, while sulfate (17,467 µg/L) was only 20% higher.

For reference only (building effluent is not meant to be drinking water and is treated by the TEDF before being discharged to the river), concentrations of ammonia and anions were compared to

the National Drinking Water Standards which exist for four of the constituents detected (chloride, fluoride, nitrate, and sulfate). Only the nitrate standard of 10 mg/L was exceeded with a maximum observed concentration of 15.4 mg/L in the effluent (this was true of almost all of the building waste streams). The TEDF waste acceptance criteria exist for only one of the constituents detected; ammonia was measured only in the retention process sewer stream at a small fraction (<3%) of the waste acceptance criteria.

Figure 6.2. Building 324 Anions: (a) Process Sewer (b) Retention Process Sewer (Ammonia Average 50 µg/L, Range N/A)

6.2.3 Metals

Heavy metals were detected at concentrations comparable to various blank and influent results, although retention process sewer cations (potassium, sodium, magnesium, and calcium) were found at elevated levels. The average sodium (5,433 $\mu\text{g/L}$) and potassium (2,150 $\mu\text{g/L}$) concentrations were

twice as high in the retention process sewer relative to the process sewer, while calcium and magnesium were 50% higher (Figure 6.3a through d).

The TEDF has waste acceptance criteria for seven of the metals detected: aluminum, chromium, copper, iron, manganese, mercury, and zinc. None of the metals exceeded the criteria.

Figure 6.3. Building 324 Metals: Concentrations Greater than 70 $\mu\text{g/L}$, (a) Process Sewer with Concentrations Less than 70 $\mu\text{g/L}$ (Mercury Average 0.12 $\mu\text{g/L}$, Range N/A) (b) Process Sewer with Concentrations Greater than 70 $\mu\text{g/L}$, (c) Retention Process Sewer with Concentrations Less than 60 $\mu\text{g/L}$ (Mercury Average 0.07 $\mu\text{g/L}$, Range 0.05 to 0.09 $\mu\text{g/L}$), (d) Retention Process Sewer with Concentrations Greater than 60 $\mu\text{g/L}$

6.2.4 Volatile Organic Compounds

Three VOCs, bromodichloromethane, dibromochloromethane, and chloroform, were detected in both the process sewer and retention process sewer (Figures 6.4a and b). All three compounds are trihalomethanes and are common byproducts of water disinfection. Of the VOCs, chloroform was measured at the highest concentrations in both waste streams (4 to 9 $\mu\text{g/L}$), but the average concentrations were roughly 70 to 80% lower compared to the treated influent. Dibromochloromethane and bromodichloromethane were measured at approximately 1 $\mu\text{g/L}$ in both the process sewer and retention process sewer; concentrations of bromodichloromethane were roughly 15 to 40% lower than treated influent levels. The TEDF waste acceptance criteria were not exceeded for these constituents.

Figure 6.4. Building 324 Volatile Organic Compounds: (a) Process Sewer

Figure 6.4. (contd) Building 324 Volatile Organic Compounds: (b) Retention Process Sewer

6.2.5 Semivolatile Organic Compounds

No target SVOCs were detected in the process sewer or retention process sewer samples.

6.2.6 Radiological Parameters

Gross alpha, gross beta, and tritium were detected at very low levels in samples from both the process sewer and retention process sewer (Figures 6.5a and b). The average concentrations of tritium and gross alpha were approximately 20 to 25% higher in the retention process sewer, while gross beta was nearly twice as high in the process sewer. Because of the low levels of radiation encountered and the relatively small number of samples analyzed, these results should be considered tentative. The TEDF waste acceptance criteria were not exceeded for these constituents.

Figure 6.5. Building 324 Radiological Parameters: (a) Process Sewer (Tritium Average 358.5 pCi/L, Range 172.0 to 545.0 pCi/L), (b) Retention Process Sewer (Tritium Average 421.7 pCi/L, Range 136.0 to 627.0 pCi/L)

7.0 Building 326 (Process Sewer)

7.1 Background and Description

Building 326 is located in the northwest part of the 300 Area along Wisconsin Street. Staff conduct studies of metallurgical, chemical, and physical properties of materials.

7.2 Routine Sampling

At Building 326, seven 24-hr composite and one grab sampling events occurred. However, eight analyses were not performed for all constituents. Table C.2 lists the analyses performed for the sampling events from Building 326. Summary data supporting the constituent class discussions in Sections 7.2.1 through 7.2.6 are shown in the accompanying figures. Comparisons to influent chemistry are based on the data in Appendix E. Tables with detailed building effluent information are in Appendix F.

7.2.1 General Chemical Parameters

Concentrations of all of the general chemical parameters in the effluent showed large fluctuations and elevated average concentrations when compared to the treated influent. Alkalinity, total carbon, and total dissolved solid concentrations were each approximately 85% higher, total organic carbon concentrations were about twice as high, and chemical oxygen demand concentrations were more than three times greater (Figure 7.1).

None of the general chemical parameters that were investigated have regulatory standards of comparison except total dissolved solids. The

Figure 7.1. Building 326 General Chemical Parameters

maximum total dissolved solids value observed for Building 326 was 210 mg/L, which is much less than the National Secondary Drinking Water Standard of 500 mg/L.

7.2.2 Ammonia and Anions

Ammonia (225 µg/L) and sulfides (307 µg/L) were found in several samples, while an easily measurable phosphate concentration was found in one sample (1,060 µg/L). Nitrate concentrations fluctuated considerably (1,200 to 12,400 µg/L) and were 15 to 20 times greater than influent levels; chloride concentrations (8,686 µg/L) were 70% greater than influent levels. Sulfate levels (29,771 µg/L) were nearly twice as high as the influent levels (Figure 7.2a and b).

For reference only (building effluent is not meant to be drinking water and is treated by the TEDF before being discharged to the river), concentrations of ammonia and anions are compared to the National Drinking Water Standards, which exist for four of the constituents detected (chloride, fluoride, nitrate, and sulfate). Only the nitrate standard of 10 mg/L was exceeded with a maximum observed concentration of 12.4 mg/L in the effluent (this was true of almost all of the building waste streams). The TEDF waste acceptance criteria exist for ammonia only; ammonia was measured at a small fraction (< 17%) of the waste acceptance criteria.

Figure 7.2. Building 326 Ammonia and Anions: (a) Concentrations Less than 1,200 µg/L, (b) Concentrations Greater than 1,200 µg/L

7.2.3 Metals

Heavy metals were found in most samples, although the low levels and frequencies of detection were comparable with those found in blanks and influent samples. One exception was mercury, which did not appear in the blank or influent samples, but was found in two samples (0.11 to 0.23 µg/L) at 2 to 3 times the method detection limit. Lead and chromium were detected in liquid effluents at levels commonly found in various blank and influent samples (i.e., below 10 µg/L). Iron, manganese, and copper were measured at 5, 20, and 25 times higher than the influent, respectively. Zinc was 15 times the level observed in the influent and exhibited large concentration variations (48 to 520 µg/L). Magnesium and calcium were observed at 60 to 80% higher levels than influent, while potassium and sodium were 2 and 4 times higher, respectively (Figure 7.3a through c).

The TEDF has waste acceptance criteria for 11 of the metals detected: aluminum, beryllium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, and zinc. Three of the seven copper measurements and two of the seven zinc measurements exceeded the criteria. These metals are believed to be from steam condensate. Also note that even though the waste acceptance criteria are exceeded, the National Drinking Water Standards are not: the waste acceptance criteria for copper and zinc are less than an order of magnitude of drinking water standards.

Figure 7.3. Building 326 Metals:
 (a) Concentrations Less than 9 µg/L,
 (b) Concentrations Between 9 and 500 µg/L,
 (c) Concentrations Greater than 500 µg/L

7.2.4 Volatile Organic Compounds

Three VOCs were detected with varying frequencies (Figure 7.4a). Concentrations of tetrahydrofuran and methylene chloride were within 10% of the concentrations found in the treated influent, but the actual presence of both compounds is suspect based on frequent blank contamination. The average chloroform level (1.2 µg/L) was almost 20 times lower than the concentration observed in the treated influent. The TEDF waste acceptance criteria for chloroform and methylene chloride were not exceeded.

Significant concentrations of isopropyl alcohol and acetone were measured in the effluent from Building 326 (Figure 7.4b). Isopropyl alcohol was only detected once, but its high concentration of 40,800 µg/L appears to account for the large range and elevated concentrations of total carbon and total organic carbon observed in the building effluent. Acetone was frequently detected and exhibited large concentration fluctuations (450 to 2,540 µg/L).

Figure 7.4. Building 326 Volatile Organic Compounds: (a) Concentrations Less than 10 µg/L

Figure 7.4 (contd). Building 326 Volatile Organic Compounds: (b) Concentrations Greater than 10 µg/L (Acetone Average 505 µg/L, Range 45 to 2,535 µg/L)

7.2.5 Semivolatile Organic Compounds

Di-n-octylphthalate and diethylphthalate were found at low concentrations and frequency in the process sewer samples (Figure 7.5a). Phthalates are commonly found at trace levels in liquids that have contacted plastic materials. Low parts-per-trillion levels of two pesticides, alpha-BHC and aldrin, were found in three samples (Figure 7.5b). Influent samples had similar constituents (both phthalates and pesticides) which were found at comparable concentrations and frequencies. The TEDF waste acceptance criteria were not exceeded.

Figure 7.5. Building 326 Semivolatile Organic Compounds: (a) Di-n-octylphthalate and Diethylphthalate, (b) Pesticides

7.2.6 Radiological Parameters

Gross alpha, gross beta, and tritium were observed at low levels (Figure 7.6). Gross beta was detected most often, with counts above the background in approximately 85% of the samples. Tritium and gross alpha had detection frequencies of 30 and 60%, respectively. However, for all three parameters, most of the sample measurements were less than 2 times the associated background counting error; no measurements were greater than 3 times

measurements were greater than 3 times the counting error. Thus, the average concentrations and frequencies of detection probably include some false-positive results. All measurements were less than the TEDF waste acceptance criteria (15 pCi/L alpha, 50 pCi/L beta, and 20,000 pCi/L tritium).

Figure 7.6. Building 326 Radiological Parameters (Tritium Average 275.3 pCi/L, Range 118.0 to 420.0 pCi/L)

8.0 Building 331 (Process Sewer)

8.1 Background and Description

Building 331 is in the southeast corner of the 300 Area near the Columbia River. Staff conduct mechanism-based biochemistry research at the cellular and molecular levels to understand the effects of environmental influences, toxicology and risk assessment, aquatic and terrestrial ecology, environmental microbiology, and macromolecular structure and dynamics.

8.2 Routine and Nonbusiness Day Sampling

At Building 331, 35 routine and 5 nonbusiness day 24-hr composite sampling events and 20 routine and 5 nonbusiness day grab sampling events occurred. However, the full range of analyses do not necessarily exist for each constituent because additional analyses may have been requested for specific constituents, or inadequate samples may have been collected for the analyses desired. Table C.2 lists the analyses performed on the samples from Building 331. Summary data supporting the constituent class discussions in Sections 8.2.1 through 8.2.6 are shown in the accompanying figures. Comparisons to influent chemistry are based on the data in Appendix E. Tables with

detailed building effluent information can be found in Appendix F.

8.2.1 General Chemical Parameters

Relative to the treated influent, elevated values for all of the general chemical parameters were observed in the routine samples. Alkalinity and total carbon results were approximately 40% higher than the treated influent concentrations, total dissolved solids and total organic carbon were about 70% greater, and chemical oxygen demand was approximately twice as high. Relatively large fluctuations were apparent in all five parameters (Figure 8.1a).

Concentrations of general chemical parameters in nonbusiness day samples were consistently lower than the routine sampling values. Alkalinity and total dissolved solids were approximately 30% less, chemical oxygen demand and total organic carbon were about 60% less, and total carbon was reduced nearly 40% (Figure 8.1b).

None of the general chemical parameters that were investigated have regulatory standards of comparison except total dissolved solids. The maximum total dissolved solid value observed for Building 331 was 480 mg/L which is under the National Secondary Drinking Water Standard of 500 mg/L.

Figure 8.1. Building 331 General Chemical Parameters: (a) Routine Sampling (Total Dissolved Solids Average 142,188 µg/L, Range 90,000 to 480,000 µg/L), (b) Nonbusiness Day Sampling

8.2.2 Ammonia and Anions

Cyanide was detected in 25 out of 32 routine samples (1 to 70 µg/L) at levels well above the method detection limit, while nitrite was found in only two samples (110 to 130 µg/L). Nonbusiness day samples had average cyanide concentrations which were 3 to 4 times lower than routine samples. Ammonia was also frequently detected in nonbusiness day samples (3 of 5 samples) with concentrations averaging less than 20% of the routine sample levels (28 µg/L). High ammonia concentrations (30 to 1,000 µg/L) were found in some routine samples. Bromide was measured at 1 to 2 times the method detection limit in two routine samples and one nonbusiness day sample. Phosphate (212 to 19,800 µg/L), nitrate (300 to 33,000 µg/L), chloride (3,600 to 167,000 µg/L), and sulfate (10,000 to 47,900 µg/L) were frequently found in routine samples and displayed large concentration excursions. These same anions were detected in nonbusiness day samples at significantly lower and more consistent concentrations (phosphate was 50% lower, nitrate was 4 times lower, chloride was 2 times lower), with the exception of sulfate (19,000 µg/L) which was present at levels similar to those found in routine samples. Relative to treated influent levels, concentrations of nitrate were 3 times higher in nonbusiness day samples (1,200 µg/L) and 15 times higher in routine samples (5,803 µg/L). Chloride concentrations for nonbusiness day samples (6,060 µg/L) were comparable with the treated influent values, but routine samples had twice the chloride levels (12,031 µg/L) (Figures 8.2a through d).

For reference only (building effluent is not meant to be drinking water and is treated by the TEDF before being discharged to the river), concentrations of

ammonia and anions were compared to the National Drinking Water Standards which exist for four of the constituents detected (chloride, fluoride, nitrate, and sulfate). Only the nitrate standard of 10 mg/L was exceeded with a maximum observed concentration of 33 mg/L in the effluent. Although all of the buildings exceeded the nitrate standard, effluent from Building 331 had the highest nitrate

concentrations. The TEDF waste acceptance criteria exist for three of the constituents detected (ammonia, cyanide, and nitrite). Ammonia and nitrate were only observed at concentrations less than the waste acceptance criteria, but cyanide was observed twice at 70 $\mu\text{g/L}$ which is above the waste acceptance criteria of 50 $\mu\text{g/L}$.

Figure 8.2. Building 331 Ammonia and Anions: (a) Routine Sampling Concentrations Less than 1,000 $\mu\text{g/L}$, (b) Routine Sampling Concentrations Greater than 1,000 $\mu\text{g/L}$, (c) Nonbusiness Day Sampling Concentrations Less than 900 $\mu\text{g/L}$ (Cyanide Average 5 $\mu\text{g/L}$, Range 2 to 8 $\mu\text{g/L}$), (d) Nonbusiness Day Sampling Concentrations Greater than 900 $\mu\text{g/L}$

8.2.3 Metals

Heavy metals were found in most samples, although the trace levels ($< 10 \mu\text{g/L}$) and low frequencies of detection ($< 10\%$) were comparable with those found in blanks and influent samples. The concentrations for many metals (e.g., arsenic) were reported at or very close to the method detection limit, where a higher probability exists for false positive results. Mercury was detected in seven routine samples (0.06 to $0.17 \mu\text{g/L}$) at 1 to 3 times the method detection limit. Levels of lead (1 to $3 \mu\text{g/L}$) and manganese ($3 \mu\text{g/L}$) were similar to the treated influent for both sample types; a small number of routine samples had slightly elevated concentrations of manganese and lead ($15 \mu\text{g/L}$ and $17 \mu\text{g/L}$, respectively). Chromium was found in four routine samples (7 to $22 \mu\text{g/L}$) at levels 2 to 4 times greater than the method detection limit. Elevated levels of copper were found in all samples (10 to $110 \mu\text{g/L}$); the greatest concentrations were found in routine samples. Tin, iron, and aluminum had average concentrations twice as high in routine versus nonbusiness day samples, which largely was a result of a few individual samples with high concentrations. Potassium and sodium were twice as high in the routine samples compared to nonbusiness day samples; magnesium and calcium were 20% higher. All four of these metals were 1 to 2 times higher in the nonbusiness day samples relative to treated influent (Figures 8.3a through e).

The TEDF has waste acceptance criteria for 14 of the metals detected: aluminum, arsenic, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. Five of the 32 aluminum measurements and one of the 33 copper measurements exceeded the waste acceptance criteria. These metals are believed to be

from piping corrosion. Compared to the National Drinking Water Standards, aluminum concentrations (maximum $630 \mu\text{g/L}$) exceed the National Secondary Drinking Water Standard of $200 \mu\text{g/L}$ while the maximum copper measurement ($110 \mu\text{g/L}$) is less than a tenth of the primary drinking water standard of $1,300 \mu\text{g/L}$.

Figure 8.3. Building 331 Metals: (a) Routine Sampling Concentrations Less than $18 \mu\text{g/L}$ (Mercury Average $0.11 \mu\text{g/L}$, Range 0.05 to $0.17 \mu\text{g/L}$; Beryllium Average $0.19 \mu\text{g/L}$, Range N/A), (b) Routine Sampling Concentrations Between 18 and $700 \mu\text{g/L}$

Figure 8.3 (contd). Building 331 Metals: (c) Routine Sampling Concentrations Greater than 700 µg/L, (d) Nonbusiness Day Sampling Concentrations Less than 90 µg/L (Lead Average 1.0 µg/L, Range 0.6 to 1.5 µg/L), (e) Nonbusiness Concentrations Greater than 90 µg/L

8.2.4 Volatile Organic Compounds

A total of 15 VOCs were detected in routine samples; 9 were also detected in the nonbusiness day samples (Figures 8.4 a through c). Several compounds, including 1,1,1-trichloroethane, trichloroethene, xylenes, toluene, and chlorobenzene, were detected infrequently, and the concentrations were always at or just slightly above the method detection limit. Thus, the results for these constituents are tentative. Likewise, the presence of methylene chloride in Building 331 effluent is doubtful, because methylene chloride was also measured at similar concentrations in the majority of the blank samples.

Among the four trihalomethanes detected, chloroform and bromoform had the highest average concentrations. Chloroform was always detected, and the average routine and nonbusiness day sample concentrations were 25 to 50% lower than the treated influent levels. Bromoform was only rarely detected, with approximately 70% higher concentrations in the routine samples. Bromodichloromethane and dibromochloromethane showed large fluctuations and approximately 40 to 135% higher concentrations in the nonbusiness day samples. Bromodichloromethane levels were approximately 1.5 to 2 times higher in effluent samples than in the treated influent samples.

A few organic solvents (i.e., acetonitrile, acetone, 2-butanone, hexone, and tetrahydrofuran) were sporadically observed in the routine samples. Acetonitrile was only detected once in the effluent, but its concentration of 430 $\mu\text{g/L}$ was greater than most of the other VOCs. Acetone showed large fluctuations in effluent concentrations including one high

result of 1,800 $\mu\text{g/L}$. Hexone and acetone were also detected once in the nonbusiness day samples; their concentrations were roughly 2 times greater (hexone) to 4 times less (acetone) than the average levels found in routine samples.

Specific waste acceptance criteria from the TEDF exist for six of the constituents detected: bromodichloromethane, chloroform, methylene chloride, toluene, 1,1,1-trichloroethane, and trichloroethylene. Of these, only chloroform (up to 33 $\mu\text{g/L}$) and bromodichloromethane (up to 9.8 $\mu\text{g/L}$) exceeded their waste acceptance criteria (26 $\mu\text{g/L}$ for chloroform; 4 $\mu\text{g/L}$ for bromodichloromethane). Both compounds are produced from chlorination of influent in the treatment facility (Building 315). The National Drinking Water Standards for two other constituents (chlorobenzene and xylenes) were not exceeded.

Figure 8.4. Building 331 Volatile Organic Compounds: (a) Routine Sampling Concentrations Less than 12 $\mu\text{g/L}$

Figure 8.4 (contd). Building 331 Volatile Organic Compounds: (b) Routine Sampling Concentrations Greater than 12 $\mu\text{g/L}$ (Acetone Average 284.9 $\mu\text{g/L}$, Range 7.4 to 1,800.0 $\mu\text{g/L}$), (c) Nonbusiness Day Sampling

8.2.5 Semivolatile Organic Compounds

Several SVOCs were detected in the effluent samples from Building 331 (Figures 8.5a through c). Di-n-butyl-phthalate and bis(2-ethylhexyl)phthalate were found at less than 5 $\mu\text{g/L}$ in 4 out of 18 and 7 out of 40 routine samples, respectively (Figure 8.5a). Bis(2-ethylhexyl)phthalate was also found at similar concentrations in nonbusiness day samples (Figure 8.5c). Benzyl alcohol (5 to 27 $\mu\text{g/L}$) and decane (35 $\mu\text{g/L}$) were found in 2 out of 18 and 1 out of 22 routine samples, respectively.

Ten pesticides were found at low part-per-trillion levels in several routine samples, while two pesticides were also found at these levels in one nonbusiness day sample. Delta-BHC was the most frequently detected pesticide in routine samples (25%), nonbusiness day samples (20%), and influent samples (20%), although its concentration averaged only 20 parts-per-trillion. Other BHC isomers were also detected in 10 to 15% of the routine samples at similar or lower concentrations. The pesticide with the highest concentration, 4,4'-DDE, was found in 3 out of 34 routine samples with results ranging from 0.002 to 0.72 $\mu\text{g/L}$. None of the TEDF waste acceptance criteria for SVOCs was exceeded.

Figure 8.5. Building 331 Semivolatile Organic Compounds: (a) Routine Sampling, (b) Routine Sampling Pesticides (Gamma-BHC Average 0.003 $\mu\text{g/L}$, Range 0.002 to 0.004 $\mu\text{g/L}$; Dieldrin Average 0.003 $\mu\text{g/L}$, Range N/A; Alpha-BHC Average 0.006 $\mu\text{g/L}$, Range 0.004 to 0.007 $\mu\text{g/L}$; 4,4'-DDE Average 0.242 $\mu\text{g/L}$, Range 0.002 to 0.720 $\mu\text{g/L}$)

Figure 8.5. (contd). Building 331
Semivolatile Organic Compounds: (c) Non-
business Day Sampling (Endosulfan Average
0.01 µg/L, Range N/A; Delta-BHC Average
0.02 µg/L, Range N/A)

8.2.6 Radiological Parameters

Low levels of gross alpha and gross beta radiation were detected in routine and nonbusiness day samples (Figures 8.6a and b). Gross alpha activity was measured over a relatively large activity range in both sample sets, but most of the sample measurements were less than 2 times the background counting error. The average activity of the nonbusiness day samples was approximately 65% higher than the routine samples' average. Gross beta was only detected once in the nonbusiness day samples; the concentration (2.7 pCi/L) was nearly 40% lower than the average activity in the routine samples. Most of the gross beta results were less than 2 times the background counting error.

Two tritium analyses were performed on routine samples; both results may be false positive readings because the

sample counts were only slightly higher (i.e., about twice as high) as the background.

Figure 8.6. Building 331 Radiological
Parameters: (a) Routine Sampling (Tritium
Average 305 µg/L, Range 280 to 330 µg/L),
(b) Nonbusiness Day Sampling

9.0 Building 3720 (Process Sewer)

9.1 Background and Description

Building 3720 is located in the northcentral corner of the 300 Area along Oregon Street. Staff conduct research in the areas of materials characterization and testing and waste management. Research activities include the use of radioactive and hazardous materials.

9.2 Routine and Nonbusiness Day Sampling

At Building 3720, 29 routine and 6 nonbusiness day 24-hr composite and 19 routine and 5 nonbusiness day grab sampling events occurred. However, the full range of analyses do not necessarily exist for each constituent because additional analyses may have been requested for specific constituents, or inadequate samples may have been collected for the analyses desired. Table C.2 lists the analyses performed for the events from Building 3720. Summary data supporting the constituent class discussions in Sections 9.2.1 through 9.2.6 are shown in the accompanying figures. Comparisons to influent chemistry are based on the data in Appendix E. Tables with detailed building effluent information can be found in Appendix F.

9.2.1 General Chemical Parameters

Except for total organic carbon, the values of general chemical parameters were slightly elevated over treated influent levels. Results from routine sampling indicate the concentrations of alkalinity and total carbon were elevated by approximately 15%, and chemical oxygen demand and total dissolved solids were roughly 30% greater. The average

concentration of total organic carbon in routine samples was approximately 15% less than the corresponding treated influent value.

