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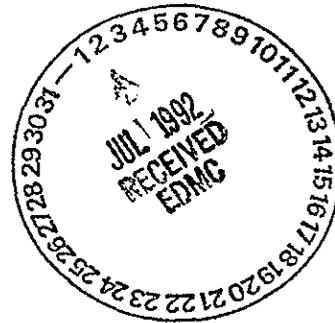
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DOE/RL-92-12
Revision 1

Sampling and Analysis of 100 Area Springs

Date Published
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United States
Department of Energy

P.O. Box 550
Richland, Washington 99352

Approved for Public Release

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EXECUTIVE SUMMARY

This revision to DOE/RL-92-12 provides revised data tables and assessment of those data. The revision is necessary to present all of the validated data available from the 1991 sampling of the Columbia River, Seeps and Springs and Sediments adjacent to the Hanford 100 Area National Priorities List Site. The original document DOE/RL-92-12, Sampling and Analysis of 100 Area Springs was provided to meet Tri-Party Agreement Milestone 30-01. That milestone was met within its appointed schedule only by providing non-validated data and by leaving out analyses from three sampling locations, because the data had not been returned from the analytical laboratory at the time of publication.

Revision 1 replaces, in its entirety, document DOE/RL-92-12. Revision 1 of DOE/RL-92-12 provides updated and complete data tables (replacements of Appendices C, D, and E) and an assessment of the entire data set. The numbering scheme for sample locations and for sample numbers has been revised and are listed completely in Appendix F. Sample locations are now assigned a alpha-numeric code. Sample numbers have been revised so that each sample type, e.g., unfiltered spring water, filtered spring water, unfiltered river water, filtered river water, and sediment have a unique number. Appendix F also presents the original sample numbers, and the revised sample numbers. In addition, an extensive discussion covering the validation of radiochemical analyses specific to samples from the study is provided as Appendix G.

The new data received from the laboratory and the validation process served to confirm the assessment provided in the earlier report. The sediment analysis associated with the 100-D Area showed the highest levels of chromium of the samples analyzed. This highest concentration of chromium in the sediments corresponds with the highest levels determined in spring discharges.

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CONTENTS

1.0	INTRODUCTION	1
1.1	PURPOSE AND SCOPE	1
1.2	OVERVIEW	1
1.3	PREVIOUS STUDIES	3
1.4	RELATIONSHIP TO THE GROUNDWATER MONITORING PROGRAM	3
2.0	HYDROLOGIC SETTING	3
3.0	SPRINGS	4
3.1	SELECTION OF SPRINGS	4
3.2	SAMPLING	5
3.2.1	River Stage	5
3.2.2	Evaluation of Springs Prior to Sampling	5
3.2.3	Sample Collection	14
3.2.4	Sample Handling	14
3.2.5	Quality Assurance/Quality Control	27
3.3	DATA ASSESSMENT	27
3.3.1	Primary Contaminants	27
3.3.2	Contaminants Discharged Through Springs by Area	28
3.3.2.1	100-B/C Area	28
3.3.2.2	100-K Area	29
3.3.2.3	100-N Area	29
3.3.2.4	100-D Area	31
3.3.2.5	100-H Area	32
3.3.2.6	100-F Area	33
3.3.2.7	Hanford Townsite	34
4.0	PRELIMINARY ASSESSMENT OF IMPACT	34
4.1	COLUMBIA RIVER	34
4.2	SPRINGS	35
5.0	RECOMMENDATIONS	35
5.1	PROCEDURAL CHANGES	36
5.1.1	Presampling Trend Measurements	36
5.1.2	Locating Identification Cairns	36
5.1.3	Sediment Sample Depth	36
5.1.4	Installation of Well Points	37
5.1.5	Sample Collection Sequence	37
5.1.6	Sample Containers	37
5.2	ADMINISTRATIVE/PROCESS CHANGES	37
5.2.1	Communication	37
5.2.2	Sample Refrigeration	38
5.2.3	Flow Control	38
5.2.4	Instruments	38
5.2.5	Absolute Location	38
5.2.6	Spring Notation	38
5.3	SCOPE CHANGES	38
5.3.1	Number of Springs Sampled	39
5.3.2	Collection of Near Shore River Samples	39
6.0	REFERENCES	39

CONTENTS (cont)

APPENDIXES

A	HANFORD REACH SPRING SAMPLING PROCEDURE.	A-1
B	NONCONFORMANCES AND VARIANCES TO APPROVED PROCEDURE.	B-1
C	CHEMICAL ANALYSES OF WATER SAMPLES.	C-1
D	RADIOLOGICAL ANALYSES OF WATER SAMPLES	D-1
E	CHEMICAL AND RADIOLOGICAL ANALYSES OF SEDIMENTS.	E-1
F	SHORELINE SAMPLING LOCATIONS AND SAMPLE NUMBERS	F-1
G	VALIDATION OF 100 AREA SPRINGS RADIOCHEMICAL DATA	G-1

FIGURES

1	Locations of Spring Sampled During 1991.	2
2	Relationship of 10-yr Average, 1991 14-day Average, and Daily Discharge. September 16 to October 21, 1991.	7
3	Time vs. Temperature, 100-B/C Area.	8
4	Time vs. Temperature, 100-D/K Areas.	9
5	Time vs. Temperature, 100-N Area.	10
6	Time vs. Temperature, 100-H Area.	11
7	Time vs. Temperature, 100-F Area.	12
8	Time vs. Temperature, Hanford Townsite.	13
9	Time vs. pH, 100-B/C Area.	15
10	Time vs. pH, 100-D/K Areas.	16
11	Time vs. pH, 100-N Area.	17
12	Time vs. pH, 100-H Area.	18
13	Time vs. pH, 100-F Area.	19
14	Time vs. pH, Hanford Townsite.	20
15	Time vs. Electrical Conductivity, 100-B/C Area.	21
16	Time vs. Electrical Conductivity, 100-D/K Area.	22
17	Time vs. Electrical Conductivity, 100-N Area.	23
18	Time vs. Electrical Conductivity, 100-H Area.	24
19	Time vs. Electrical Conductivity, 100-F Area.	25
20	Time vs. Electrical Conductivity, Hanford Townsite.	26

TABLES

1	Columbia River Discharge, Historical and Period of Sampling.	6
2	Calculated Concentration Due to 100 Area Spring Discharges	35

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1.0 INTRODUCTION

Springs and seeps discharge groundwater to the Columbia River along both banks within the Hanford Reach. The springs located along the Benton County bank are potentially impacted by nuclear operations on the Hanford Site.

1.1 PURPOSE AND SCOPE

This study was initiated to ascertain the concentrations of chemical and radiological constituents discharged through springs into the Columbia River. Definition of the chemical and radiological concentrations retained on sediments adjacent to springs was attempted. Sediment samples were collected adjacent to the springs to indicate retention of contaminants by the sediments. Near-shore river water samples were also collected adjacent to the springs.

River, spring, and sediment sampling was limited to those locations along the Hanford bank of the Columbia River where springs discharged at sufficient volume to allow sampling. The area of interest (Figure 1) extended from immediately above the 100-B/C Area water intake (3.7 mi below the Vernita Bridge) to the Hanford Townsite (25.2 mi below the bridge).

Sampling was conducted during the period of annual minimum stream flow so that the greatest number of springs would be exposed and to provide the greatest probability to sample the highest concentrations of potential contaminants in the spring water by minimizing the effects of precedent bank storage. Maximum concentrations of contaminants would be those found in nearby groundwater that was uninfluenced by mixing with surface water.

1.2 OVERVIEW

Water and sediment samples were collected from 26 locations between September 16, 1991, and October 21, 1991, coinciding with the normal low-flow period of the Columbia River. Samples were submitted for chemical and radiological analyses following onsite screening for radioactivity. Samples were controlled under standard chain-of-custody procedures (WHC 1988) following their collection.

Samples were collected from the south and west bank of the Columbia River, within the Hanford Reach. The most upstream sample was collected above the intake structure at the 100-B/C reactor area. Maps of springs sampled during 1984 and 1988 were used to help locate probable spring locations, no springs were noted above this location. The most downstream sample was collected in the vicinity of the Hanford Townsite downstream of the 100 Area National Priority List (NPL) site boundary.

Samples were collected in accordance with a sampling procedure developed specifically for this task (Appendix A). Onsite screening for radioactive constituents was conducted at the radiological laboratory at the 100-N Area. No samples were found to exceed radiological standards for shipping.

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1.3 PREVIOUS STUDIES

Studies addressing groundwater discharge impacts on the quality of the Columbia River have been conducted along the Hanford Reach over the past several years. These studies were conducted through Pacific Northwest Laboratory (PNL) as part of the Environmental Assessment Program for the Hanford Site (McCormack and Carlile 1984) (Dirkes 1990). This study differs from the earlier efforts in that the samples were collected, handled, and analyzed in accordance with established and defined *Comprehensive Environmental Response Compensation and Liability Act of 1980* (CERCLA) protocols. Approximate sampling locations used in the previous efforts were obtained from PNL on map plots at a scale of 1:2000. The detailed work of walking the riverbank and locating individual springs conducted by McCormack and Carlile (1984) was not repeated during this effort. Those areas indicated on the plots provided by PNL were surveyed in the field to pinpoint springs and seeps that could be sampled.

1.4 RELATIONSHIP TO THE GROUNDWATER MONITORING PROGRAM

Groundwater beneath the Hanford Site is monitored through several ongoing programs. The site-wide Groundwater Monitoring Program is conducted by PNL for the U.S. Department of Energy. Sampling frequencies and analytical parameters used in this program are determined through an assessment of the activities that can affect groundwater quality. The program is used to assess onsite and offsite impacts due to Hanford groundwater discharges. In addition to the site-wide program, specific subareas are monitored on supplemental schedules for other parameters. Schedules for special efforts are driven by operating needs and/or the requirements of investigations under CERCLA and *Resource Conservation and Recovery Act of 1976* (RCRA). The data developed during this effort provide a point-in-time check of the Hanford contributions to the chemistry of the Columbia River.

2.0 HYDROLOGIC SETTING

The Hanford Reach of the Columbia River extends from Priest Rapids Dam, approximately 10 mi upstream of the Vernita Bridge to the Hanford Site 300 Area, approximately 44 mi downstream of the bridge. The river in this reach is the only remaining free flowing section above Bonneville Dam.

In this reach of the river, flow is controlled by Priest Rapids Dam. There are no backwater effects of the downstream impoundment at McNary Dam. Flow is contained within the natural channel of the river. The Columbia River exhibits a normal distribution of discharge that peaks between April and June due to snowmelt and is at its minimum during the late fall and early winter. Superimposed on this natural flow distribution are hourly, daily, and weekly perturbations caused by power generation through the network of Columbia River hydroelectric dams, most directly by Priest Rapids Dam, approximately 13 mi upstream of the first sampling point.

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During the periods of peak flow (annual and daily), the river may rise above the level of adjacent groundwater, causing a reversal of flow direction. Surface water is temporarily stored in the bank sediments during these events. As river stage drops, this water is discharged from the sediments back into the river; this phenomenon is referred to as "bank storage". During extended periods of high river stage, the groundwater is restricted from discharging to the river by the "hydraulic dam" of temporarily stored surface water. As the river level recedes a mixture of surface and groundwater is released. As time progresses the discharged water becomes more representative of groundwater.

Groundwater discharges to the Columbia River along both banks within the Hanford Reach. These discharges are the result of natural and anthropogenic influences. Groundwater flows in a general northerly to easterly direction from the highlands that border the Hanford Site toward the Columbia River. This natural flow system is influenced by a variety of activities on the Hanford Site that dispose of water to the ground. This water is predominately discharged to the ground in the central portions of the site, and does include or has included contaminated waste streams. Plutonium production reactors located adjacent to the river discharged large volumes of water (contaminated and noncontaminated) directly to the river and to disposal trenches located near the river. These activities have resulted in the distribution of contaminants addressed in this study.

Of interest to this study are the effects of Hanford operations on the chemistry of groundwater discharges to the river and ultimately the effects of those discharges on the quality of the Columbia River. At several locations, the groundwater discharges occur as recognizable springs emanating from the banks. Figure 1 shows the locations where springs were identified and sampled during this project.

3.0 SPRINGS

In an attempt to provide comparability with the previous PNL studies by McCormack and Carlile (1984) Dirkes (1990), maps were obtained from PNL showing the approximate locations sampled during that effort. Descriptions of the springs located between the Vernita Bridge and the Hanford Townsite were then used as a basis for developing plans and estimates of the effort required for sampling.

3.1 SELECTION OF SPRINGS

The spring location maps provided by PNL were field checked to assess their representativeness under the 1991 Columbia River flow regime. Springs that were accessible for sampling were selected from the mapped locations of springs and seeps. A general selection occurred during a 1-d field reconnaissance prior to onset of sampling. As the field work continued, additional springs were located and sampled. Locations of the selected springs were mapped in the field as they were sampled.

3.2 SAMPLING

Access and availability of springs for sampling are dependant on the stage of the Columbia River. Average annual flow of the Columbia River is approximately 120,000 ft³/s. Criteria developed for the sampling stated that sampling would be conducted only when the running 14-d average flow of the river was below 120,000 ft³/s.

3.2.1 River Stage

River discharge at Priest Rapids Dam was obtained through the system dispatcher for the Grant County Public Utility District in Ephrata, Washington. The Hanford Reach of the Columbia River is subject to frequent and rapid changes in discharge due to operations of Priest Rapids Dam. The availability of springs for sampling depends on river stage. Discharge during sampling was generally lowest early in the day, rising noticeably around noon and then receding sometime after dark. Over the period of this study, flows were generally highest during mid-week and lowest on the weekends. River discharge forecasts were obtained prior to attempting to sample springs exposed only at very low stage. These forecasts proved generally unreliable as power needs varied. Sampling efforts were aborted on several occasions when the river rose and inundated spring locations.

The previous 10 yr of record for daily discharge of the Columbia River at Priest Rapids Dam were obtained from the U.S. Geological Survey (USGS), Water Resources Division. A comparison of the 10-yr average derived from the USGS data and the discharge reported by the Grant County Public Utility District for the period of sampling are shown in Table 1 and graphically presented in Figure 2. Discharge during the sampling period was generally greater than the 10-yr average.

3.2.2 Evaluation of Springs Prior to Sampling

Measurements of spring temperature, pH, and conductivity were taken at 5-min intervals for a period of 1 h prior to attempting collection of samples for analysis.

Temperature: Measurements were obtained by placing the instrument thermistor probe in the spring and recording the temperature. Care was taken to minimize external influences by shading the spring during the period of measurement. Spring temperatures remained generally stable, and only one sampling point changed more than 0.7°C during the 1-h period.

The premise behind the 1 h of measurements was that if a substantial portion of the spring discharge was derived from bank storage the temperature would be expected to approach groundwater temperature as time progressed. Figures 3 through 8 show the relationship of time verses temperature for the springs sampled. In the majority of cases, temperature had stabilized for more than three consecutive measurements before the springs were sampled.

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Table 1. Columbia River Discharge, Historical and Period of Sampling.

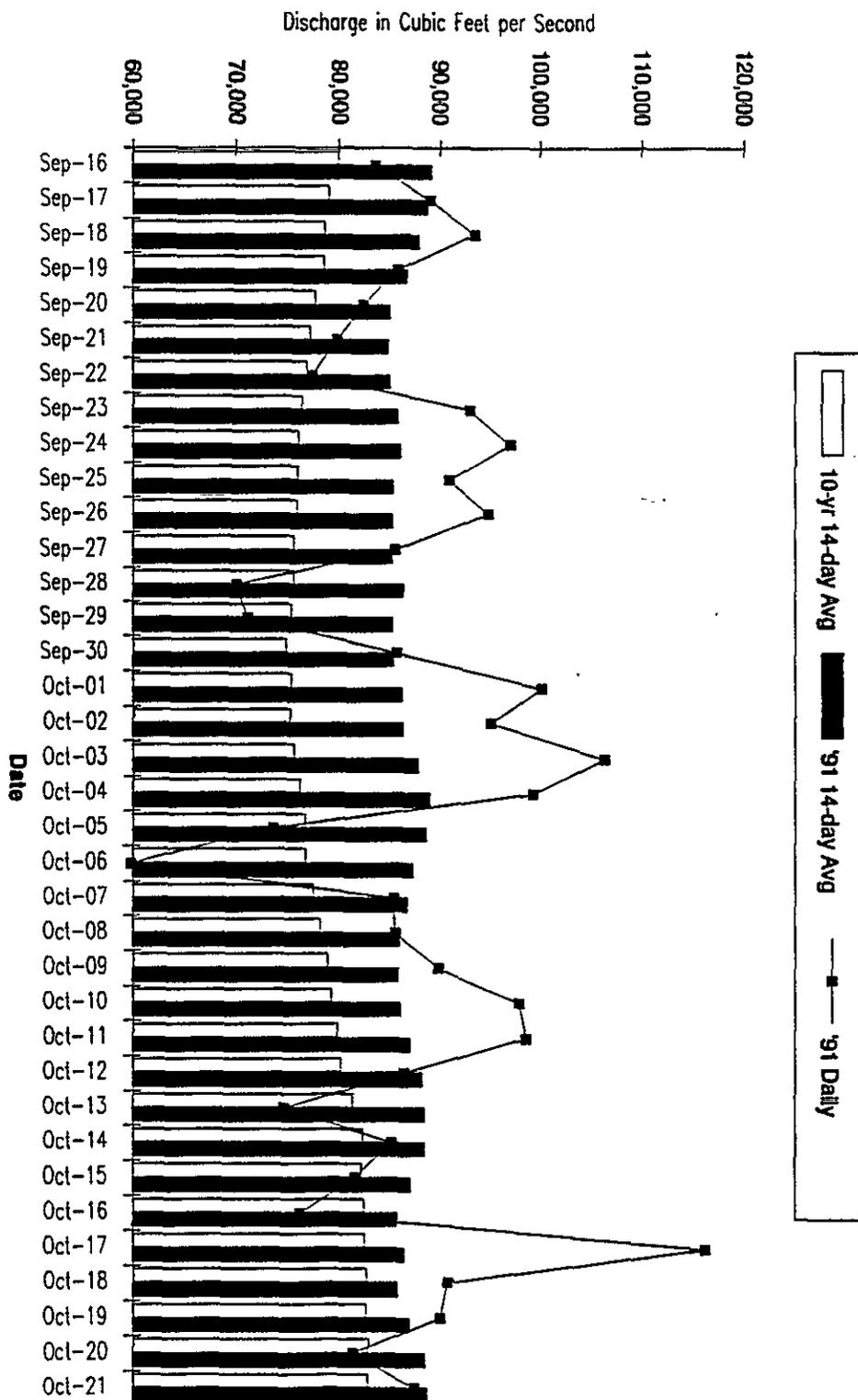
<u>Date</u>	<u>10-year 14-day Avg.¹</u>	<u>1991 14-day Avg.²</u>	<u>1991 Daily</u>
Sept-16	79,407	89,162	83,600
Sept-17	78,448	88,708	89,000
Sept-18	78,679	87,923	93,500
Sept-19	78,554	86,731	85,800
Sept-20	77,724	85,015	82,400
Sept-21	77,194	84,869	79,800
Sept-22	76,926	85,038	77,400
Sept-23	76,444	85,846	93,000
Sept-24	76,109	86,038	97,000
Sept-25	76,029	85,385	90,900
Sept-26	75,961	85,238	94,800
Sept-27	75,686	85,262	85,500
Sept-28	75,606	86,362	70,000
Sept-29	75,385	85,271	71,100
Sept-30	74,852	85,421	85,700
Oct-01	75,404	86,214	100,100
Oct-02	75,296	86,329	95,100
Oct-03	75,689	87,793	106,300
Oct-04	76,259	89,000	99,300
Oct-05	76,776	88,557	73,600
Oct-06	76,811	87,300	59,800
Oct-07	77,541	86,757	85,400
Oct-08	78,199	85,943	85,600
Oct-09	78,866	85,864	89,800
Oct-10	79,223	86,086	97,900
Oct-11	79,839	87,021	98,600
Oct-12	80,167	88,193	86,400
Oct-13	81,350	88,450	74,700
Oct-14	82,317	88,414	85,200
Oct-15	82,233	87,093	81,600
Oct-16	82,462	85,742	76,200
Oct-17	82,561	86,450	116,200
Oct-18	82,727	85,843	90,800
Oct-19	82,719	87,014	90,000
Oct-20	82,914	88,557	81,400
Oct-21	82,889	88,707	87,500

¹⁾ 10-yr 14-day average -- The running 14-day average flow, derived using the 10-yr daily mean flow (USGS Data).

²⁾ 1991 14-day average -- The running 14-day average flow at Priest Rapids Dam, obtained from Grant County Public Utility District, for the days of concern.

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Figure 2. Relationship of 10-yr Average, 1991 14-day Average, and Daily Discharge. September 16 to October 21, 1991.



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Figure 3. Time vs. Temperature, 100-B/C Area.

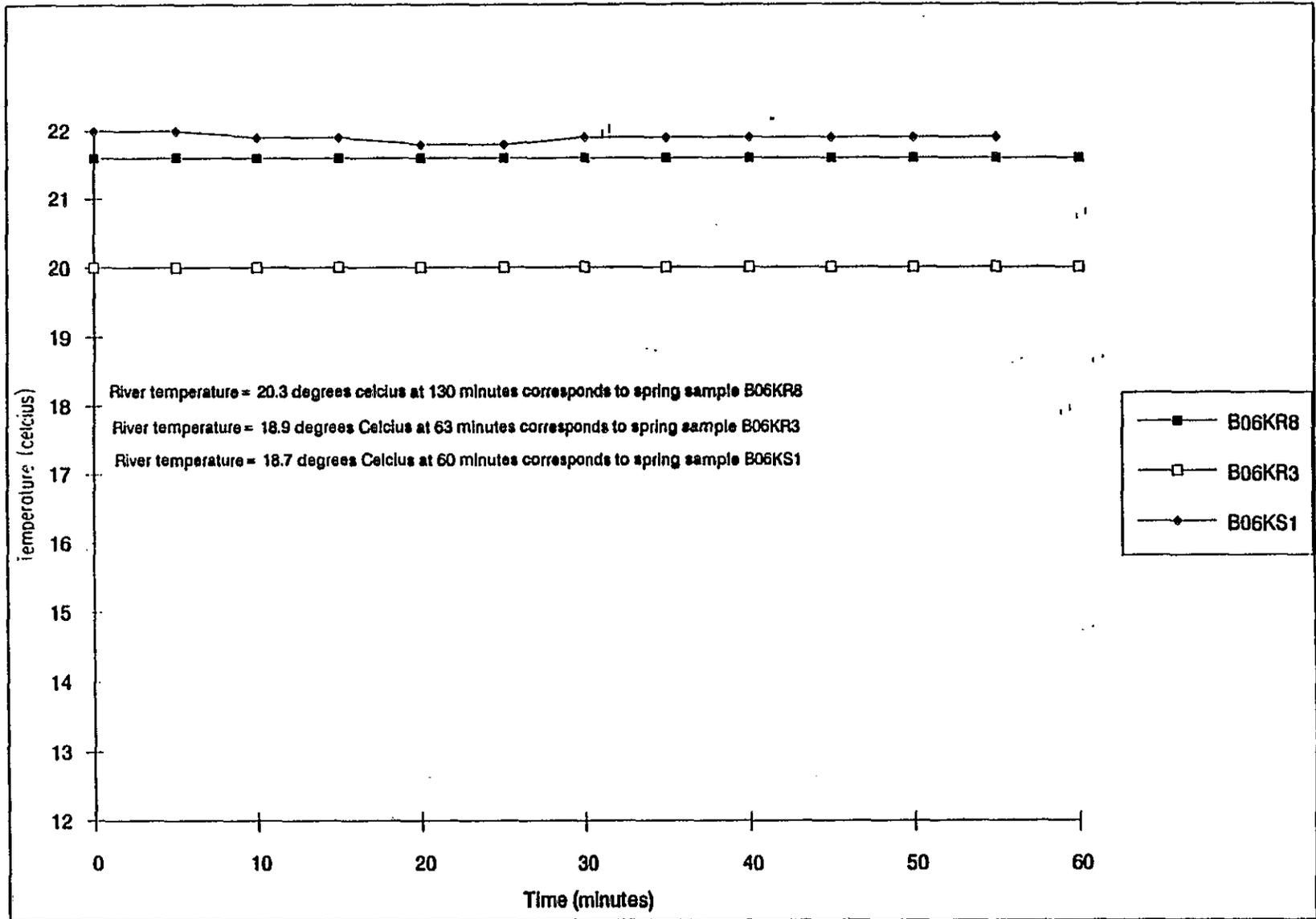


Figure 4. Time vs. Temperature, 100-D/K Areas.

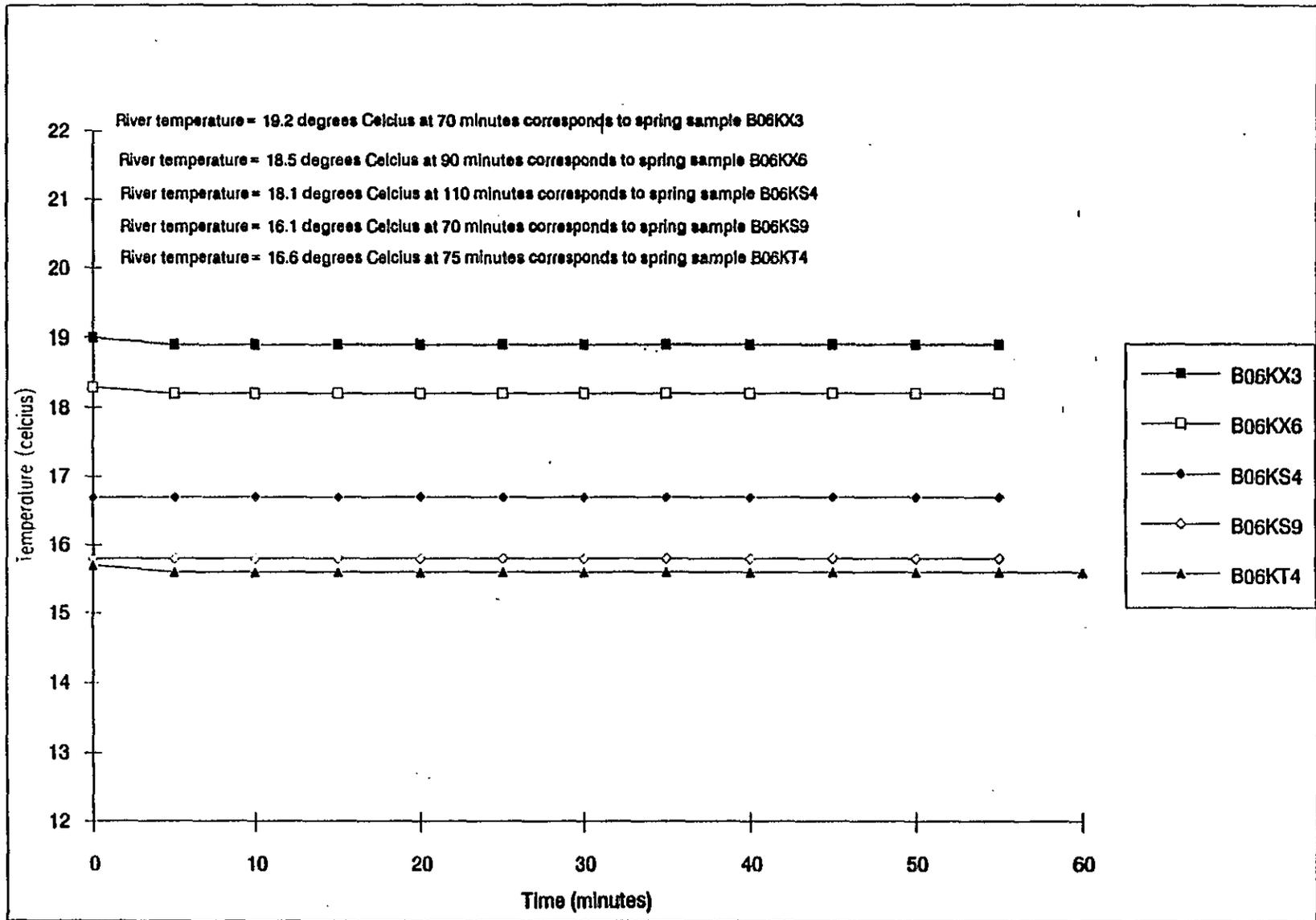


Figure 5. Time vs. Temperature, 100-N Area.

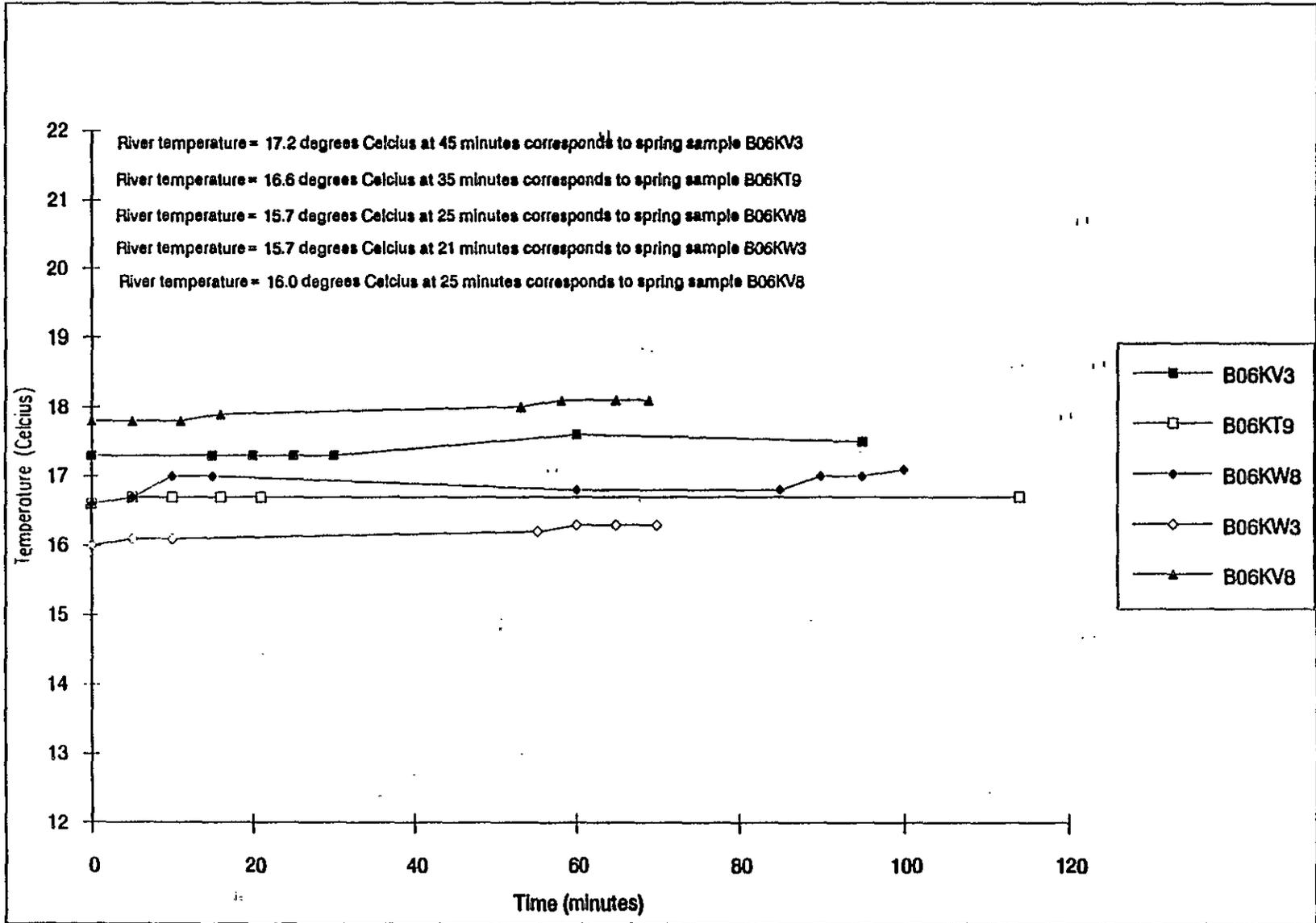


Figure 6. Time vs. Temperature, 100-H Area.

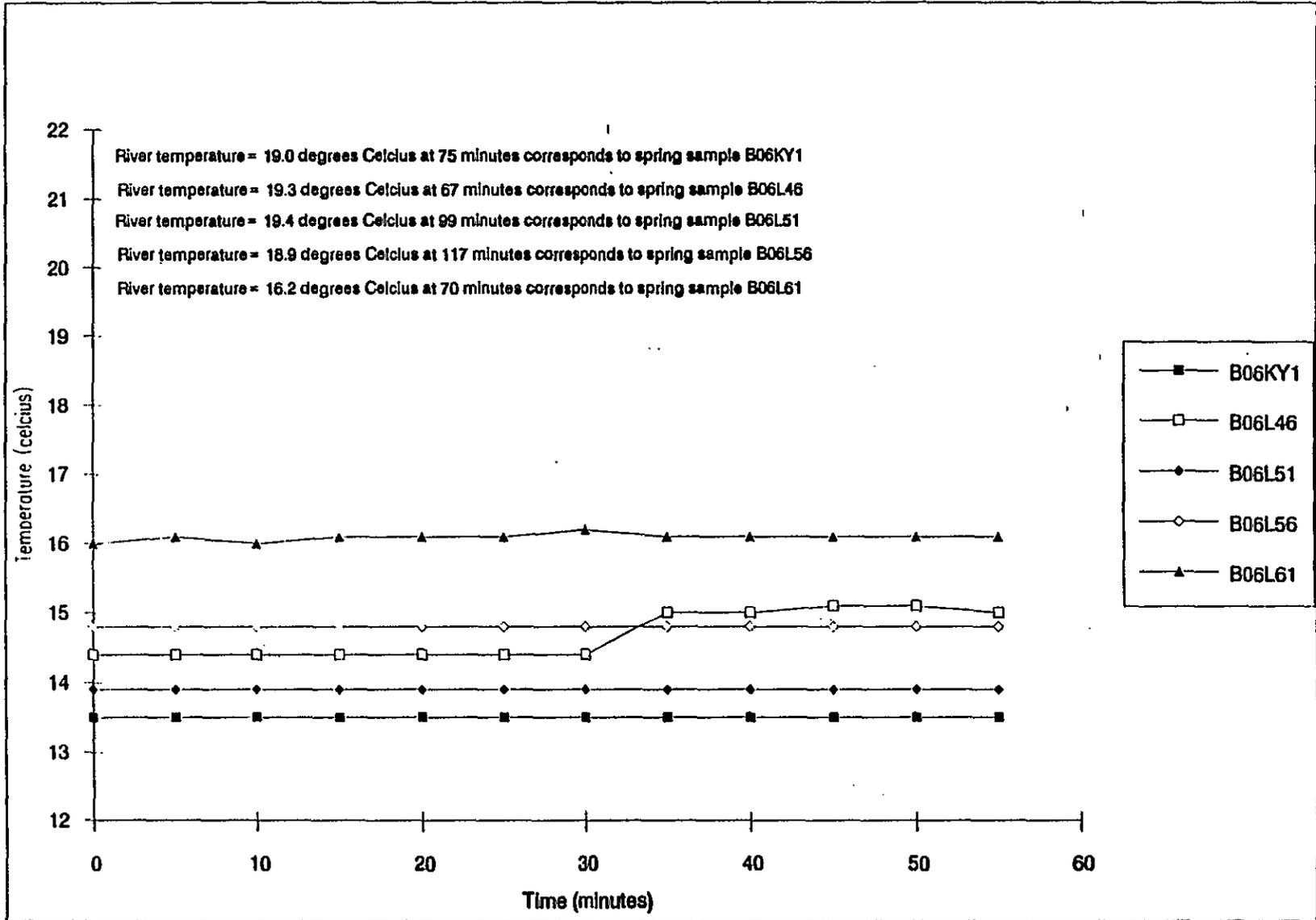


Figure 7. Time vs. Temperature, 100-F Area.

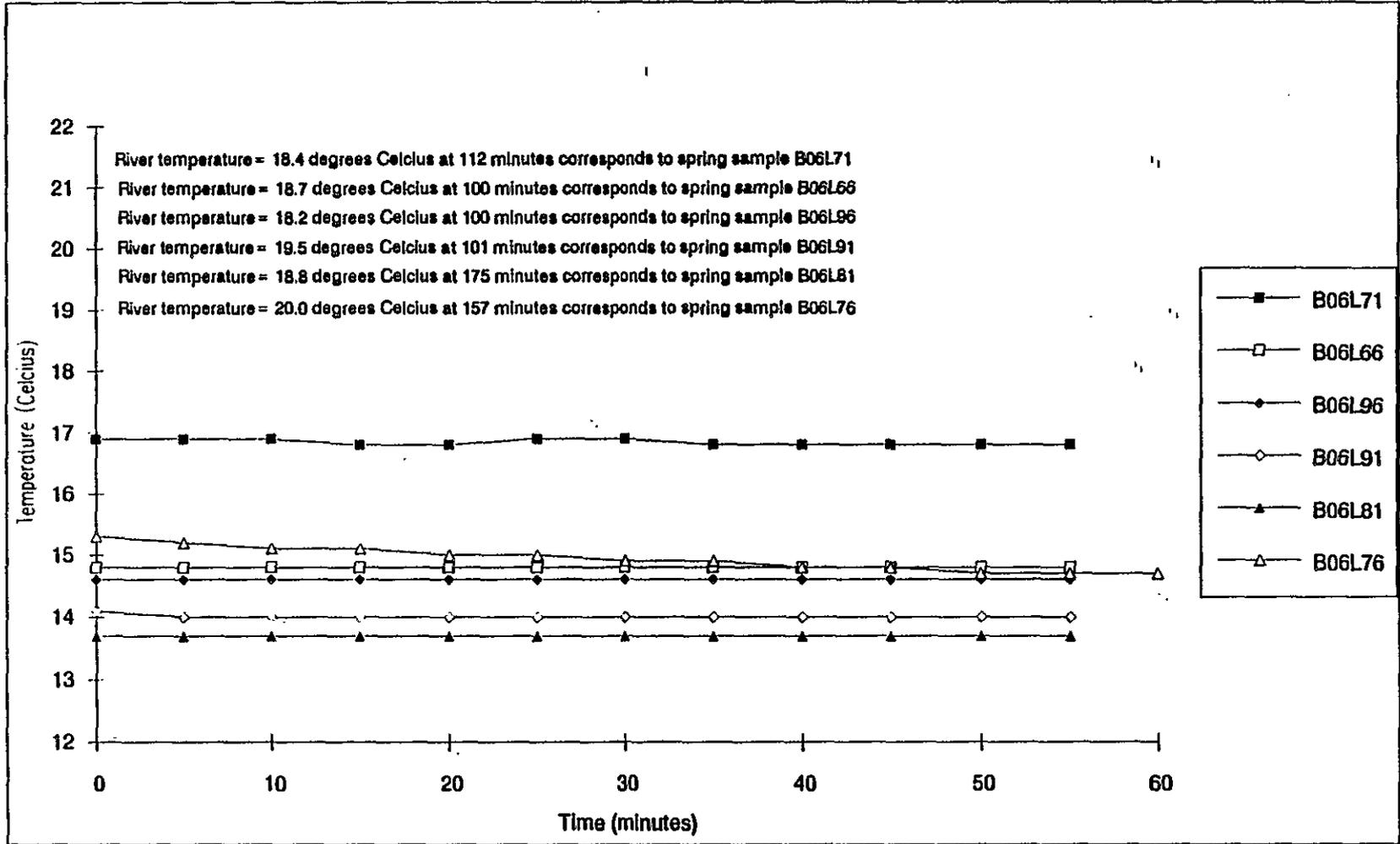
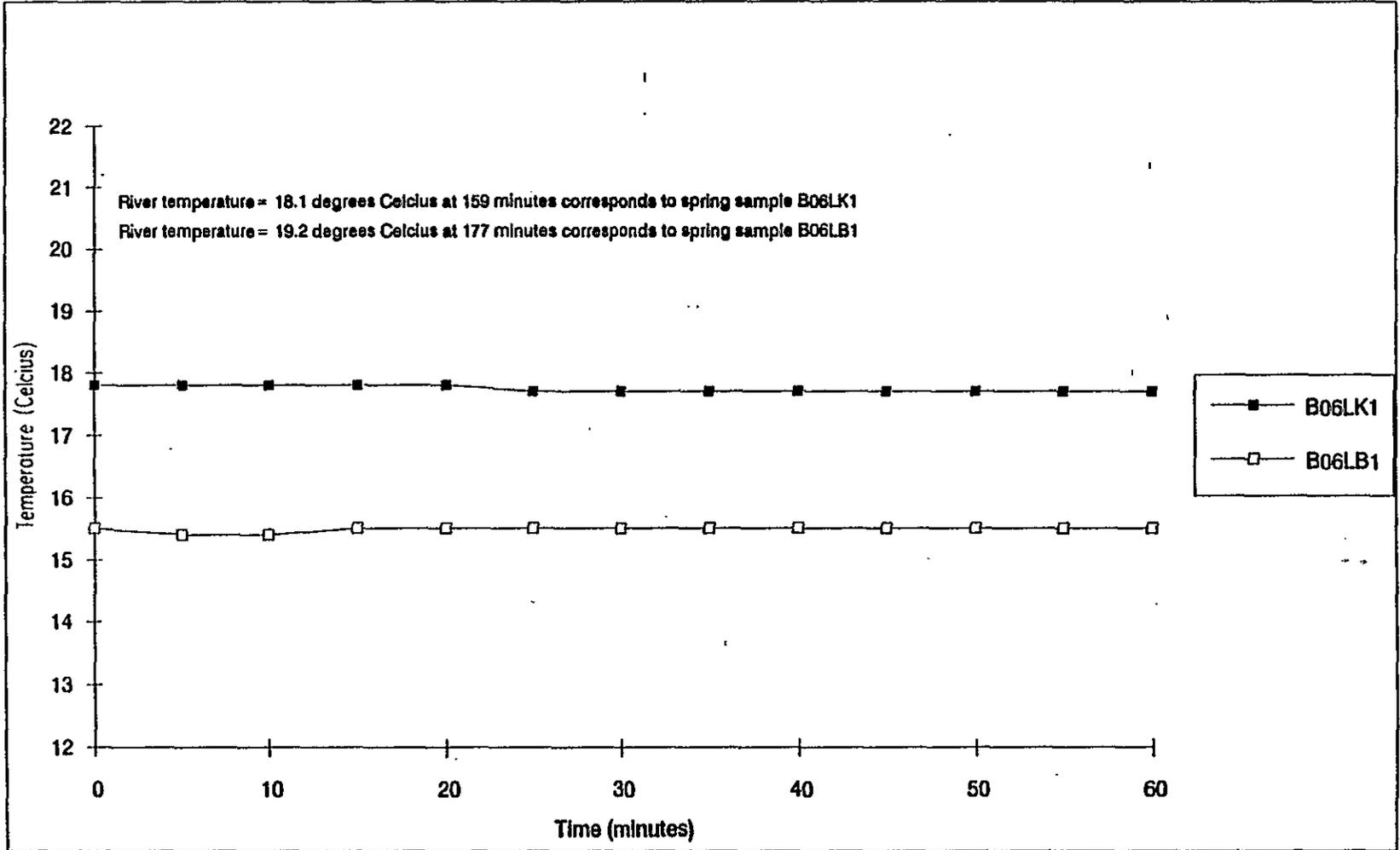


Figure 8. Time vs. Temperature, Hanford Townsite.