Values of general chemical parameters for nonbusiness day samples were generally 10 to 25% lower than routine samples levels, although the one positive, nonbusiness day result for chemical oxygen demand was nearly 10% higher than the average value for routine samples. All five parameters showed larger fluctuations in the routine samples (Figures 9.1 a and b).

None of the general chemical parameters that were investigated have regulatory standards of comparison except total dissolved solids. The maximum total dissolved solid value observed for Building 3720 was 190 mg/L which is much less than the National Secondary Drinking Water Standard of 500 mg/L.

Figure 9.1. Building 3720 General Chemical Parameters: (a) Routine Sampling

Figure 9.1. (contd). Building 3720 General Chemical Parameters: (b) Nonbusiness Day Sampling

9.2.2 Ammonia and Anions

Ammonia and sulfides were detected in low concentrations and with similar frequencies in routine and nonbusiness day samples (ammonia's detection frequency was 15%; sulfides' detection frequency was 40 to 50%). Cyanide was detected in four routine samples at an average concentration of 5 µg/L. Compared to the concentrations in treated influent samples, average nitrate levels were twice as high in nonbusiness day samples (867 µg/L) and eight times higher in routine samples (3,234 µg/L). In addition, large fluctuations in nitrate concentration (600 to 16,000 µg/L) were observed for the routine samples (Figures 9.2a through d).

For reference only (building effluent is not meant to be drinking water and is treated by the TEDF before being discharged to the river), concentrations of ammonia and anions were compared to the National Drinking Water Standards which exist for four of the constituents

detected (chloride, fluoride, nitrate, and sulfate). Only the nitrate standard of 10 mg/L was exceeded with a maximum observed concentration of 16 mg/L in the effluent (this was true of almost all of the building waste streams). The TEDF waste acceptance criteria exist for two of the constituents detected (ammonia and cyanide). Both of these constituents were measured at a small fraction (< 20%) of the waste acceptance criteria.

Figure 9.2. Building 3720 Ammonia and Anions: (a) Routine Sampling Concentrations Less than 900 µg/L (Cyanide Average 5.3 µg/L, Range 2 to 10 µg/L)

Figure 9.2. (contd). Building 3720 Ammonia and Anions: (b) Routine Sampling Concentrations Greater than 900 µg/L, (c) Nonbusiness Day Sampling Concentrations Less than 900 µg/L

Figure 9.2. (contd). Building 3720 Ammonia and Anions: (d) Nonbusiness Day Sampling Concentrations Greater than 900 µg/L

9.2.3 Metals

Heavy metals were found in most routine and nonbusiness day samples (Figures 9.3a through e), although the trace levels and modest frequencies of detection for most were comparable with those found in the blanks and treated influent samples. Mercury was detected in greater than 70% of both sample types at concentrations below 1 µg/L. Chromium was detected in five routine samples (4.7 to 27 µg/L) at an average concentration which was only 3 times greater than the method detection limit. Copper and barium levels (19 and 29 µg/L, respectively) were elevated in routine samples relative to both nonbusiness day samples (copper 10.2 µg/L; barium 25 µg/L) and treated influent (copper 3 µg/L; barium 28 µg/L). Zinc, aluminum, and iron were higher in routine samples (60 µg/L, 69 µg/L, 89 µg/L, respectively) than in nonbusiness day samples (zinc 34 µg/L; aluminum 77 µg/L; iron 65 µg/L); zinc

was also detected at levels 3 to 5 times greater than those observed in the treated influent. Cations above 1,000 $\mu\text{g/L}$ (potassium, calcium, magnesium, and sodium) showed larger fluctuations and somewhat higher levels in routine (1,537 $\mu\text{g/L}$, 21,897 $\mu\text{g/L}$, 4,803 $\mu\text{g/L}$, 5,766 $\mu\text{g/L}$) than in nonbusiness day samples (1,100 $\mu\text{g/L}$, 19,833 $\mu\text{g/L}$, 4283 $\mu\text{g/L}$, 2,983 $\mu\text{g/L}$, respectively) (Figure 9.3c through e).

The TEDF has waste acceptance criteria for 12 of the metals detected: aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, and zinc. One of the 29 copper measurements and one of the 29 zinc measurements exceeded the waste acceptance criteria. These metals are believed to be from steam condensate. Also, note that even though the waste acceptance criteria were exceeded, the National Drinking Water Standards were not: the waste acceptance criteria for copper and zinc are more than an order of magnitude less than the drinking water standards.

Figure 9.3. (contd). Building 3720 Metals: (b) Routine Sampling Concentrations Between 14 and 300 $\mu\text{g/L}$, (c) Routine Sampling Concentrations Greater than 300 $\mu\text{g/L}$

Figure 9.3. Building 3720 Metals: (a) Routine Sampling Concentrations Less

Figure 9.3. (contd). Building 3720 Metals: (d) Nonbusiness Day Sampling Concentrations Less than 200 µg/L (Mercury Average 0.18 µg/L, Range 0.1 to 0.26 µg/L)

9.2.4 Volatile Organic Compounds

Figure 9.3. Building 3720 Metals: (e) Non-business Day Sampling Concentrations Greater than 200 µg/L

VOCs constitute the bulk of the organic compounds detected in both the routine and nonbusiness day samples. In most cases, the concentrations of VOCs were significantly above the method detection limits, and the chances for false positive detection should have been fairly low. However, the two compounds with the lowest average concentrations, 1,2-dichloroethylene and ethylbenzene, were always measured at levels near the method detection limits. Consequently, the presence of these compounds in the effluent should be considered tentative. The recurrence of methylene chloride is also questionable, because it was frequently observed in the sample and reagent blanks. Nonetheless, one methylene chloride result (approximately 10 µg/L) is considered significant because it was higher than the concentrations reported in all of the blanks (Figure 9.4a).

Three trihalomethanes were detected in routine samples; two of these compounds were also measured in nonbusiness day samples. Chloroform

was always detected; routine monitoring and nonbusiness day concentrations were within 20% of each other but were approximately 40% lower compared to the treated influent (Figures 9.4b and c). Bromodichloromethane and dibromochloromethane were observed sporadically in the range of 1 to 2 $\mu\text{g/L}$ in the routine samples. Bromodichloromethane was also measured between 0.9 and 2.5 $\mu\text{g/L}$ in the treated influent and nonbusiness day samples (Figures 9.4a and c).

Several common solvents were occasionally observed in the routine samples. Acetone, which was measured over a wide concentration range (8 to 530 $\mu\text{g/L}$), was detected in almost 50% of the samples. Roughly 65% lower concentrations of acetone were also observed in the nonbusiness day samples. Acetonitrile, toluene, and tetrahydrofuran each had one high result (i.e., in the range from 400 to 800 $\mu\text{g/L}$) but were also measured at much lower concentrations. Low levels (i.e., less than 25 $\mu\text{g/L}$) of hexone (methyl isobutyl ketone), diethyl ether, and xylenes were also infrequently detected in the routine samples (Figure 9.4b).

Ethanol and isopropanol were identified in a few of the routine samples. Because both compounds are nontarget analytes with low detection efficiencies, their results require some additional explanation. In the analysis method employed (i.e., purge-and-trap gas chromatography), the concentrations of nontarget compounds may be inaccurately estimated because a rigorous calibration is not performed for such compounds. In the case of highly water-miscible compounds such as ethanol and isopropanol, detection efficiencies are very low, resulting in relatively high method detection limits. Thus, the ethanol and isopropanol concentrations

shown in Figure 9.4b (approximately 14 $\mu\text{g/L}$) are probably 100 to 1,000 times lower than the actual values. Isopropanol was also observed in one nonbusiness day sample; its concentration was approximately 50% lower compared to the routine monitoring average.

Three other VOCs were detected with varying frequencies. Trichloroethene was measured at low concentrations in all of the routine and nonbusiness day samples. Low levels of carbon disulfide and 1,1,2-trichloroethane were also observed in the routine samples.

Specific waste acceptance criteria from TEDF exist for five of the VOCs detected: bromodichloromethane, chloroform, methylene chloride, trichloroethylene, and toluene. Of these, chloroform (up to 40 $\mu\text{g/L}$) exceeded the waste acceptance criteria and is believed to be produced from chlorination of influent in the treatment facility (Building 315). One out of 39 methylene chloride measurements and four out of seven toluene measurements also exceeded the waste acceptance criteria. National Drinking Water Standards exist for five other constituents (1,1,2-trichloroethane, 1,2-dichloroethylene, chlorobenzene, ethylbenzene, and xylenes); the standards were not exceeded for any of these constituents.

Figure 9.4. Building 3720 Volatile Organic Compounds: (a) Routine Sampling Concentrations Less than 10 µg/L, (b) Routine Sampling Concentrations Greater than 10 µg/L (Chloroform Average 12.4 µg/L, Range 2.5 to 32.0 µg/L; Isopropanol Average 13.1 µg/L, Range 5.2 to 34.0 µg/L; Ethanol Average 14.1 µg/L, Range 5.5 to 26.0 µg/L)

Figure 9.4. Building 3720 Volatile Organic Compounds: (c) Nonbusiness Day Sampling (Toluene Average 0.4 µg/L, Range 0.2 to 0.6 µg/L)

9.2.5 Semivolatile Organic Compounds

Di-n-butylphthalate and bis(2-ethylhexyl)phthalate were found in 20 to 30% of both routine and nonbusiness day samples. Bis(2-ethylhexyl)phthalate was detected at levels ranging from 1 to 10 µg/L. An exception was diethylphthalate, which was found in 4 out of 18 routine samples at levels ranging from 35 to 170 µg/L. The constituent is regulated as a toxic material and thus is included in the TEDF waste acceptance criteria at 100 µg/L. This value was exceeded in one measurement at Building 3720. Tributyl phosphate was found in 2 out of 33 routine samples at an average concentration of 8 µg/L (Figures 9.5a).

Figure 9.5. Building 3720 Semivolatile Organic Compounds (Diethylphthalate Average 81.3 µg/L, Range 35.0 to 170.0 µg/L)

9.2.6 Radiological Parameters

Gross alpha and gross beta radiation were generally observed at low levels in 85% or more of the routine and non-business day samples (Figures 9.6a and b). The average gross beta concentration was approximately 20% higher in the routine samples, while the average gross alpha activity was roughly 25% higher in the nonbusiness day samples. Compared to the other monitoring locations with detectable gross alpha, the average concentration in routine samples was 3 to 9 times higher.

Because of the relatively high gross alpha and gross beta results as well as past practices and inventories at Building 3720, one routine sample was analyzed for several potential alpha and beta emitters, including ^{241}Am , ^{60}Co , ^{137}Cs , ^{238}Pu , $^{239,240}\text{Pu}$, ^{106}Ru , ^{125}Sb , ^{90}Sr , ^{234}U , ^{235}U , and ^{238}U . The only radionuclides

detected were the three uranium isotopes, and the activity of the enriched form (^{235}U) was negligible compared to the other two. Thus, the gross alpha radiation was primarily attributed to ^{234}U and ^{238}U .

The gross alpha measurements at Building 3720 exceeded the TEDF waste acceptance criteria (15 pCi/L) 13 out of 34 times including almost all of the nonbusiness day samples. The activity is believed to be caused by residual uranium in the building piping.

Figure 9.6. Building 3720 Radiological Parameters: (a) Routine Sampling (^{235}U Average 0.4 pCi/L, Range N/A)

Figure 9.6. (contd). Building 3720
Radiological Parameters: (b) Nonbusiness
Day Sampling

10.0 End-of-Pipe (Process Sewer)

10.1 Background and Description

The end-of-pipe sample collection station is located just south of the TEDF Collection Sump. This location is downstream of the point of confluence for all 300 Area process sewer streams and includes effluent from WHC and ICF-Kaiser Hanford facilities in addition to PNL facilities. At this location, the stream also contains any retention process sewer effluent that has not been diverted to the Radioactive Liquid Waste Sewer. Diversions are rare, and this location normally contains all of the process sewer and retention process sewer effluent. Samples collected at this point are representative of the waste water which enters TEDF.

10.2 Routine and Nonbusiness Day Sampling

At end-of-pipe, 29 routine and 7 nonbusiness day 24-hr composite and 17 routine and 6 nonbusiness day grab sampling events occurred. However, the full range of analyses do not necessarily exist for each constituent because additional analyses may have been requested for specific constituents, or inadequate samples may have been collected for the analyses desired. Table C.2 lists the analyses performed on the samples from end-of-pipe. Summary data supporting the constituent class discussions in Sections 10.2.1 through 10.2.6 are shown in the accompanying figures. Comparisons to influent chemistry are based on the data in Appendix E. Tables with detailed information can be found in Appendix F.

10.2.1 General Chemical Parameters

Overall, general chemical parameter levels were higher in the routine samples than in the treated influent. The effluent samples showed approximately 15% higher alkalinity and total carbon concentrations, while chemical oxygen demand and total dissolved solids concentrations were about 30% higher. Large fluctuations were apparent in the total organic carbon data, but the average concentration (3,800 $\mu\text{g/L}$) was approximately the same as the treated influent value (Figure 10.1a).

General chemical parameter concentrations in nonbusiness day samples were consistently lower than routine sample levels. Concentrations of alkalinity averaged 10% lower, total carbon and total dissolved solids averaged nearly 20% lower, and total organic carbon was approximately 45% lower. Chemical oxygen demand was only detected in one nonbusiness day sample (Figure 10.1b); the concentration was about 30% lower than the average routine monitoring concentration.

Figure 10.1. End-of-Pipe General Chemical Parameters: (a) Routine Sampling, (b) Nonbusiness Day Sampling

None of the general chemical parameters that were investigated have regulatory standards of comparison except total dissolved solids. The maximum total dissolved solids value observed for end-of-pipe was 240 mg/L, which is much less than the National Secondary Drinking Water Standard of 500 mg/L.

10.2.2 Ammonia and Anions

Cyanide was detected in 4 out of 28 routine samples at 1 to 5 times the method detection limit of 1 µg/L, while ammonia was detected at an average concentration of 48 µg/L in 8 out of 26 samples. Nonbusiness day samples had a frequency of detection for ammonia (approximately 15%) that was half that of the routine samples, although the concentrations in both sample sets were similar. Bromide was measured at two times the method detection limit in one routine sample, but the result could be the result of laboratory error. Sulfides were detected with similar frequencies in both sample types; the routine samples had somewhat elevated concentrations, although these levels are not significantly different from those observed in some blank and treated influent samples. Phosphate was found 25% of the time in routine samples at readily detectable levels. Phosphate was not found in any blank or treated influent samples. Fluoride concentrations and frequencies of detection were equivalent for both sample types and were very similar to treated influent values. Nitrate was always found in both sample types; routine samples had an average concentration approximately 4 times higher than nonbusiness day samples and 8 to 10 times higher than treated influent samples. Chloride and sulfate levels (chloride was 4,740 µg/L; sulfate was 16,200 µg/L) for nonbusiness day samples were similar to treated influent;

sulfate concentrations in routine samples were also comparable to treated influent. Large concentration excursions of chloride were found in the routine samples (Figures 10.2a through d).

For reference only (the combined building effluent is not meant to be drinking water and is treated by the TEDF before being discharged to the river), concentrations of ammonia and anions were compared to the National Drinking Water Standards, which exist for four of the constituents detected (chloride, fluoride, nitrate, and sulfate). Only the nitrate standard of 10 mg/L was exceeded with a maximum observed concentration of 20 mg/L in the effluent. The TEDF waste acceptance criteria exist for two of the constituents detected (ammonia and cyanide). Both of these constituents were measured at a small fraction (< 10%) of the waste acceptance criteria.

Figure 10.2. End-of-Pipe Ammonia and Anions: (a) Routine Sampling Concentrations Less than 800 µg/L (Cyanide Average 2.5 µg/L, Range 1 to 5 µg/L)

Figure 10.2. (contd). End-of-Pipe Ammonia and Anions: (b) Routine Sampling Concentrations Greater than 800 µg/L, (c) Nonbusiness Day Sampling Concentrations Less than 900 µg/L

Figure 10.2. (contd). End-of-Pipe Ammonia and Anions: (d) Nonbusiness Sampling Concentrations Greater than 900 µg/L

10.2.3 Metals

Mercury was detected in only routine samples at a frequency of nearly 50%; the concentration ranged from 1 to 8 times the method detection limit. Other heavy metals found at concentrations below 20 µg/L were also found in blank and treated influent samples with similar concentrations and detection frequencies. Some analytes (e.g., arsenic and cadmium) had average concentrations at or slightly below their method detection limits (some concentrations were below the method detection limits because the limits changed later in the year). In addition, many species detected near their method detection limits in some end-of-pipe samples (e.g., tin, beryllium, selenium, thallium, and lead) were also found with similar frequencies in the reagent blanks (Appendix D). Chromium was found in three routine samples at slightly elevated levels relative to treated influent and blank samples. Barium had a twofold greater concentration range in routine samples, but the average was

similar to treated influent and non-business day samples. Aluminum, iron, and zinc were observed at similar average concentrations for both sample types, but higher concentration excursions were observed for routine samples. Average aluminum and iron levels were comparable to influent; aluminum was also found at similar levels in blanks. The concentration of zinc in routine samples (39 µg/L) was about 3 times higher than the influent concentration. The alkali and alkaline earth metals (potassium, magnesium, sodium, and calcium) had average concentrations which were 15 to 20% higher in routine than nonbusiness day samples. A large excursion of sodium was also detected in one routine sample. Levels of these metals were slightly elevated over concentrations observed in treated influent samples (Figures 10.3a through e).

The TEDF has waste acceptance criteria for 12 of the metals detected: aluminum, arsenic, beryllium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, and zinc. None of the metals exceeded the waste acceptance criteria.

Figure 10.3. End-of-Pipe Metals: (a) Routine Sampling Concentrations Less than 10 µg/L

Figure 10.3. (contd). End-of-Pipe Metals: (b) Routine Sampling Concentrations Between 10 and 450 µg/L, (c) Routine Sampling Concentrations Greater than 450 µg/L, (d) Nonbusiness Day Sampling Concentrations Less than 160 µg/L

Figure 10.3. (contd). (e) Nonbusiness Day Sampling Concentrations Greater than 160 µg/L

10.2.4 Volatile Organic Compounds

Several VOCs were detected in routine and nonbusiness day samples (Figures 10.4a through c). Methylene chloride and four trihalomethanes were observed most frequently, although the actual presence of methylene chloride is uncertain because of suspected laboratory contamination. Among the trihalomethanes, chloroform was detected most often and had the highest concentrations (up to 20 µg/L). The average chloroform concentration in routine samples (11.2 µg/L) was approximately 50% lower than the level observed in the treated influent samples and was 20% higher relative to nonbusiness day samples. Bromodichloromethane was observed in approximately 50% of the routine and nonbusiness day samples; the average concentrations were roughly 1.5 times higher than treated influent levels. The remaining trihalomethanes, dibromochloromethane and bromoform, were detected less often (i.e., in 33% or fewer of the samples), and their

concentrations were approximately 20 to 140% higher in the nonbusiness day samples.

Four other chlorinated hydrocarbons were detected in a small fraction of the effluent samples. Trichloroethene and tetrachloroethene were observed at trace levels ($2 \mu\text{g/L}$ or lower) in both the routine and nonbusiness day samples. However, the presence of trichloroethene is questionable, because trichloroethene was also found in some of the blanks. Trichlorofluoromethane, a common refrigerant also known as Freon 11®, was measured at approximately the same concentration range in both routine and nonbusiness day samples. Notably, this compound was not detected in any of the samples from other monitoring locations. 1,1,1-trichloroethane was detected at a low concentration ($1.4 \mu\text{g/L}$) in one routine sample.

A variety of volatile organic solvents were infrequently detected in the routine samples; two of these compounds were also observed in nonbusiness day samples. Isopropyl alcohol was detected once with a relatively high concentration of approximately $600 \mu\text{g/L}$. This value should be more accurate than the alcohol data at Building 3720, because the end-of-pipe sample measurement was made at a later date when a more thorough calibration was applied. Acetone and hexone (methyl isobutyl ketone) were detected in both routine and nonbusiness day samples. While the average acetone concentration was approximately the same for both sample sets, the average hexone concentration was slightly more than 2 times higher in the nonbusiness day samples. Acetonitrile was measured at a concentration of $76 \mu\text{g/L}$ in one routine sample. Low levels (i.e., less than $10 \mu\text{g/L}$) of two other solvents, tetrahydrofuran and toluene, were also detected in the routine samples.

Ethylbenzene and xylenes were detected in a few samples, but these data are tentative because the compounds were measured near their method detection limits. Xylenes were measured at $2 \mu\text{g/L}$ or lower in both routine and nonbusiness samples; the concentrations were approximately twice as high in the nonbusiness day samples.

Figure 10.4. End-of-Pipe Volatile Organic Compounds: (a) Routine Sampling Concentrations Less than $4.5 \mu\text{g/Lm}$, (b) Routine Sampling Concentrations Greater than $4.5 \mu\text{g/L}$

Figure 10.4. (contd). End-of-Pipe Volatile Organic Compounds: (c) Nonbusiness Day Sampling

10.2.5 Semivolatile Organic Compounds

Three phthalate compounds (5 to 37 µg/L), tributyl phosphate (6 µg/L), and seven pesticides (2 to 35 ng/L) were found in 5 to 40% of the routine samples (Figures 10.5a and b). Delta-BHC,

heptachlor, and bis(2-ethylhexyl)phthalate were found in several nonbusiness day samples (Figure 10.5c). One routine sample had the highest concentration (36 ng/L) of endosulfan sulfate, a pesticide. The TEDF waste acceptance criteria were not exceeded.

Figure 10.5. End-of-Pipe Semivolatile Organic Compounds: (a) Routine Sampling Pesticides, (b) Routing Sample

Figure 10.5. End-of-Pipe Semivolatile Organic Compounds: (c) Non business Day Sampling (Delta-BHC Average 0.01 µg/L, Range N/A; Heptachlor Average 0.01 µg/L, Range N/A)

10.2.6 Radiological Parameters

Gross alpha, gross beta, and tritium were detected at low levels in routine and nonbusiness day samples (Figure 10.6a and b). Gross alpha was detected most frequently, although its average concentrations in routine (3.3 pCi/L) and nonbusiness day samples (2.4 pCi/L) were lowest among the three parameters. Both gross alpha and gross beta were measured over a wider range and had higher average concentrations (40 to 60% higher) in the routine samples. Tritium was only detected once in each sample set; the nonbusiness day result (423 pCi/L) was approximately twice as high as the routine sampling result (227 pCi/L). All measurements for radioactivity were less than the TEF waste acceptance criteria (15 pCi/L alpha, 50 pCi/L beta, and 20,000 pCi/L tritium).

Figure 10.6. End-of-Pipe Radiological Parameter: (a) Routine Sampling (Tritium Average 227.0 pCi/L, Range N/A), (b) Nonbusiness Day Sampling (Tritium Average 423 pCi/L, Range N/A)

10.3 Comparison of CY 1994 End-of-Pipe Data to Historical Information

Table 10.1 lists historical and CY 1994 concentration ranges for parameters and constituents in effluent at end-of-pipe. A more detailed summary of the historical data can be found in Section A.3 of Appendix A. Comparisons were made for a total of 27 parameters and constituents. With three exceptions, all of the parameters and constituents in CY 1994 had observed concentration ranges that were within a factor of 3 of the concentration ranges observed in the historical data. The three exceptions were chloride, nitrate, and sodium; these constituents had maximum concentrations that significantly exceeded the maximum concentrations of the historical data. In addition, the CY 1994 average concentrations of chloride and sodium exceeded the maximum concentrations of the historical data, and the associated standard deviations of all three constituents greatly exceeded those averages. These latter observations suggest that a few of the CY 1994 samples were collected when excursions containing large concentrations of these constituents were occurring. Cadmium, which was reported present in the historical data, was not detected in CY 1994 end-of-pipe samples. Ranges reported for gross radioactivity were well within the levels observed for historical data.

10.4 Comparison of CY 1994 End-of-Pipe Data to Regulatory Limits

Table B.2 in Appendix B summarizes the observed concentrations of parameters and constituents at end-of-pipe for CY 1994 and federal and state regulatory limits. Comparisons were made for a total of 33 parameters and constituents. Seven constituents exceeded the EPA MCL and/or TEF NPDES limits. Bis(2-ethylhexyl)phthalate exceeded both the EPA MCL and NPDES limit. Zinc, copper, and lead frequently exceeded the NPDES limits. Occasionally, aluminum exceeded both EPA MCL and NPDES limits, whereas nitrate and gross beta occasionally exceeded the EPA MCLs. For those parameters and constituents exceeding regulatory limits, maximum levels exceeded were within a factor of 10 of the regulatory limit.

Table 10.1. Comparison of Observed Concentration Ranges ($\mu\text{g/L}$) of Parameters and Constituents at End-of-Pipe During CY 1994 to Historical Data

Parameter or Constituent	Historical Concentration Range	Observed Concentration Range and (Average $\pm$ SD) for CY 1994
General Chemical Parameters		
Alkalinity	40,000 - 60,000	40,000 - 140,000 (59,936 $\pm$ 21,852)
Ammonia	100 - 400	23 - 100 (48 $\pm$ 28)
Total carbon	10,000 - 16,000	13,000 - 42,000 (17,929 $\pm$ 5,850)
Anions		
Chloride	3,000 - 4,000	2,500 - 190,000 (14,024 $\pm$ 35,457)
Cyanide	10 - 15	1 - 5 (3 $\pm$ 2)
Fluoride	200 - 250	200 - 800 (565 $\pm$ 158)
Nitrate	1,000 - 3,500	200 - 20,000 (2,988 $\pm$ 4,495)
Phosphate	1,800 - 8,500	383 - 800 (522 $\pm$ 166)
Sulfate	17,000 - 20,000	10,000 - 36,900 (17,756 $\pm$ 4,467)
Cations		
Aluminum	150 - 300	40 - 410 (89 $\pm$ 68)
Barium	30 - 40	15 - 64 (29 $\pm$ 9)
Cadmium	2 - 30	ND
Calcium	~20,000	18,000 - 45,000 (23,241 $\pm$ 6,828)
Copper	10 - 125	8 - 30 (14 $\pm$ 6)
Iron	100 - 550	23 - 250 (92 $\pm$ 45)
Lead	5 - 15	0.7 - 5.9 (2.4 $\pm$ 1.2)
Magnesium	4,000 - 5,000	4,200 - 10,000 (5,221 $\pm$ 1,409)
Manganese	5 - 35	1.5 - 9.3 (3.0 $\pm$ 1.7)
Mercury	0.1 - 2	0.08 - 0.41 (0.15 $\pm$ 0.09)
Nickel	10 - 15	16 - 18 (17)
Potassium	800 - 1,500	950 - 3,100 (1,533 $\pm$ 567)
Sodium	2,500 - 5,000	3,200 - 95,000 (9,969 $\pm$ 17,937)
Zinc	15 - 500	20 - 84 (39 $\pm$ 14)
Organic Compounds		
Acetone	30 - 110	13 - 63 (33.6 $\pm$ 16.7)
Chloroform	12 - 55	3.4 - 20 (11.2 $\pm$ 4.1)
Gross Radioactivity		
Alpha activity	1 - 900 ^(a)	1.4 - 9.2 (3.3 $\pm$ 0.8)
Beta activity	1 - 380 ^(a)	2.1 - 12.5 (3.8 $\pm$ 1.2)
(a) Units are picocuries/liter. ND = not detected.		

11.0 Waste Stream Dynamics Tests

Waste stream dynamics tests involve the release of a known concentration and volume of a nonhazardous, fluorescent dye (Acid Red #52) into a facility waste stream. The dye's concentration is then monitored using a fluorometer at the facility sampling point and at the end-of-pipe. Based on the fluorescence readings (which are directly proportional to concentration), important stream flow parameters such as contaminant transit times and dilution factors can be assessed.

Two facilities were chosen for an initial appraisal of stream dynamics for the 300 Area process sewer:

- Building 331, the PNL facility furthest from the end-of-pipe
- Building 3720, the PNL facility closest to the end-of-pipe.

In each experiment, continuous, real-time data collection was facilitated by diverting a portion of the stream through a flow cell mounted inside each fluorometer. The temperature and pH of the stream were also continuously monitored for later correction of the fluorescence measurements.

11.1 Testing

Initial tests at Buildings 331 and 3720 in February 1994, 1) generated information to refine test design, 2) evaluated field logistics, and 3) developed and tested the dye measurement system.

Table 11.1 summarizes the test activity during July. A total of 12 dye releases were made at Building 3720,

while 6 releases were made at Building 331. Unfortunately, seven of the releases were not useful for quantitative dilution estimates, because the dye concentration at the end-of-pipe was too high for the limited dynamic range of the fluorometer. However, the off-scale data were useful for determining transit and clearance times.

11.2 Results

Figures 11.1 and 11.2 display representative end-of-pipe fluorescence profiles associated with dye releases at Buildings 3720 and 331, respectively. Normally, each dye release at Building 3720 resulted in one predominant peak (observed initially at the building and later at the end-of-pipe) from which timing parameters and dilution factors were calculated. The data from Building 331 were more complex. Multiple peaks with decreasing intensities were observed at the end-of-pipe following each dye release (Figure 11.2). This behavior appears to result from incomplete purging of the 3906 lift-station sump located southeast of Building 315. Clearly, the multiple peaks from Building 331 releases will be important in potential event-response activities associated with this facility.

Three types of time measurements were collected in each waste stream dynamics test: arrival time, transit time, and clearance time (Figure 11.3). Arrival time is the time at which a contaminant is first detected at the end-of-pipe. Transit time is the time required for the maximum concentration to reach a given point (for example, end-of-pipe). Clearance time is the time required for a discrete stream constituent (that is, a contaminant which

has been released into a stream) to completely flow past a given point. Clearance times were determined at both facilities and at end-of-pipe.

11.2.1 Arrival Times and End-of-Pipe Transit Times

The average and range of arrival times and end-of-pipe transit times for Buildings 3720 and 331 are listed in Tables 11.2 and 11.3. Generally, the transit times were about 5 to 8 minutes greater than the arrival times. For Building 3720, the average transit time was 49 minutes; the corresponding time for Building 331 was 4 hours and 21 minutes (for the primary dye peak). The longer time required to travel from Building 331 is consistent with the longer flow path from Building 331 to the end-of-pipe (Figure 3.1). In principle, the average transit times in Tables 11.2 and 11.3 serve as a range that should encompass the transit times of the other 300 Area facilities. However, low flow rates at some facilities and the unknown retention properties of sumps could place other facilities outside this range.

Each facility showed a large range in transit times (Tables 11.2 and 11.3). Indeed, the ranges are greater than the corresponding average transit times. These variations are primarily caused by the activation of sump pumps and fluctuations in the process sewer flow rates.

11.2.2 Clearance Times

The average clearance times at the two buildings and the end-of-pipe are listed in Table 11.4. For both buildings, the band(s) of dye broadened by the time they reached the end-of-pipe. This broadening was attributed to normal dilution and dispersion of the dye as it passed through the process sewer.

However, for Building 331, the primary influence on the clearance time was the action of a sump, which resulted in an average clearance time of 4 hours, 23 minutes. This sump-enhanced increase is approximately 13 times greater than the estimated change from dispersion alone. An additional factor that may lengthen clearance times at both facilities is chemical interaction by some contaminants (for example, adsorption of metals on a pipe). Because the fluorescent dye is relatively inert, such interactions have not influenced these results.

11.2.3 Dilution Factors

Dilution factors for the two buildings are summarized in Table 11.5. On average, the dye was diluted by a factor of 30 as it passed from Building 3720 to the end-of-pipe; the corresponding dilution factor for Building 331 was 524. These values are consistent with the observed dispersion (peak-width) changes associated with the two facilities.

For Building 331, each pulse of dye created by the action of the 3906 sump was approximately two to three times more dilute than its predecessor (Table 11.5).

Thus, for an event involving the release of a contaminant from Building 331, the number of significant pulses at the end-of-pipe will depend largely on the initial concentration of the contaminant. Consequently, the initial concentration will have a major influence on the end-of-pipe clearance time.

As these results indicate, clearance times, sump effects, and contaminant concentration will have to be considered seriously along with flow rates in determining the overall impacts of facility releases on the chemistry at the end-of-pipe.

Figure 11.1. End-of-Pipe Fluorescence From Two Dye Releases at Building 3720

Figure 11.2. End-of-Pipe Fluorescence at Building 331

S9409001.2

A = arrival time. B = transit time. C = clearance time.

Figure 11.3. Time Measurement from Fluorescence Data. The lower trace corresponds to a flow path with an intercepting sump.

Table 11.1. Stream Dynamics: July Test Dates and Number of Dye Releases

Building	Number of Dye Releases					
	July 1	July 7	July 8	July 11	July 14	July 21
3720	1 ^(a,b) 2 ^(a)	1 1 ^(a) 1 ^(b)	2 ^(a)	1 3 ^(b)	—	—
331	—	1 ^(a)	—	1 ^(a)	2	2 ^(b)
(a) Detection at end-of-pipe only. (b) Off-scale measurement(s) at end-of-pipe (data not useful for dilution estimates).						

Table 11.2. Building 3720 Arrival and Transit Times

	Average	Range
Arrival Time	42 min	18 min to 1 hr 12 min
Transit Time	49 min	19 min to 1 hr 25 min

Table 11.3. Building 331 Arrival and Transit Times

	Primary Dye Peak		Secondary Dye Peak		Tertiary Dye Peak ^(a)	
	Average	Range	Average	Range	Average	Range
Arrival Time	4 hr 13 min	2 hr 38 min to 7 hr 30 min	6 hr 16 min	3 hr 35 min to 10 hr 53 min	7 hr 59 min	6 hr 6 min to 10 hr 34 min
Transit Time	4 hr 21 min	2 hr 51 min to 7 hr 36 min	6 hr 20 min	3 hr 39 min to 10 hr 55 min	8 hr 1 min	6 hr 7 min to 10 hr 36 min
(a) A third peak was not observed in every test.						

Table 11.4. Average Clearance Times

Building	At the Building	At the End-of-Pipe	Relative Increase (%)
3720	6 min 36 s	8 min 30 s	29
331	9 min 12 s	4 hr 23 min	2,760

Table 11.5. Dilution Factors

Building	Primary		Secondary		Tertiary ^(a)	
	Average	Range	Average	Range	Average	Range
3720	30	8 – 54	—	—	—	—
331	524	471 – 616	980	638 – 1561	3,092	2,893 – 3,290
(a) A third peak was not observed in every test at Building 331.						

12.0 Technology Evaluation

Technologies under development (during late FY 1993 and early FY 1994) in DOE's Office of Technology Development (EM-50) were screened for potential use in the Effluent Management Program. Also screened were technologies on display at the U.S.'s largest show of modern laboratory equipment sponsored by the Spectroscopy Society of Pittsburgh and the Society for Analytical Chemists of Pittsburgh (also known as the Pittsburgh Conference) (February 27 through March 4, 1994, in Chicago, Illinois). Through the task-planning process, three technologies were selected for evaluation and possible future deployment, beginning in FY 1994. The three technologies were selected and evaluated based on the potential to improve near- and intermediate-term cost effectiveness and quality for effluent characterization and monitoring. The technologies are as follows:

- field transportable gas chromatograph/mass spectrometer (GC/MS) to measure VOCs
- adsorptive stripping voltametry (ASV) for field measurement of chemical uranium
- solid phase extraction (SPE) for pre-concentration and cleanup of liquid samples in the laboratory or the field.

A fourth technology, continuous monitoring of general waste stream parameters, was also chosen for evaluation during the last quarter of 1994.

12.1 Gas Chromatograph/Mass Spectrometer

Of the field transportable GC/MS systems available, the SpectraTrak GC/MS was chosen and purchased because it is capable of powerful analyses in both field or laboratory use (McDonald et al. 1994). To provide complete remote capability for the GC/MS, a small 2.4-KVA generator was also purchased. The SpectraTrak GC/MS has been used to measure VOCs at Sandia National Laboratory's Chemical Waste Landfill (as part of DOE's Office of Technology Development program) and in Department of Defense remediation activities. Moreover, the SpectraTrak GC/MS has been used in the commercial sector addressing remediation and health and safety issues.

12.1.1 Methods Development and Analysis of Water Samples

The primary emphasis in 1994 was water analysis. The GC/MS can analyze either VOCs or SVOCs in water or gaseous matrices. However, because sample preparation is more laboratory intensive for SVOCs, the GC/MS was used primarily to analyze the VOCs using standard methods (for example, EPA Method 502.2) or methods developed in our laboratory. A second GC/MS was acquired to analyze SVOCs.

Purge-and-trap gas chromatography, using EPA Method 502.2, has very good sensitivity for water analysis and a reasonably high degree of selectivity for

known or expected components. However, it is not well suited for identification of unknowns and may be somewhat prone to occasional misidentification. The analysis time is very long on a per sample basis (approximately 75 minutes per sample). Because effluent samples may potentially contain a wide range of unknown or unexpected water soluble organic compounds, this method was used primarily in this project for quality control of samples sent to the analytical services laboratory.

To augment EPA Method 502.2, procedure development has concentrated on testing a headspace method for analysis of VOCs in waste water samples. The method chosen has adequate sensitivity, excellent identification capability, and high sample throughput (20 minutes per sample). The detection levels attainable by this method are quite respectable, typically around 1 $\mu\text{g/L}$ for most VOC species of interest. Thus, the headspace method can be used with confidence down to and somewhat below drinking water standards for all major VOC species of interest, except vinyl chloride. Quantitative comparisons between the headspace method and purge-and-trap gas chromatography, where possible, were uniformly favorable as expected because the same calibration standard was used on both instruments. The procedure was successfully implemented both in the laboratory and in the field (300 Area) on samples from several PNL facilities.

The headspace method depends upon partitioning VOCs between the water and a confined gas space above the liquid. Samples without bubbles are collected from the headspace in commercially available 44-mL brown glass septum-sealed VOC vials and stored at a low temperature (typically 4°C). Just before analysis, a 20-mL aliquot of the sample is put in a graduated cylinder with the

remainder disposed to a waste container. The 20-mL volume is returned to the original vial and immediately capped.

A 5- μL aliquot of EPA Method 8260 internal standard mixture (2,000 $\mu\text{g/L}$ in methanol) is injected through the vial cap with a chromatography syringe. This internal standard mixture contains 1,4-difluorobenzene, chlorobenzene-d5, and 1,4-dichlorobenzene-d5 (-d4 and -d5 indicate deuterated analogs of the more common chlorobenzene compounds). Typically, these four compounds are not found in samples, and these compounds give unique mass signatures in the GC/MS method.

The GC/MS method combines chromatographic retention time and mass spectral information to provide an essentially unique signature for each compound; thus, internal standards can be used with each sample. The internal standards link the individual compound standards, which are prepared in an identical manner. The internal standard compensates for any variation in system response on a sample-to-sample basis. In this implementation, the pentafluorobenzene peak is used as a quantitation reference and the other three are used as recovery checks. Thus, each sample has its own standard and surrogate information provided for quality control purposes.

After adding the internal standard, the vial is placed on a block heater and heated to 75°C. The samples are left on the block heater for at least 15 minutes before analysis to allow temperature equilibration. A 500- μL aliquot is withdrawn from the vial through the septum cap with a gas tight syringe. The sample is immediately injected into the split/splitless injection port. The injection port is set to a split ratio of approximately 5:1 before injection. The instrument is equipped with a 30-m column specially

designed to separate even the most highly volatile organic compounds without the use of cryogenic focusing. The column temperature, using a computer program, is then ramped from 40°C to 200°C over a 20-minute period. All compounds with any reasonable degree of volatility are eluted with most of the common compounds up through xylene eluting within the first 10 minutes.

Mass spectra spanning a mass range of 45 to 400 amu are collected once every 150 milliseconds. Data are stored continuously on the integral hard disk. Data may be quantified immediately using the software in the on-board computer or may be saved to floppy disk for off-line quantification using Hewlett-Packard's Enviroquant software, which provides superior peak auditing capabilities and improved reporting format. Each mass peak is examined visually to assure correct peak integration. If necessary, individual peaks are manually reintegrated using the interactive graphical integration capability of either software package.

While more sensitive methods for VOC analysis exist, the detection levels attainable by the headspace method described above are quite respectable. Quality control checks routinely implemented include daily tuning of the mass spectrometer, daily calibration of the target analyte responses, and the use of blanks, including column blanks, laboratory blanks, and trip blanks.

12.1.2 Results

To date, two major VOC liquid sampling and analysis campaigns have been carried out in the 300 Area. These two events are described in the following text.

The first sampling exercise was performed at Building 3720 during the week of June 13, 1994. The PNL mobile laboratory containing the GC/MS was moved to the back parking lot of Building 3720. Water samples for VOC analysis were collected from the building sewer pipe outfall through a 4.6-m (15-ft) length of 0.6-cm (0.25-in.) stainless steel line connected to a positive displacement pump at street level. The VOC vials were filled at periodic intervals through the pump.

The principal VOC found routinely in the samples was chloroform, which was presumably associated with the chlorination of source water. Chloroform levels in Building 3720 were somewhat higher than in past measurements and were moderately variable, ranging from 37 to 95 µg/L. No measurable levels of the brominated trihalomethanes were observed. Very minor amounts of methylene chloride, ranging from 1 to 9 µg/L, were also observed in some samples.

After the baseline measurements, a tracer release was performed using a test point at the far corner of the building. Extremely small quantities of methylene chloride, a mixture of xylenes, and tetrabromoethene were released in a manner designed to simulate a glassware cleanup. Based on conservative tracers such as pH, the transit time to the sampling point was estimated to be 5 to 10 minutes. A significantly longer transit time was observed for all species. Xylene arrived first after about a 30-minute delay, then methylene chloride about 30 to 45 minutes later. The tetrabromoethene was not observed as a sharp peak; it was observed as a broad peak of tribromoethene (an apparent degradation

product or impurity) after significant delay. These results show that the building plumbing has a significant storage capacity for a slow release of even moderately water-soluble organic compounds (Figure 12.1).

A second sampling activity was performed during the week of July 18, 1994, focusing on sampling points at Building 320, Building 331, and near the end-of-pipe. Grab samples were collected in duplicate at approximately 1- to 2-hour intervals from each sampling point during mid-day over a 3-day period. Composite samples collected over 24 hours were taken on July 20 at all three sampling points for comparison with results from the commercial laboratory. Samples were analyzed promptly in the PNL Sigma 5 Building GC/MS laboratory.

Only chloroform was detected in the samples (that is, grab and composite) using the headspace GC/MS procedure as a screening tool. This is consistent with data reported by the commercial laboratory on samples collected during the same period. Chloroform levels varied over a wide range at all three sampling sites with the widest variability seen at Building 331 with values ranging from 7 to 250 $\mu\text{g/L}$ in 18 measurements. Chloroform levels were observed to exceed the 100 $\mu\text{g/L}$ EPA MCL at the Building 331 sampling point on two occasions as shown in Figure 12.2. The other two sampling points also showed significant variability but at levels well below the EPA MCL. Chloroform levels ranged from 30 to 63 $\mu\text{g/L}$ at Building 320 and from 12 to 39 $\mu\text{g/L}$ at the end-of-pipe.

Figure 12.1. Building 3720 Volatile Organic Compound Tracer Tests

Figure 12.2. Chloroform Concentrations in Building 331 Effluent

In general, chloroform concentrations measured by PNL in grab samples and composite samples tended to be significantly higher (a factor of 2 to 3) than comparable measurements reported by the commercial laboratory. A review of the pertinent quarterly quality control data for the commercial laboratory showed excellent performance for chloroform on both the spike blind samples submitted by PNL and the EPA quality control samples. Cross checks between internal PNL

methods have shown a high degree of reliability to the assay method and attendant standardization procedure. The most likely explanation for the discrepancy is volatile loss during the sampling process itself. The use of the Isco® samplers for volatiles sampling is known to be not fully satisfactory because of the potential for loss of analytes to the headspace. Similar considerations apply during the compositing and subsampling step; however, to date, no better method has been identified.

12.2 Adsorptive Stripping Voltametry

ASV is an analytical technique that pre-concentrates selected trace metals (for example, uranium, chromium, and iron) from a ligand-treated (for example, cupferron) sample solution. The ligand forms an electrolytically stable complex that is adsorbed into the mercury during the deposition process (also called preconcentration). This step is an effective electrochemical extraction where the analyte is preconcentrated in the mercury phase to a much higher concentration than it was in solution.

After preconcentration, the analyte is measured using advanced electrochemical methods. This combination of preconcentration and electrochemical measurement generates an extremely favorable signal-to-background ratio, which allows detection limits at the parts-per-billion level for most metals. Because of the potential attributes of ASV for effluent monitoring of uranium, a flow system was laboratory and field tested. The purpose was to measure the concentration of uranium in 300 Area process sewer water.

The uranium monitoring flow system (Figure 12.3) was designed and

laboratory tested by Jianmin Lu under the direction of Professor Joseph Wang at New Mexico State University, under a subcontract agreement. The system was designed to detect uranium in near-real time (4 to 5 minutes) with a detection limit of 5 $\mu\text{g/L}$ uranium(VI) in solution.

The system consisted of a two-channel, variable-speed peristaltic pump. The first channel supplied a sample flow, and the second channel supplied the cupferron/acetate buffer solution flow to a plastic "Y". The uranium and cupferron reacted in a glass reaction spiral (reaction resonance time of approximately 1 minute). Then, the reaction solution was focused upwards onto a mercury drop suspended from the base of a dropping mercury electrode. The mercury drop was suspended with a 2.5-cm (1-in.)-long segment of a 6.2 mm OD x 1.0 mm ID glass tube. The end of the glass tube was approximately 5 mm from the base of the mercury drop. The lower portion of the dropping mercury electrode and the glass tube used to focus the flow were contained in a glass reservoir below the liquid surface. Initially, the reservoir contained distilled water, but as the system operated, sample-cupferron mixture accumulated. No memory effect was seen for the uranium measurements with this type of reservoir system. The static liquid level within the reservoir was maintained by a drain spout near the top of the reservoir (Figure 12.2). The system controller for

the dropping mercury electrode was a Radiometer America Inc. TraceLab System coupled to a computer.

Figure 12.3. Uranium Monitoring Flow System

12.2.1 Laboratory and Field Testing

Flow injection analysis was initially evaluated as a sample introduction method. However, this approach failed to provide consistent results. Subsequent work focused exclusively on a continuous flow system.

Figure 12.4 shows the system response versus uranium concentration. The uranium monitoring flow system was found to be linear from 0 to 200 $\mu\text{g/L}$ uranium. From 0 to 40 $\mu\text{g/L}$, there

appears to be a nonlinear effect, possibly from kinetic effects of the uranium-cupferron interaction.

Figure 12.5 demonstrates the reproducibility of the uranium flow monitoring system at 50 $\mu\text{g/L}$ uranium using a single mercury drop. The relative standard deviation of 15 measurements using a single mercury drop was 4.7%. Subsequent work suggested a more realistic relative standard deviation of approximately 10%.

After initial testing with distilled water, the system was used testing 300 Area process sewer water. The process sewer water was found to contain a potential interferant to the uranium measurement, believed to be a surfactant (detergent) (Figure 12.6). This caused a significant error with the integration of the uranium peak. To minimize the effect of the interferant on the uranium peak, the mercury drop was manually replaced after every three or four analyses. This procedure was used for subsequent laboratory analyses using process sewer water and during field testing.

Field testing for near-real-time monitoring of uranium in process sewer water was conducted June 14 through 16, 1994, by PNL and New Mexico State University personnel. The testing was done using the PNL mobile laboratory. This was located south of Building 3720 adjacent to an access hole at a junction of the Building 3720 sewer line and the

300 Area process sewer line. A 0.6-cm (0.25-in.) stainless steel tube (used for volatile sampling) and a 0.6-cm (0.25-in.) polypropylene tube were inserted adjacent to the pH and conductivity probes into the flow stream behind the retention dam. The retention dam was previously inserted into the 3720 process stream to elevate the water level for pH and conductivity monitoring. A Fluid Metering Inc. variable speed (0 to 46 mL/min) piston pump with a Teflon/stainless steel pump head was installed in the mobile laboratory and connected to the polypropylene tubing. During testing, the flow rate from the pump ranged from 20 to 30 mL/min. This testing was done concurrently with the GC/MS test.

The purpose of the field test was to prove that the fundamental ideas behind the uranium monitoring flow system would work (Figure 12.2). During testing, diverted flow from the sewer to the uranium monitoring flow system was provided by a variable flow pump. The flow rate ranged from 5 to 20 mL/min. The uranium monitoring flow system was "Teed" into the sampling line after the sampling pump and sampled at a flow rate of 1 to 2 mL/min. Excess flow was discarded into a drain. During the course of testing, five integrated samples--spanning 5 to 55 minutes of monitoring--were collected for uranium analysis by an inductively coupled argon plasma-mass spectrometer (ICAP-MS). These results were compared to the ASV field measurements.