The pH measurements were taken by inserting the pH electrode directly into the spring. The measurement was recorded once the meter had equilibrated. The pH appeared to decrease over the period of measurement. The noted changes were consistent between springs as shown in Figures 9 through 14. The consistency of the changes suggests that pH electrode response is the most likely reason, rather than actual changes in pH.

Electrical conductivity provides a gross indicator of the total ionic strength of water (concentration of total dissolved solids). The Columbia River generally has a low electrical conductivity, indicating the river has low dissolved solids content. Groundwater generally exhibits higher electrical conductivity than the river due to the higher total dissolved solids content resulting from interactions with the aquifer matrix.

Measurements were taken by collecting an aliquot of water in the cup of the conductivity bridge and reading the resulting value. Values of spring electrical conductivity ranged from 140 micro siemens per centimeter ($\mu\text{S}/\text{cm}$) to 335 $\mu\text{S}/\text{cm}$. The changes of electrical conductivity with time before sampling are shown in Figures 15 through 20. Conductivity values for the river ranged from 91 $\mu\text{S}/\text{cm}$ to 301 $\mu\text{S}/\text{cm}$. At 22 of the 28 locations where river conductivity was recorded, the values ranged from 91 $\mu\text{S}/\text{cm}$ to 139 $\mu\text{S}/\text{cm}$.

3.2.3 Sample Collection

The procedure used for collection of spring, sediment, and river samples is included as Appendix A. The procedure was developed to encompass foreseeable occurrences that might occur during field work. In some instances field operations required deviation from written protocols. In these instances deviations were recorded in the daily log and a variance or nonconformance report was prepared that described the alternate actions taken. Variance/nonconformance logs are contained in Appendix B. Suggested changes to the field procedure based on experience are provided in Section 5.0.

3.2.4 Sample Handling

Samples were labeled, bagged, and iced immediately after collection. Aliquots of the spring water, river water, and sediment samples were transported to the Westinghouse Hanford Company (Westinghouse Hanford) Health Physics Screening Laboratory at 100-N Area for radiological screening before the primary samples were shipped offsite. Chilled samples were controlled under chain-of-custody pending receipt of permission for offsite shipment. Once permission was received, the samples were repackaged in additional ice, secured for shipment and delivered to Westinghouse Hanford Transportation for shipment to Westinghouse Hanford's contracted laboratory. Analytical services for this effort were provided by TMA Norcal and Weston Analytical Services. Analyses were returned to Westinghouse Hanford Office of Sample Management (OSM) for validation.

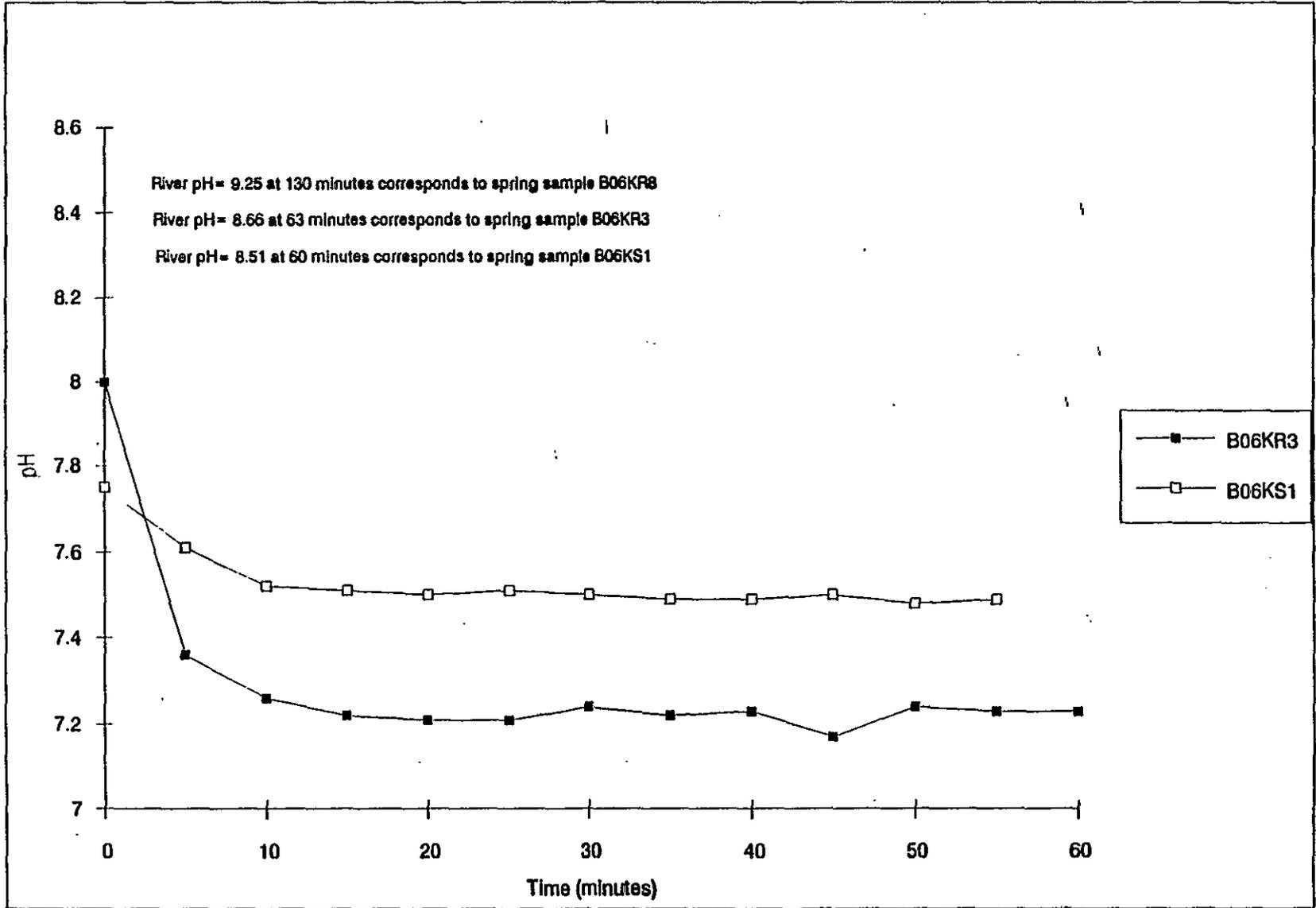


Figure 9. Time vs. pH, 100-B/C Area.

Figure 10. Time vs. pH, 100-D/K Areas.

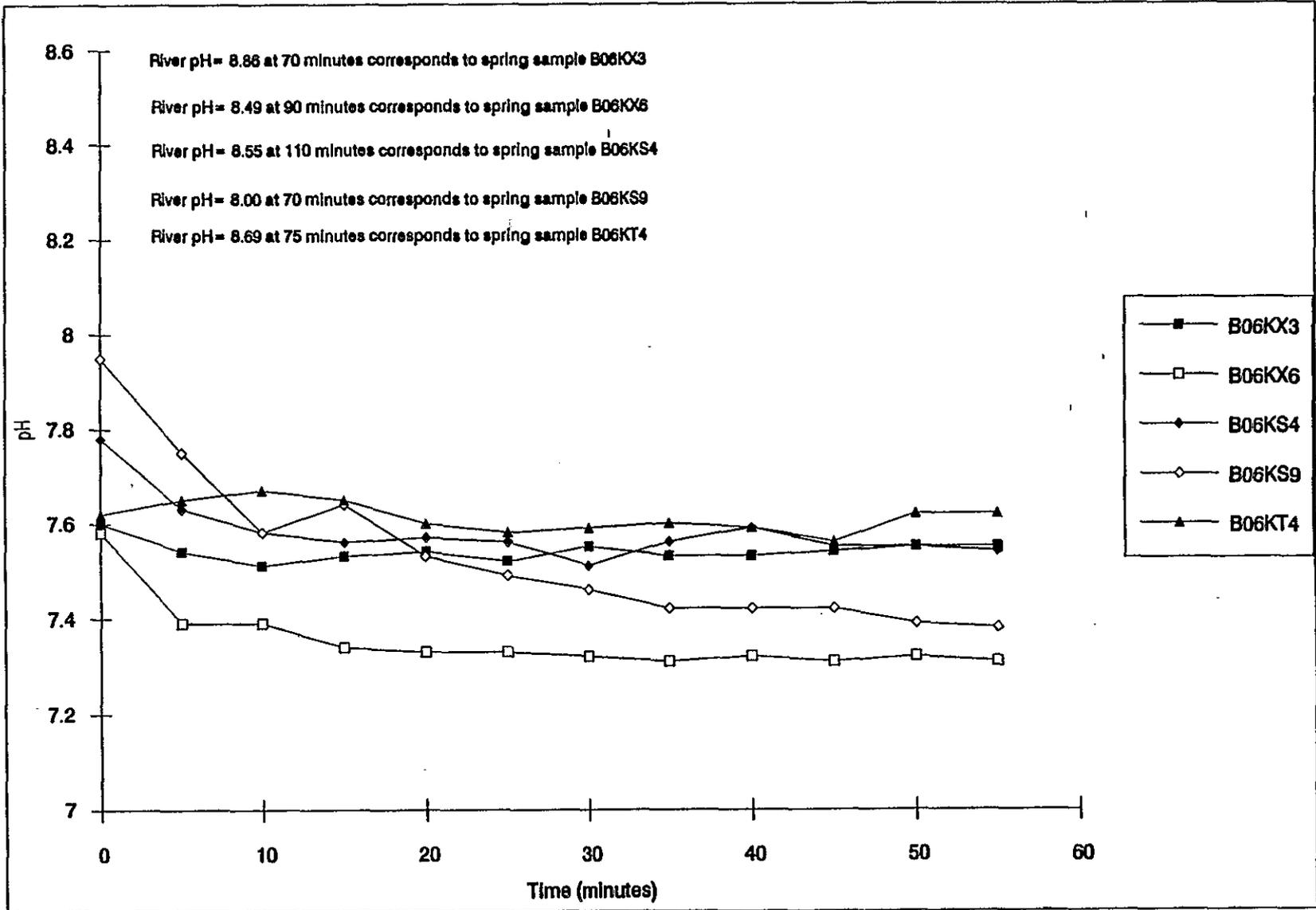


Figure 11. Time vs. pH, 100-N Area.

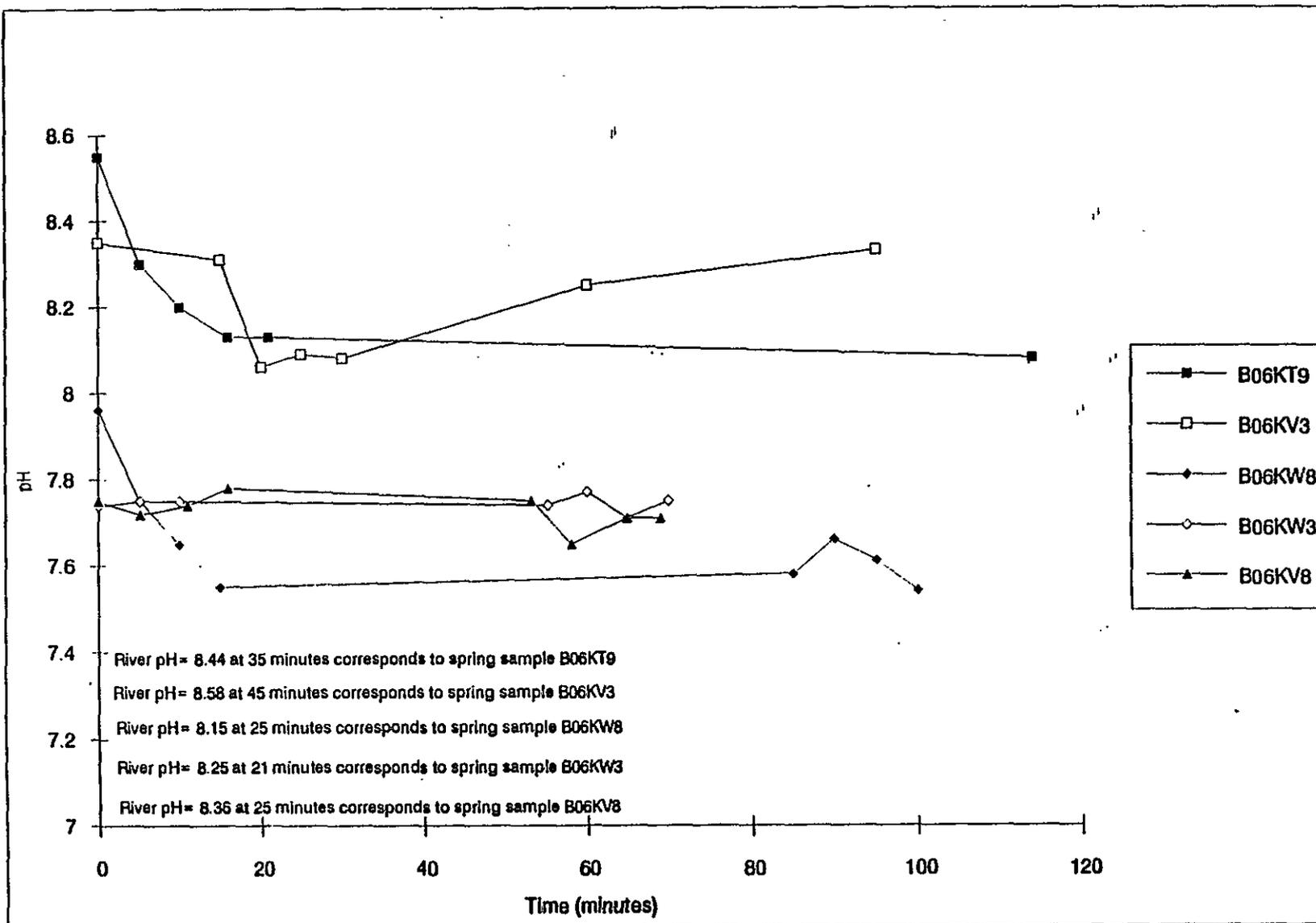


Figure 12. Time vs. pH, 100-H Area.

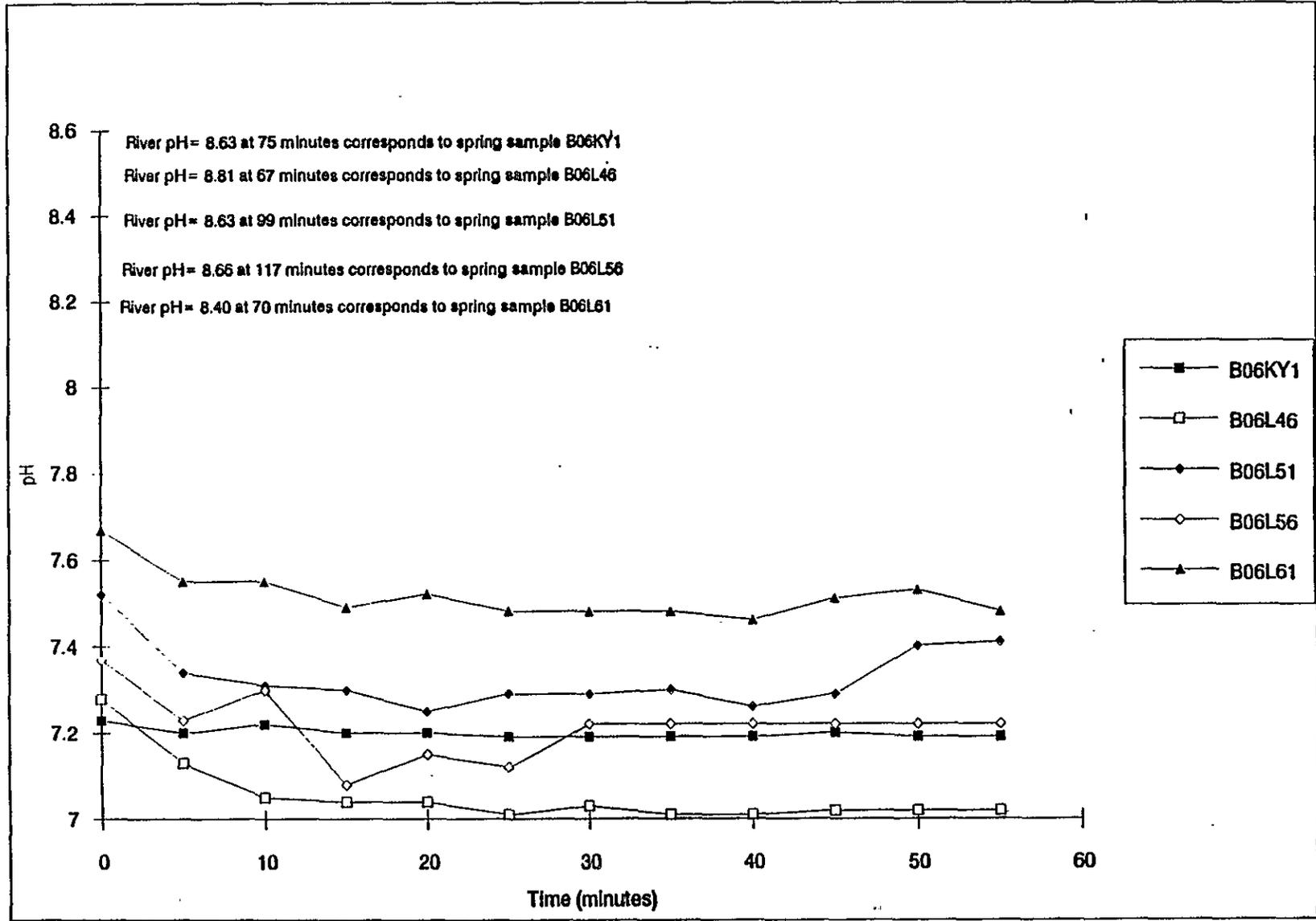


Figure 13. Time vs. pH, 100-F Area.

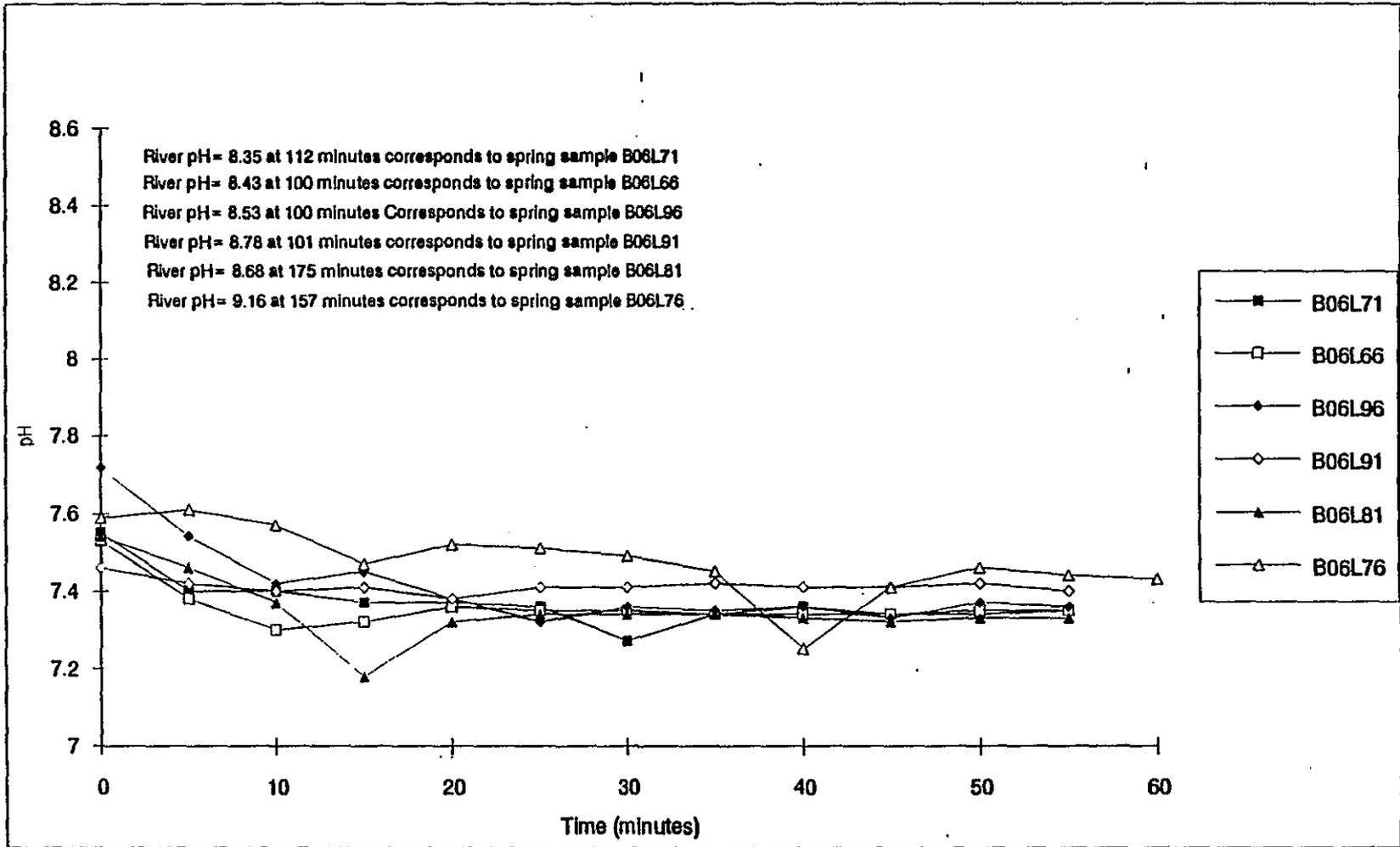


Figure 14. Time vs. pH, Hanford Townsite.

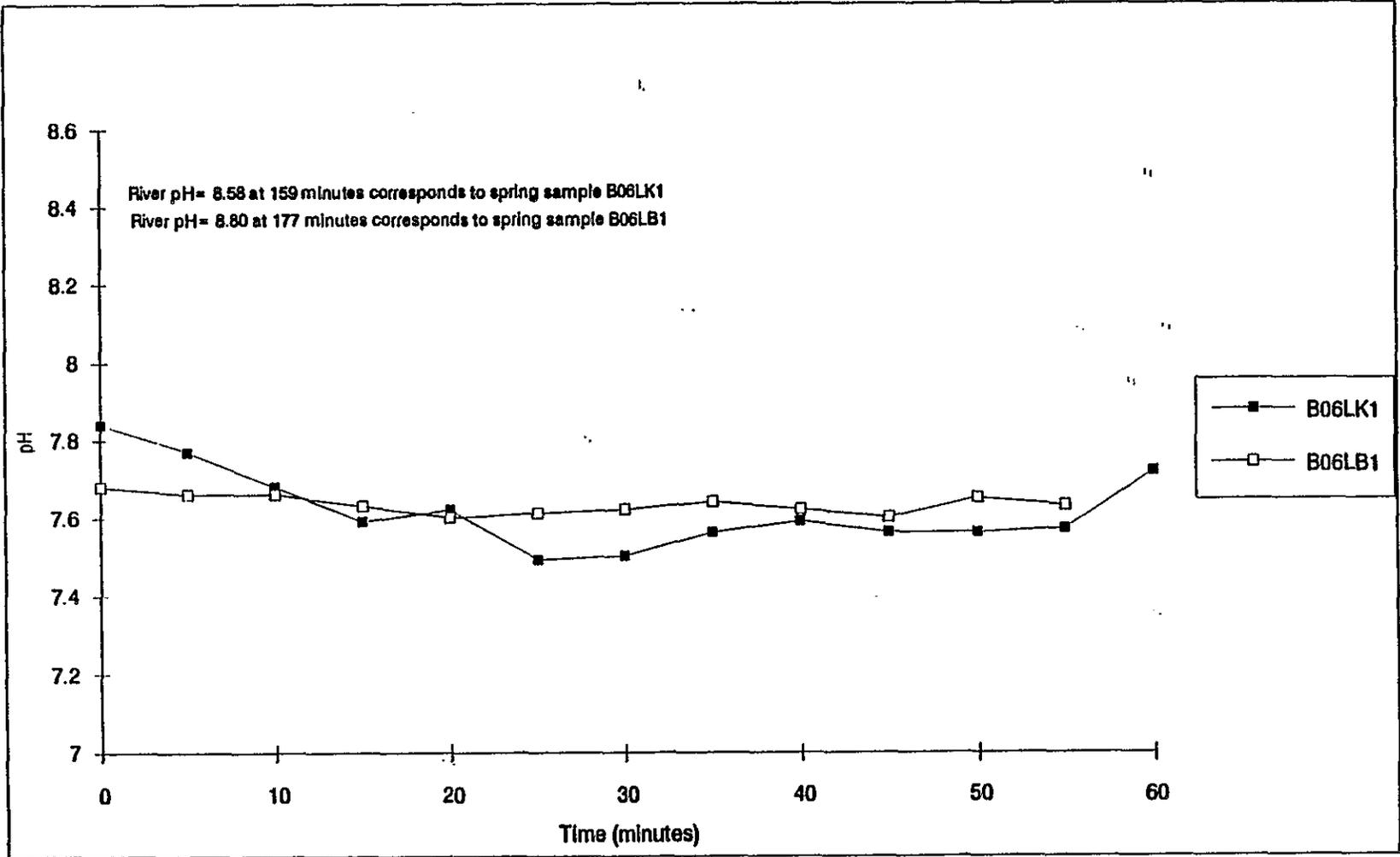


Figure 15. Time vs. Electrical Conductivity, 100-B/C Area.

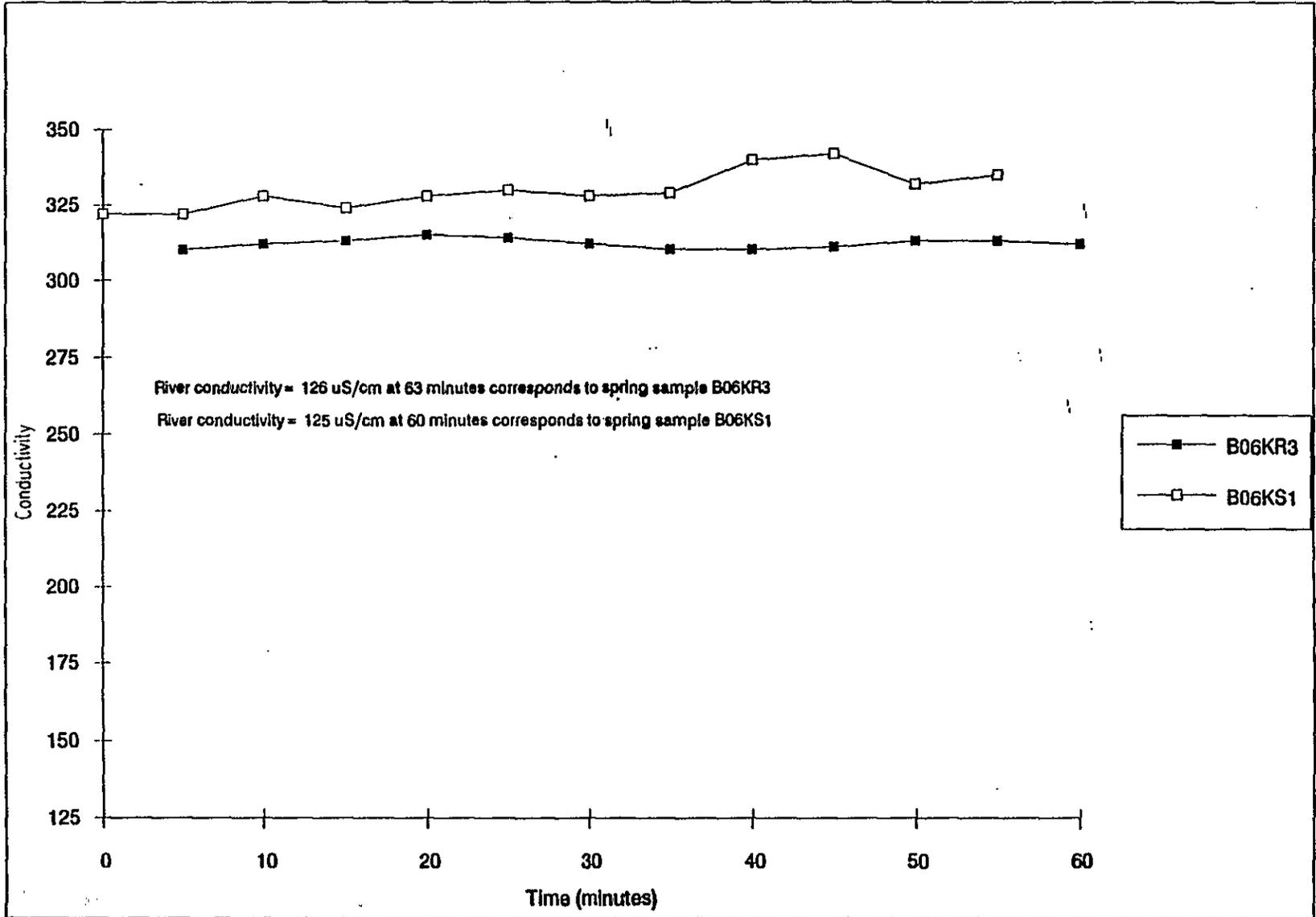


Figure 16. Time vs. Electrical Conductivity, 100-D/K Areas.

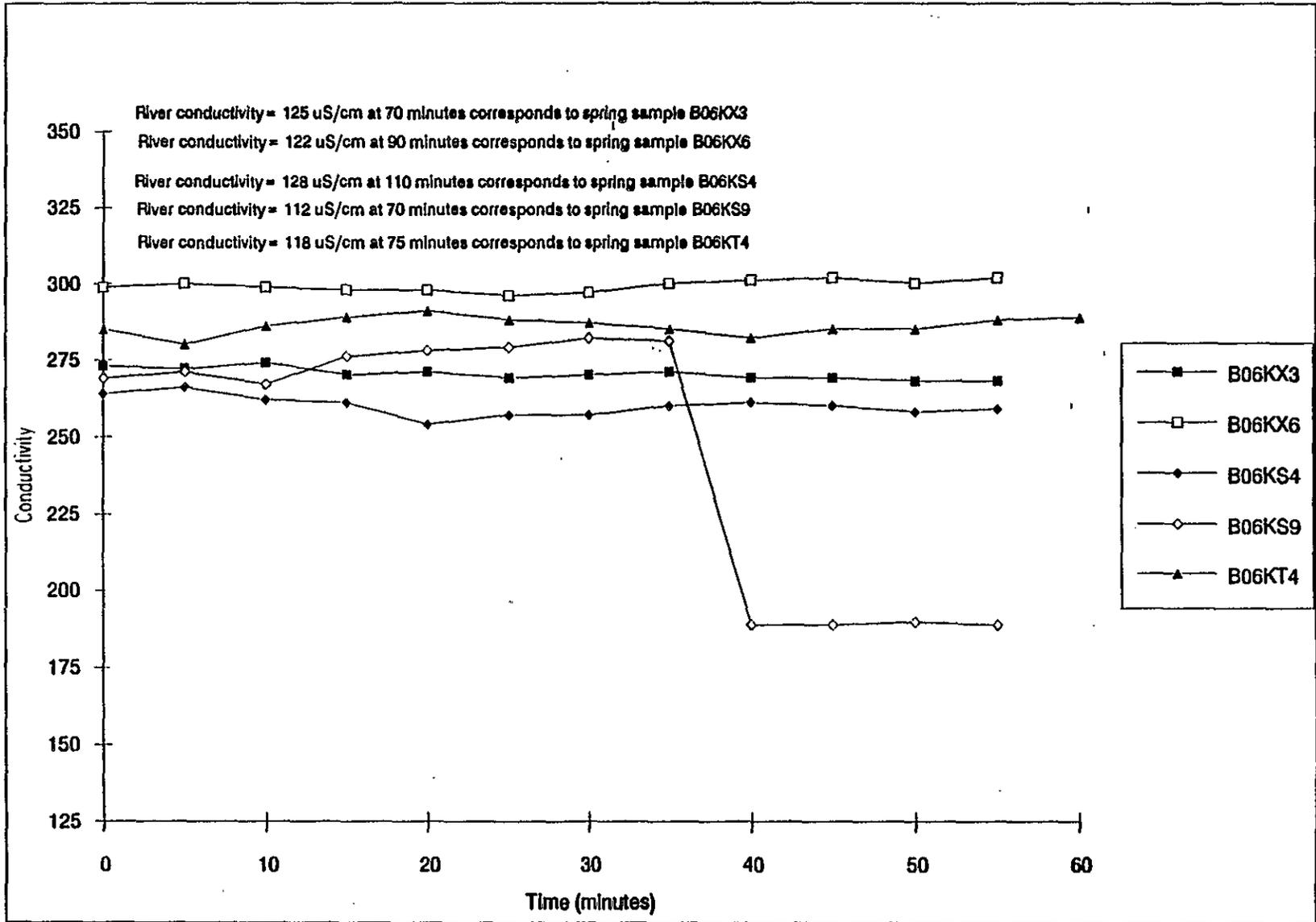


Figure 17. Time vs. Electrical Conductivity, 100-N Area.

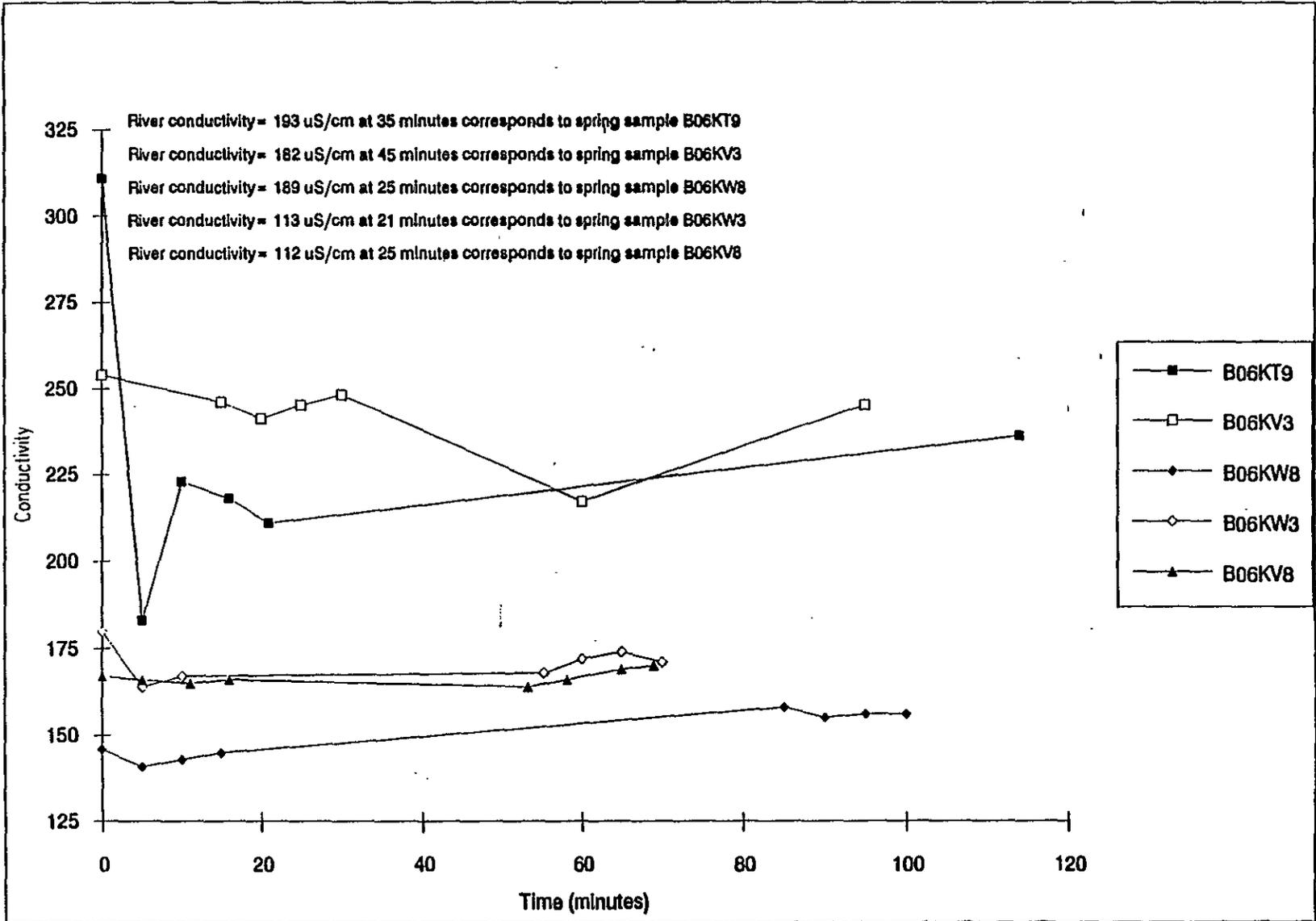


Figure 18. Time vs. Electrical Conductivity, 100-H Area.

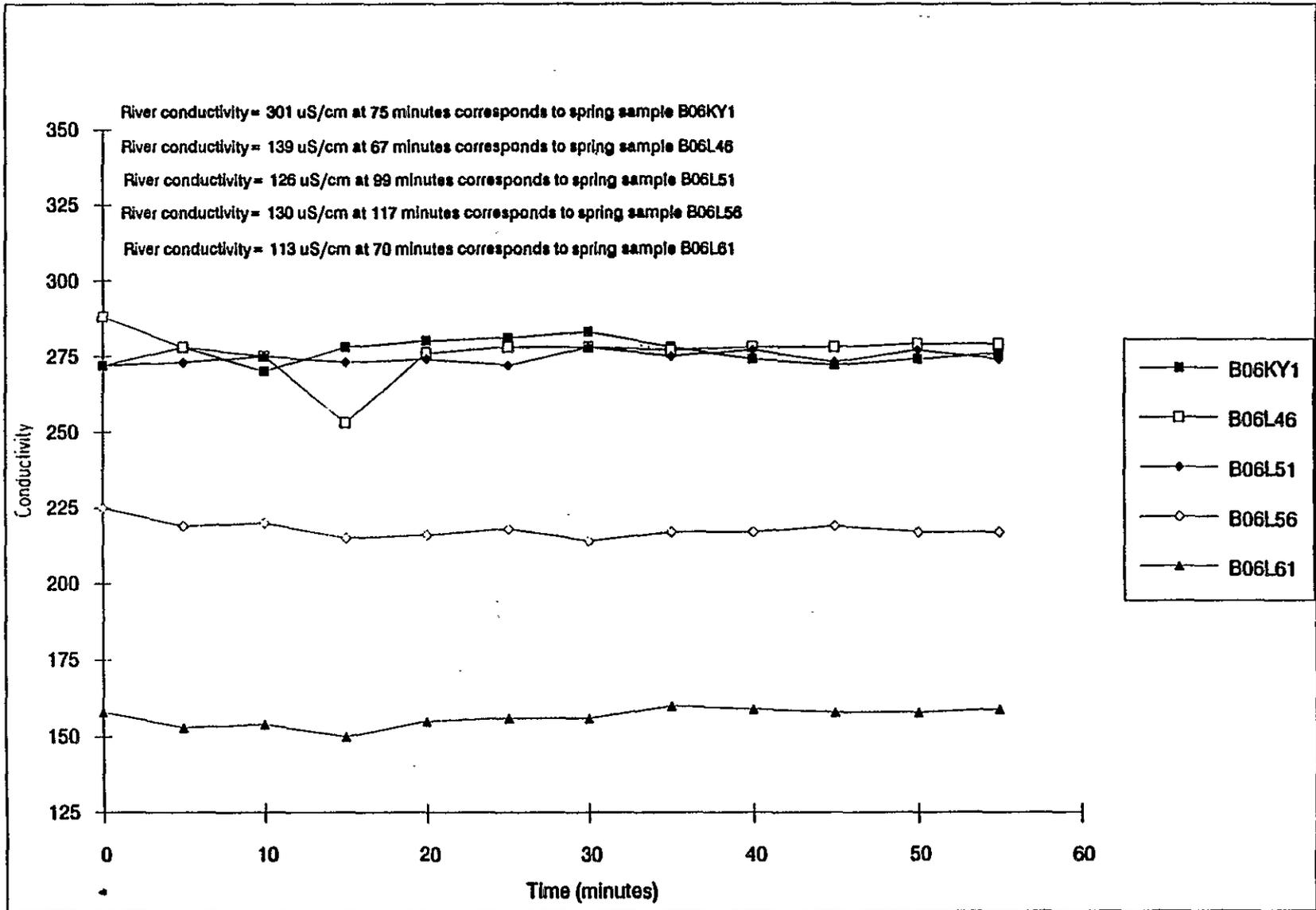


Figure 19. Time vs. Electrical Conductivity, 100-F Area.