Figure 12.4. Cupferron Flow System

Figure 12.5. Uranium-Cupferron Flow System

S9408065.3

Figure 12.6. Uranium (VI) and Surfactant

12.2.2 Results

The ICAP-MS analysis of integrated grab samples measured the background concentration at approximately $30 \mu\text{g/L}$. Values measured by ASV during online monitoring ranged from 10 to $20 \mu\text{g/L}$ during the same period. The results of the field testing suggest the ASV uranium monitoring flow system can measure uranium at a detection limit of $5 \mu\text{g/L}$. The system response to uranium was found to depend on the pH of the process sewer water sample. Increasing the acetate buffer solution from 0.1 to 1 M is expected to significantly decrease or eliminate the affects of pH on the uranium measurement. Near-real-time tests also showed optimal replacement of the mercury drop after every second or third measurement. These refinements

should increase the accuracy and precision of the ASV measurement. Another refinement will include configuring the system to routinely calibrate and zero check itself for adaptation to long-term unattended monitoring of process effluents.

12.3 Solid Phase Extraction

SPE, which is strongly supported by the EPA's Office of Solid Waste, can eliminate some of the sample preparation activities that are performed in the field and/or the laboratory. Operation in the field can enhance sample stability during transport from the field. In turn, sample quality and data quality should be improved. Characterization cost effectiveness should also be enhanced by minimizing sample collection, transportation, preparation, and disposal costs. As seen at the Pittsburgh Conference, SPE technology is readily available from manufacturers for application to a broad and expanding suite of semivolatile analytes and liquid matrices. In addition, several highly automated SPE systems and integrated samplers are commercially available. These systems can process multiple samples simultaneously with minimal operator attention. Favorable results down to very low levels (nanogram/liter) have been reported for these filter disks in the open literature (Tompkins et al. 1992).

12.3.1 Methods Development

Commercially available SPE disks were evaluated for efficiency of concentrating (i.e., recovery) SVOCs from water. SPE disks produced by Spec (C18 bonded phase) and Empore (C8 bonded phase) were evaluated using laboratory standards. The results would serve as a quantitative basis for how they might perform extractions of SVOCs from waste

water samples. Spec C18 disks produced the best overall recoveries of pesticides and phthalates (plasticizers) from mixtures of prepared standards.

The preferred Spec C18 disks were then tested on waste water collected from the 300 Area. In the laboratory, 1-L samples of waste water spiked with a known amount of three SVOC internal standards (nitrobenzene-d5, 2 fluoro-biphenyl, and p-terphenyl-d14) were passed through the disks by application of a mild vacuum to the filtration apparatus.

Sorbed analytes were recovered by eluting the disks with 20 mL of methylene chloride. The elution power of other solvents (e.g., acetone and ethyl acetate) were investigated. While the more polar solvents produced somewhat better recovery efficiency, their presence in the analysis sample led to poor GC separations. After drying over sodium sulfate, the solvent was evaporated under nitrogen to a final volume of 1 mL and placed in a crimp vial. The final overall concentration factor in the injected solvent was typically 1000:1, which allowed GC to be used to achieve original sample detection limits of low parts-per-billion. The extraction process could be performed in under 10 minutes. Solvent reduction of several samples was performed in parallel, reducing the time associated with sample prep. Recoveries of analytes from Spec C18 disks using the different solvents ranged from 50 to 90%. Recovered extracts were subjected to one of two analysis methods; a GC with flame ionization detection was used for routine samples, and GC/MS was used on any samples showing unknown peaks. The final procedure adopted closely matched the manufacturers' recommendations. The process of screening samples using SPE coupled to GC and using GC/MS only for unknown peak

identification is cost effective and helps to ensure that no constituents in the liquid waste stream sample are missed.

12.3.2 Field Application

SPE coupled with GC or GC/MS has been deployed successfully on the preparation and analysis of liquid waste samples collected from Buildings 320, 331, 3720, and end-of-pipe. Analysis of SPE-prepared samples from all four locations resulted in the detection by GC/MS of the compound 2-(2-butoxyethoxy)ethanol acetate. Estimated concentrations found at the four locations were 0.5 mg/L at Building 320, 1 mg/L at Buildings 331 and 3720, and 2 mg/L at end-of-pipe. This compound, 2-(2-butoxyethoxy)ethanol acetate, more commonly known as butyl carbitol® (Merck Index), is a component of some cleaning agents. However, the compound has not been detected by GC or GC/MS of extracts of samples of some cleaning agents commonly used in 300 Area facilities. The source of the compound in the process sewer is still under investigation.

12.4 Continuous Monitoring Systems

Systems for continuous monitoring of effluent flow, pH, and conductivity have been permanently installed at the building locations where samples were collected as part of the routine sampling for the effluent monitoring task. The purpose of the systems is to gather real-time data to aid in identifying trends in sewer usage. Trends identified so far indicate that certain events have their own "fingerprint." For example, a dishwasher may cause a sharp increase in flow, conductivity, and pH. In contrast, the use of a laboratory sink may cause a gradual change in the pH and conductivity with

no measurable change in flow. Evaluation of these trends may yield some limited correlations between the real-time monitoring data and the composite sample results for each building.

At most buildings, data from each system will be collected via the Facilities Management Control System (FMCS). The FMCS is a computer network primarily dedicated to collecting information regarding building climate controls. Once upgrades to the FMCS are complete, real-time monitoring data will be available for effluent monitoring stations located at six buildings (nine separate stations). Stand-alone data logging systems will be required for Buildings 331 and 3720, because the FMCS is unavailable for use at these locations.

12.4.1 Stand-Alone Data Logging System

A stand-alone data logging system has been constructed to meet the continuous effluent monitoring needs of Buildings 331 and 3720. The typical configuration of a waste water monitoring system is shown in Figure 12.7. The pH and conductivity probes are immersed in the flowing waste water stream. Signals from the probes and flow meter are converted to engineering units and displayed locally at each station. Each measurement is then sent to a stand-alone data logger via a 4 to 20 mA current loop. The monitoring results are stored by the data logger and can be retrieved up to 1 week later using a computer.

Figure 12.7. Continuous Effluent Monitoring Systems

12.4.2 Preliminary Results

Some preliminary monitoring data has been collected using the stand-alone data logging system at Building 331.

Figure 12.8 shows an example of data collected over a 24-hour period. Flow rate, pH, and conductivity are plotted together. Data were collected every minute, with each data point representing

the average of three measurements made at 20-second intervals.

The data shows direct correlations of response of the three parameters during changes in the effluent. Recovery of the effluent from significant changes in pH (i.e., two log units) can take several hours.

Figure 12.8. Example of Data Collected on a Stand-Alone Data Logging System

12.4.3 Future Plans

Plans are in place to further explore the chemistry of excursions by conducting event-triggered sampling. Discharge events are normally the result of routine building operations. Measured changes in the pH or conductivity will be used to trigger a composite sampler to collect a discrete sample for subsequent laboratory analysis. Selective sampling of waste streams based on continuous monitoring parameters should help to focus sample collection efforts for each building and

yield the following benefits for the Effluent Monitoring Program:

- Improved detection of constituents in the waste water through the minimization of sample dilution. (Standard 24-hr flow proportional composite sampling techniques yield an average concentration, because both acute release and nonrelease samples are collected and then mixed.
- Efficient allocation of laboratory resources by analyzing only those samples for which the presence of constituents are expected.

13.0 Conclusions

During CY 1994, PNL's Effluent Monitoring Program characterized and monitored the liquid effluent streams from six DOE-owned and PNL-operated facilities (Building 306, 320, 324, 326, 331, and 3720) and end-of-pipe in the 300 Area of the Hanford Site for six general classes of parameters and constituents. These classes were 1) general chemical parameters, 2) ammonia and anions, 3) metals, 4) volatile organic compounds, 5) semi-volatile organic compounds, and 6) radiological parameters. To assist in delineating data quality and the contribution made by individual buildings to waste stream composition, analytical results of samples collected from building waste streams and end-of-pipe were compared against 1) background (i.e., untreated and treated influent), 2) the chemistry of facility waste streams on nonbusiness days, and 3) quality control information. In CY 1994, facility contributions to waste stream composition were compared to historical waste stream data and federal and state regulatory limits. The program also investigated the dynamics of selected building streams, generating information important to responsible management of building effluent discharges. Several characterization and monitoring technologies were evaluated for future deployment in ways that would improve program data quality and cost effectiveness.

The key conclusions from these assessments are summarized in the following sections.

13.1 General Chemical Parameters

Based on the magnitude of their general chemical parameters, the buildings and end-of-pipe followed this order:

331 ~ 326 > > 3720 ~
end-of-pipe > 320 > 324.

This approximate comparison shows that Buildings 331 and 326 when compared to the other facilities and end-of-pipe have roughly the highest levels of general chemical parameters. Building 324 has roughly the lowest levels of general chemical parameters. This ranking was based on 1) the number of constituents observed, 2) their actual concentrations, and 3) frequency of observance.

Buildings 326 and 331 had 50 to 100% higher average total organic carbon concentrations relative to the influent. The average end-of-pipe concentration was similar to the source water, but end-of-pipe had concentration excursions up to 9 times greater than influent levels. Total organic carbon at Building 3720 also exhibited large concentration fluctuations (up to 4 times greater than the average), but the average was approximately 20% lower than the influent. Total carbon levels at Building 326 were 65% higher relative to the untreated influent and almost twice as high as the treated influent. Buildings 306 and 331 had elevated total carbon

concentrations, with Building 331 having excursions 4 to 5 times higher than influent levels. Chemical oxygen demand was detected most frequently at Building 326; the concentrations were generally 4 to 5 times greater than influent levels. Building 331 had an average chemical oxygen demand twice that of the influent with excursions up to 14 times greater. In general, alkalinity and total dissolved solids were relatively constant among all of the sampling locations with average concentrations 1 to 2 times greater than influent levels. However, Building 331 had total dissolved solid fluctuations up to 6 times greater than the average influent levels.

The only standard of comparison for the general chemical parameters measured is the EPA drinking water standard of 500 mg/L for total dissolved solids. Although the maximum total dissolved solid value for Building 331 approached this concentration, one of the total dissolved solid values exceeded it.

13.2 Ammonia and Anions

Based on the magnitude of their ammonia and anions, the buildings and end-of-pipe followed this order:

331 >> 326 ~ end-of-pipe >
306 > 324 ~ 320 ~ 3720.

Ammonia was detected at seven sampling locations including the alternate influent, but it was never detected in the other influent samples or in any of the blanks. Building 3720 had levels of ammonia twice as high as other locations. Building 331's average concentrations were 3 to 5 times higher; excursions at

Building 331 were 35 times higher than the average level at other locations. Cyanide was found at Buildings 331 (75% of samples), 3720 (17%), and end-of-pipe (8%) during routine sampling, but only Building 331 had detectable cyanide in any (40%) of the nonbusiness day samples. The highest concentration of cyanide (70 $\mu\text{g/L}$) was observed at Building 331. The TEDF waste acceptance criteria for cyanide (50 $\mu\text{g/L}$) was exceeded in two measurements at Building 331.

Chloride levels at end-of-pipe averaged 3 to 4 times greater than treated influent levels with maximum levels 40 times higher. Building 331 chloride levels were 3 times higher than treated influent concentrations with excursions up to 30 times higher. Other facilities and treated influent samples had comparable levels that were 2 to 3 times higher than untreated influent (Columbia River) levels.

Building 326 had the highest average nitrate concentration which was approximately 22 times greater than the treated influent average. Buildings 306 and 331 had average nitrate concentrations which were 20 and 18 times higher than the treated influent average, respectively; Building 331 had maximum concentrations which were up to 100 times greater than the influent level. The EPA drinking water standard for nitrate was exceeded at most of the facilities and at end-of-pipe.

Phosphate was detected at Buildings 331 (2,800 $\mu\text{g/L}$), 326 (500 $\mu\text{g/L}$), and end-of-pipe (1,000 $\mu\text{g/L}$); 20% lower levels were found in Building 331 nonbusiness day samples.

13.3 Metals

In general, metals were detected in influent and effluent at trace levels (i.e., in the range of 0.1 to 10 $\mu\text{g/L}$). Their presence is suspected to be the result of artifacts introduced during sample collection and analysis process and/or leaching of residuals associated with the aged building and sewer piping systems.

Mercury was found at 0.2 to 0.25 $\mu\text{g/L}$ in 70 to 80% of the Building 3720 routine and nonbusiness day samples; maximum levels reached 1.1 $\mu\text{g/L}$. Levels of mercury at end-of-pipe averaged 0.16 $\mu\text{g/L}$ and were detected in 40% of the samples; the maximum level of mercury at end-of-pipe was 0.41 $\mu\text{g/L}$. Other heavy metals were generally within 3 to 4 times the concentration of each other and the levels detected in blanks and influent samples. One end-of-pipe sample had a sodium concentration 30 times higher than influent levels. Some locations had 3 to 4 times higher concentrations of metals such as aluminum, copper, iron, and zinc; this may have resulted from facility piping differences. The TEDF waste acceptance criteria was exceeded periodically for aluminum, copper, and zinc and some of the facilities. The drinking water standards for copper and zinc were not exceeded.

13.4 Volatile Organic Compounds

Chlorination of influent (Columbia River water) introduces volatile byproducts (i.e., chloroform, bromoform, bromodichloromethane, and dibromochloromethane) into building source water at levels slightly higher than those observed in the building effluents.

Observed concentrations ranged from 0.5 to 40 $\mu\text{g/L}$ in building waste streams and 0.9 to 20 $\mu\text{g/L}$ at end-of-pipe. The observed concentration range for all four trihalomethanes at end-of-pipe was below the EPA MCL of 100 $\mu\text{g/L}$. However, both chloroform and bromodichloromethane values exceeded the TEDF waste acceptance criteria at a number of facilities and in the treated influent.

Six other volatile halogenated hydrocarbons (i.e., 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,2-dichloroethylene, trichloroethene, tetrachloroethene, and trichlorofluoromethane) were detected infrequently in building waste streams and end-of-pipe at trace levels (0.6 to 2 $\mu\text{g/L}$). None of the observed levels of these constituents exceeded EPA MCLs or TEDF NPDES limits.

Several volatile solvents were sporadically found in the routine samples of some buildings. A general ranking of the buildings and end-of-pipe based on the solvent concentrations and detection frequencies is as follows:

3720 > > 331 > 320 >
326 ~ end-of-pipe > > 324 ~ 306.

Acetone was observed most frequently and at the most locations (Buildings 306, 320, 326, 331, 3720, and end-of-pipe). In most instances, the acetone concentrations were low (i.e., less than 50 $\mu\text{g/L}$). However, Building 326 had five results in the range from 100 to 2,500 $\mu\text{g/L}$, Building 331 had one result of 1,800 $\mu\text{g/L}$, and Building 3720 had four results ranging from 200 to 500 $\mu\text{g/L}$. Significant concentrations of acetonitrile were measured once at Buildings 320, 331, 3720, and end-of-pipe. Levels ranged from 76 $\mu\text{g/L}$ at end-of-pipe to 820 $\mu\text{g/L}$ at Building 3720.

Tetrahydrofuran was found with varying frequencies in the source waters and at Buildings 320, 326, 331, 3720, and end-of-pipe. While the tetrahydrofuran concentrations of the influent, Building 326, and end-of-pipe samples were similar to levels in the sample blanks, one result at Building 320 (36 $\mu\text{g/L}$) and four results at Building 3720 (13 to 400 $\mu\text{g/L}$) were notably higher.

Methylene chloride was found at 10 $\mu\text{g/L}$ in one Building 3720 sample; this concentration was significantly higher than the concentrations found in the sample blanks and exceeded the TEDF waste acceptance criteria of 5 $\mu\text{g/L}$.

Toluene and xylenes were infrequently measured in samples from Buildings 320, 331, 3720, and end-of-pipe. Except for one high toluene result of 400 $\mu\text{g/L}$ at Building 3720, the concentrations ranged from approximately 0.1 to 10 $\mu\text{g/L}$. The TEDF waste acceptance criteria for toluene is 9 $\mu\text{g/L}$ and was exceeded at Building 3720.

Hexone and 2-butanone were detected in less than 10% of the samples at Buildings 320 and 331; hexone was also infrequently observed at Building 3720 and end-of-pipe. Levels of both compounds were typically below 25 $\mu\text{g/L}$, except 2-butanone ranged from 50 to 170 $\mu\text{g/L}$ at Building 331, and hexone was measured from 24 to 110 $\mu\text{g/L}$ at Building 320.

Diethyl ether was found in two samples from Building 3720; the average concentration was 22 $\mu\text{g/L}$.

Two alcohols, ethanol and isopropanol, were measured in routine samples from Building 3720. Although the average concentrations of both compounds were reported as approximately 15 $\mu\text{g/L}$, the

actual concentrations were probably much higher, because of limitations of the analytical method and calibration procedure which were employed. High levels of isopropanol were also found once at end-of-pipe (600 $\mu\text{g/L}$) and Building 326 (40,800 $\mu\text{g/L}$).

13.5 Semivolatile Organic Compounds

Pesticides were found in the effluents of Buildings 326 and 331 but for the most part were detected at trace levels (i.e., < 20 ng/L). Phthalates were also detected in several building effluents (326, 331, and 3720). Bis(2-ethylhexyl)phthalate was detected at end-of-pipe at levels above the EPA MCL of 6 $\mu\text{g/L}$ but not above the TEDF waste acceptance criteria of 80 $\mu\text{g/L}$. Diethylphthalate at Building 3720 was measured at 170 $\mu\text{g/L}$ and exceeded the TEDF waste acceptance criteria.

13.6 Radiological Parameters

Building 3720 effluent consistently had gross alpha radiation levels in the range of 4 to 45 pCi/L, while other buildings and end-of-pipe had much lower levels (1 to 4 pCi/L). For all locations, the average gross beta activity was in the range of 3.5 to 7.4 pCi/L. Tritium was frequently detected in the effluent from Buildings 306, 324 (process and retention process sewer), 326, and 331 in the range of 118 to 687 pCi/L. Tritium was also detected once at end-of-pipe at an activity level of 227 pCi/L. Tritium levels are greatly below the TEDF waste acceptance criteria and EPA drinking water standards. On occasion, radiological activities (gross alpha and/or gross beta) in samples was found to slightly exceed regulatory limits at

Buildings 306, 324, and 3720. Several gross alpha measurements at Building 3720 exceeded the TEDF waste acceptance criteria (15 pCi/L). Gross alpha is believed to be caused by residual uranium in the piping.

13.7 Comparison of CY 1994 End-of-Pipe Data to Historical Information and Regulatory Limits

In general, CY 1994 concentrations of chemical and radiological parameters and constituents at end-of-pipe were similar to historical values. Exceptions were the occasional observances of high concentrations of chloride, nitrate, and sodium. These elevated concentrations are believed to be associated with excursions that were occurring at the time that samples were being collected.

During CY 1994, nitrate, aluminum, copper, lead, zinc, bis(2-ethylhexyl)-phthalate, and gross beta exceeded EPA MCL or TEDF NPDES limits on a frequent or occasional basis at some of the facilities, but at end-of-pipe only the drinking water standard for bis(2-ethylhexyl)phthalate was exceeded.

13.8 Waste Stream Dynamics

Concentrations and clearance times for contaminants at end-of-pipe were highly dependent on waste stream flow rates, dispersion, and the mechanical action of sumps. When present, the action of sumps had the greatest impact on contaminant clearance times. In the absence of sump activity, dispersion and flow rate were the controlling factors.

Dye tests performed at Buildings 331 and 3720 also showed the following results:

- Average transit times for Buildings 3720 and 331 were 49 minutes, and 4 hours, 21 minutes, respectively.
- The mechanical action of a sump intercepting the Building 331 waste stream resulted in the splitting of the dye into discrete fractions that led to subsequent dye discharges at end-of-pipe. The total number of dye pulses at end-of-pipe depended on the initial dye concentration.
- Clearance times (at the building and at end-of-pipe) for Building 3720 were less than 15 minutes in all cases. The generation of three discrete dye fractions in the Building 331 waste stream by an intercepting sump led to an average end-of-pipe clearance time of 4 hours, 23 minutes. This is 13 times greater than the estimated change from dispersion alone.
- Average dilution factors (concentration measured at a building divided by the estimated end-of-pipe concentration) for the dye as it passed from Buildings 3720 and 331 were 30 and 525, respectively.

13.9 Program Development

Initial field evaluations of transportable GC/MS, ASV, SPE, and continuous monitoring for pH, flow, and conductivity were favorable. Future application of these capabilities in concert with continuous monitoring of pH, flow, and conductivity will allow greater clarification building waste stream chemistry during excursions.

14.0 References

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Appendix A

Historical Information on 300 Area Process Sewer System and Liquid Waste Stream Chemistry

Appendix A

Historical Information on 300 Area Process Sewer System and Liquid Waste Stream Chemistry

A.1 Process Sewer

The original 300 Area process sewer system was primarily made of vitrified clay pipes with acid-proof joints that connected the buildings to a process pond. Large quantities of uranium were released via the process sewer to the process pond in the first years of operation. From 1948 to 1956, liquids containing uranyl nitrate hexahydrate, ammonium nitrate, hexone, and other solvents from Building 321 operations were passed through the process sewer to cribs, which were built 8 km (5 mi) north of the 300 Area. Some process waste buildup (i.e., solid materials containing chemical and radiological residuals) may be found in process sewer drains, pipes, trenches, and sewer access holes.

As a result of the requirements in the Tri-Party Agreement (Ecology et al. 1989), flow to the process sewer was reduced significantly by 1994 by installing closed-loop cooling water systems in facilities and redirecting cooling-water waste streams from the process sewer to the sanitary sewer. As a result, the process sewer system currently receives an average of 760 L/min (200 gal/min) of liquid waste (CH2M Hill and IT Corporation 1994); this is down 79.8% from the previous level of approximately 3,800 L/min (990 gal/min).

A.2 Retention Process Sewer

In 1953, the retention process sewer was built for facilities with the potential for releasing radioactive material into the waste stream. Liquid wastes, considered clean but having the potential to be radiologically contaminated, are fed via the retention process sewer piping to the 307 Basins. At the 307 Basins, the liquids are screened for radiological activity. If radioactivity is not detected above release limits, the wastes are discharged to end-of-pipe. If levels exceed release limits, the wastes are pumped into the Building 340 radioactive liquid waste system tanks for subsequent landfill disposal at Hanford.

A.3 300 Area Process Sewer Design and Waste Stream Composition

The *Preliminary 300 Area Process Wastewater Stream-Specific Report* (Millikin et al. 1990) describes the process sewer network as being subdivided into major contributing branches. Based on the network design, approximately 20 strategic locations were identified within the process sewer for sampling. The endpoints of several branches of the process sewer corresponded to specific points where constituents released from PNL-operated buildings could be monitored. However, many of the branches reflected contributions from multiple facilities.

Characterization data from Millikin et al. (1990) and other published reports (McKenney 1989; WHC 1992) constitute the main sources of historical data on the chemical and radiological composition of 300 Area facility liquid waste streams. These data are summarized in Table A.1. Numerous organic compounds and heavy metals were detected at upstream locations in the process sewer but not at end-of-pipe. The data are considered of limited use because all of the samples were taken as grab samples and, therefore only, represent a "snapshot" of the liquid waste stream composition. In addition, the stream has changed considerably in the last 5 years as a result of flow minimization and new regulations.

Facility activities in the 300 Area are subject to continuous changes. Thus, the chemical and radiological composition of the waste stream released from buildings and coming together at end-of-pipe is also subject to continuous change. Determination of the composition of the waste stream at any given point in time is impossible with the current characterization technology. Furthermore, comparisons between past and current data can only be made on a qualitative basis because of the high level of uncertainty associated with very limited sampling of facility waste streams.

A.4 References

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**Table A.1. Historical Data Summary of
300 Area Waste Stream Composition**

Parameter	Concentration Range ($\mu\text{g/L}$)
General Chemical Parameter	
Alkalinity	40,000 - 60,000
Ammonia	100 - 400
Cyanide	10 - 15
Total carbon	10,000 - 16,000
Anions	
Chloride	3,000 - 4,000
Fluoride	200 - 250
Nitrate	1,000 - 3,500
Phosphate	1,800 - 8,500
Sulfate	17,000 - 20,000
Cations	
Aluminum	150 - 300
Barium	30 - 40
Cadmium	2 - 30
Calcium	~20,000
Copper	10 - 125
Iron	100 - 550
Lead	5 - 15
Magnesium	4,000 - 5,000
Manganese	5 - 35
Mercury	0.1 - 2
Nickel	10 - 15
Potassium	800 - 1,500
Sodium	2,500 - 5,000
Zinc	15 - 500
Organic Compounds	
Acetone	30 - 110
Chloroform	12 - 55
Gross Radioactivity	
Alpha activity	1 - 900 ^(a)
Beta activity	1 - 380 ^(a)
(a) Units are picocuries/liter.	

Appendix B

Parameter and Constituent Selection and Monitoring Process

Appendix B

Parameter and Constituent Selection and Monitoring Process

B.1 Process for Identifying Constituents to Characterize and Monitor

In early April 1993, the Pacific Northwest Laboratory's (PNL's) Facility Effluent Monitoring Program manager sent a memo to all users of U.S. Department of Energy (DOE)-owned and PNL-operated facility process and retention process sewers in the 300 Area. The memo described the goals and objectives of the liquid effluent monitoring task and requested the users to attend a follow-up meeting to discuss sewer usage. Approximately 2 weeks after the memo was distributed, members of the liquid effluent monitoring task team met with building managers, group leaders, and senior researchers from these facilities. The audience was further briefed on the goals and objectives of the task, and time was allowed for questions. At the end of the meeting, the users were asked to complete a wastewater discharge survey form and return it in 2 weeks. To facilitate cooperation, information was collected in an anonymous fashion. The survey requested information on types, concentrations, and volumes of liquid wastes discharged to process and retention process sewers during conduct of their work.

The survey information was compiled into a table that listed material discharged by building. The table included volumes of liquid waste discharged, estimated concentrations of constituents in the discharge, and the frequency of discharges. Information from the table was compared against constituents listed in 1) the Westinghouse Hanford Company (WHC) waste acceptance criteria, 2) U.S. Environmental Protection Agency (EPA) drinking water standards, and 3) proposed discharge limits in the National Pollutant Discharge Elimination System (NPDES) permit under negotiation with the EPA for the operation of the Treated Effluent Disposal Facility (TEDF). From this comparison, a list of targeted constituents was identified for characterizing and monitoring as part of the routine liquid effluent monitoring subtask. The classes of parameters and constituents identified for monitoring are summarized in Table B.1. In some instances, nonregulated constituents were included on the list because the task team believed they should be monitored based upon responsible management practices. The targeted constituent list was used to establish methods for sample collection and specify analytical methods for the conduct of analyses to be performed by the analytical services contractors.

Table B.1. Classes of Parameters and Constituents Identified for Monitoring

General Chemical Parameters
alkalinity chemical oxygen demand total dissolved solids total carbon total organic carbon
Ammonia and Anions
ammonia cyanide sulfides other anions amenable to analysis by ion chromatography
Metals
heavy metals common cations
Volatile Organic Compounds
Semivolatile Organic Compounds
acids/bases/neutrals
pesticides
Radiological Parameters
gross alpha gross beta tritium

B.2 Process for Identifying Constituents Requiring Continuous Monitoring or Potential Control

As a part of responsible PNL waste management, regulated and nonregulated constituents identified in building liquid effluents using the process described in Section B.1 are evaluated to assess their potential impact on TEDF operations and treated wastewater releases to the Columbia River. Regulated constituents are those listed in EPA drinking water standards or TEDF NPDES discharge limits. Nonregulated constituents are those chemicals and radionuclides that are not governed by a regulatory agency.

The process by which the constituents are evaluated starts with comparing the concentrations of constituents in liquid effluents to the chemistry of treated and untreated

Columbia River water, background-level effluents, and quality control data. Background-level effluents are measured using the chemistry of the wastewater present during weekends or off-shift hours. Quality control data is derived from the analysis of blanks which normalizes wastewater data against artifacts introduced during the sampling and analysis process. This process helps identify those constituents whose source is clearly caused by a building discharge.

Concentrations of building-derived regulated constituents in liquid effluent are compared to regulatory limits (Table B.2) to assess whether further action is required (e.g., further monitoring or potential control). For nonregulated constituents, PNL uses the limits governing the discharge of toxic substances described under the general requirements section of the TEDF NPDES permit. Other factors considered in the assessment include the frequency a constituent is detected in the effluent and the confidence level of the measurements. Decisions on further action also take into account the effects of effluent transport to TEDF on constituent concentration and recognition that the effluent is treated at TEDF before it is discharged to the Columbia River.

Table B.2. Comparison of Concentration of Parameters and Constituents at End-of-Pipe with Federal and State Regulatory Limits

Parameter or Constituent	EPA MCL ($\mu\text{g/L}$) ^(a)	TEDF NPDES Limits ^(b) ($\mu\text{g/L}$)	Toxic Pollutant List ^(c)	Range of EOP Concentrations ($\mu\text{g/L}$) (Average $\pm$ SD)
General Chemical Parameters				
Total dissolved solids	500000			80,000 - 240,000 (109,630 $\pm$ 36,319)
Metals				
Aluminum	200	215		40 - 410 (89 $\pm$ 68)
Arsenic	50	13	yes	2 - 3
Barium	2000			15 - 64 (29 $\pm$ 9)
Chloride	250000			2,500 - 190,000 (14,024 $\pm$ 35,457)
Chromium	100		yes	15 - 20 (17 $\pm$ 3)
Copper	1300	3	yes	8 - 30 (14 $\pm$ 6)
Cyanide	200	6	yes	1 - 5 (3 $\pm$ 2)

Table B.2. (contd)

Parameter or Constituent	EPA MCL ($\mu\text{g/L}$) ^(a)	TEDF NPDES Limits ^(b) ($\mu\text{g/L}$)	Toxic Pollutant List ^(c)	Range of EOP Concentrations ($\mu\text{g/L}$) (Average $\pm$ SD)
Iron	300			23 - 250 (92 $\pm$ 45)
Lead		2	yes	0.7 - 5.9 (2.4 $\pm$ 1.2)
Manganese	50	10		1.5 - 9.3 (3.0 $\pm$ 1.7)
Mercury	2	0.9	yes	0.08 - 0.41 (0.15 $\pm$ 0.09)
Nickel	100	35	yes	16 - 18
Nitrate	10000			200 - 20,000 (2,988 $\pm$ 4,495)
Selenium	50	5	yes	1.1 - 2.0
Sulfate	400,000 - 500,000			10,000 - 36,900 (17,756 $\pm$ 4,467)
Thallium	2		yes	1.4 - 2.0
Zinc		25	yes	20 - 84 (39 $\pm$ 14)
Volatile Organic Compounds				
1,1,1-Trichloroethane	200	5	yes	1.4
Bis(2-ethylhexyl)-phthalate	6	3		2 - 38.0 (21.9 $\pm$ 10.5)
Dibromochloromethane		2.2	yes	1.0 - 2.2 (1.6 $\pm$ 0.4)
Ethylbenzene	700		yes	0.2
Methylene chloride	5	3	yes	0.2 - 1.6 (0.9 $\pm$ 0.4)
Tetrachloroethene	5	5	yes	2.0
Toluene	100	6	yes	1.4
Trichloroethene		1.9	yes	0.3 - 0.7 (0.5 $\pm$ 0.1)
Trichlorofluoromethane	100		yes	1.4 - 4.4 (2.4 $\pm$ 1.7)
Xylenes (total)	10000			0.5 - 1.6 (1.1 $\pm$ 0.4)

Table B.2. (contd)

Parameter or Constituent	EPA MCL ($\mu\text{g/L}$) ^(a)	TEDF NPDES Limits ^(b) ($\mu\text{g/L}$)	Toxic Pollutant List ^(c)	Range of EOP Concentrations ($\mu\text{g/L}$) (Average $\pm$ SD)
Total trihalomethanes	100	6.1 - 27.0		
Semivolatile Organic Compounds				
Heptachlor	0.4		yes	0.008 - 0.010 (0.009)
Radiological Parameter				
Gross alpha	15 pCi/L			1.4 - 9.2 (3.3 $\pm$ 0.8)
Gross beta	8 pCi/L			2.1 - 12.5 (3.8 $\pm$ 1.2)
Tritium	20000 pCi/L			227.0
<p>(a) U.S. Environmental Protection Agency (EPA). 1994. "Is Your Drinking Water Safe?" EPA 810-F-94-002, U.S. Environmental Protection Agency, Office of Water, Washington, D.C.</p> <p>(b) Treated Effluent Disposal Facility (TEDF) National Pollutant Discharge Elimination System (NPDES) Permit No. WA-0025917.</p> <p>MCL = maximum contaminant level.</p>				

Appendix C

Description of Sampling and Analysis Processes and Capabilities

Appendix C

Description of Sampling and Analysis Processes and Capabilities

C.1 Scope and Assignment of Responsibilities for Sampling and Analysis Processes

Eight buildings, including process and retention (radiological) process sewers, were scheduled for routine and nonbusiness day sampling in calendar year (CY) 1994. Of these eight buildings, liquid waste streams from six (Buildings 306, 320, 324, 326, 331, and 3720) were sampled and analyzed for chemical and radiological constituents (Section 1.0).

Routine sampling of liquid influents and effluents is performed by Pacific Northwest Laboratory's (PNL's) Field Sampling Team. Collected samples are screened for radioactivity. Radiological screening is performed by PNL's Analytical Chemistry Laboratory with backup support from Westinghouse Hanford Company's (WHC's) 222S Laboratory. After screening, samples are sent to offsite or onsite laboratories for radiological or chemical analysis. IT Corporation (Richland, Washington) performed radiochemical analysis, and DataChem (Salt Lake City, Utah) performed chemical and general parameter analyses. Volatile organic analyses and anion analyses were performed by PNL's Sigma 5 laboratory. Received data were evaluated by the project team for completeness and adherence to the statement of work requirements. Then, the data were stored in a database for subsequent evaluation to address the task objectives.

C.2 Sampling Station Type and Capability

Sampling stations are access points at buildings for collection of process sewer and retention process sewer samples. The stations contain equipment for monitoring waste stream flow, pH, and conductivity. Permanent sampling stations were installed at those locations where there was a high potential for discharge of hazardous constituents into the 300 Area sewer systems. Facilities with lower discharge potentials were sampled with portable sampling equipment.

Permanent sampling stations are equipped with a refrigerated sampler, flow meter, pH meter, and conductivity meter. The samplers collect flow-proportional composite samples

using a peristaltic pump and 9.5-mm (3/8-in.) Teflon®-lined tubing. Flow, pH, and conductivity data from nine dedicated stations will be collected continuously and communicated to a centralized information center for storage and processing using the Facility Management Control System. Data collection (i.e., flow, pH, and conductivity) at nondedicated locations (Buildings 331 and 3720) is provided on a continuous basis via field transportable stand-alone data-acquisition equipment.

C.3 Routine Composite Sampling

The majority of the samples were collected using refrigerated, flow-proportional composite samplers at dedicated sampling locations. Because an integrated sampler and flow meter were not available at end-of-pipe, time-proportional composite samples were collected at this location from April 6, 1994, through October 26, 1994. Using portable samplers, time proportional composite samples were collected from Building 306 effluent, and treated and untreated influent. The sampler located at the Building 326 process sewer was time proportional because of insufficient flow. All samples were composited for approximately 24 hours. Samplers were programmed the day before to start collecting samples between 7 a.m. and 9 a.m. Between June 21, 1994, and September 27, 1994, samples were collected in the evening because of a shortage of sampling personnel. During this time period, samplers were programmed the day before to start collecting samples between 3 p.m. and 4 p.m. Collected samples were held in a locked, climate-controlled facility until the results of a radiological screen analysis were reviewed against shipping requirements. When all shipping requirements were met, samples were transferred to the appropriate analytical laboratory.

From the beginning of the CY 1994 sampling campaign through September 26, 1994, sample blanks were prepared and incorporated into collections of samples that were sent to analytical laboratories. The sample blanks consisted of laboratory purified water and preservatives, as required. Tables C.1 through C.3 provide a complete listing of composite samples and sample blanks that were analyzed. From October 1, 1994, through December 1994, only trip blank (volatile organic compound) samples, were prepared and analyzed.

C.4 Methods of Analysis

Samples transferred to the various PNL and commercial analytical laboratories were analyzed for the targeted parameters and constituents using approved methods. The methods used and their specific applications are summarized in Table C.4.

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Table C.1. Code Interpretation

Code	Definition
Heading	
Alpha	Analysis includes alpha and beta radioactivity
Grab	Analysis is for volatile organic analytes that were sampled directly from a sewer and not composited
ICP	Analysis includes inductively coupled plasma metals, arsenic, lead, selenium, and thallium
Comment	
BBL	Bottle Blank
BKG	Background Sample
CO	Unusual Water Color
CL	Composite Bottle Cleaned in Prep Laboratory
DUP	Duplicate
F	Unusual Field Conditions
FER	Transfer Blank
FTR	Full Trip Blank
LW	Low Water in Composite Bottle
M	Mechanical Problems
NW	No Water in Composite Bottle
NT	New Tubing
NB	New Bottle
P	Priority
QC	QC Report
R	Rapid
S	Scheduled
SC	Scheduled and Collected
SCL	Scheduled and Collected for Long List of Constituents
SE	Sediment in Composite Bottle
T	Less Than 24 Hour Composite
TE	Improper Sample Temperature
TRP	Trip Blank
W	Unusual Water Conditions
X	Misc

Table C.2. Summary of Composite and Grab Samples Collected and Analyzed During CY 1994

Sample Site	Collection	GRAB	VOA	ABN	PHENOL	PEST PCB	ICP	HG	IONS	ALKA	AMMO	COD	CYAN	SULF	TC	TDS	TOC	ALPHA	TRIT	TYPE	COMMENT
306	9/27/94		SCL	S	S	S	SC	SC	S	S	S	S	S	S	SC	S	SC	SC	SC		LW
306	10/12/94		SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
306	10/26/94		SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
306	11/09/94		SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
306	11/29/94		SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
306	12/09/94		SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		S/COAL DUST & F/COAL DUST/TRAFFIC
306	12/20/94		SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
320	3/31/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			P
320	4/07/94		S	S			S	S	S	S	S	S	S	S	S	S	S	S			LW
320	4/12/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			F/CHLORINE SMELL
320	4/19/94		SC	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	4/26/94		SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	5/03/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			QC
320	5/11/94	SCL	SCL	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	5/18/94	SC	SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	5/23/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
320	5/25/94	SC	SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	6/01/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	6/06/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
320	6/09/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	6/15/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	6/15/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		DUP	
320	6/20/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
320	6/21/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	6/28/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	7/06/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
320	7/08/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	7/12/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			QC
320	7/18/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
320	7/20/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			X/INFLUENT RICHLAND CITY
320	7/26/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	8/01/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	QC
320	8/04/94		S	S			S	S	S	S	S	S	S	S	S	S	S	S			NW
320	8/10/94	SC	SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	8/15/94	SC	SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
320	8/18/94	SC	SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			

Table C.2. (contd)

Sample Site	Collection	GRAB	VOA	ABN	PHENOL	PEST PCB	ICP	HG	IONS	ALKA	AMMO	COD	CYAN	SULF	TC	TDS	TOC	ALPHA	TRIT	TYPE	COMMENT
320	8/18/94		S	S			S	S	S	S	S	S	S	S	S	S	S	S		DUP	LW
320	8/23/94	SC	SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	8/31/94	SC	SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	9/06/94	SC	SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	9/15/94	SC	SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	9/21/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	9/27/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	10/12/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	10/26/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	11/09/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	11/29/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	12/09/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
320	12/20/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
324 PS	11/29/94		SCL	SCL			S	S	S	S	S	S	S	S	S	S	S	SC	S		LW
324 PS	12/09/94		SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
324 PS	12/20/94		SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
324 RPS	11/29/94		SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
324 RPS	12/09/94		SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
324 RPS	12/20/94		SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
325 DIVE	5/20/94																				X/SCREEN ONLY
326 PS	8/31/94		S	S		S	S	S	S	S	S	S	S	S	S	S	S	S	S		NW
326 PS	9/27/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
326 PS	10/12/94		SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
326 PS	10/26/94		SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
326 PS	11/09/94		SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
326 PS	11/29/94		SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
326 PS	12/09/94		SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
326 PS	12/20/94		SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
327 PS	12/20/94																	SC	SC		X/HAZ CHEM SAMPLES COLLECTED/HELD
327 RPS	12/20/94																	SC	SC		C/BROWN & X/HAZ CHEM SAMPLES COL
329	8/04/94		S	S		S	S	S	S	S	S	S	S	S	S	S	S	S	S		NW
331	3/22/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			P & S/BROWN
331	3/30/94		SC	SC		SC	SC	SC	SC	SC	SC	S	SC	SC	SC	SC	SC	SC			S & X/COD BROKEN & P

Table C.2. (contd)

Sample Site	Collection	GRAB	VOA	ABN	PHENOL	PEST PCB	ICP	HG	IONS	ALKA	AMMO	COD	CYAN	SULF	TC	TDS	TOC	ALPHA	TRIT	TYPE	COMMENT
331	4/06/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		S	
331	4/13/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	4/19/94		SC	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	4/26/94		SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		S
331	4/26/94		SCL	SCL		SC	SC	SC	SC	SC	SC		SC						SC	DUP	
331	5/03/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			C/MILKY
331	5/11/94	SCL	SCL	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	5/18/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			C/CLOUDY
331	5/23/94		S	S		S	S	S	S	S	S	S	S	S	S	S	S	S			NW
331	5/25/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			C/MILKY
331	6/01/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	6/06/94	SCL	SCL	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
331	6/09/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	6/15/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	6/20/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
331	6/21/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	6/28/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	7/06/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
331	7/08/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	7/12/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	7/18/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
331	7/20/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			X/INFLUENT RICHLAND CITY
331	7/26/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	8/01/94		S	S		S	S	S	S	S	S	S	S	S	S	S	S	S		BKG	NW
331	8/04/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			QC
331	8/10/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	8/15/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
331	8/18/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			QC
331	8/23/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			C/MILKY
331	8/23/94	SC	SC	SC		SC	SC	S	SC	S	S	SC	S	S	S	S	S	SC		DUP	LW
331	8/31/94		S	S		S	S	S	S	S	S	S	S	S	S	S	S	S			NW
331	9/06/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	9/15/94		SC	SC		S	S	SC	SC	SC	SC	SC	S	SC	SC	S	SC	S			LW
331	9/21/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	9/27/94	SCL	SCL	SCL		SC	S	S	SC	SC	SC	SC	S	SC	SC	SC	SC	SC			LW

Table C.2. (contd)

Sample Site	Collection	GRAB	VOA	ABN	PHENOL	PEST PCB	ICP	HG	IONS	ALKA	AMMO	COD	CYAN	SULF	TC	TDS	TOC	ALPHA	TRIT	TYPE	COMMENT
331	10/12/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	10/26/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	11/09/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	11/29/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
331	12/09/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			S/BROWN
331	12/20/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
340	6/15/94			SCL																	
3720	3/30/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			P & R/RADS & S
3720	4/06/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	4/19/94		S	S			S	S	S	S	S	S	S	S	S	S	S	S			NW
3720	4/26/94		S	S			S	S	S	S	S	S	S	S	S	S	S	S			NW
3720	5/03/94		SC	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	5/11/94		SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	5/18/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	5/23/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
3720	5/25/94		SC	SC			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	6/01/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	6/06/94		S	S			S	S	S	S	S	S	S	S	S	S	S	S		BKG	NW
3720	6/09/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	6/15/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			F/GENERATOR RUNNING
3720	6/20/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
3720	6/21/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			QC
3720	6/28/94	SCL	SCL	SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	7/06/94	SCL	SCL	SCL	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
3720	7/08/94	SCL	SCL	SCL	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			C/LAVENDER
3720	7/12/94	SCL	SCL	S	S		SC	SC	SC	SC	SC	SC	S	S	SC	SC	SC	SC			LW
3720	7/12/94	SCL	SCL	SCL	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			DUP	LW
3720	7/18/94	SCL	SCL	SCL	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
3720	7/20/94		S	S	S		S	S	S	S	S	S	S	S	S	S	S	S			NW
3720	7/26/94	SCL	SCL	SCL	SC		SC	S	SC	SC	SC	SC	S	S	S	S	S	SC			LW
3720	8/01/94	SC	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
3720	8/04/94	SC	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	8/10/94	SC	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	8/15/94	SC	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
3720	8/18/94	SC	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			

Table C.2. (contd)

Sample Site	Collection	GRAB	VOA	ABN	PHENOL	PEST PCB	ICP	HG	IONS	ALKA	AMMO	COD	CYAN	SULF	TC	TDS	TOC	ALPHA	TRIT	TYPE	COMMENT
3720	8/23/94	SC	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			C/PINK
3720	8/31/94	SC	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	9/06/94	SC	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	9/15/94	SC	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			QC
3720	9/21/94	SCL	SCL	SCL	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	9/27/94	SCL	SCL	SCL	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	9/27/94	SCL	SCL	SCL			SC		SC	SC	SC	SC	S	SC	SC		SC	SC		DUP	
3720	10/12/94		SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	10/26/94		S	S	S		S	S	S	S	S	S	S	S	S	S	S	S			M/ELECTRICAL OUT
3720	11/09/94		S	S	S		S	S	S	S	S	S	S	S	S	S	S	S			M/ELECTRICAL OUT
3720	11/29/94		SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	12/09/94		SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
3720	12/20/94		SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
382B	8/04/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC				
EOP	4/06/94		SC	SC		S	SC	SC	SC	SC	S	S	SC	S	SC	S	SC	SC	SC		LW
EOP	4/14/94		SC	SC		S	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		LW
EOP	4/19/94		S	S		S	S	S	S	S	S	S	S	S	S	S	S	S	S		NW
EOP	5/03/94		SCL	SCL		S	SC	SC	SC	SC	SC	SC	S	SC	SC	SC	SC	S	SC		LW & F/DIRTY
EOP	5/11/94		SCL	SCL		SC	SC	S	SC	S	S	SC	SC	SC	SC	SC	SC	SC	SC		LW & F/DIRTY
EOP	5/18/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
EOP	5/23/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	BKG	F/DIRTY
EOP	5/25/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
EOP	6/01/94		SCL	S		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		X/ABNL IN WRONG BOTTLE
EOP	6/06/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	BKG	
EOP	6/09/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
EOP	6/15/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
EOP	6/20/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	BKG	
EOP	6/21/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		
EOP	6/28/94		S	S		S	S	S	S	S	S	S	S	S	S	S	S	S	S		NW
EOP	7/06/94		S	S		S	S	S	S	S	S	S	S	S	S	S	S	S	S	BKG	NW
EOP	7/08/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	7/12/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	7/18/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	QC
EOP	7/20/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			X/INFLUENT RICHLAND CITY
EOP	7/26/94	SCL	SCL	SCL		SC	SC	S	S	SC	SC	SCSC	S	SC	SC	SC	S				LW

Table C.2. (contd)

Sample Site	Collection	GRAB	VOA	ABN	PHENOL	PEST PCB	ICP	HG	IONS	ALKA	AMMO	COD	CYAN	SULF	TC	TDS	TOC	ALPHA	TRIT	TYPE	COMMENT
EOP	7/26/94	SCL	SCL	SCL		SC	SC	S	S	SC	S	SC	SC	S	SC	S	SC	SC		DUP	LW
EOP	8/01/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
EOP	8/01/94	SC	SC	SC		S	SC	S	SC	SC	SC	SC	SC	S	S	S	SC	SC		DUP	LW
EOP	8/04/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	8/10/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	8/15/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		BKG	
EOP	8/18/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			S
EOP	8/23/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			QC
EOP	8/31/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	9/06/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	9/15/94	SC	SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	9/21/94	SCL	SCL	SCL	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	9/27/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	10/12/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	10/26/94		SC	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	11/09/94		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	11/29/94		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	12/09/94		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			
EOP	12/20/94		S	S		S	S	S	S	S	S	S	S	S	S	S	S	S			NW
RIVER	5/11/94	SCL	SCL	SCL		SC	SC	S	S	S					SC	S	SC				LW
RIVER	5/25/94	SC	SCL	SCL		SC	SC	SC	SC	SC					SC	SC	SC				
RIVER	6/09/94	SCL	SCL	SCL		SC	SC	SC	SC	SC					SC	SC	SC				
RIVER	6/21/94	SCL	SCL	SCL		SC	SC	SC	SC	SC					SC	SC	SC				
RIVER	7/08/94	SCL	SCL	SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC				QC
TREAT MENT	5/11/94	SCL	SCL	SCL		SC	S	S	SC	S					SC	S	SC				LW & F/GENERATOR RUNNING
TREAT MENT	5/25/94	SC	SCL	SCL		SC	SC	SC	SC	SC			SC	SC	SC						
TREAT MENT	6/01/94																				
TREAT MENT	6/09/94	SCL	SCL	SCL		SC	SC	SC	SC	SC			SC	SC	SC						
TREAT MENT	6/21/94	SCL	SCL	SCL		SC	SC	SC	SC	SC			SC	SC	SC						
TREAT MENT	7/08/94	SCL	SCL	SCL		SC1	SC	SC	SC	SC	SC	SC	SC	SC1	SC	SC	SC				LW