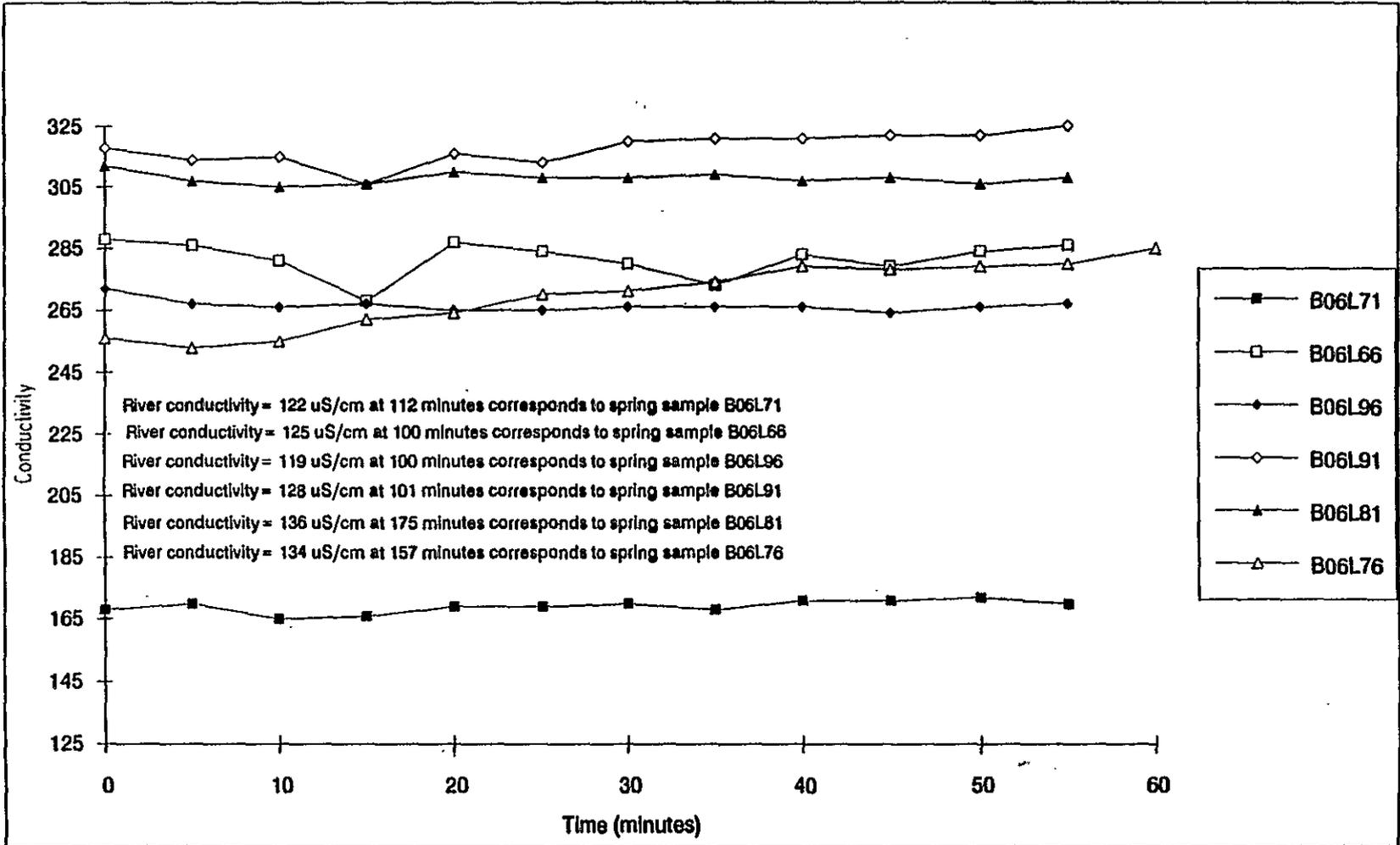
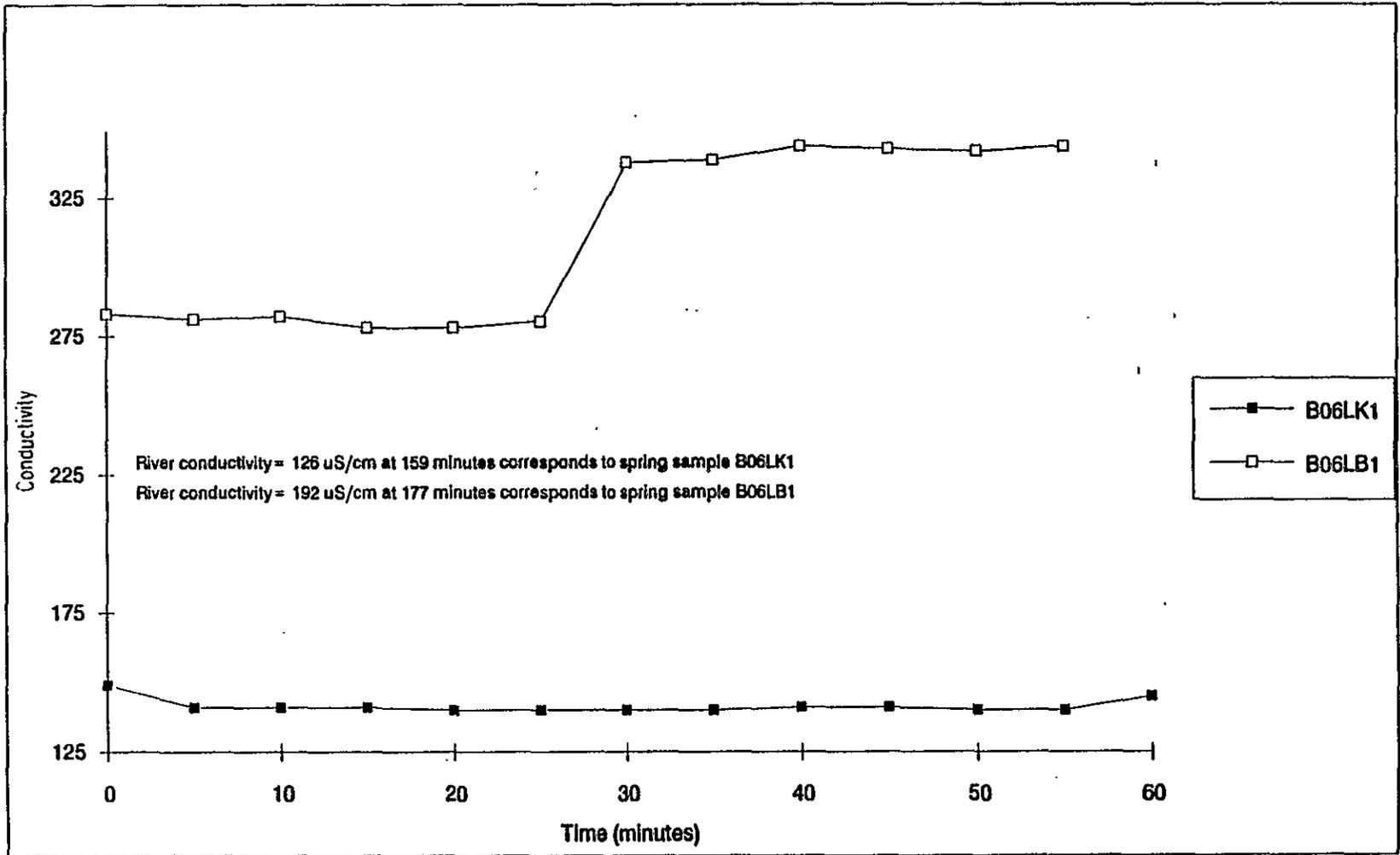


Figure 20. Time vs. Electrical Conductivity, Hanford Townsite.



3.2.5 Quality Assurance/Quality Control

Quality assurance/quality control was accomplished through the collection of duplicate samples at two locations (4 samples, 2 river and 2 spring). These samples were submitted as blind samples to the laboratory through the normal procedures for sample submission. The analytical results of these duplicate samples are provided along with other analyses in the appendices to this report.

3.3 DATA ASSESSMENT

Chemical and radiological data, as well as the onsite measurements, were evaluated to assess contaminant levels. As discussed in Section 3.3.2, field measurements of temperature and conductivity indicate that, in the majority of instances, the samples collected from the springs are representative of groundwater. In a few cases these parameters indicate that a mixture of surface and groundwater may have been sampled. In areas such as 100-N, where large quantities of deionized water have been discharged to the ground, groundwater chemistry may exhibit electrical conductivity intermediate between groundwater and the adjacent Columbia River.

The radiological data derived from analysis of the water and sediment samples were evaluated to assess the relative contribution of radionuclide loading on the Columbia River. Gross alpha and gross beta analyses were taken as overall indicator parameters, no attempt was made to correlate the concentration of indicators with the concentration of specific radionuclides. A general correlation exists for example between the gross alpha concentration as the concentration of total uranium; and between the gross beta concentration and the concentration of ⁹⁰Sr, a beta-emitting radionuclide. However, the gross beta value includes all possible beta emitting radionuclides. Concentrations of radionuclides analyzed through the gamma scan are generally reported as "less than" values, in spite of the fact that many of those numbers are large. No "less than" values were used in evaluating contaminant contributions.

This report summarizes the data by contaminant type and by sample location (i.e., reactor area).

3.3.1 Primary Contaminants

Contaminants are entering the Columbia River through springs along the Hanford Reach. Contaminants enter the river in the following areas: 100-B/C, 100-K, 100-N, 100-D, 100-H, and 100-F. The primary (most prevalent) contaminants are tritium (³H), strontium-90 (⁹⁰Sr), chromium (Cr), and nitrate (NO₃).

Tritium: Tritium is the most wide spread constituent and occurs in spring water at most of the reactor areas. Concentrations of ³H range from less than 200 picocurie/liter (pCi/L) to a maximum of 24,300 pCi/L. Measured concentrations of ³H in spring water that are at or above 20,000 pCi/L, are restricted to springs located at 100-B and 100-N areas. Tritium is transported as part of the water molecule and is not subject to adsorption processes.

Strontium-90: Concentrations of ^{90}Sr exceeding 8 pCi/L, occur at springs in the 100-N, 100-K, 100-H and 100-F areas. Concentrations of ^{90}Sr are near the detection limits in other springs. Concentrations determined during this study ranged from a high of $3,200 \pm 70$ pCi/L to lows of <0.2 pCi/L. Strontium-90 exhibits a moderate tendency to adsorb onto the soil matrix and is released through time by normal desorption processes.

Strontium-90 was detected in all of the sediment samples. The ^{90}Sr concentrations ranged from 0.2 picocuries per gram (pCi/g) at 100-H Area to a high of 207 pCi/g at 100-N Area. This result was anticipated because ^{90}Sr tends to adsorb onto the surfaces of soil and sediment particles, as stated previously.

Chromium: Concentrations of Cr near or above 50 micrograms per liter ($\mu\text{g/L}$) occur in spring waters sampled at the 100-B/C, 100-K, 100-D and 100-H areas. Springs at site 110-2 in the 100-D Area had the maximum Cr concentration, i.e., 124 $\mu\text{g/L}$. Chromium is the primary contaminant identified for the 100-H and 100-D areas (DOE/RL 1990). Chromium was generally in the anionic state (Cr_2O_7) when released to the ground. Anionic species do not sorb to sediments as readily as cationic species.

Chromium was detected in all of the sediment samples. Chromium is a naturally occurring element and is common to sediments derived from basaltic environments such as at Hanford. Chromium levels ranged from a low of 9.1 milligrams per kilogram (mg/kg) to a high of 122 mg/kg. The highest level of Cr in sediments correlated with the highest levels found in spring water.

Nitrate: Concentrations of NO_3 ion ranging from 1.6 to 5.5 milligrams per liter (mg/L) were present in all springs sampled. Nitrate values reported in this document are as nitrate (NO_3), values should be multiplied by 4.5 to equal nitrate-nitrogen concentrations. Nitrate is considered to be a conservative constituent that travels with the water.

3.3.2 Contaminants Discharged Through Springs by Area

Appendix C provides the chemical data for the springs and associated river samples derived during this study. Appendix D provides the radiological data for those same samples. All the data is provided by sampling location in downstream order from the 100-B/C Area to upstream of the ferry landing at the Hanford Townsite.

3.3.2.1 100-B/C Area. Three springs at sites 037-1, 038-3, and 039-2, were sampled. Detectable concentrations of Cr (37, 41, and 54 $\mu\text{g/L}$) along with ^3H (3,100, 20,600 and 13,000 pCi/L) and total uranium ($^{\text{tot}}\text{U}$) (1.6, 1.6, and 1.5 pCi/L) discharge to the river from the 100-B/C Area. Sampling of the Columbia River adjacent to these springs showed concentrations of Cr at 6 $\mu\text{g/L}$, ^3H at 300 pCi/L, and $^{\text{tot}}\text{U}$ at 0.4 pCi/L. Contaminants being discharged to the river coincide with known groundwater contaminants at this location.

Spring temperatures were the highest measured of all the reactor areas, ranging from 20°C to 22°C.

The ^3H concentration observed during the 1991 sampling was significantly higher than that earlier reported. Dirkes (1990) reported a ^3H concentration

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of 1,100 pCi/L, while this study determined a concentration 20,600 pCi/L. Nitrate concentrations at this same location were reported at 6.7 mg/L versus 2.3 mg/L determined during this study. Differences in concentration are not readily explained, but may be due to the effects of river stage history immediately preceding sampling for the two sampling periods.

Analyses of sediment samples show that some residual radionuclide contamination exists at the 100-B/C Area. Positive analyses were noted for ^{90}Sr at 0.3, 0.4, and 0.19 pCi/g, cesium-137 (^{137}Cs) at 0.15 and 0.03 pCi/g, radium-226 (^{226}Ra) at 0.78, 0.45, and 0.72 pCi/g, thorium-228 (^{228}Th) at 1.02, 0.78, and 1.81 pCi/g, and thorium-232 (^{232}Th) at 0.96, 0.67, and 1.29 pCi/g.

Nonradiological analyses of the sediments showed Cr concentrations of 52.1, 51.7, and 35.6 mg/kg. The data are presented in Appendix E.

3.3.2.2 100-K Area. Three springs at sites 057-3, 074-1, and 082-2 were sampled. Detectable concentrations of Cr (17, 64.5 and 13.9 $\mu\text{g/L}$), ^3H (1400, 400 and 8900 pCi/L), ^{90}Sr (a single detection at 8.8 pCi/L at site 074-1), technetium-99 (^{99}Tc) (5.2 and 2 pCi/L at sites 074-1 and 082-2), and $^{\text{tot}}\text{U}$ (1, 0.24, and 1.1 pCi/L) were found. Samples of the Columbia River adjacent to the springs at these locations showed ranges in concentration for Cr (2 to 6 $\mu\text{g/L}$), ^{90}Sr (<0.4 to 0.7 pCi/L), ^{99}Tc (2 and <3 pCi/L), and $^{\text{tot}}\text{U}$ (0.2, 0.3, and 0.5 pCi/L). Tritium concentrations were all below the statistically derived detectable concentration.

Water temperature ranged from 15.6°C to 16.7°C for the three springs sampled. Temperatures were constant over the presampling interval at each of the springs. Measurements of pH exhibited the universal lowering with time that is attributed to pH electrode response. Conductivity measurements were within normal variation with the exception of the spring at site 074-1, sample B06KS9. At this location, the temperature compensation adjustment was changed thereby affecting the conductivity measurements. Successive measurements after the change remained consistent and constant indicating that the spring chemistry did not change.

The low concentrations of various constituents is compatible with the limited ongoing activities in 100-K Area and the restriction of most groundwater discharge to the Ringold Formation. No comparison with analyses of Dirkes (1990) are possible as no springs were located during the 1988 sampling effort.

Sediment analyses from the 100-K Area show low concentrations of ^{90}Sr , (0.2, 0.6, and 0.6 pCi/g). Concentrations of ^{137}Cs were 0.148, 0.214, and 0.187 pCi/g, indicating that this radionuclide has discharged through the springs during the site's history, even though ^{137}Cs is not now detectable in spring discharges. Other radionuclides present in quantifiable amounts include ^{226}Ra (0.73, 0.82, and 1.02 pCi/g), ^{228}Th (0.79, 0.93, and 1.52 pCi/g), and ^{232}Th (0.78, 1.05, and 1.42 pCi/g).

Results of sediment analyses are presented in Appendix E.

3.3.2.3 100-N Area. Five springs at sites 090-1, 092-2, 092-3, 093-1, and 094-1 were sampled. These springs are the same springs that have been routinely sampled as part of the 100-N Area environmental monitoring program. The springs at 100-N Area were sampled in conjunction with the annual sampling

conducted by the 100 Area Environmental Assurance personnel. Sampling was done following the general protocols developed for the overall spring sampling effort while under the direct guidance of 100-N Area Health Physics Technicians for radiation safety procedures. Some deviation from the protocols was allowed to facilitate coordination with 100-N Area personnel, including elimination of some of the presampling measurements.

Detectable concentrations of several contaminants were found in the springs at 100-N Area. Gross beta levels in spring water ranged from 5 to 6,830 pCi/L (the lowest level is subject to question, as repetitive analyses showed levels as high as 886 pCi/L). Tritium concentrations ranged from 3,400 to 24,300 pCi/L. As noted during data validation, the 3,400 pCi/L value may be low due to the acidification and subsequent neutralization of that sample. Strontium-90 was detected in two springs at concentrations of 3,210 (site 090-1) and 395 pCi/L (site 092-2). Technetium-99 was detected in samples from all five spring sites in concentrations ranging from 2.5 to 6.2 pCi/L. Analysis for Antimony 125 was performed on only one sample. The sample, from site 092-2, contained 31 pCi/L of ^{125}Sb .

Samples collected from the 100-N Area springs contained the highest concentrations of radioactive contaminants observed during this sampling effort. Nonradiological contaminants were detected at low levels. Chromium was not detected above the sample quantitation limit in any of the springs. Although the N-Reactor is the most recently used facility along the river, ^{238}U concentrations are amongst the lowest determined. The presence of ^{90}Sr at concentration levels of 3,210 pCi/L is consistent with results of previous sampling of these springs. Analysis of the spring data show that the concentrations of contaminants differs among the 100-N Area springs. The furthest upstream sample, sample B06KT9 from site 090-1, showed the highest concentration of ^{90}Sr . The spring at site 092-3 (sample B06KV8), approximately 0.2 mi downstream has the highest concentration of ^3H .

Analysis of Columbia River water collected adjacent to the 100-N Area springs showed contaminant concentrations significantly below those in the springs. Gross Beta analyses ranged from 1 to 2 pCi/L while ^3H ranged from <200 to 800 pCi/L. Results from ^{90}Sr analyses ranged from 0.9 to 8.1 pCi/L. Three positive analyses for ^{99}Tc ranged from 1.7 to 3.9 pCi/L. A single positive ^{226}Ra analysis of 22.6 pCi/L was determined through the gamma scan. The rapid dispersal of contaminants in the river at 100-N Area can be attributed to the flow characteristics at that location. The river is flowing in a northeasterly direction past 100-N Area, without islands or bank protrusions to deflect the current or cause eddies. The banks are steep so that water depths exceed 10 ft close to the shoreline.

Significant decreases in radionuclide contributions to the Columbia River are evident when analytical results from this sampling are compared to data reported by Dirkes (1990) for the 1988 sampling effort. Some constituents have remained constant, while none have increased in concentration. In the spring at site 090-1, gross beta concentrations have declined from 13,800 pCi/L to 6,830 pCi/L, a factor of two. Tritium concentrations have reduced from 111,000 pCi/L to 15,900 pCi/L, a factor of nearly seven. Strontium-90 concentrations in 1988 were reported at 6,680 pCi/L, while 1991 concentrations were determined to be 3,210 pCi/L, again a reduction by a factor of about two. Nitrate concentrations have been reduced from 28.6 mg/L in 1988 to 1.4 mg/L in 1991, a factor of almost 20. Similar,

yet not as dramatic changes in concentration are noted further downstream. These changes can be partially attributed to the inactive status of the N-Reactor and the near total cut-off of liquid discharges to contaminated cribs and trenches in the 100-N Area and partially to the possible influence of the Columbia River during the period these springs were sampled. This reduction in discharges results in a decreased groundwater mound and an associated reduction in the groundwater gradient toward the springs. Additional and continued sampling of the 100-N Area springs will be necessary to fully address the reasons for the lower concentrations of radioactive contaminants derived through this study.