Table C.3. Summary of QC Samples Prepared and Analyzed During CY 1994

Sample Site	Collection	VOA	GRAB	ABN	PHENOL	PEST PCB	ICP	HG	IONS	ALKA	AMMO	COD	CYAN	SULF	TC	TDS	TOC	ALPHA	TRIT	TYPE	Comment/ Building Association
BBL 2	9/21/94	SCL		SCL	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC				
BBL 3	9/21/94	SCL		SCL	SC	SC	SC		SC	SC			SC	SC							
BBL 4	9/21/94			SC	SC		SC						SC								
BBL 5	9/21/94						SC						SC								
BBL 6	9/21/94			SC	SC	SC		SC									SC				
BBL 6	9/21/94	SC		SC	SC	SC	SC	SC				SC	SC	SC		SC	SC				
BBL 7	9/29/94	SC		SC	SC	SC	SC	SC				SC	SC	SC		SC	SC				
BBL 7	9/29/94	SC		SC	SC	SC	SC	SC				SC	SC	SC		SC	SC				
BBL 7	9/29/94	SC					SC	SC				SC	SC	SC			SC				
BBL 7	9/29/94	SC																			
BBL 7	9/29/94	SC																			
BBL 7	9/29/94	SC																			
EQUIP BLANK	2/24/94	SC		SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		R
EQUIP BLANK	2/24/94	SC		SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		R
EQUIP BLANK	2/24/94	SC		SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC		R
FER 1	3/30/94	SC																			331
FER 2	4/06/94	SC																			331
FER 3	6/06/94	SC																			331
FER 4	6/21/94	SC																			320
FER 5	7/06/94	SC																			3720
FER 6	7/12/94	SC																			320
FER 7	7/20/94	SC																			320
FER 8	7/26/94	SC																			331
FER 10	8/15/94	SC																			320
FER 11	9/06/94	SC																			320
FTR 1	4/26/94	SCL		SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			320
FTR 2	5/18/94	SC		SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			331
FTR 3	7/08/94	SCL		SCL		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			EOP
FTR 4	7/26/94	SCL		SCL	SC		SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			3720
FTR 225	9/21/94	SCL		SCL			SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC			320

Table C.3. (contd)

Sample Site	Collection	VOA	GRAB	ABN	PHENOL	PEST PCB	ICP	HG	IONS	ALKA	AMMO	COD	CYAN	SULF	TC	TDS	TOC	ALPHA	TRIT	TYPE	Comment/ Building Association
TRP 1	3/30/94	SC																			331
TRP 2	4/06/94	SC																			331
TRP 3	4/14/94	SC																			EOP
TRP 4	5/11/94	SC																			RIVER
TRP 5	5/23/94	SC																			320
TRP 6	6/06/94	SC																			331
TRP 7	6/09/94	SC																			331
TRP 8	6/15/94	SC																			331
TRP 9	6/20/94	SC																			331
TRP 10	6/21/94	SC																			320
TRP 11	7/06/94	SC																			3720
TRP 12	7/12/94	SC																			320
TRP 13	7/20/94	SC																			320
TRP 14	7/26/94	SC																			331
TRP 15	8/01/94	SC																			320
TRP 16	8/15/94	SC																			320
TRP 17	8/18/94	SC																			320
TRP 18	8/23/94	SC																			320
TRP 19	8/31/94	SC																			EOP
TRP 20	9/06/94	SC																			320
TRP 21	9/15/94	SC																			320
TRP 22	9/21/94	SC																			320
TRP 23	9/27/94	SC																			3720
TRP 24	10/12/94	SC																			331
TRP 25	10/26/94	SC																			331
TRP 26	11/09/94	SC																			320
TRP 27	11/29/94	SC																			320
TRP 28	12/09/94	SC																			331
TRP 29	12/20/94	SC																			324 PS

Table C.4. Analytical Methods Used to Characterize Waste Stream Samples

Parameter	Method Number	Basis of Method
General Chemical Parameter		
Alkalinity	310.2 ^(a)	Titrimetry
Chemical oxygen demand	410.4 ^(a)	Colorimetry
Total dissolved solids	209B ^(b)	Gravimetry
Total carbon	D2579A ^(c)	Combustion/infrared absorption
Total organic carbon	9060 ^(d)	Combustion/infrared absorption
Ammonia and Anions		
Ammonia	D1426C ^(c)	Colorimetry
Cyanide	9012 ^(d)	Colorimetry
Sulfides	9030 ^(d)	Titrimetry
Other anions	D4327-88 ^(c)	Ion chromatography
Metals		
Arsenic	7060 ^(d)	Atomic absorption
Lead	7421 ^(d)	Atomic absorption
Mercury	7470 ^(d)	Atomic absorption
Selenium	7740 ^(d)	Atomic absorption
Thallium	7841 ^(d)	Atomic absorption
Other metals	6010 ^(d)	Inductively coupled plasma/atomic emission
Organic Compounds		
Volatile organics	8240 ^(d) , 502.2 ^(e)	Gas chromatography/mass spectrometry
Semivolatile organics	8270 ^(d)	Gas chromatography/mass spectrometry
Pesticides	8080 ^(d)	Gas chromatography
Phenols	8040 ^(d)	Gas chromatography
Radiological Parameters		
Gross alpha	9310 ^(d)	Liquid scintillation
Gross beta	9310 ^(d)	Liquid scintillation
Tritium	906 ^(f)	Liquid scintillation
<p>(a) U.S. Environmental Protection Agency (EPA). 1983. <i>Methods for Chemical Analysis of Water and Wastes</i>, EPA/600/4-79/020, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio.</p> <p>(b) American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1985. <i>Standard Methods for the Examination of Water and Wastewater</i>, 16th Edition. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, D.C.</p> <p>(c) American Society for Testing and Materials (ASTM). 1986. <i>Annual Book of ASTM Standards</i>, Volume 11.01 and 11.02. American Society for Testing Materials, Philadelphia, Pennsylvania.</p> <p>(d) U.S. Environmental Protection Agency (EPA). 1986. <i>USEPA Methods for Evaluating Solid Waste: Physical/Chemical Methods</i>, SW-846, 3rd ed. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Note: this method was used for all volatile organic samples collected before October 1, 1994.</p> <p>(e) In-house method based on EPA method 502.2 (EPA 1983). This method was used on samples collected between 10/1/94 and 12/31/94.</p> <p>(f) Krieger, H. L. and E. L. Whittaker. 1980. <i>Section 10, Tritium in Drinking Water, Method 906.0, Prescribed Procedures for Measurement of Radioactivity in Drinking Water</i>, EPA/600/4-80/032. U.S. Environmental Protection Agency, Cincinnati, Ohio.</p>		

Appendix D

Quality Control Data: Sample Blanks and Duplicate Samples

Appendix D

Quality Control Data: Sample Blanks and Duplicate Samples

The results from the analysis of the quality control blanks and duplicate samples are summarized in this appendix.

D.1 Reagent Blanks

A comprehensive listing of the analytes that were detected in reagent blanks is shown in Figure D.1. Although the concentrations of reagent blank contaminants were not reported by the analytical service contractors, the frequency at which a chemical is detected in the blanks can indicate the potential for laboratory contamination of field-collected samples. Lead and methylene chloride were detected most frequently, appearing in approximately 51 and 77% of the reagent blanks, respectively. Alkalinity, total carbon, iron, sodium, aluminum, and zinc were also detected in greater than 10% of the associated reagent blanks.

Figure D.1. Laboratory Reagent Blanks

D.2 Bottle Blanks

The results from the analyses of bottle blanks are summarized in Figure D.2. Most of the detected constituents were measured at levels much lower than building effluent concentrations, suggesting minimal bottle contamination. However, sulfides, lead, thallium, and methylene chloride were all measured at concentrations comparable to those found in the effluent samples. Other important results include the frequent detection of iron and zinc, and the low, yet significant concentrations of aluminum, acetone, chloroform, tetrahydrofuran, trichloroethene, and toluene. Chromium was detected at concentrations comparable to some of the effluent samples, but the impact on sample data quality is somewhat diminished by its low frequency of detection (approximately 12%). Several constituents (e.g., aluminum, iron, lead, sodium, total carbon, zinc, and methylene chloride) were also detected in the reagent blanks, implying some cases of laboratory contamination rather than bottle contamination. For additional information, see Tables D.1 through D.5.

Figure D.2. Concentrations of Parameters and Constituents Found in Bottle Blanks: (a) General Chemical Parameters (Turbidity Average 0.08 NTU, Range 0.08 to 0.09 NTU), (b) Anions,

Figure D.2 (contd). Concentrations of Parameters and Constituents Found in Bottle Blanks: (c) Metals (Beryllium Average 0.3 µg/L, Range 0.9 to 1.4 µg/L; Thallium 1.0 µg/L; Range 0.9 to 1.4 µg/L), (d) Volatile Organic Compounds, (e) Semivolatile Organic Compounds

Table D.1. Bottle Blanks: General Chemical Parameters

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Total carbon	1/1	—	600	—
Total organic carbon	2/6	140 - 200	170	—
Turbidity	2/2	0.08 - 0.09 ^(b)	0.08 ^(b)	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				
(b) Nephelometric turbidity units (NTU)				

Table D.2. Bottle Blanks: Ammonia and Anions

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Nitrate	1/2	—	80	—
Sulfides	5/6	260 - 420	360	68
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table D.3. Bottle Blanks: Metals

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	5/8	36 - 86	52	20
Beryllium	4/8	0.3 - 0.4	0.3	0.1
Calcium	1/8	—	130	—
Chromium	1/8	—	10	—
Iron	8/8	6 - 44	14	12
Lead	7/8	2.0 - 5.4	3	1
Magnesium	1/8	—	25	—
Sodium	4/8	80 - 140	108	25
Thallium	3/8	0.9 - 1.4	1	0.3
Zinc	7/8	7 - 13	11	2
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table D.4. Bottle Blanks: Volatile Organic Compounds

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acetone	2/10	16 - 19	17.5	—
Chloroform	2/10	3.0 - 3.7	3.4	—
Methylene chloride	10/10	1.1 - 1.6	1.2	0.2
Tetrahydrofuran	2/10	3.5 - 4.5	4.0	—
Toluene	1/10	—	0.5	—
Trichloroethene	1/10	—	0.3	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table D.5. Bottle Blanks: Semivolatile Organic Compounds

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Diethylphthalate	2/5	18 - 49	34.0	—
2,4,6-Trichlorophenol	1/7	—	5.3	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

D.3 Equipment Blanks

The results from the analyses of the three equipment blanks are summarized in Figure D.3. The most significant results were obtained on a few metals and volatile organic compounds. Chromium, lead, manganese, and vanadium were each identified at concentrations similar to the levels observed in building effluents. Likewise, the volatile organic compounds methylene chloride and tetrahydrofuran were also measured at levels near those observed in effluent samples. Less substantial levels of nitrate, chemical oxygen demand, and chloroform were also observed in the equipment blanks. For additional information, see Tables D.6 through D.10.

Figure D.3. Concentrations of Parameters and Constituents Found in Equipment Blanks: (a) General Chemical Parameters (Turbidity Average 0.05 NTU, Range N/A), (b) Anions, (c) Metals (Beryllium Average 0.3µg/L, Range N/A)

Figure D.3 (contd). Concentrations of Parameters and Constituents Found in Equipment Blanks: (d) Volatile Organic Compounds

Table D.8. Equipment Blanks: Metals

Constituent	Frequency ^(a)	Concentration ($\mu\text{g/L}$)		
		Range	Average	Standard Deviation
Barium	2/3	—	0.5	—
Beryllium	1/1	—	0.3	—
Calcium	3/4	37 - 52	45	7.5
Chromium	1/2	—	11	—
Iron	2/2	6 - 21	14	—
Lead	1/1	—	1.3	—
Manganese	2/2	1 - 3	2	—
Sodium	3/4	52 - 60	56	4
Vanadium	1/2	—	8	—
Zinc	3/4	2 - 6	4	2
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table D.9. Equipment Blanks: Volatile Organic Compounds

Constituent	Frequency ^(a)	Concentration ($\mu\text{g/L}$)		
		Range	Average	Standard Deviation
Chloroform	3/3	3.8 - 4.6	4.2	0.4
Methylene chloride	1/1	—	0.7	—
Tetrahydrofuran	3/3	5.6 - 6.7	6.1	0.6
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table D.10. Equipment Blanks: Radiological Parameters

Parameter	Frequency ^(a)	Concentration (pCi/L)		
		Range	Average	2SEM ^(b)
Gross beta	1/3	—	2.3	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				
(b) Two times the standard error of the calculated mean.				

D.4 Field-Transfer Blanks

The results from the analyses of the field-transfer blanks are summarized in Figure D.4. The concentrations of acetone and methylene chloride are significant when compared to some of the building effluent sample concentrations. Acetone, which was detected in a Building 331 transfer blank, was also measured at approximately the same concentration in the associated Building 331 effluent sample. Thus, acetone vapors may have been present at the Building 331 sampling site when the two samples were collected. The frequent detection of methylene chloride in the reagent blanks suggests laboratory contamination was the source of this constituent. For additional information, see Table D.11.

Table D.11. Field-Transfer Blanks: Volatile Organic Compounds

Constituent	Frequency ^(a)	Concentration ($\mu\text{g/L}$)		
		Range	Average	Standard Deviation
Acetone	2/11	—	21.0	—
Methylene chloride	8/10	0.4 - 1.2	0.8	0.4
Toluene	1/10	—	0.2	—

(a) Number of samples with detectable concentrations/total number of samples analyzed.

Figure D.4. Concentrations of Parameters and Constituents Found in Transfer Blanks
(Toluene Average 0.2 $\mu\text{g/L}$, Range N/A)

D.5 Full-and Daily-Trip Blanks

The results from the analyses of the full- and daily-trip blanks are summarized in Figure D.5. None of the general chemical parameters were measured in significant quantities. Aluminum, chromium, iron, lead, and nickel were measured at notable concentrations. Of these metals, aluminum, iron, and lead were also measured in the associated effluent samples from Buildings 320, 331, 3720, and end-of-pipe. However, because these metals were frequently detected in the reagent blanks, laboratory contamination is probably their source. Sulfides (not shown) were also measured in 80% of the full-trip blanks at relatively low levels (290 $\mu\text{g/L}$).

Low concentrations of acetone, chloroform, methylene chloride, and tetrahydrofuran were observed in both the full and daily trip blanks. Acetone was detected at the highest concentrations and was also observed in an associated Building 3720 sample. Chloroform and methylene chloride were also detected in both the blanks and the corresponding building-effluent samples. However, laboratory contamination is suspected as the source of methylene chloride in these and most of the effluent samples. For additional information, see Tables D.12 through D.15.

Figure D.5. Concentrations of Parameters and Constituents Found in Full and Daily Trip Blanks (a) Full-Trip Blanks General Chemical Parameters

Figure D.5. Concentrations of Parameters and Constituents Found in Full and Daily Trip Blanks
(b) Full-Trip Blanks Metals (Beryllium Average 0.3 µg/L, Range N/A), (c) Full and Daily Trip Blanks Volatile Organic Compounds

Table D.12. Full-Trip Blanks: General Chemical Parameters

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Total carbon	4/5	500 - 800	650	129
Total dissolved solids	1/4	—	20000	—
Total organic carbon	1/4	—	500	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table D.13. Full-Trip Blanks: Ammonia and Anions

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Sulfides	4/5	200 - 400	290	84
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table D.14. Full-Trip Blanks: Metals

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	2/4	22 - 38	30	—
Beryllium	1/4	—	0.3	—
Calcium	1/4	—	42	—
Chromium	1/4	—	19	—
Iron	3/4	24 - 74	45	26
Lead	5/5	0.6 - 3.2	1.5	1.1
Nickel	1/4	—	14	—
Sodium	1/4	—	61	—
Zinc	2/4	7 - 8	7	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table D.15. Full-Trip and Daily-Trip Blanks: Volatile Organic Compounds

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acetone	5/31	12.0 - 18.0	14.6	2.2
Chloroform	8/31	1.6 - 3.5	2.9	0.7
Methylene chloride	24/27	0.4 - 1.5	0.9	0.4
Tetrahydrofuran	9/33	2.5 - 7.1	4.4	1.5
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

D.6 Duplicate Samples

A total of seven duplicate samples were collected and analyzed during CY 1994 to assess analytical laboratory reproducibility. However, because of the limited sample volume obtainable from the composite samplers, not all constituent classes were analyzed for in any given pair of duplicate samples. Figure D.6 summarizes the analytical results for each compound class.

The primary information in this figure is the average of the **relative percent differences** (RPDs) calculated from all of the matching pairs of results for **each analyte**. This is indicated by the height of each column. In other words, the height of each column represents the significance of the differences found between the matching results. The black diamond over the analyte name indicates how close the **average concentration** is to the method detection limit (MDL). A value of one or higher indicates that the average concentration was equal to or less than the MDL. For analytes measured at trace concentrations (i.e., near the MDL), the chance for false detection is higher, and the measurement reproducibility is lower. Thus, the measurement precision of parameters or constituents in Figure D.6 with a high RPD and a low MDL to average-concentration ratio are of the most concern.

For most analytes, the average RPD was 25% or less (i.e., fairly low). However, seven metals, four organic compounds, and two radiological parameters had average RPDs greater than 25%. The metals iron, potassium, manganese, tin, arsenic, nickel, and silver, showed significant variability, although the latter four were measured near their MDLs. The source of the lower precision associated with the iron, potassium, and manganese measurements is unknown but may be caused by sample contamination, measurement interferences, or poor analytical technique. Carbon disulfide, bis(2-ethylhexyl)phthalate, di-n-butylphthalate, and gamma-BHC all had RPDs of 100%, but carbon disulfide was the only organic constituent which exhibited a low precision at concentrations well above the MDL. All three of the radiological parameters had average concentrations within a factor

of 1.5 of the MDLs; this appears to account for the high RPDs for gross alpha (31.8%) and gross beta (42.2%).

Overall, these results suggest that the level of precision associated with CY 1994 analytical measurements on effluent samples should not have a significant impact on data interpretation. However, these results illustrate the lower precision associated with analytes frequently measured at trace levels, such as metals, pesticides, and radiological parameters. Additional caution should be applied when drawing conclusions from such results. Tabulated information on the duplicate samples' results can be found in Table D.16.

Table D.16. Summary of Duplicate Sample Results

Compound	Number of Duplicates ^(a)	Average Difference ^(b) (µg/L)	Average RPD ^(c)
General Chemical Parameters			
Alkalinity	5	200	0.4
Chemical Oxygen Demand	3	1000	11.9
Total carbon	3	333	2.5
Total dissolved solids	2	0	0
Total organic carbon	4	0	0
Ammonia and Anions			
Ammonia	1	0	0
Chloride	5	80	1.5
Cyanide	1	0	0.0
Fluoride	5	20	3.6
Nitrate	5	40	1.4
Phosphate	1	200	8.7
Sulfate	5	200	1.9
Metals			
Aluminum	6	27.2	14.8
Arsenic	1	2.0	100.0
Barium	6	1.2	5.0
Calcium	6	833.3	3.4

Table D.16. (contd)

Compound	Number of Duplicates ^(a)	Average Difference ^(b) (µg/L)	Average RPD ^(c)
Chromium	1	3.0	14.6
Copper	6	3.1	17.5
Iron	5	40.2	27.1
Lead	6	0.5	20.7
Magnesium	6	233.3	4.7
Manganese	5	1.3	50.9
Mercury	1	0.03	10.2
Nickel	1	17.00	100.0
Potassium	6	383.3	27.9
Silver	1	3.6	100.0
Sodium	6	283.3	5.6
Tin	2	22.0	63.3
Zinc	6	6.0	10.9
Volatile Organic Compound			
Acetone	1	3.0	8.5
Carbon disulfide	1	2.5	100.0
Chloroform	6	0.6	4.1
Methylene chloride	5	0.04	8.0
Trichloroethene	1	0.1	6.5
Semivolatile Organic Compounds			
Beta-BHC	1	0.000	1.0
Bis(2-ethylhexyl) phthalate	1	3.6	100.0
Delta-BHC	1	0.001	11.5
Di-n-butylphthalate	2	3.9	100.0
Gamma-BHC	1	0.002	100.0

Table D.16. (contd)

Compound	Number of Duplicates ^(a)	Average Difference ^(b) ($\mu\text{g/L}$)	Average RPD ^(c)
Radiological Parameters			
Gross alpha (pCi/L)	3	1.4	31.8
Gross beta (pCi/L)	3	1.9	42.2
Tritium (pCi/L)	1	50	16.4
<p>(a) Number of duplicate results with a positive detect in at least one of the two samples.</p> <p>(b) Average of the absolute values of the differences calculated from each pair of duplicate results.</p> <p>(c) Average of the relative percent differences calculated from each pair of duplicate results.</p>

Figure D.6. Concentrations of Parameters and Constituents Found in Duplicates: (a) General Chemical Parameters (Total Organic Carbon RPD = 0; Alkalinity RPD = 0.4), (b) Ammonia and Anions (Ammonia RPD = 0; Cyanide RPD = 0), (c) Metals

Figure D.6 (cond). Concentrations of Parameters and Constituents Found in Duplicates: (d) Volatile Organic Compounds, (e) Semivolatile Organic Compounds (Beta-BHC RPD = 1.0), (f) Radiological Parameters

Appendix E

Data on Influent Water Chemistry

Appendix E

Data on Influent Water Chemistry

This appendix provides additional detailed information about the untreated, treated, and alternate influents. The figures and tables are organized into the same groupings as the chapters: general chemical parameters (Figures E.1 through E.3, and Tables E.1 through E.3), ammonia and anions (Figures E.4 through E.6, and Tables E.4 through E.6), metals (Figures E.7 through E.9, and Tables E.7 through E.9), volatile organic compounds (Figures E.10 through E.12, and Tables E.10 through E.12) and semivolatile organic compounds (Figure E.13 and Table E.13). Radiological analyses were not performed on influent samples.

Figure E.1. Untreated Influent General Chemical Parameters

Figure E.3. Alternate Influent General Chemical Parameters

Figure E.2. Treated Influent General Chemical Parameters

Table E.1. Untreated Influent: General Chemical Parameters

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Alkalinity	4/4	48000 - 60000	52000	5000
Chemical Oxygen Demand	1/1	—	9000	—
Total carbon	5/5	16000 - 21000	18200	2280
Total dissolved solids	4/4	80000 - 90000	82500	5000
Total organic carbon	5/5	3000 - 7000	4400	1517
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table E.2. Treated Influent: General Chemical Parameters

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Alkalinity	4/4	40000 - 60000	50000	11550
Chemical Oxygen Demand	1/1	—	10000	—
Total carbon	5/5	13000 - 19000	15800	2588
Total dissolved solids	4/4	80000 - 90000	82500	5000
Total organic carbon	5/5	3000 - 5000	3800	837
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table E.3. Alternate Influent: General Chemical Parameters

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Alkalinity	1/1	—	70000	—
Total carbon	1/1	—	17000	—
Total dissolved solids	1/1	—	110000	—
Total organic carbon	1/1	—	2000	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.

Figure E.4. Untreated Influent Ammonia and Anions

Figure E.5. Treated Influent Ammonia and Anions

Figure E.6. Alternate Influent Ammonia and Anions (Ammonia Average 30 µg/L, Range N/A)

Table E.4. Untreated Influent: Ammonia and Anions

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Chloride	4/4	1000 - 1200	1075	96
Fluoride	4/4	100 - 400	225	126
Nitrate	3/4	200 - 300	267	58
Sulfate	4/4	8500 - 10000	9000	707
Sulfides	1/1	—	300	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table E.5. Treated Influent: Ammonia and Anions

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Chloride	5/5	4000 - 5700	4740	709
Fluoride	5/5	500 - 600	540	55
Nitrate	4/5	100 - 500	325	171
Sulfate	5/5	16000 - 17000	16200	447
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table E.6. Alternate Influent: Ammonia and Anions

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Ammonia	1/1	—	30	—
Chloride	1/1	—	1800	—
Fluoride	1/1	—	200	—
Nitrate	1/1	—	700	—
Sulfate	1/1	—	8500	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.

Figure E.7. Untreated Influent Metals: (a) Concentration Less than 500 µg/L (Arsenic Average 2 µg/L, Range N/A; Lead Average 2.4 µg/L, Range 0.6 to 8.1 µg/L), (b) Concentration Greater than 500 µg/L

Figure E.8. Treated Influent Metals: (a) Concentration Less than 100 µg/L (Lead Average 0.9 µg/L, Range 0.7 to 1.2 µg/L; Manganese Average 1.1 µg/L, Range N/A), (b) Concentration Greater than 100 µg/L

Figure E.9. Alternate Influent Metals: (a) Concentration Less than 40 $\mu\text{g/L}$, (b) Concentration Greater than 40 $\mu\text{g/L}$

Table E.7. Untreated Influent: Metals

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	5/5	36 - 260	93	94
Arsenic	2/5	—	2	—
Barium	5/5	27 - 33	29	2
Calcium	5/5	17000 - 21000	18600	1517
Chromium	1/5	—	13	—
Cobalt	1/5	—	7	—
Copper	3/5	4.4 - 35.0	15.2	17.2
Iron	5/5	56 - 530	160	207
Lead	5/5	0.6 - 8.1	2.4	3.2
Magnesium	5/5	4100 - 5100	4440	397
Manganese	5/5	4 - 16	7	5
Potassium	3/5	1200 - 1400	1267	115
Sodium	5/5	2300 - 3000	2600	292
Tin	1/5	—	69	—
Zinc	3/5	10 - 110	44	57
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table E.8. Treated Influent: Metals

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	4/4	51 - 93	75	19
Barium	4/4	27 - 30	28	1
Calcium	4/4	17000 - 19000	18250	957
Copper	2/4	3.1 - 3.7	3	—
Iron	2/4	23 - 69	46	—
Lead	3/4	0.7 - 1.2	0.9	0.3
Magnesium	4/4	4100 - 4500	4275	206
Manganese	1/4	—	1.1	—
Potassium	2/4	1100 - 1500	1300	—
Sodium	4/4	2600 - 2800	2675	96
Tin	2/4	61 - 62	62	—
Zinc	3/4	5 - 11	9	4
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table E.9. Alternate Influent: Metals

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Barium	1/1	—	12	—
Calcium	1/1	—	22000	—
Copper	1/1	—	34	—
Lead	1/1	—	2	—
Magnesium	1/1	—	4400	—
Potassium	1/1	—	1300	—
Sodium	1/1	—	2700	—
Zinc	1/1	—	9	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.

Figure E.10. Untreated Influent Volatile Organic Compounds

Figure E.11. Treated Influent Volatile Organic Compounds (Toluene Average $0.3 \mu\text{g/L}$, Range 0.1 to $0.4 \mu\text{g/L}$)

Figure E.12. Alternate Influent Volatile Organic Compounds

Table E.10. Untreated Influent: Volatile Organic Compounds

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Chloroform	1/9	—	6.2	—
Methylene chloride	10/10	1.0 - 1.7	1.3	0.2
Tetrahydrofuran	1/9	—	3.6	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table E.11. Treated Influent: Volatile Organic Compounds

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Benzene	1/9	—	0.7	—
Bromodichloromethane	8/9	0.9 - 2.5	1.4	0.5
Chlorobenzene	1/9	—	2.3	—
Chloroform	10/10	15.0 - 41.0	22.4	7.3
Methylene chloride	10/10	1.1 - 1.6	1.3	0.2
Tetrahydrofuran	2/9	3.7 - 8.6	6.2	—
Toluene	2/9	0.1 - 0.4	0.3	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table E.12. Alternate Influent: Volatile Organic Compounds

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Chloroform	2/2	5.6 - 6.0	5.8	—
Methylene chloride	2/2	0.4 - 0.5	0.5	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.

Figure E.13. Treated Influent Semivolatile Organic Compounds (Delta-BHC Average 0.0065 µg/L, Range N/A)

Table E.13. Treated Influent: Semivolatile Organic Compounds

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acid/Bases/Neutrals (ABNs)				
Di-n-butylphthalate	1/5	—	1.9	—
Pesticides				
Delta-BHC	1/5	—	0.0065	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Appendix F

Detailed Tabular Information on the Parameters and Constituents Detected in Buildings 306, 320, 324, 326, 331, 3720, and End-of-Pipe

Appendix F

Detailed Tabular Information on the Parameters and Constituents Detected in Buildings 306, 320, 324, 326, 331, 3720, and End-of-Pipe

This appendix contains tabulated information on the parameters and constituents detected in the effluent samples from Buildings 306, 320, 324, 326, 331, and 3720. Information is also provided on samples taken at end-of-pipe.

Table F.1. Building 306: General Chemical Parameters

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Alkalinity	6/6	60000 - 120000	86667	25033
Chemical Oxygen Demand	6/6	4500 - 13000	8850	3068
Total carbon	7/7	18000 - 30000	23143	4634
Total dissolved solids	6/6	100000 - 180000	140000	36332
Total organic carbon	7/7	2000 - 5000	3143	1069
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.2. Building 306: Ammonia and Anions

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Ammonia	3/6	40 - 100	60	35
Chloride	6/6	4740 - 11700	7650	2636
Fluoride	5/6	231 - 459	333	109
Nitrate	6/6	1450 - 13500	6865	4356
Sulfate	6/6	13400 - 22600	17650	3106
Sulfides	3/6	220 - 300	273	46
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.3. Building 306: Metals

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	5/7	33 - 190	72	66
Arsenic	1/7	—	3	—
Barium	7/7	26 - 43	35	6
Calcium	7/7	22000 - 41000	30143	7128
Copper	7/7	9.4 - 56	18	17
Iron	7/7	160 - 910	285.7	275.6
Lead	2/7	3.2 - 7.2	5	—
Magnesium	7/7	4800 - 8800	6571.4	1453.4
Manganese	7/7	7.2 - 21	14	5
Mercury	1/7	—	0.1	—
Potassium	7/7	1200 - 3100	1985.71	753.7
Selenium	1/7	—	1	—
Silver	1/7	—	4	—
Sodium	7/7	3400 - 11000	6557	2693
Thallium	1/7	—	1	—
Zinc	7/7	66 - 280	105	78
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.4. Building 306: Volatile Organic Compounds

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acetone	2/8	14 - 15	14.5	—
Bromoform	1/8	—	2.0	—
Chloroform	7/8	0.9 - 1.8	1.4	0.3
Methylene chloride	2/8	1.1 - 1.2	1.2	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.5. Building 306: Radiological Parameters

Parameter	Frequency ^(a)	Concentration (pCi/L)		
		Range	Average	2SEM ^(b)
Gross alpha	7/7	0.9 - 6.4	3.7	1.3
Gross beta	5/7	2.4 - 19.7	7.4	6.4
Tritium	5/7	155.0 - 687.0	326.2	188.9
(a) Number of samples with detectable concentrations/total number of samples analyzed.				
(b) Two times the standard error of the calculated mean.				

Table F.6. Building 320: General Chemical Parameters Detected in Routine Samples

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Alkalinity	32/32	40000 - 130000	60469	19596
Chemical Oxygen Demand	6/32	3000 - 13000	7200	3720
Total carbon	32/32	11000 - 31000	16219	4301
Total dissolved solids	32/32	70000 - 210000	104063	33491
Total organic carbon	32/32	1000 - 3000	1781	608
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.7. Building 320: General Chemical Parameters Detected in Nonbusiness Day Samples

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Alkalinity	7/7	40000 - 70000	52290	9780
Total carbon	7/7	12000 - 17000	13857	2035
Total dissolved solids	7/7	80000 - 110000	91430	10690
Total organic carbon	7/7	1000 - 3000	1714	756
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.8. Building 320: Ammonia and Anions Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Ammonia	2/32	—	30	—
Chloride	32/32	2100 - 11800	5025	1854
Fluoride	29/32	274 - 700	516	112
Nitrate	32/32	100 - 15600	1997	3611
Sulfate	32/32	10000 - 23500	16472	2205
Sulfides	9/32	220 - 400	296	50
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.9. Building 320: Ammonia and Anions Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Ammonia	1/7	—	50	—
Chloride	7/7	1800 - 5500	4343	1204
Fluoride	7/7	200 - 900	571	221
Nitrate	7/7	200 - 1700	729	482
Sulfate	7/7	8500 - 18000	15643	3275
Sulfides	4/7	200 - 300	225	50
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.10. Building 320: Metals Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	31/32	29 - 140	65	29
Antimony	2/32	37 - 39	38	—
Arsenic	1/32	—	0.7	—
Barium	32/32	16 - 46	29	6
Beryllium	1/32	—	0.4	—
Cadmium	2/32	3.5 - 4.3	3.9	—
Calcium	32/32	18000 - 44000	22031	6167
Chromium	4/32	6 - 18	11	6
Cobalt	2/32	7.5 - 7.6	7.6	—
Copper	32/32	3.5 - 13	6.9	2.1
Iron	26/32	9 - 71	30	13
Lead	20/32	0.6 - 15.0	2.1	3.2
Magnesium	32/32	4000 - 9300	4869	1245
Manganese	19/32	0.9 - 7.1	1.5	1.4
Mercury	7/32	0.1 - 0.5	0.2	0.1
Potassium	20/32	860 - 2900	1444	515
Selenium	5/32	0.7 - 2.3	1.1	0.7
Sodium	32/32	2300 - 11000	3531	1999
Thallium	6/32	0.6 - 1.6	0.8	0.4
Tin	4/32	26 - 82	46	25
Zinc	32/32	11 - 120	29	19
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.11. Building 320: Metals Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	7/7	26 - 170	71	47
Arsenic	1/7	—	2	—
Barium	7/7	15 - 31	27	5
Cadmium	1/7	—	4	—
Calcium	7/7	18000 - 22000	19286	1254
Copper	7/7	3.4 - 14.0	6.9	3.3
Iron	4/7	25 - 62	38	17
Lead	6/7	0.6 - 1.2	0.9	0.2
Magnesium	7/7	3900 - 4400	4157	162
Manganese	4/7	1.2 - 1.6	1.3	0.2
Mercury	2/7	0.14 - 0.15	0.15	—
Potassium	3/7	990 - 1200	1097	105
Silver	1/7	—	5	—
Sodium	7/7	2500 - 3200	2843	230
Tin	2/7	24 - 66	45	—
Zinc	7/7	16 - 61	35	16
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.12. Building 320: Volatile Organic Compounds Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acetone	5/53	8.8 - 43	26.0	12.5
Acetonitrile	1/27	—	170.0	—
Bromodichloromethane	22/33	1.1 - 3.3	1.7	0.6
Bromoform	1/33	—	0.5	—
2-Butanone	1/53	—	26.0	—
Chloroform	53/53	6.9 - 32	19.2	6.4
Dibromochloromethane	3/33	1.4 - 2	1.8	0.3
Ethylbenzene	4/33	0.5 - 4.9	1.7	2.1
Hexone	4/53	24 - 110	54.8	39.7
Methylene chloride	39/53	0.4 - 1.6	1.1	0.4
Tetrahydrofuran	1/53	—	36.0	—
Toluene	2/53	0.14 - 0.18	0.16	—
1,1,1-Trichloroethane	3/53	1.2 - 2.6	1.77	0.7
Xylenes (total)	7/53	0.5 - 12.0	5.4	4.6
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.13. Building 320: Volatile Organic Compounds Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acetone	1/13	—	25.0	—
Bromodichloromethane	6/8	1.1 - 2.1	1.6	0.3
Chloroform	13/13	7.4 - 30.0	20.4	6.6
Ethylbenzene	1/8	—	0.8	—
Hexone	1/13	—	26.0	—
Methylene chloride	13/13	0.4 - 1.4	0.8	0.4
Toluene	1/13	—	0.2	—
Xylenes (total)	3/13	0.5 - 4.4	2.0	2.1
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.14. Building 320: Semivolatile Organic Compounds

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acids/Bases/Neutrals (ABNs)				
Di-n-butylphthalate	2/14	2.5 - 2.6	2.6	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.15. Building 320: Radiological Parameters Detected in Routine Samples

Parameter	Frequency ^(a)	Concentration (pCi/L)		
		Range	Average	2SEM ^(b)
Gross alpha	8/32	0.9 - 2.9	1.7	0.5
Gross beta	10/32	2.1 - 4.3	3.1	0.4
(a) Number of samples with detectable concentrations/total number of samples analyzed.				
(b) Two times the standard error of the calculated mean.				

Table F.16. Building 324 Process Sewer: General Chemical Parameters

Parameter	Frequency ^(a)	Concentration ($\mu\text{g/L}$)		
		Range	Average	Standard Deviation
Alkalinity	2/2	—	50000	—
Chemical Oxygen Demand	2/2	4200 - 6400	5300	—
Total carbon	2/2	14000 - 15000	14500	—
Total dissolved solids	2/2	80000 - 100000	90000	—
Total organic carbon	2/2	—	1000	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.17. Building 324 Process Sewer: Ammonia and Anions

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Chloride	2/2	3170 - 3430	3300.0	—
Fluoride	2/2	319 - 434	377	—
Nitrate	2/2	729 - 982	856	—
Sulfate	2/2	12900 - 15400	14150	—
Sulfides	1/2	—	300	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.18. Building 324 Process Sewer: Metals

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	2/2	49 - 66	58	—
Barium	2/2	25 - 28	27	—
Calcium	2/2	19000 - 20000	19500	—
Chromium	2/2	5.7 - 8.1	6.9	—
Copper	2/2	7.4 - 8.0	7.7	—
Iron	2/2	23 - 47	35	—
Magnesium	2/2	4400 - 4600	4500	—
Manganese	2/2	0.9 - 1.3	1.1	—
Mercury	1/2	—	0.1	—
Potassium	2/2	980 - 1500	1240	—
Sodium	2/2	2400 - 2900	2650	—
Thallium	1/2	—	1.1	—
Zinc	2/2	—	11	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.19. Building 324 Process Sewer: Volatile Organic Compounds

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Bromodichloromethane	3/3	0.8 - 1.6	1.2	0.4
Chloroform	3/3	4.9 - 8.9	7.4	2.2
Dibromochloromethane	2/3	0.6 - 1.4	1.0	—

(a) Number of samples with detectable concentrations/total number of samples analyzed.

Table F.20. Building 324 Process Sewer: Radiological Parameters

Parameter	Frequency ^(a)	Concentration (pCi/L)		
		Range	Average	2SEM ^(b)
Gross alpha	2/3	1.1 - 1.8	1.5	—
Gross beta	2/3	3.0 - 9.7	6.4	—
Tritium	2/2	172.0 - 545.0	358.5	—

(a) Number of samples with detectable concentrations/total number of samples analyzed.
(b) Two times the standard error of the calculated mean.

Table F.21. Building 324 Retention Process Sewer: General Chemical Parameters

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Alkalinity	3/3	48000 - 120000	72667	41004
Chemical Oxygen Demand	3/3	2800 - 8800	6800	3464
Total carbon	3/3	14000 - 30000	19667	8963
Total dissolved solids	3/3	90000 - 200000	126667	63509
Total organic carbon	3/3	600 - 1000	767	208

(a) Number of samples with detectable concentrations/total number of samples analyzed.

Table F.22. Building 324 Retention Process Sewer: Ammonia and Anions

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Ammonia	1/3	—	50	—
Chloride	3/3	3590 - 12000	6427	4827
Fluoride	3/3	322 - 379	341	33
Nitrate	3/3	685 - 15400	5748	8362
Sulfate	3/3	12600 - 23800	17467	5742
Sulfides	2/3	300 - 400	350	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.23. Building 324 Retention Process Sewer: Metals

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	2/3	56 - 58	57	—
Barium	3/3	25 - 48	34	13
Calcium	3/3	19000 - 45000	28000	14731
Copper	2/3	—	5.3	—
Iron	3/3	32 - 43	36	6
Magnesium	3/3	4400 - 9600	6233	2919
Manganese	3/3	1.7 - 2.1	2	0
Mercury	2/3	0.05 - 0.10	0.07	—
Potassium	2/3	1400 - 2900	2150	—
Sodium	3/3	2400 - 11000	5433	4827
Thallium	1/3	—	2	—
Zinc	2/3	7 - 9	8	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.24. Building 324 Retention Process Sewer: Volatile Organic Compounds

Constituent	Frequency ^(a)	Concentration ($\mu\text{g/L}$)		
		Range	Average	Standard Deviation
Bromodichloromethane	2/3	0.5 - 1.1	0.8	—
Chloroform	3/3	4.4 - 6.3	5.2	1.0
Dibromochloromethane	1/3	—	0.7	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.25. Building 324 Retention Process Sewer: Radiological Parameters

Parameter	Frequency ^(a)	Concentration (pCi/L)		
		Range	Average	2SEM ^(b)
Gross alpha	1/3	—	1.9	—
Gross beta	3/3	3.2 - 4.2	3.6	0.6
Tritium	3/3	136.0 - 627.0	421.7	294.6
(a) Number of samples with detectable concentrations/total number of samples analyzed.				
(b) Two times the standard error of the calculated mean.				

Table F.26. Building 326: General Chemical Parameters

Parameter	Frequency ^(a)	Concentration ($\mu\text{g/L}$)		
		Range	Average	Standard Deviation
Alkalinity	7/7	48000 - 130000	92571	29205
Chemical Oxygen Demand	6/7	9000 - 89000	33167	31288
Total carbon	7/7	14000 - 44000	29857	11082
Total dissolved solids	7/7	80000 - 210000	151429	50143
Total organic carbon	7/7	2000 - 24000	8286	7910
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.27. Building 326: Ammonia and Anions

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Ammonia	2/7	150 - 300	225	—
Chloride	7/7	5600 - 12000	8686	2432.5
Fluoride	7/7	265 - 544	404	102
Nitrate	7/7	1200 - 12400	7286	3830
Phosphate	1/7	—	1060	—
Sulfate	7/7	18200 - 53000	29771	14316
Sulfides	3/7	220 - 400	307	90
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.28. Building 326: Metals

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	7/7	29 - 100	58	26
Barium	7/7	26 - 42	34	6
Beryllium	1/7	—	0	—
Calcium	7/7	21000 - 43000	32286	7868
Chromium	3/7	5.0 - 6.6	5.8	0.8
Copper	7/7	35 - 140	80	46
Iron	7/7	23 - 350	198	125
Lead	5/7	1.9 - 8.6	4.0	2.7
Magnesium	7/7	4600 - 9100	6857	1722
Manganese	7/7	2 - 60	22	22
Mercury	2/7	0.11 - 0.23	0.17	—
Nickel	2/7	24 - 27	26	—
Potassium	7/7	1200 - 3400	2500	757
Selenium	1/7	—	1.2	—
Sodium	7/7	5500 - 24000	11071	6595
Thallium	2/7	0.9 - 1.2	1.1	—
Zinc	7/7	48 - 520	156	171
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.29. Building 326: Volatile Organic Compounds

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acetone	7/8	45 - 2535	505	908
Chloroform	6/8	0.6 - 1.9	1.2	0.5
Isopropyl alcohol	1/8	—	40798	—
Methylene chloride	2/8	—	1.2	—
Tetrahydrofuran	5/8	3.7 - 9.0	6.8	2.2
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.30. Building 326: Semivolatile Organic Compounds

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acids/Bases/Neutrals (ABNs)				
Di-n-octylphthalate	1/6	—	1.3	—
Diethylphthalate	1/6	—	6.6	—
Pesticides				
Aldrin	1/7	—	0.004	—
Alpha-BHC	2/7	0.001 - 0.002	0.002	—
Delta-BHC	1/7	—	0.004	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.31. Building 326: Radiological Parameters

Parameter	Frequency ^(a)	Concentration (pCi/L)		
		Range	Average	2SEM ^(b)
Gross alpha	2/7	1.3 - 1.7	1.5	—
Gross beta	6/7	2.5 - 7.8	5.0	1.4
Tritium	4/7	118.0 - 420.0	275.3	137.3
(a) Number of samples with detectable concentrations/total number of samples analyzed.				
(b) Two times the standard error of the calculated mean.				

Table F.32. Building 331: General Chemical Parameters Detected in Routine Samples

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Alkalinity	34/34	40000 - 130000	69250	21379
Chemical Oxygen Demand	27/33	6000 - 140000	20593	25755
Total carbon	33/33	14000 - 76000	22364	10591
Total dissolved solids	32/32	90000 - 480000	142188	69083
Total organic carbon	33/33	2000 - 61000	6394	10176
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.33. Building 331: General Chemical Parameters Detected in Nonbusiness Day Samples

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Alkalinity	5/5	45000 - 50000	48200	2050
Chemical Oxygen Demand	2/5	7000 - 8000	7500	710
Total carbon	5/5	13000 - 15000	13800	837
Total dissolved solids	5/5	90000 - 120000	102000	10950
Total organic carbon	5/5	2000 - 3000	2400	548
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.34. Building 331: Ammonia and Anions Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration ($\mu\text{g/L}$)		
		Range	Average	Standard Deviation
Ammonia	23/34	30 - 1000	169	270
Bromide	2/35	140 - 200	170	—
Chloride	35/35	3600 - 167000	12031	27068
Cyanide	25/32	1 - 70	19	22
Fluoride	35/35	400 - 900	643	126
Nitrate	35/35	300 - 33000	5803	7885
Nitrite	2/29	110 - 130	120	—
Phosphate	24/35	212 - 19800	3626	4083
Sulfate	35/35	10000 - 47900	19631	6332
Sulfides	12/33	200 - 400	235	64
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.35. Building 331: Ammonia and Anions Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration ($\mu\text{g/L}$)		
		Range	Average	Standard Deviation
Ammonia	3/5	23 - 30	28	4
Bromide	1/5	—	110	—
Chloride	5/5	4700 - 6800	6060	847
Cyanide	2/5	2 - 8	5	—
Fluoride	5/5	600 - 800	700	71
Nitrate	5/5	300 - 2700	1200	1005
Phosphate	1/5	—	2200	—
Sulfate	5/5	17000 - 21000	19000	1871
Sulfides	1/5	—	300	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.36. Building 331: Metals Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	32/33	22 - 630	168	178
Arsenic	5/33	2 - 3	2	1
Barium	33/33	17 - 41	29	5
Beryllium	1/33	—	0	—
Cadmium	2/33	—	3	—
Calcium	33/33	18000 - 43000	24424	6888
Chromium	4/33	7 - 22	17	7
Copper	33/33	10 - 110	30	22
Iron	31/33	18 - 460	81	85
Lead	27/33	0.6 - 17.0	2.6	3.1
Magnesium	33/33	4000 - 18000	5755	2439
Manganese	24/33	1 - 15	3	3
Mercury	7/33	0.06 - 0.17	0.11	0.04
Nickel	2/33	16 - 17	17	—
Potassium	32/33	940 - 7700	2670	1723
Selenium	1/33	—	2.0	—
Silver	1/33	—	3.6	—
Sodium	1/33	3300 - 110000	11958	18299
Thallium	33/33	0.8 - 1.1	1.0	—
Tin	5/33	24 - 110	71	31
Vanadium	1/33	—	7	—
Zinc	33/33	22 - 140	59	27

(a) Number of samples with detectable concentrations/total number of samples analyzed.