The concentration of ^{90}Sr in sediments was less than the quantitation limit at three springs, but was 207 and 24.5 pCi/g at spring sites 090-1 and 092-2, respectively. Other radionuclides ^{137}Cs , ^{226}Ra , ^{228}Th and ^{232}Th were within the range present in sediments sampled from other reactor areas. Potassium-40 (^{40}K), a naturally occurring radionuclide, was present at an average concentration of 12.7 pCi/g in sediment samples.

Concentrations of analytes in 100-N Area sediments are shown in Appendix E.

3.3.2.4 100-D Area. Two springs at sites 110-1 and 110-2 were sampled at 100-D Area. These springs show the highest concentrations of Cr of all sample locations. Samples B06KX3 and B06KX4, collected at site 110-1, contained 71.7 and 75.8 $\mu\text{g/L}$ Cr. Samples B06KX6 and B06KX7, collected at site 110-2, contained 124 and 123 $\mu\text{g/L}$ Cr. Radiological contaminants detected in the two springs included ^3H at 1,200 and 3,100 pCi/L, ^{90}Sr at 4.5 and 1.8 pCi/L, ^{99}Tc at 0.3 and 4.9 pCi/L and $^{\text{tot}}\text{U}$ at 0.9 and 1 pCi/L. Analysis of Columbia River water at this location showed Cr and all other contaminants except $^{\text{tot}}\text{U}$ at concentrations below the quantitation limits. The $^{\text{tot}}\text{U}$ concentration of 0.33 pCi/L is not elevated relative to any of the river samples.

The springs at 100-D Area showed the second highest temperatures of those springs sampled. The springs were discharging at 18.2°C and 18.9°C.

The pH and conductivity of the springs stabilized after 10 min in both springs. The range of pH was 7.55 to 7.31 between the springs. Conductivity range for the two springs was 268 to 302 $\mu\text{S/cm}$.

Comparison with concentrations reported in Dirkes (1990) is difficult because of the relatively low concentrations and the statistical nature of radionuclide analyses. Concentrations of ^3H (3,100 pCi/L) were determined to be higher in 1991 than those reported in Dirkes (1990) for the spring at River Mile 11 (site 110-2). This spring discharges close to river level and may reflect river influences on the chemistry. The higher ^3H concentration seen from this sampling indicates a lesser influence during the 1991 sampling. Dirkes (1990) did not analyze for Cr at this location.

Sediments collected from these 100-D Area locations show Cr in concentrations higher than other samples. The maximum Cr concentration for all sediments (122 mg/kg) was found at site 110-2-S, in sample B06KX5. This sample location coincides with the highest Cr concentration determined for spring water, i.e., 123 and 124 $\mu\text{g/L}$. Gross beta analysis of the sediments from the two sites were 19 pCi/g (sample B06KX5) and 18 pCi/g (sample B06KY0). The ^{90}Sr concentrations in the same samples were -0.04 ± 0.2 and <0.3 pCi/g,

respectively. Other constituents were within the ranges determined for all samples.

3.3.2.5 100-H Area. Five springs at sites 144-1, 145-1, 145-2, 150-1, and 153-1, were located and sampled at 100-H Area. All of the sampled springs showed Cr contamination, ranging from 15.7 to 51.6 $\mu\text{g/L}$. It is of interest to note that samples collected from sites 144-1, 145-1, and 145-2 had (unfiltered) Cr concentrations that ranged from 46.3 to 51.6 $\mu\text{g/L}$. Samples at sites 144-1 and 145-1 were collected on September 20, 1991. The samples at site 145-2 were collected on September 25, 1991. The spring water discharging at these three locations appears to show stable concentrations of Cr both over the 5-d time period and in an areal nature. Site 145-2 is about 1/10 mi downstream of site 144-1. Concentrations of Cr (unfiltered) were lower, i.e., 35.3 and 20.9 $\mu\text{g/L}$ at downstream sample sites 150-1 and 153-1, relative to the three upstream sites. The ^3H concentrations ranged from 400 to 3,800 pCi/L. Samples analyzed from sites 144-1, 145-1, and 145-2 had ^3H levels of 2,900, 2,900, and 3,800 pCi/L, whereas samples from sites 150-1 and 153-1 contained 1,100 and 400 pCi/L ^3H . The ^{90}Sr concentrations ranged from 0.4 to a high of 12.7 pCi/L. The highest ^{90}Sr concentration was reported from site 153-1, a situation unlike that for Cr and ^3H in which their highest concentrations occur upriver at 100-H Area spring sites. The ^{238}U concentrations in the five springs ranged from 0.7 to 1.2 pCi/L. Columbia River samples collected adjacent to the springs were at or very near the quantitation limits for contaminant species.

The temperature of the springs emanating at the 100-H Area is close to normal groundwater temperatures and ranged from 13.5°C to 16.1°C. The spring at site 153-1 (sample B06L61), the furthest downstream, exhibited the highest temperatures. The spring at site 145-1 (sample B06L46) was the only spring to exhibit a definite increase in temperature during the 1-h presampling monitoring. Temperature rose from 14.4°C to 15.1°C, over a 5-min interval, where it stabilized.

The pH of the individual springs in this area stabilized earlier than any of the other springs, generally within 10 min of the first measurement.

Electrical conductivity measurements were relatively constant during the measurement interval. Springs at sites 144-1, 145-1, and 145-2 had conductivities of about 275 $\mu\text{S/cm}$. The spring at site 150-1 had an average conductivity of about 220 $\mu\text{S/cm}$. The spring at site 153-1 had the lowest average electrical conductivity of 156 $\mu\text{S/cm}$. This value could be indicative of a relatively high dilution of groundwater with river water. This possibility is reduced by the parallel high temperature of the spring indicating thermal influences in the groundwater system.

The changes in field-measured parameters in this area indicate the possibility of bank storage influences on the chemical and physical make-up of some of the springs sampled. It appears that the sites 144-1, 145-1, and 145-2 may be less affected by bank storage than site 153-1, since conductivity data are indicative of groundwater, and were essentially the same for the three upstream sites over a period of 5 d. While the parameters measured at site 153-1 are indicative of the status of discharges on the day sampled, and likely reflect bank storage effects, the parameters may not be totally representative of the chemistry following an extended period of low-river flow.

Elevated Cr concentrations are consistent with known contamination of the groundwater system at this area (DOE/RL 1990). The level of Cr reaching the river through the springs is at or slightly below the concentrations expected based on historically reported groundwater concentrations.

High NO₃ concentrations are reported for groundwater at 100-H Area and were anticipated from the spring samples collected in this reach. Nitrate concentrations in groundwater at 100-H Area commonly exceed the drinking water standard of 45 mg/L. All samples collected were below this level by a factor of 10, which may reflect bank storage effects on chemical and radiological concentrations. Groundwater gradients in the vicinity of the 100-H Area are very low; this low gradient limits the movement of groundwater toward the river. The artificial gradient imposed by the changes in river level is likely a primary cause for flushing of the groundwater system.

Direct comparison with the results reported in Dirkes (1990) is difficult. Sampling during that study was reported to be influenced by a recent change in river level and the possibility of bank storage influence on spring chemistry. Similar conditions existed during this study. As postulated above, discharges at the downstream 100-H Area spring (site 153-1) appears to be more sensitive to river stage changes than the three sites farthest upstream.

Sediment samples collected from the springs at 100-H Area showed positive detections of ⁹⁰Sr for three of the samples. The concentrations were 0.3, 0.2, and 0.9 pCi/g among the lowest of the positive detections for this radionuclide. Cesium-137 was detected in the sediments from all five springs at an average concentration of 0.26 pCi/g. Naturally occurring ⁴⁰K was the most prevalent radioactive component in the sediments, averaging 13.3 pCi/g. Average concentrations for other detected radionuclides were; ²²⁶Ra at 0.74 pCi/g, ²²⁸Th and ²³²Th both at 1.03 pCi/g.

Results of sediment analyses are presented in Appendix E.

3.3.2.6 100-F Area. Two springs were sampled adjacent to the 100-F Area, sites 187-1 and 190-4, and an additional four springs were sampled immediately downstream of the area at sites 207-1, 211-1, 213-1, and 216-1. Concentrations of all constituents were close to the detection limit except for positive values for ⁹⁰Sr at 40 and 2.5 pCi/L. Sample B06L91, collected at site 213-1, had a reported ⁹⁰Sr concentration of 40 pCi/L. Analyses of samples of the Columbia River were all reported as less than analyte quantitation limits.

Temperature of the springs at 100-F Area was indicative of mixed water sources, ranging from 16.8°C at site 187-1 to 14.8°C at site 190-4. Values remained constant for the entire presampling period. Such a wide range of temperature is unusual for non-thermally altered groundwater. River temperature at the time of sampling was 18.3°C and 18.7°C, respectively. The pH of both springs stabilized after 15 min, and final readings were 7.35 for both springs. Conductivity measurements indicate possible mixing of groundwater and river water in spring site 187-1 (sample B06L66) with a conductivity of 170 μS/cm and a higher percentage of groundwater contribution at spring site 190-4 (sample B06L71) with a conductivity of 286 μS/cm.

Direct comparison with Dirkes (1990) is not possible as no 100-F Area springs were located during that effort and, therefore, were not sampled.

Sediments from springs at 100-F Area showed one positive occurrence of ^{90}Sr . Sample B06L65 from site 190-4-S was found to contain 20 pCi/g of ^{90}Sr . Cesium-137 was detected at an average concentration of 0.35 pCi/g. Positive detections of europium-155 (^{155}Eu) were found in these spring sediments and ranged from 0.326 to 0.066 pCi/g. Cobalt-60 (^{60}Co) was detected in the gamma scan analyses at levels ranging from 0.06 to 0.25 pCi/g. Average concentrations for other radionuclides were; ^{226}Ra at 0.77 pCi/g, ^{228}Th at 1.24 pCi/g, and ^{232}Th at 1.19 pCi/g.

Sediment analyses are presented in Appendix E.

3.3.2.7 Hanford Townsite. Two springs at sites 241-1 and 247-1 were sampled in the vicinity of the Hanford Townsite. All analyses showed concentrations of potential contaminants at or below the detection limit. Water from the river was at or below the detection limit for suspected contaminants.

Sediment samples from the Hanford Townsite springs showed positive detections of several radionuclides including ^{60}Co , ^{137}Cs , europium-152 (^{152}Eu), ^{155}Eu , ^{226}Ra , ^{228}Th , ^{232}Th , and ^{235}U . These results are provided in Appendix E. There are no sources available other than the 200 Area groundwater plume that could provide this spectrum of constituents.

Dirkes (1990) did not sample these springs at the Hanford Townsite, therefore, comparisons are not possible.

4.0 PRELIMINARY ASSESSMENT OF IMPACT

4.1 COLUMBIA RIVER

Contaminants are entering the Columbia River through springs along the Hanford Reach. However, the concentrations of contaminants in river water samples are generally below analytical detection limits. Where concentrations are above detection limits, with the exception of specific locations noted previously, the concentrations are significantly lower than health-based drinking water standards. Samples of all media collected near the Hanford Townsite showed no detectable quantities of radionuclides, and the general chemistry of the river was good. Although the constituents added to the river through the Hanford springs remain in the water, their impact on the quality of the river was not discernible due to the high dilution factor.

An attempt was made to qualify the impact of the 100 Area springs on the Columbia River. A conservative approach was taken as follows:

- A total groundwater discharge from the 100 Area NPL of 100 ft³/s was assumed
- The minimum mandated flow for the river (36,000 ft³/s) was assumed

- The maximum concentration for each primary radiological constituent was applied to the assumed spring discharge.

The resulting concentration contribution, with complete mixing is shown in Table 2.

Table 2. Calculated Concentration Due to 100 Area Spring Discharges.

Gross Beta	18.9 pCi/L
Tritium	67.5 pCi/L
Strontium-90	8.9 pCi/L
Technetium-99	0.03 pCi/L
Total Uranium	0.8 pCi/L

The average concentration of Cr is 0.34 $\mu\text{g/L}$ when calculated using these extremely conservative assumptions and applying the same criteria.

4.2 SPRINGS

Water emanating from springs in the vicinity of retired reactor areas commonly exceeds regulatory (drinking water) standards for one or more contaminants. Depending on river stage, this water enters the Columbia River directly or within several feet of where it surfaces and is rapidly diluted by the river. The chemistry of the springs sampled during this study cannot be absolutely designated as either groundwater or stored surface water. It is evident that groundwater contaminants enter the river through these springs. The sediments that are influenced by changes in river level serve as a zone of mixing for the groundwater and surface water.

While positive quantities of contaminants were noted entering the river, the mixing of contaminant containing water with the noncontaminated Columbia River resulted in levels of contaminant concentrations that were below the analytical detection limits used in this study. Work plans for the 100 Areas have called for additional studies to address the impact of groundwater discharges on the Columbia River. This study, as well as earlier studies by Dirkes (1990) and McCormack and Carlile (1984), point out the difficulties associated with relating spring discharge chemistry to river chemistry. It is the authors' impression that time and effort are better spent concentrating on the springs and the complex interrelationship of the groundwater and surface water flow systems than on attempting whole river analyses of groundwater inflow.

5.0 RECOMMENDATIONS

During the course of this effort it became apparent that certain revisions to the requirements and/or procedures could be implemented without sacrificing the quality and acceptability of the resulting data. In addition, certain administrative actions could be taken to supplement and ensure that

the effort could proceed more effectively. These recommendations are detailed in the following sections.

5.1 PROCEDURAL CHANGES

5.1.1 Presampling Trend Measurements

Current: The procedure states that measurements of temperature, pH, and electrical conductivity will be taken at 5-min intervals for a period of 1-h prior to the onset of sampling activity.

Proposed: Field measurement of temperature, pH, and conductivity will be taken upon arrival at the sampling site and subsequently during sampling and at the completion of sampling. A minimum of four measurements will be taken and recorded.

Justification: Field practice showed that these measurements did not change appreciably over the period of sampling after stabilization of instruments. The current requirement had an adverse impact on several occasions when sampling was aborted due to rapidly rising river levels. Reducing the amount of time spent at each spring would allow more rapid sampling of the springs and provide a more synoptic view of spring discharges. The understood purpose of this requirement was to allow determination of the influences of bank storage on the effluent water. As measured, these parameters were only of minimal use in determining whether or not the samples represented surface water, groundwater, or a mixture of the two. Detailed and extensive instrumentation of every spring is not justified.

5.1.2 Locating Identification Cairns

Current: The procedure states that one cairn at each site should be placed above the high-water line.

Proposed: Eliminate the necessity for above high-water line placement.

Justification: At the 100-B Area, in some areas downstream of 100-D Area and at 100-K Area, the lateral distance to reach a point above the high-water line is sufficiently far that cairn would be out of sight.

5.1.3 Sediment Sample Depth

Current: Samples of sediments are to be collected from the top 4 in. of sediments at each spring site.

Proposed: Eliminate depth restriction, allowing sediments to be collected from whatever depth is necessary to provide sufficient sample mass.

Justification: The cobbly nature of the typical spring site makes this requirement excessive. Fine grained sediments collected deeper than 4 in. will be equally representative of potentially contaminated soils at any spring site.

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5.1.4 Installation of Well Points

Current: Well points may be installed to enhance the ability to collect spring samples.

Proposed: Eliminate reference to well points.

Justification: Although installing well points may ensure a constant sampling location, such installation is impractical. The extremely cobbly nature of the spring locations makes the possibility of well point installation unrealistic. Gross excavation to improve the spring discharge area proved to be the most practical means of providing a sampling site.

5.1.5 Sample Collection Sequence

Current: Collect sediment sample prior to spring/seep improvement.

Proposed: Allow collection of sediment sample following collection of water samples.

Justification: Difficulties in obtaining sufficient sediment quantities (2 kg) results in high turbidity in the spring water. The ability to defer sediment sampling until after collection of the water will speed the entire sampling process. Stabilization of the sediments at the sampling point will not adversely affect the representativeness of the sediment samples.

5.1.6 Sample Containers

Current: Total activity screening calls for glass or plastic small vial (≥ 1 milliliters (ml)).

Proposed: Increase the volume required to 500 ml for water and 250 ml for sediment.

Justification: The volume required is dependent on the screening laboratory used. The increased container size is sufficient to meet the requirements of all screening laboratories.

5.2 ADMINISTRATIVE/PROCESS CHANGES

5.2.1 Communication

Westinghouse Hanford communication with outside personnel during the collection of the spring sample was limited to a plant radio. Use of or access to a cellular telephone to contact the operators at Priest Rapids Dam or other support personnel would be advantageous.

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5.2.2 Sample Refrigeration

Access to a sample-holding refrigerator would significantly affect the cost and time associated with sample preservation. Such a refrigerator could be located at the embarkation point or at a location close to the screening laboratory. Ice would only be needed for cooling immediately following collection and for ultimate shipment. There would be no need to care for samples over weekends and other nonwork periods.

5.2.3 Flow Control

Administrative agreements should be made with the Grant County Public Utility District, the U.S. Army Corps of Engineers and the Bonneville Power Administration to control the flow of the Columbia River during the period of sampling. This control would provide insurance that springs would be available for sampling as required. Overall time and expense of sampling could be reduced by up to 30% if this control was instituted. Attempts to plan and conduct field activities based on projections of flow proved unreliable.

5.2.4 Instruments

Use of a portable data logger to collect pH, temperature, and conductivity data from the springs is recommended.

5.2.5 Absolute Location

During this effort, the boat used had Long Range Navigation onboard, this instrument provided a general latitude and longitude for the sampling location. Handheld Global Positioning Satellite units are currently available that could be used to define actual location to within ± 25 ft. Use of Global Positioning Satellite technology would permit rapid, reproducible reduction of sampling locations to the Computer Aided Design mapping system, currently available at the Hanford Site.

5.2.6 Spring Notation

As the springs are sampled over time a great deal of confusion will be generated when attempts are made to correlate analyses from separate sampling episodes. A distinct spring notation system has now been developed and implemented, see Appendix F.

5.3 SCOPE CHANGES

Changes in the scope of sampling and analysis activities are suggested based on the quantity, quality, and usefulness of the data collected during this effort.

5.3.1 Number of Springs Sampled

Sampling of springs in the vicinity of the 100 Areas Groundwater Operable Units should be continued. The data derived through a continued monitoring effort can be used to assess the overall impact of remediation efforts. Without sufficient precedent information an analysis of cleanup success will be difficult or impossible to make; for the 100 Areas sampling of the Hanford Townsite is not necessary.

5.3.2 Collection of Near Shore River Samples

Sampling the Columbia River immediately adjacent to the springs should only be done where contaminants are entering the river at levels above some agreed upon level.

6.0 REFERENCES

- Dirkes, R.L., 1988, *Hanford Riverbank Springs Characterization Report*, PNL-7500, December 1990, Pacific Northwest Laboratory, Richland, Washington.
- Evans, J.C., R.W. Bryce, D.J. Bates, and M.L. Kemner, 1990, *Hanford Site Ground Water Surveillance 1989*, PNL-7396, Pacific Northwest Laboratory, Richland, Washington.
- McCormack, W.D. and J.M.V. Carlile, *Investigation of Ground-Water Seepage from the Hanford Shoreline of the Columbia River*, PNL-5289, November 1984, Pacific Northwest Laboratory, Richland, Washington.
- DOE/RL, 1990, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-HR-3 Operable Unit, Hanford Site, Richland, WA*, DOE\RL 88-36, Richland Field Office, Richland, Washington.
- WHC, 1988, *Environmental Investigations and Site Characterization Manual*, WHC-CM-7-7, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX A
HANFORD REACH SPRING SAMPLING PROCEDURE

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HANFORD REACH SPRING SAMPLING

PERFORMANCE PROCEDURE

Prepared by:

IT Corporation
1145 Jadwin Avenue, Suite C
Richland, Washington 99352

Task Order I-91-21
Purchase Order No. MLV-SVV-073751

For:

Westinghouse Hanford Company

Revision 0
August 30, 1991

Prepared by: *David A. Myers* Date 9/13/91
David A. Myers
IT Senior Task Manager
Richland, WA

Approved by: *Richard O. Mahood* Date 9/17/91
Richard O. Mahood
IT Quality Assurance Officer
Richland, WA

Approved by *Kenneth R. Porter* Date 9/13/91
Kenneth R. Porter
IT WHC Program Manager
Richland, WA

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1.0 PURPOSE

This procedure is designed to provide a consistent means of sampling springs/seeps and streams so that the analytical results are indicative of environmental conditions at the sampling point.

2.0 SCOPE

This procedure applies to sampling of springs/seeps and adjacent near-shore waters of the Columbia River and is limited to IT Corp., Westinghouse Hanford Company and their subcontractors involved in the 100 Area spring sampling effort.

3.0 DEFINITIONS

Spring/seep. An area along the bank of the Columbia River where groundwater is discharging to the surface.

Drive Point. A commercially available device commonly used to create a small diameter well. Drive points are available in a narrow range of diameters (1.25 to 2.5 in.), and are commonly 1.5 to 2.0 ft in length.

4.0 RESPONSIBILITIES

Specific individual responsibilities may vary depending on the magnitude of the sampling operation. Personnel will be assigned to the effort and their responsibilities designated by the Field Team Leader. The following responsibility descriptions are presented as general guidelines.