Table F.37. Building 331: Metals Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	5/5	56 - 81	70	11
Antimony	1/5	—	42	—
Barium	5/5	28 - 33	30	2
Calcium	5/5	19000 - 21000	20000	1000
Copper	5/5	10 - 36	20	13
Iron	4/5	23 - 65	39	19
Lead	3/5	0.7 - 1.5	1.1	0.4
Magnesium	5/5	4300 - 5000	4700	292
Manganese	1/5	—	3	—
Potassium	4/5	1000 - 2000	1400	432
Selenium	1/5	—	2	—
Silver	2/5	3.4 - 4.2	3.8	—
Sodium	5/5	3200 - 7200	4140	1714
Tin	1/5	—	33	—
Zinc	5/5	42 - 79	58	15
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.38. Building 331: Volatile Organic Compounds Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acetone	7/55	7.4 - 1800.0	284.9	668.2
Acetonitrile	1/26	—	430.0	—
Bromodichloromethane	16/32	0.5 - 9.8	2.3	2.3
Bromoform	1/32	—	26.0	—
2-Butanone	3/55	51 - 170	103.3	60.8
Chlorobenzene	1/26	—	0.4	—
Chloroform	55/55	3.1 - 33.0	11.4	6.5
Dibromochloromethane	6/32	0.7 - 11.0	2.7	4.1
Hexone	2/55	—	19.0	—
Methylene chloride	41/55	0.4 - 2.0	1.0	0.4
Tetrahydrofuran	1/55	—	3.0	—
Toluene	4/55	0.22 - 0.86	0.53	0.26
1,1,1-Trichloroethane	1/55	—	2.1	—
Trichloroethene	2/55	0.5 - 0.9	0.7	—
Xylenes (total)	3/55	1.4 - 2.4	1.8	0.5
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.39. Building 331: Volatile Organic Compounds Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acetone	1/10	—	67.0	—
Bromodichloromethane	6/8	1.2 - 9.5	3.2	3.2
Bromoform	1/8	—	15.0	—
Chloroform	10/10	8.6 - 26.0	16.9	5.3
Dibromochloromethane	2/8	1.7 - 11.0	6.4	—
Hexone	1/10	—	38.0	—
Methylene chloride	10/10	0.4 - 1.1	0.8	0.3
Toluene	2/10	0.4 - 0.5	0.5	—
Xylenes (total)	2/10	0.3 - 1.9	1.1	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.40. Building 331: Semivolatile Organic Compounds Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acids/Bases/Neutrals (ABNs)				
Benzyl alcohol	2/14	4.1 - 28.0	16.1	—
Bis(2-ethylhexyl)phthalate	6/35	1.7 - 6.4	3.7	2.1
Decane	1/21	—	37.0	—
Di-n-butylphthalate	4/14	2.0 - 3.6	2.5	0.8
Pesticides				
4,4'-DDE	3/34	0.002 - 0.720	0.242	0.414
Aldrin	1/34	—	0.011	—
Alpha-BHC	3/34	0.004 - 0.007	0.006	0.002
Beta-BHC	3/34	0.010 - 0.026	0.015	0.009
Delta-BHC	9/34	0.005 - 0.033	0.012	0.009
Dieldrin	1/34	—	0.003	—
Endosulfan I	5/34	0.002 - 0.005	0.003	0.001
Endrin	1/34	—	0.007	—
Endrin aldehyde	1/34	—	0.012	—
Gamma-BHC (Lindane)	5/34	0.002 - 0.004	0.003	0.001
Methoxychlor	1/34	—	0.019	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.41. Building 331: Semivolatile Organic Compounds Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acids/Bases/Neutrals (ABNs)				
Bis(2-ethylhexyl)phthalate	1/5	—	3.6	—
Pesticides				
Aldrin	1/5	—	0.004	—
Delta-BHC	1/5	—	0.017	—
Endosulfan I	1/5	—	0.006	—
Gamma-BHC (Lindane)	1/5	—	0.005	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.42. Building 331: Radiological Parameters Detected in Routine Samples

Parameter	Frequency ^(a)	Concentration (pCi/L)		
		Range	Average	2SEM ^(b)
Gross alpha	17/33	0.8 - 8.3	3.0	1.0
Gross beta	23/33	2.1 - 9.5	4.4	0.9
Tritium	2/2	280.0 - 330.0	305.0	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				
(b) Two times the standard error of the calculated mean.				

Table F.43. Building 331: Radiological Parameters Detected in Nonbusiness Day Samples

Parameter	Frequency ^(a)	Concentration (pCi/L)		
		Range	Average	2SEM ^(b)
Gross alpha	3/5	0.9 - 12.8	4.9	7.9
Gross beta	1/5	—	2.7	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				
(b) Two times the standard error of the calculated mean.				

Table F.44. Building 3720: General Chemical Parameters Detected in Routine Samples

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Alkalinity	29/29	40000 - 120000	58862	15887
Chemical Oxygen Demand	21/29	3000 - 51000	12900	11550
Total carbon	28/28	12000 - 30000	18036	4501
Total dissolved solids	27/27	80000 - 190000	105556	23751
Total organic carbon	28/28	1000 - 16000	3214	3011
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.45. Building 3720: General Chemical Parameters Detected in Nonbusiness Day Samples

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Alkalinity	6/6	40000 - 70000	52670	10630
Chemical Oxygen Demand	1/6	—	14000	—
Total carbon	6/6	11000 - 23000	15333	4227
Total dissolved solids	6/6	90000 - 100000	95000	5480
Total organic carbon	6/6	1000 - 5000	2333	1506
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.46. Building 3720: Ammonia and Anions Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration ($\mu\text{g/L}$)		
		Range	Average	Standard Deviation
Ammonia	5/29	30 - 100	74	36
Chloride	29/29	2200 - 11600	5658	1774
Cyanide	4/26	2 - 10	5	3
Fluoride	29/29	200 - 1000	554	162
Nitrate	29/29	600 - 16000	3234	3606
Sulfate	29/29	8500 - 28000	15879	3523
Sulfides	10/27	200 - 300	232	39
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.47. Building 3720: Ammonia and Anions Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration ($\mu\text{g/L}$)		
		Range	Average	Standard Deviation
Ammonia	1/6	—	23	—
Chloride	6/6	1900 - 5800	4167	1271
Fluoride	6/6	200 - 800	517	223
Nitrate	6/6	500 - 1600	867	398
Sulfate	6/6	15000 - 40000	19833	9908
Sulfides	3/6	200 - 300	267	58
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.48. Building 3720: Metals Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	28/29	21 - 140	69	29
Antimony	1/29	—	33	—
Arsenic	1/29	—	2	—
Barium	29/29	14 - 66	29	9
Cadmium	3/29	—	4	0
Calcium	29/29	19000 - 43000	21897	4723
Chromium	5/29	4.7 - 27.0	14	9
Copper	29/29	4 - 130	19	24
Iron	29/29	27 - 230	89	41
Lead	24/29	1.1 - 7.1	3.0	1.7
Magnesium	29/29	4000 - 9100	4803	1012
Manganese	27/29	1.0 - 13.0	4.2	2.8
Mercury	19/27	0.06 - 0.87	0.24	0.19
Nickel	4/29	15 - 18	17	1
Potassium	23/29	910 - 2800	1537	507
Selenium	3/29	0.6 - 2.0	1.1	0.8
Sodium	29/29	3000 - 13000	5766	2309
Thallium	5/29	0.6 - 2.0	1.1	0.5
Tin	6/29	34 - 65	47	14
Zinc	29/29	16 - 280	60	52
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.49. Building 3720: Metals Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	6/6	42 - 190	77	57
Barium	6/6	15 - 29	25	5
Cadmium	1/6	—	3	—
Calcium	6/6	19000 - 21000	19833	983
Cobalt	1/6	—	7	—
Copper	6/6	6.6 - 14.0	10.2	3.4
Iron	6/6	44 - 84	65	14
Lead	5/6	1.0 - 4.1	2.4	1.3
Magnesium	6/6	4100 - 4700	4283	223
Manganese	4/6	1.5 - 3.3	2.1	0.9
Mercury	5/6	0.11 - 0.26	0.18	0.06
Potassium	3/6	1000 - 1300	1100	173
Silver	1/6	—	4.7	—
Sodium	6/6	2700 - 3600	2983	407
Thallium	1/6	—	2	—
Tin	1/6	—	24	—
Zinc	6/6	15 - 49	34	12
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.50. Building 3720: Volatile Organic Compounds Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acetone	23/48	7.7 - 530.0	88.8	142.9
Acetonitrile	2/56	7.1 - 820.0	413.6	—
Bromodichloromethane	10/31	0.85 - 2.0	1.3	0.4
Carbon disulfide	1/44	—	2.5	—
Chloroform	47/48	2.5 - 32.0	12.4	5.4
Dibromochloromethane	1/31	—	1.7	—
1,2-Dichloroethylene	6/44	0.4 - 1.0	0.6	0.2
Ethanol	6/44	5.5 - 26.0	14.1	8.7
Diethyl ether	2/44	5.0 - 38.0	21.5	—
Ethylbenzene	3/31	0.4 - 0.9	0.6	0.2
Hexone	3/48	5.8 - 37.0	21.9	15.6
Isopropyl alcohol	11/44	5.2 - 34.0	13.1	8.6
Methylene chloride	39/48	0.4 - 9.7	1.4	1.5
Tetrahydrofuran	8/48	3.4 - 406.0	63.4	138.8
Toluene	7/48	0.1 - 410	69.4	150.8
1,1,2-Trichloroethane	1/44	—	0.8	—
Trichloroethene	47/48	0.7 - 2.1	1.3	0.4
Xylenes (total)	3/48	2.1 - 2.9	2.4	0.4
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.51. Building 3720: Volatile Organic Compounds Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acetone	2/11	25.0 - 37.0	31.0	—
Bromodichloromethane	1/6	—	2.0	—
Chlorobenzene	1/6	—	0.7	—
Chloroform	11/11	5.8 - 40.0	14.7	9.7
1,2-Dichloroethylene	4/11	0.4 - 1.1	0.7	0.3
Isopropyl alcohol	1/11	—	7.5	—
Methylene chloride	11/11	0.3 - 1.5	0.9	0.4
Tetrahydrofuran	1/11	—	7.0	—
Toluene	2/11	0.2 - 0.6	0.4	—
Trichloroethene	11/11	0.8 - 1.6	1.2	0.3
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.52. Building 3720: Semivolatile Organic Compounds Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acids/Bases/Neutrals (ABNs)				
Bis(2-ethylhexyl)phthalate	10/28	1.2 - 8.6	3.4	2.2
Di-n-butylphthalate	4/13	1.9 - 3.6	2.5	0.8
Diethylphthalate	3/14	35.0 - 170.0	81.3	76.8
Tributyl phosphate	2/28	5.6 - 9.8	7.7	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.53. Building 3720: Semivolatile Organic Compounds Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration ($\mu\text{g/L}$)		
		Range	Average	Standard Deviation
Bis(2-ethylhexyl)phthalate	2/6	1.5 - 7.6	4.6	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.54. Building 3720: Radiological Parameters Detected in Routine Samples

Parameter	Frequency ^(a)	Concentration (pCi/L)		
		Range	Average	2SEM ^(b)
Gross alpha	28/28	4.1 - 44.6	13.7	3.0
Gross beta	25/28	2.6 - 17.6	5.2	1.2
Uranium-234	1/1	—	8.0	—
Uranium-235	1/1	—	0.4	—
Uranium-238	1/1	—	6.5	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				
(b) Two times the standard error of the calculated mean.				

Table F.55. Building 3720: Radiological Parameters Detected in Nonbusiness Day Samples

Parameter	Frequency ^(a)	Concentration (pCi/L)		
		Range	Average	2SEM ^(b)
Gross alpha	6/6	7.4 - 28.0	17.3	5.8
Gross beta	5/6	4.0 - 10.6	6.1	2.3
(a) Number of samples with detectable concentrations/total number of samples analyzed.				
(b) Two times the standard error of the calculated mean.				

Table F.56. End-of-Pipe: General Chemical Parameters Detected in Routine Samples

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Alkalinity	28/28	40000 - 140000	59536	21852
Chemical Oxygen Demand	19/28	4700 - 84000	12953	17600
Total carbon	28/28	13000 - 42000	17929	5850
Total dissolved solids	27/27	80000 - 240000	109630	36319
Total organic carbon	29/29	1000 - 36000	3793	6315
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.57. End-of-Pipe: General Chemical Parameters Detected in Nonbusiness Day Samples

Parameter	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Alkalinity	7/7	40000 - 70000	53860	11580
Chemical Oxygen Demand	1/7	—	9000	—
Total carbon	6/6	12000 - 17000	14167	1941
Total dissolved solids	6/6	80000 - 100000	90000	6320
Total organic carbon	7/7	2000 - 3000	2143	378
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.58. End-of-Pipe: Ammonia and Anions Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration ($\mu\text{g/L}$)		
		Range	Average	Standard Deviation
Ammonia	8/26	23 - 100	48	28
Bromide	1/27	—	200	—
Chloride	27/27	2500 - 190000	14024	35457
Cyanide	4/28	1 - 5	3	2
Fluoride	26/27	200 - 800	565	158
Nitrate	27/27	200 - 20000	2988	4495
Phosphate	5/27	383 - 800	522	166
Sulfate	27/27	10000 - 36900	17756	4467
Sulfides	8/26	200 - 400	283	63
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.59. End-of-Pipe: Ammonia and Anions Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration ($\mu\text{g/L}$)		
		Range	Average	Standard Deviation
Ammonia	1/7	—	60	—
Chloride	7/7	2200 - 6100	4629	1743
Fluoride	7/7	200 - 800	486	248
Nitrate	7/7	500 - 900	714	177
Sulfate	7/7	10000 - 20000	15857	3848
Sulfides	2/6	—	200	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.60. End-of-Pipe: Metals Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	29/29	40 - 410	89	68
Arsenic	2/28	2 - 3	3	—
Barium	29/29	15 - 64	29	9
Beryllium	1/29	—	1	—
Calcium	29/29	18000 - 45000	23241	6828
Chromium	3/29	15 - 20	17	3
Copper	29/29	8 - 30	14	6
Iron	29/29	23 - 250	92	45
Lead	24/28	0.7 - 5.9	2.4	1.2
Magnesium	29/29	4200 - 10000	5221	1409
Manganese	29/29	1.5 - 9.3	3.0	1.7
Mercury	12/26	0.08 - 0.41	0.15	0.09
Nickel	2/29	16 - 18	17	—
Potassium	26/29	950 - 3100	1533	567
Selenium	2/28	1.1 - 2.0	1.6	—
Sodium	29/29	3200 - 95000	9969	17937
Thallium	2/28	1.4 - 2.0	1.7	—
Tin	7/29	26 - 68	42	17
Zinc	29/29	20 - 84	39	14
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.61. End-of-Pipe: Metals Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Aluminum	7/7	36 - 150	75	38
Arsenic	1/7	—	2	—
Barium	7/7	16 - 31	26	7
Cadmium	1/7	—	3	—
Calcium	7/7	19000 - 22000	20286	1254
Copper	7/7	9 - 15	11	2.1
Iron	7/7	55 - 90	75	12
Lead	6/7	1.3 - 3.0	2.3	0.8
Magnesium	7/7	4300 - 4800	4543	162
Manganese	6/7	1.4 - 3.5	2.2	0.7
Nickel	1/7	—	24	—
Potassium	7/7	940 - 1700	1304	325
Sodium	7/7	3200 - 4100	3514	372
Tin	1/7	—	100	—
Zinc	7/7	18 - 52	32	14
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.62. End-of-Pipe: Volatile Organic Compounds Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acetone	10/47	13 - 63	33.6	16.7
Acetonitrile	1/24	—	76.0	—
Bromodichloromethane	15/29	0.9 - 3.2	2.0	0.7
Bromoform	2/29	0.5 - 0.9	0.7	—
Chloroform	47/47	3.4 - 20.0	11.2	4.1
Dibromochloromethane	7/29	1.0 - 2.2	1.6	0.4
Ethylbenzene	1/29	—	0.2	—
Hexone	1/47	—	10.0	—
Isopropyl alcohol	1/47	—	575.0	—
Methylene chloride	38/47	0.2 - 1.6	0.9	0.4
Tetrachloroethene	1/47	—	2.0	—
Tetrahydrofuran	2/47	7.4 - 9.4	8.4	—
Toluene	1/47	—	1.4	—
1,1,1-Trichloroethane	1/47	—	1.4	—
Trichloroethene	5/47	0.3 - 0.7	0.5	0.1
Trichlorofluoromethane	3/24	1.4 - 4.4	2.4	1.7
Xylenes (total)	5/47	0.5 - 1.6	1.1	0.4
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.63. End-of-Pipe: Volatile Organic Compounds Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acetone	1/13	—	33.0	—
Bromodichloromethane	3/6	1.8 - 3.3	2.4	0.8
Bromoform	1/6	—	1.7	—
Chloroform	13/13	3.1 - 18.0	9.2	4.6
Dibromochloromethane	2/6	1.0 - 2.7	1.9	—
Hexone	2/13	20.0 - 33.0	26.5	—
Methylene chloride	13/13	0.3 - 1.4	0.7	0.5
Tetrachloroethene	1/13	—	0.5	—
Trichloroethene	1/7	—	0.8	—
Trichlorofluoromethane	2/6	1.7 - 4.2	3.0	1.8
Xylenes (total)	1/13	—	2.0	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.64. End-of-Pipe: Semivolatile Organic Compounds Detected in Routine Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acids/Bases/Neutrals (ABNs)				
Bis(2-ethylhexyl)phthalate	11/28	2.0 - 38.0	21.9	10.5
Butylbenzylphthalate	1/12	—	7.6	—
Di-n-butylphthalate	4/12	2.6 - 5.7	3.9	1.3
Tributyl phosphate	1/28	—	6.4	—
Pesticides				
4,4'-DDE	2/26	0.004 - 0.024	0.014	—
Beta-BHC	1/26	—	0.002	—
Delta-BHC	6/26	0.002 - 0.014	0.006	0.005
Endosulfan I	2/26	0.004 - 0.005	0.005	—
Endosulfan sulfate	1/26	—	0.036	—
Gamma-BHC (Lindane)	1/26	—	0.003	—
Heptachlor	2/26	0.008 - 0.010	0.009	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.65. End-of-Pipe: Semivolatile Organic Compounds Detected in Nonbusiness Day Samples

Constituent	Frequency ^(a)	Concentration (µg/L)		
		Range	Average	Standard Deviation
Acids/Bases/Neutrals (ABNs)				
Bis(2-ethylhexyl)phthalate	3/7	16.0 - 31.0	22.7	7.6
Pesticides				
Delta-BHC	1/6	—	0.013	—
Heptachlor	2/6	0.008 - 0.013	0.011	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				

Table F.66. End-of-Pipe: Radiological Parameters Detected in Routine Samples

Parameter	Frequency ^(a)	Concentration (pCi/L)		
		Range	Average	2SEM ^(b)
Gross alpha	26/27	1.4 - 9.2	3.3	0.8
Gross beta	16/27	2.1 - 12.5	3.8	1.2
Tritium	1/10	—	227.0	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				
(b) Two times the standard error of the calculated mean.				

Table F.67. End-of-Pipe: Radiological Parameters Detected in Nonbusiness Day Samples

Parameter	Frequency ^(a)	Concentration (pCi/L)		
		Range	Average	2SEM ^(b)
Gross alpha	7/7	1.3 - 4.4	2.4	0.9
Gross beta	3/7	2.2 - 2.7	2.4	0.3
Tritium	1/3	—	423.0	—
(a) Number of samples with detectable concentrations/total number of samples analyzed.				
(b) Two times the standard error of the calculated mean.				

Appendix G

Glossary

Appendix G

Glossary

alkalinity	a property of water which indicates its capacity to neutralize a strong acid to a designated pH.
alternate influent	water from the city of Richland that has undergone chlorination and filtration. Alternate influent is supplied to the Hanford Site at Building 382B.
bottle blank	a blank sample which is prepared by filling a sample bottle with reagent water and any preservatives used with actual field samples. Bottle blanks are not transported to the field. Bottle blanks are used to assess sample contamination from bottles and sample preservatives.
building	a structure with a roof and walls on the Hanford Site (also called a facility).
Chemical Oxygen Demand	a measure of the oxygen required to oxidize all organic and inorganic compounds in water.
composite sample	sample collected over time in small increments.
constituent	a chemical or radiological component of a mixture or solution (for example, chloroform is a chemical constituent in the treated influent).
daily-trip blank	a bottle blank which is transported out to the field (unopened at all times). Daily-trip blanks are used to check for contamination from bottles, sample preparation, and handling. Unlike full-trip blanks which may be analyzed for all constituent classes, daily-trip blanks are exclusively prepared and analyzed for volatile organic compounds.
diverter station	when retention process sewer water leaves a building it goes through a retention process sewer electric valve. This valve diverts the water to the radioactive liquid waste system if the radiation monitor detects radiation.

If the water is not radioactive, it is sent to the 307 Basins.

effluent	treated or untreated water that flows out of a building, treatment plant, sewer, or industrial outfall. Generally, this refers to wastes that are discharged into surface waters (such as the Columbia River) and are regulated under the Clean Water Act.
end-of-pipe	a location south of the Treated Effluent Disposal Facility Collection Sump where all of the 300 Area process and retention process sewer streams meet.
equipment blank	a blank sample which consists of preservatives and reagent water which has been passed through and collected by a sampler. Equipment blanks provide a check on sampler cleanliness and potential contamination from sampler components, such as tubing.
field-transfer blank	a blank sample which is prepared at the sampling site by pouring reagent water into a sample bottle and adding any preservatives used with effluent samples. Field-transfer blanks are used to quantify sample contamination which arises from conditions at the sampling location.
flow-proportional composite sample	a composite sample in which an increment is collected every time a specified volume of water has flowed past the sampling point (for example, a system might be set to collect 1 L every time 500 have passed the system).
grab sample	a sample collected by rapidly filling a sample container with sample solution (i.e., effluent). Unlike composite samples, grab samples represent only a "snapshot" of the waste stream.
full-trip blank	a bottle blank which is transported out to the field (unopened at all times). Full-trip blanks are used to check for contamination from bottles, sample preparation, and handling.
laboratory reagent blank	a blank sample that consists of reagent water which is carried through an entire analysis procedure, including the addition of any required chemicals. Laboratory reagent blanks provide an indication of contamination during analysis.

maximum contaminant levels	the highest permissible amount of a chemical or radiological constituent in water delivered to any user of a public water system. Maximum contaminant levels are enforceable standards.
method detection limit	the minimum concentration of a compound that can be measured and reported with a 99% probability that the value is above zero.
National Pollutant Discharge Elimination System (NPDES)	a provision of the Clean Water Act that prohibits discharge of pollutants into waters within the U.S. unless a special permit is issued by the U.S. Environmental Protection Agency, a state (where delegated), or a tribal government on an Indian reservation.
nonbusiness day sample	a sample collected on a weekend (Saturday or Sunday) or a holiday (e.g., Memorial Day).
nonregulated constituent	chemical or radiological compounds which do not have specified concentration limits set by the U.S. Environmental Protection Agency
quality control	the planned and systematic actions that provide a way to control and measure the characteristics of equipment and processes to meet established requirements.
regulated constituent	chemical or radiological compounds which have specified concentration limits set by the U.S. Environmental Protection Agency.
relative percent difference	a measure of how similar two numbers are to each other. The RPD is calculated using <div data-bbox="885 1390 1234 1461" data-label="Equation-Block"> $RPD = \frac{ x_1 - x_2 }{\bar{x}} \times 100$ </div> <p>where x_1 and x_2 are the numbers being compared, and $\bar{x}$ is their average.</p>
routine sample	a sample of effluent or influent taken on a regularly scheduled workday (Monday through Friday).
semivolatile organic compound	an organic compound with a relatively high boiling point and a low vapor pressure at room temperature.

standard error of
the mean (SEM)

a measure of the variability of an estimated mean,
which is calculated using the formula

$$\text{SEM} = \sigma/\sqrt{n}$$

where n is the number of measurements, and σ is the standard deviation of the measurements. If the data follows a normal distribution, there is a 95% probability that the true mean falls within the estimated mean plus or minus two times the standard error of the mean (2SEM).

statement of work

a work document that provides the technical and quality assurance requirements applicable to a specific work activity.

time-proportional
composite sample

a composite sample in which an increment is collected at uniformly spaced time intervals (for example, a sampling system might be set to collect 1 L every 2 hours)

total carbon

a measure of the total carbon content of water, which arises from both organic and inorganic constituents.

total organic carbon

a measure of the organic chemical content of water.

total dissolved solids

a measure of dissolved and suspended solids in a wastewater sample. Generally, total dissolved solids are determined by drying the sample and weighing the remaining residue.

treated influent

water taken from the Columbia River at the 312 Intake Pumphouse that has undergone chlorination and filtration at Building 315.

trihalomethane

an organic compound similar to methane which contains a carbon atom, a hydrogen atom, and three halogen atoms such as chlorine or bromine. Trihalomethanes are common byproducts of water chlorination.

untreated influent

water taken from the Columbia River at the 312 Intake Pumphouse that has not undergone chlorination and filtration.

volatile organic compound

an organic compound with a low boiling point and a high vapor pressure at room temperature.

waste acceptance criteria

the criteria that the liquid waste stream to the Treated Effluent Disposal Facility (TEDF) must meet to ensure that the TEDF can meet regulatory requirements.