4.1. IT CORP. FIELD TEAM LEADER/COGNIZANT ENGINEER

The Field Team Leader/Cognizant Engineer is responsible for:

- Directing field operations
- Coordinating IT, Westinghouse Hanford, PNL support activities
- Assigning sampler responsibilities
- Maintaining Field Logbook(s)
- Coordinating transportation and shipment of samples
- Acquiring sample numbers from OSM.

4.2. WHC FIELD REPRESENTATIVE

The Westinghouse Hanford Field Representative is responsible for direct interface between subcontractors.

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4.3. IT CORP.. SAMPLER

The Sampler(s) reports to the Field Team Leader and is responsible for:

- Installation of sample site improvements and location markers
- Completing appropriate forms as directed for each sample
- Ensuring that proper sample containers are used
- Containerizing, labeling, and sealing (e.g., evidence tape) individual water and sediment samples
- Maintaining field custody (in accordance with WHC-CM-7-7, EII 5.1 "Chain of Custody") for all samples pending transportation to the analytical laboratory
- Performing decontamination of sampling equipment
- Conducting required field measurements.

5.0 REQUIREMENTS

5.1. SAFETY REQUIREMENTS

All sampling activities shall comply with applicable site-specific Job Safety Analysis (JSA) requirements for the areas being sampled. In addition, a "tailgate" safety meeting will be held before the beginning of work each day to brief field personnel on specific hazards anticipated for that day's effort. Activity specific safety concerns are detailed in Section 6.0.

5.2. RADIOLOGICAL SAFETY

Sampling activities conducted in areas under radiological control will require a Radiation Work Permit (RWP). Before sampling is initiated a radiological survey shall be made of the immediate vicinity of the site(s) to be sampled to determine site-specific background radiation levels. Sample containers shall be closed and sealed while still inside the posted boundaries of the controlled area. All sampling equipment and samples shall be surveyed by a Health Physics Technician (HPT) and either unconditionally released or appropriately labeled upon removal from the controlled area. Sample containers shall not be permitted to leave the controlled area until exterior surfaces are found to be free of removable radioactive contamination. The determination of the presence or absence of removable radioactive contamination shall be accomplished using standard wipe/counting methods.

During sampling activities all protective clothing and/or waste that are used or generated shall be controlled in a manner that protects it

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from undue exposure to the elements (wind, rain, etc.) and prevents inadvertent loss of control.

Used protective clothing and waste that are generated during the sampling activities conducted in radiologically controlled areas shall be containerized, surveyed, labeled, and transported to appropriate storage or disposal areas at completion of activities. Upon completion of sampling activities, surface radiological contamination levels shall be determined; radiological contamination levels in excess of pre-sampling levels shall be remediated prior to cessation of activities in that area.

5.3. RECORDS

The Field Team Leader is responsible for processing field generated records in accordance with WHC-CM-7-7, EII 1.6 "Records Management."

5.4. TRAINING

Personnel involved directly in the collection and handling of sediment and water samples shall be trained to meet the requirements of 29CFR1910.120, documentation of such training will be available at the IT Richland Engineering Office. Person(s) in direct control of the watercraft used to transport sampling personnel shall meet all applicable state and federal requirements and the specifications set forth in the Westinghouse Hanford statement of work for that subcontract, documentation will be maintained with subcontracts files.

5.5. TIMING

Spring/seep sampling conducted to yield samples representative of true groundwater discharges to the river must be accomplished during periods of near to below average river discharge. Late summer to early winter river flows historically meet this condition. It is expected that sustained 14-d average flows of less than 125,000 ft³/s will result in effluent groundwater rather than bank storage being the predominant source of spring flow.

6.0 PROCEDURE

6.1. SAMPLE LOCATION MARKING

All sampling locations are to be clearly marked on the shoreline above the high-water line by two markers that form a "range" defining a line. This will allow individual sampling points to be relocated for any subsequent event.

- The "range" will be installed so that the spring is on line with the range

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- Range markers will be installed above the high water mark
- Markers must be highly visible and durable to resist exposure and weathering. Metal fence posts, painted fluorescent orange, are a type of marker that meet these criteria
- The distance from the marker nearest the river to the sampling point will be measured using either a cloth or steel tape to the nearest 1-ft increment and recorded in a controlled logbook
- Where feasible the range markers will be driven into the sediments using either a sledge hammer or fence-post driver
- Where posts cannot be driven, they will be installed using a wire mesh-supported cairn.

Care should be used in installing the range markers as there is potential danger of pinching of hands during post installation. Leather gloves should be worn during this activity. Proper lifting techniques are essential when securing the markers using the wire mesh cairn.

6.2. SAMPLE COLLECTION SEQUENCE

Sampling of sediments shall precede spring/seep groundwater sampling when both media are to be sampled at a single site. This is to accommodate the probable necessity of improving individual seeps and springs to direct water to a sampling point.

- Collect sediment sample prior to spring/seep improvement. This will ensure representativeness of the sediment sample
- Spring/seep samples and surface water samples (Columbia River) are to be collected contemporaneously
- Coordinate spring/seep and surface water sampling with sampling of groundwater sampling conducted at nearby monitoring wells if possible
- Due to the nature of the spring discharges, no preferred order of water sample collection is necessary
- Conformance with WHC CM-7-7, EII 10.3 PURGEWATER MANAGEMENT is not required
- Water samples shall be collected in general conformance with WHC-CM-7-7, EII 5.8, Rev. 1, GROUNDWATER SAMPLING, Sections 6.4 through 6.8 and Appendix A (other portions of EII 5.8 do not apply to spring/seep sampling)
- Sample numbers shall be assigned by Westinghouse Hanford OSM.

6.3. COLLECTION OF SEDIMENT SAMPLES

Sediment samples are to be collected from areas where springs/seeps emanate from the riverbank. These sediments are to be used to assess the accumulation of contaminants through sorption processes. For this reason only sediments less than or about 2 mm in diameter are appropriate. Two methods of sample collection are available for gathering these samples; excavation and vacuum extraction. General procedures described in WHC-CM-7-7, EII 5.2, Rev. 3, SOIL AND SEDIMENT SAMPLING are to be followed with the following alterations.

6.3.1. Excavation Sampling

- Personnel will don new latex or nitrile gloves prior to each sampling event and between sediment sampling and water sampling activities to reduce potential for cross contamination of samples
- Use a decontaminated (per Section 6.7) stainless steel trowel or similar size implement
- Collect sediments from the vicinity of where the springs/seeps first discharge from the riverbank
- Sediments will be gathered from the surface to a maximum depth of 4 in. and placed in the appropriate container(s)
- Collect approximately 2 kg of sediment
- Note in the field activity daily log or controlled logbook (per Section 6.8) the approximate size of the area sampled to meet the volume requirements
- Decant excess water from the sample container(s)
- Immediately after collection seal, label and place sample on ice.

6.3.2. Vacuum Sampling via Peristaltic Pump

- Use new C-Flex vacuum/suction tubing at each site
- Work the intake portion of the sampler between the coarse materials so that the fine interstitial materials enter the collector
- Decant water from sample accumulator regularly
- Collect sample from the surface to a maximum depth of 4 in.
- Transfer the sediments from the collection system to the sample bottles immediately following collection
- Immediately after collection seal, label and place sample on ice.

6.4. PREPARATION OF SAMPLES FOR OFFSITE SHIPMENT

Samples transported off the Hanford Site or to uncontrolled areas/facilities on the Hanford Site require radiological release. If the samples cannot be opened for analysis, a representative split (water and sediment) from each site sampled shall be submitted for radiological release counting purposes.

6.5. PREPARATION OF SPRING/SEEP SAMPLING POINT

An initial survey of the known spring/seep areas will be made to ascertain if naturally occurring zones of accumulation are present that permit sample collection without improvement. If no such accumulation zone can be located, improvement of the spring will be necessary. Two methods are acceptable, drive point or surface accumulation area.

6.5.1. Installation of a Drive Point

- Attach short segment of standard steel pipe to the drive point (this serves to protect the point during installation).
- Align the drive point and steel pipe so that they will penetrate the sediments at a moderate angle, e.g., $\leq 20^\circ$ from horizontal, vertical depth of penetration should not exceed 1 ft
- Using a sledge hammer or fence-post driver, drive the steel pipe and attached drive point into the riverbank until the screened area is fully covered
- Remove the steel pipe from the drive point
- If needed for sampling, a short length of stainless steel or PVC pipe may be threaded onto end of the drive point to aid sample collection.

Special safety considerations are involved in this method. Extreme care must be taken when installing the drive point into the riverbank. Safety goggles are essential to protect against metal spalls from either the sledge, steel pipe, or the drive point. Hands are potentially subject to impact from the sledge hammer or post driver. Leather gloves should be worn as protection from metal slivers. Footing may be tenuous due to wet and/or slippery surfaces.

6.5.2. Preparation of Surface Accumulation Area

- Select an area where the springs/seeps produce noticeable flow at the surface.
- Selectively remove cobbles, boulders, etc., to create an accumulation basin.

- Removed sediments may be used to create a dam around the excavated area.
- Channel spring/seep discharges to the collection point.
- If necessary the accumulation basin may be lined with clean sheet plastic or decontaminated stainless steel bowl.

Special safety considerations are involved in this method. Extreme care must be taken in lifting and moving large rocks. Surfaces at the springs/seeps are likely to be slippery due to the water and due accumulations of algae or slime. Slip, trip and fall hazards may be present, as well as stress to lower back from frequent lifting under nonideal conditions. Additional hazard may exist due to potential over steepening of the bank and may cause sloughing from above. Caution must be exercised during these activities.

6.5.3. Spring/Seep Sample Collection

- Personnel will don new latex or nitrile gloves prior to each sampling event to reduce the potential for sample cross contamination
- Measure and record temperature, pH and conductivity of spring discharge for 1 h at 5-min intervals. If the site being sampled is being influenced by direct sunlight, shade the sample site to help stabilize induced thermal variations
- Collect sample directly from the end of drive point or from the end of the stainless steel or PVC pipe attached to the drive point
- The area immediately below the discharge point of the drive point or attached pipe may be modified to facilitate filling the sample bottles
- Where the above options cannot be used, the water may be discharged into a decontaminated (per Section 6.7.2) stainless steel bowl and then transferred to the sample containers using a peristaltic pump.
- In instances where the spring was improved by construction of an accumulation area, samples will be transferred into sample containers by pumping directly from the accumulation area using a peristaltic pump
- Filter the sample collected for ICP metals (filtered)
- Immediately after collection seal label and place sample on ice
- Discard any used flexible tubing between sampling events/locations to prevent possible cross contamination. Segregate discarded tubing by placing in a sealable plastic bag and marking the bag with the sampling location. All wastes, except that generated in

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areas under radiological control, will be contained and controlled in accordance with WHC-CM-7-7, EII 4.2, INTERIM CONTROL OF UNKNOWN, SUSPECTED HAZARDOUS AND MIXED WASTE. Wastes generated from areas under radiological control will be handled in accordance with WHC-IP-0718, GUIDELINES FOR THE CONDUCT OF RADIOLOGICAL WORK.

6.6. NEAR-SHORE RIVER WATER SAMPLING

Near-shore river water samples will be collected adjacent to the springs to indicate the impact of spring/seepage zone discharges on river water chemistry. In the event that river discharge is greater than 125,000 ft³/s and covers the spring, only the river sample will be collected.

6.6.1. Sample Site Location

- Samples will be collected as near to the range line as possible
- All samples will be collected from areas of moving water
- The location of the sampling position will be recorded in the field activity daily log or controlled logbook.

6.6.2. Sample Depth

- Samples will be collected where water depth is ≤ 3 ft, at a maximum distance of < 0.5 ft above the bottom
- Water depth will be determined by use of a wading staff marked in feet and tenths of feet.

6.6.3. Sample Collection

Samples may be collected using either of two methods; direct filling sampler or, use of a peristaltic pump.

6.6.3.1. Direct Sampling

- Lower sampler to selected depth
- Allow flow through for minimum of 10 s.
- Close container while holding at sampling depth
- Transfer the collected sample to the filter apparatus or sample container
- Filter the sample collected for ICP metals (filtered)

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- Immediately after collection seal, label and place sample on ice.

6.6.3.2. Peristaltic Pump Sampling

- Determine desired sampling depth (0 to 0.5 ft above bottom)
- Attach new C-Flex suction tubing to wading staff at desired depth
- Install tubing on pump according to manufacturers instructions
- Actuate pump and collect samples in appropriate containers
- Filter the sample collected for ICP metals (filtered)
- Immediately after collection seal, label, and place sample on ice per WHC-CM-7-7, EII 5.11. Rev 1, SAMPLE PACKAGING AND SHIPPING.

Working in and around moving water in the Columbia River creates specific hazard exposures. The buddy system will be used whenever samples are being collected in the river. A life-line will be attached to the in-river sampler and controlled by the on shore "buddy". In addition, an inflatable "Mae West" floatation device will be worn. Hip or chest-high waders shall be worn during sample collection. In no case shall the river be entered while barefoot. Slip, trip and fall hazards are normal when working in moving water, care must be taken to assure positive footing. Hypothermia is a hazard.

6.7. ANALYTES, PRESERVATIVES, SAMPLE CONTAINERS AND HOLDING TIMES

All glassware and plasticware used to contain and ship samples shall be purchased "certified clean".

6.7.1. Sediment

Sediment samples will be collected and transported in the containers listed in Table 1. Following collection and labeling all sediment samples will be placed in an ice chest and cooled with frozen "blue ice" or doubly bagged water ice.

6.7.2. Water

Water samples from springs/seeps and the Columbia river will be collected and transported in the containers listed in Table 2. Following collection and labeling all water samples will be placed in an ice chest and cooled with frozen "blue ice" or doubly bagged water ice.

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6.8. DECONTAMINATION OF EQUIPMENT

Decontamination of sampling equipment shall be done in accordance with WHC-CM-7-7, EII 5.4 Rev 3, FIELD DECONTAMINATION OF DRILLING, WELL DEVELOPMENT AND SAMPLING EQUIPMENT, and shall consist of the following at a minimum:

6.8.1. Sediment sampling equipment

Sediment sampling equipment shall be decontaminated at the start of each day's activity and between sampling locations. Decontamination shall consist of the following:

- Scrubbing the instrument in river water to remove coarse material
- Wash and scrub using Alconox or equivalent detergent solution
- Rinse twice using commercially available distilled or deionized water
- Wrap in clean plastic wrap pending use at next sample location
- Any flexible tubing used in vacuum system shall be discarded and new tubing used for subsequent sample collection.

6.8.2. Water sampling equipment

Water sampling and filtering equipment shall be decontaminated between sampling locations. Decontamination shall consist of the following:

- Equipment contacting sample shall be rinsed in river water to remove any sediments
- Wash and scrub, if possible, the interior and exterior using Alconox or equivalent detergent solution
- Rinse twice using commercially available distilled or deionized water
- Wrap in clean plastic pending use at next sampling event
- Any flexible tubing used in peristaltic pump system shall be discarded and new tubing used for subsequent sample collection.

6.9. FIELD MEASUREMENTS

Site characteristics shall be recorded in the sampling log or controlled notebook prior to and during the sampling events. A new page is necessary for each sampling location. These measurements consist of the following:

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- Record date, time, and names of sample crew members
- Spring Temperature: record temperature to nearest 0.5°C at 5-min intervals for 1 h prior to sampling, then at completion of sampling. If collection from an accumulation area is used, provide shading of that area to limit insolation-induced heating
- Air Temperature: record to nearest 0.5°C once at beginning of sample period and once at end
- Time: record start and finish times for each sampling segment; sediments, spring/seep and river, use 24-h clock and record to nearest minute
- pH: record to nearest 0.1 pH unit at 5-min intervals for 1 h prior to spring sampling and before and following river sampling
- Calibrate instrument at beginning and completion of each day of field activity using standards pH 4.0, 7.0 and 10
- Record adjustments on Field Instrument Calibration Log
- Specific Conductivity: record to nearest 10 μS (microseimens) at 5-min intervals for 1 h prior to spring sampling and before and following river sampling
- Calibrate instrument daily
- Calibrate using a standard solution of 1,000 μS
- Unusual Occurrences: record when appropriate
- Flow Rate: record approximate discharge rate of springs/seeps
- Where samples are collected through a drive point discharge report as the rate of filling a known volume container, e.g., 1 L/min
- Where samples are collected from a surface accumulation area visually estimate the discharge rate
- River discharge rate will be determined from discharge records based on time of collection
- Spring Description: record a physical description of the spring/seep
- Indicate the appearance of the sediments
- Note wetted areas above and below the sample point
- Indicate expanse of discharge area
- Indicate the size (dimensions) of any accumulation area

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- Note any rise or fall of the river stage over the sampling period and any evidence of recent high water
- River Description: Record a subjective description of river water clarity (clear, colored, muddy, etc.) and other conditions at the time of sampling
- Atmospheric Conditions: Record a simple description of weather conditions from the start of site preparations through completion of sampling.

6.10. SAMPLE CONTROL AND SHIPMENT

6.10.1. Sample Packaging and Shipment

Sample packaging and shipment procedures shall be those described in WHC-CM-7-7, EII 5.11, SAMPLE PACKAGING AND SHIPPING.

6.10.2. Chain-of-Custody

Maintenance of Chain-of-Custody shall be in accordance with WHC-CM-7-7, EII 5.1 CHAIN OF CUSTODY.

7.0 REFERENCES

WHC-CM-7-7, EII 4.2. Rev 2, INTERIM CONTROL OF UNKNOWN, SUSPECTED HAZARDOUS AND MIXED WASTE.

WHC-CM-7-7, EII 5.1 CHAIN OF CUSTODY.

WHC-CM-7-7, EII 5.2. Rev. 3, SOIL AND SEDIMENT SAMPLING.

WHC-CM-7-7, EII 5.4 Rev 3, FIELD DECONTAMINATION OF DRILLING, WELL DEVELOPMENT AND SAMPLING EQUIPMENT.

WHC-CM-7-7, EII 5.8, Rev. 1, GROUNDWATER SAMPLING.

WHC-CM-7-7, EII 5.11, SAMPLE PACKAGING AND SHIPPING.

WHC CM-7-7, EII 10.3 PURGEWATER MANAGEMENT.

WHC-IP-0718, GUIDELINES FOR THE CONDUCT OF RADIOLOGICAL WORK.

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Table 1. Sampling Containers for Sediment Samples.

ANALYTE	METHOD	HOLDING TIME	CONT./VOL
ICP METALS	6010	6 months	G/120 ml
GROSS ALPHA GROSS BETA GAMMA SPEC.	Lab. SOP Lab. SOP Lab. SOP	6 months 6 months 6 months	G/2 kg of soil (~1000 ml)
TOTAL ACTIVITY	N/A		G or P small vial (≥ 100 ml)

Table 2. Sampling Containers, Method Numbers, Holding Times for Water Samples.

ANALYTE	METHOD	HOLDING TIME	PRESERV.	CONT./VOL.
ICP METALS (filtered)	6010	6 months	HNO ₃	P/1000 ml
ICP METALS (unfiltered)	6010	6 months	HNO ₃	P/1000 ml
ANIONS (IC) CONDUCTIVITY ALKALINITY TDS TURBIDITY pH	300.0 9050 9040	48 hrs 28 days 14 days 7 days 48 hrs ASAP (upon lab arrival)	N/A	P/1000 ml
AMMONIUM COD		28 days 28 days	H ₂ SO ₄ H ₂ SO ₄	P/250 ml
TOC	9060	28 days	H ₂ SO ₄	Gs/250 ml
GROSS ALPHA GROSS BETA GAMMA SPEC. TOTAL URANIUM TRITIUM Sr-90 Tc-99	Lab. SOP Lab. SOP Lab. SOP Lab. SOP Lab. SOP Lab. SOP Lab. SOP	6 months 6 months 6 months 6 months 6 months	HNO ₃ HNO ₃ HNO ₃ HNO ₃ HNO ₃ HNO ₃ HNO ₃	P/4000 ml G/120 ml Gs/250 ml P/1000 ml P/1000 ml
TOTAL ACTIVITY	N/A			G or P small vial (≥ 100 ml)

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APPENDIX B
NONCONFORMANCES AND VARIANCES TO APPROVED PROCEDURE

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NONCONFORMANCE REPORT

PROJECT NO. 199806-121-02

PAGE 1 OF 1

PROJECT NAME Hanford Reach Spring Sampling

DATE: 2-12-92

NONCONFORMANCE: The conductivity meter used during the Hanford Reach Spring Sampling (September through November 1991) was not calibrated at the frequency required in the Hanford Reach Spring Sampling Performance Procedure, Revision 0, dated August 30, 1991. Section 6.9 requires use of a daily calibration using a standard solution of 1000 μ S.

Calibration was performed using the required standard, but only on two occasions: on 11-01-91 and 11-24-91. On both occasions the instrument "as found" condition was within 10% of the standard, which was felt to be sufficiently accurate and showed instrument stability over time.

IDENTIFIED BY: Richard Mahood DATE: 2-12-92

CORRECTIVE ACTION REQUIRED: ~~Perform calibration at required frequency.~~

Because the conductivity meter showed stability and because meter readings were only used to show sampling source consistency prior and during sampling, no corrective action for the data obtained is necessary. For future sampling events, a meter with improved temperature correction function should be used.

TO BE PERFORMED BY: N.A. DATE: N.A.

MUST CORRECTION BE VERIFIED? YES NO

TO BE VERIFIED BY: ~~F.A. Carter~~ PREPARED BY: F.D. Carter DATE: 2/12/92

CORRECTIVE ACTION TAKEN:

PERFORMED BY: _____ DATE: _____

VERIFIED BY: _____ DATE: _____

CC:

Approved By: [Signature] Date: 2/13/92

[Signature] Date: 2/12/92

F.D. Carter
QA Manager

92126431329



NONCONFORMANCE REPORT

PROJECT NO. 199806-121-02

PAGE 1 OF 1

PROJECT NAME Hanford Reach Spring Sampling

DATE: 2-12-92

NONCONFORMANCE: Installation of range markers during Hanford Reach Spring Sampling (September through November 1991) did not completely follow the Hanford Reach Spring Sampling Performance Procedure, Revision 0, dated August 30, 1991. Section 6.1 requires that range markers be installed above the high water mark.

Range markers were installed above the apparent seasonal high water line. However, many of the range markers are located at elevations below the high water line associated with the annual maximum river discharge. Range markers would not be visible from the river if installed above the annual high water line in some sampling locations at the 100-H, 100-F, 100-K, and 100-B/C areas. The annual high water line was indicated by debris entangled in the branches and crowns of trees and shrubs found along the shoreline. Locations of springs were also plotted on 1 to 2000 scale maps to provide a back-up method of locating the springs.

IDENTIFIED BY: Richard Mahood DATE: 2-12-92

CORRECTIVE ACTION REQUIRED: Revise the Hanford Reach Spring Sampling Performance Procedure, Revision 0, dated August 30, 1991 to accommodate field conditions and information gained during the 1991 field season. The revision should incorporate information gained from inspection, after the period of annual maximum flow, of the range markers installed during the 1991 field effort. The revision should be performed prior to the next sampling period.

TO BE PERFORMED BY: Richard Mahood DATE: 2-12-92

MUST CORRECTION BE VERIFIED? YES X NO

TO BE VERIFIED BY: D.A. Myers PREPARED BY: R. Mahood/F.D. Carter DATE: 2-12-92

CORRECTIVE ACTION TAKEN:

PERFORMED BY: _____ DATE: _____

VERIFIED BY: _____ DATE: _____

CC: Corrective Action Required

Approved By: [Signature] Date: 2/13/92

[Signature] Date: 2/12/92

F.D. Carter
QA Manager

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NONCONFORMANCE REPORT

PROJECT NO. 199806-121-02

PAGE 1 OF 1

PROJECT NAME Hanford Reach Spring Sampling

DATE: 2-12-92

NONCONFORMANCE: Collection of sediment samples during Hanford Reach Spring Sampling (September through November 1991) did not completely follow the Hanford Reach Spring Sampling Performance Procedure, Revision 0, dated August 30, 1991. Section 6.2 requires that sediments be collected before spring water collection, and Section 6.3.1 requires sediments be collected no more than four inches below the surface.

Spring and river water were collected concurrently but before sediment collection. This allowed all samples to be collected as quickly as possible and did not diminish the quality of the samples. Collecting water before sediment reduced the possibility that rising river level would flood the spring during sampling, before all types of samples could be collected. The river water level was found to be capable of rising many feet in a few hours which limited the time available for sampling at a location.

When sampling sediment on shorelines consisting largely of gravel, cobbles, or boulders the fine-grained sediments were collected as much as 12 inches below the surface to obtain the required two kg of fine-grained sediment.

IDENTIFIED BY: Richard Mahood DATE: 2-12-92

CORRECTIVE ACTION REQUIRED: Revise the Hanford Reach Spring Sampling Performance Procedure, Revision 0, dated August 30, 1991 to include information gained during the 1991 field season. The revision should include the order in which water and sediment samples are collected, and modification of the procedure to accommodate field conditions. The revision should be performed prior to the next sampling period.

TO BE PERFORMED BY: Richard Mahood DATE: 2-12-92

MUST CORRECTION BE VERIFIED? YES X NO

TO BE VERIFIED BY: D.A. Myers PREPARED BY: R. Mahood/F.D. Carter DATE: 2-12-92

CORRECTIVE ACTION TAKEN:

PERFORMED BY: _____ DATE: _____

VERIFIED BY: _____ DATE: _____

CC: Corrective Action Required

Approved By: [Signature] Date: 2/13/92

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[Signature]
F.D. Carter
QA Manager

Date: 2/12/92

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APPENDIX C
CHEMICAL ANALYSES OF WATER SAMPLES

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APPENDIX C
EXPLANATION OF TERMS

- 9 2 1 2 6 4 3 1 3 3 3
- Site Identification: Identifies the specific sample site. The first three digits, e.g., 037, identify the location using the Hanford River Mile (HRM) system. A location at 037 is at HRM 3.7 miles. The next digit 037-1 identifies sites in an upstream to downstream order at that river mile. The letter R indicates a river sample location, e.g., 037-1-R. The letter S denotes a sediment sample location, e.g., 037-1-S.
- Sample Area: This identifier denotes the specific reactor area or general position of the associated sample.
- Sample Type: Identifies the source of the sample, either spring or river
- Discharge river/spring (ft^3/s): Identifies the average discharge of the Columbia River for the day of sampling or the estimated discharge of the individual spring at the time of sampling. Discharges are in cubic feet per second.
- Coordinates E (m)
Coordinates N (m): Identifies the location of the sample location according to the NAD 1983 Washington State South Zone Coordinates in Meters .
- River Mile (nearest 0.1 mi.): Identifies the approximate Hanford River Mile. Hanford River Mile 0.0 is at the Vernita Bridge. Measurements are scaled from the 1:2000 maps of the Hanford Site.
- Date: Day on which the specific sample was collected.
- Time Interval: The sampling interval, starting with the initiation of presampling measurements for the springs. For river samples, the interval denotes the actual time during which the sample was collected.
- OSM Sample No.: The sample tracking number assigned to a specific set of samples. Each spring/sediment sample had a single number; the adjacent river sample was assigned a separate number. All numbers were supplied by Westinghouse Hanford OSM.
- Sample Comments: Identifies samples that were filtered during collection using a 0.45 micron filter. Both filtered and unfiltered water samples were collected for analysis of metals using inductively coupled plasma atomic emission spectroscopy.
- nr: Data not recorded in the field.

Q (Qualifier):

Qualifier codes were supplied through the data validation process. All data validation was done by Westinghouse Hanford OSM.

- U - none detected; numerical value is sample quantitation limit
- J - estimated value (less than quantitation limit)
- B - analyte found in associated blank as well as in sample
- E - concentration exceeds calibration range
- Q - not analyzed
- D - compound identified at secondary dilution factor
- N - Presumptive evidence of presence of material
- NJ - Presumptive evidence of presence of material at estimated quantity
- UJ - not detected; quantitation limit is estimated
- R - data unusable; compound may/may not be present
- <blank> - positive
- DIL/C - diluted out
- N/A - not analyzed

9 2 1 2 6 4 3 1 3 3 4

Appendix C: Water Chemistry

Site Identification	037-1		037-1		037-1-R		037-1-R		038-3	
Sample Area	100B		100B		100B		100B		100B	
Sample Source	spring		spring		river		river		spring	
Discharge river/spring (cfs)	5.90E-04		5.90E-04		9.35E+04		9.35E+04		3.30E-03	
Coordinates E (m)	564540		564540		564940		564940		564675	
Coordinates N (m)	145275		145275		145350		145350		145275	
River Mile (nearest 0.1 mi.)	3.7		3.7		3.7		3.7		3.8	
Date	9/18/91		9/18/91		9/18/91		9/18/91		9/17/91	
Time Interval	9:45 - 11:45		9:45 - 11:45		10:48 - 11:45		10:48 - 11:45		13:25 - 16:19	
OSM Sample No.	B06KR4	Q	B06KR3	Q	B06KR6	Q	B06KR5	Q	B06KR9	Q
Quality Control Sample										
Sample Comments	filtered				filtered				filtered	
Aluminum (ug/l)	44.70	U	71.30	U	38.20	B	55.60	U	41.70	U
Antimony (ug/l)	47.00	U	47.00	U	47.00	U	47.00	U	47.00	U
Barium (ug/l)	58.70	B	58.70	B	26.10	B	27.20	B	56.50	B
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	3.00	U	3.00	U	3.00	U	3.00	U	3.00	U
Calcium (ug/l)	38000.00		38800.00		17300.00		17500.00		44400.00	
Chromium (ug/l)	54.10		27.70	J	6.00	UJ	6.00	UJ	40.60	
Cobalt (ug/l)	8.00	U	8.00	U	8.00	U	8.00	U	8.00	U
Copper (ug/l)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
Iron (ug/l)	1550.00		64.90	U	12.00	U	63.60	U	41.80	U
Magnesium (ug/l)	8810.00		9010.00		3920.00	B	3950.00	B	6910.00	
Manganese (ug/l)	46.60		2.00	U	3.70	B	8.60	U	2.00	U
Nickel (ug/l)	130.00		9.00	U	9.00	U	9.00	U	9.00	U
Potassium (ug/l)	3700.00	B	3710.00	B	732.00	B	658.00	B	4440.00	B
Silver (ug/l)	4.00	U	4.00	U	4.00	U	5.50	B	4.00	U
Sodium (ug/l)	10400.00		10600.00		1850.00	J	2080.00	J	9630.00	
Vanadium (ug/l)	8.00	B	6.70	B	5.00	U	5.00	U	5.40	B
Zinc (ug/l)	7.00	UJ	7.00	UJ	7.00	UJ	7.00	UJ	7.00	UJ
TOC (mg/l)			1.3	J			2.4	J		
COD (mg/l)			<60				<60			
Ammonia (mg/l)			<0.5	UJ			<0.5	UJ		
Fluoride (mg/l)			0.2	J			<0.05	J		
Chloride (mg/l)			8.03	J			0.11	J		
Nitrite (mg/l)			<0.05	UJ			<0.05	UJ		
Nitrate (mg/l)			1.62	J			<0.1	J		
Sulfate (mg/l)			38.76	J			2.1	J		
Phosphate (mg/l)			<0.1	UJ			<0.1	UJ		
Elec. Cond. (umho/cm)			287	J			121	J		
pH			7.4				8.09			
TDS (mg/l)			190				64			
Turbidity (mg/l)			<0.2				<0.2			
Alkalinity (mg/l)			99	J			53	J		

Appendix C: Water Chemistry

Site Identification	038-3		039-2		039-2		057-3		057-3		057-3-R	
Sample Area	100B		100B		100B		100K		100K		100K	
Sample Source	spring		spring		spring		spring		spring		river	
Discharge river/spring (cfs)	3.30E-03		2.00E-03		2.00E-03		2.90E-04		2.90E-04		9.30E+04	
Coordinates E (m)	564675		564940		564940		567585		567585		567585	
Coordinates N (m)	145275		145350		145350		146210		146210		146210	
River Mile (nearest 0.1 mi.)	3.8		3.9		3.9		5.7		5.7		5.7	
Date	9/17/91		33500		33500		9/25/91		9/25/91		9/25/91	
Time Interval	13:25 - 16:19		9:20 - 11:06		9:20 - 11:06		7:25 - 9:05		7:25 - 9:05		9:15 - 9:50	
OSM Sample No.	B06KR8	Q	B06KS2	Q	B06KS1	Q	B06KS5	Q	B06KS4	Q	B06KS7	Q
Quality Control Sample												
Sample Comments			filtered				filtered				filtered	
Aluminum (ug/l)	268.00		20.00	U	65.00	UJ	17.00	U	37.40	U	17.00	U
Antimony (ug/l)	47.00	U	8.00	U	8.00	UJ	14.00	U	14.00	U	14.00	U
Barium (ug/l)	64.10	B	63.00	B	63.00	U	38.70	B	38.00	J	24.70	B
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	3.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Calcium (ug/l)	43100.00		44400.00		43500.00		36500.00		35600.00		17300.00	
Chromium (ug/l)	38.90	J	16.90		13.70		17.40		5.00	U	2.00	U
Cobalt (ug/l)	8.00	U	3.00	U	3.00	U	2.00	U	2.00	U	2.00	U
Copper (ug/l)	5.00	U	3.00	UJ	3.00	UJ	2.00	U	2.00	UJ	2.00	U
Iron (ug/l)	395.00	U	13.30	U	62.60	B	59.80	B	68.90	U	7.00	U
Magnesium (ug/l)	6770.00		6910.00		6750.00		9150.00		8800.00		3820.00	B
Manganese (ug/l)	6.60	U	1.00	U	1.40	U	1.00	U	3.10	U	1.50	B
Nickel (ug/l)	9.00	U	4.00	U	4.00	U	5.00	U	5.00	U	5.00	U
Potassium (ug/l)	4490.00	B	2590.00	B	2490.00	J	2630.00	J	2540.00	J	709.00	J
Silver (ug/l)	4.00	U	2.40	U	2.00	U	5.00	U	5.00	UJ	5.00	U
Sodium (ug/l)	9620.00		7230.00		7010.00		11300.00	J	11000.00	J	1900.00	J
Vanadium (ug/l)	7.80	B	5.10	U	4.40	U	8.60	U	8.50	U	2.00	U
Zinc (ug/l)	7.00	UJ	7.50	U	4.00	U	5.00	U	5.00	U	5.00	U
TOC (mg/l)	1.4	J							0.5	U		
COD (mg/l)	<60				<30				<60			
Ammonia (mg/l)	<0.5	UJ			0.1	J			<0.5	UJ		
Fluoride (mg/l)	0.15	J			0.1	J			<0.05			
Chloride (mg/l)	9.65	J							5.94			
Nitrite (mg/l)	<0.05	UJ			<0.1	R			<0.05	UJ		
Nitrate (mg/l)	2.26	J			2.4	J			1.47	J		
Sulfate (mg/l)	41.29	J			37	J			19.16			
Phosphate (mg/l)	<0.1	UJ							<0.1	UJ		
Elec. Cond. (umho/cm)	303	J			28				296	J		
pH	7.68				7.9				7.71			
TDS (mg/l)	210				194				182			
Turbidity (mg/l)	<0.2				<1				<0.2			
Alkalinity (mg/l)	107	J			98				119	J		

9 2 1 2 6 4 3 1 3 3 6

Appendix C: Water Chemistry

Site Identification	057-3-R		077-1		077-1		077-1-R		077-1-R	
Sample Area	100K		100K		100K		100K		100K	
Sample Source	river		spring		spring		river		river	
Discharge river/spring (cfs)	9.30E+04		1.80E-02		1.80E-02		7.62E+04		7.62E+04	
Coordinates E (m)	567585		569680		569680		569680		569680	
Coordinates N (m)	146210		148070		148070		148070		148070	
River Mile (nearest 0.1 mi.)	5.7		7.7		7.7		7.7		7.7	
Date	9/25/91		10/16/91		10/16/91		10/16/91		10/16/91	
Time Interval	9:15 - 9:50		12:30 - 13:30		12:30 - 13:30		12:40 - 13:26		12:40 - 13:26	
OSM Sample No.	B06KS6	Q	B06KT0	Q	B06KS9	Q	B06KT2	Q	B06KT1	Q
Quality Control Sample										
Sample Comments			filtered				filtered			
Aluminum (ug/l)	97.30	U	45.00	U	255.00		21.10	U	74.90	U
Antimony (ug/l)	14.90	U	14.00	U	47.00	U	14.00	U	47.00	U
Barium (ug/l)	27.40	J	36.30	B	35.90	B	25.00	B	29.70	B
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	1.00	U	1.00	U	3.00	U	1.00	U	3.00	U
Calcium (ug/l)	17600.00		28400.00		27100.00		17500.00		16600.00	
Chromium (ug/l)	2.00	U	64.50		68.70		2.00	U	6.00	U
Cobalt (ug/l)	2.00	U	2.00	U	8.00	U	2.00	U	8.00	U
Copper (ug/l)	2.00	UJ	2.00	U	6.50	B	2.00	U	5.00	U
Iron (ug/l)	97.60	B	45.40	U	243.00		10.50	U	171.00	
Magnesium (ug/l)	3850.00	B	6560.00	J	6350.00		3890.00	J	3700.00	B
Manganese (ug/l)	8.90	B	1.00	U	8.70	B	1.50	U	19.60	
Nickel (ug/l)	5.00	U	5.00	U	9.00	U	5.00	U	9.00	U
Potassium (ug/l)	718.00	J	1470.00	B	1460.00	B	713.00	B	779.00	B
Silver (ug/l)	5.00	UJ	5.00	U	5.50	B	5.00	U	4.00	U
Sodium (ug/l)	2140.00	J	3270.00	J	3270.00	J	1670.00	J	1580.00	J
Vanadium (ug/l)	2.00	U	3.80	U	6.30	B	4.10	U	5.00	U
Zinc (ug/l)	6.40	B	5.00	U	8.70	U	5.00	U	7.00	U
TOC (mg/l)	1.5				0.75				1.4	
COD (mg/l)	<60				<60				<60	
Ammonia (mg/l)	<0.5	UJ			<0.5				<0.5	
Fluoride (mg/l)	0.44				0.36				0.05	
Chloride (mg/l)	0.75				2.61				0.83	
Nitrite (mg/l)	<0.05	UJ			<0.05	UJ			<0.05	UJ
Nitrate (mg/l)	<0.1	UJ			0.97	J			<0.1	UJ
Sulfate (mg/l)	8.4				29.13				8.97	
Phosphate (mg/l)	<0.1	UJ			<0.1	UJ			<0.1	UJ
Elec. Cond. (umho/cm)	123	J			206.8				113.2	
pH	7.89				7.12				7.88	
TDS (mg/l)	34				126				80	
Turbidity (mg/l)	<0.2				5.3				1.4	
Alkalinity (mg/l)	52	J			68.4	J			53.2	J

9 2 1 2 6 4 3 1 3 3 7

Appendix C: Water Chemistry

Site Identification	082-2		082-2		082-2-R		082-2-R		090-1	
Sample Area	100K		100K		100K		100K		100N	
Sample Source	spring		spring		river		river		spring	
Discharge river/spring (cfs)	2.20E-02		2.20E-02		9.08E+04		9.08E+04		2.90E-01	
Coordinates E (m)	570415		570415		570415		570415		571300	
Coordinates N (m)	148780		148780		148780		148780		149920	
River Mile (nearest 0.1 mi.)	8.3		8.3		8.3		8.3		9.0	
Date	10/18/91		10/18/91		10/18/91		10/18/91		10/15/91	
Time Interval	14:10 - 16:05		14:10 - 16:05		15:25 - 15:55		15:25 - 15:55		11:00 - 12:30	
OSM Sample No.	B06KT5	Q	B06KT4	Q	B06KT7	Q	B06KT6	Q	B06KV0	Q
Quality Control Sample										
Sample Comments	filtered				filtered				filtered	
Aluminum (ug/l)	17.00	U	132.00	U	17.00	U	94.40	U	50.20	U
Antimony (ug/l)	14.00	U	47.00	U	30.40	B	47.00	U	14.00	U
Barium (ug/l)	40.30	B	42.10	B	19.60	B	27.20	B	29.60	B
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	1.00	U	3.00	U	1.00	U	3.00	U	1.00	U
Calcium (ug/l)	33500.00		32400.00		17100.00		16400.00		24900.00	
Chromium (ug/l)	13.90	U	10.50		2.60	U	6.00	U	2.00	U
Cobalt (ug/l)	2.00	U	8.00	U	2.00	U	8.00	U	2.00	U
Copper (ug/l)	2.00	U	5.00	U	2.00	U	5.00	U	2.00	U
Iron (ug/l)	8.50	U	130.00		7.90	U	130.00		28.10	U
Magnesium (ug/l)	8180.00	J	8050.00		3780.00	J	3670.00	B	4230.00	B
Manganese (ug/l)	1.00	U	2.50	B	1.80	U	5.80	B	2.30	U
Nickel (ug/l)	5.00	U	9.00	U	5.00	U	9.00	U	5.00	U
Potassium (ug/l)	2530.00	N	2560.00	B	756.00	B	722.00	U	1230.00	J
Silver (ug/l)	5.00	U	4.00	U	5.00	U	4.00	U	5.00	U
Sodium (ug/l)	17100.00	J	17000.00	J	1850.00	J	1660.00	J	2590.00	B
Vanadium (ug/l)	10.90	U	10.70	B	4.70	U	5.00	U	3.20	U
Zinc (ug/l)	5.00	U	7.00	U	5.00	U	7.00	U	5.00	U
TOC (mg/l)			0.5	U			1.4			
COD (mg/l)			<60				<60			
Ammonia (mg/l)			<0.5				<0.5			
Fluoride (mg/l)			0.28				0.11			
Chloride (mg/l)			6.01				0.86			
Nitrite (mg/l)			<0.05	UJ			<0.05	UJ		
Nitrate (mg/l)			1.11	J			0.5	J		
Sulfate (mg/l)			63.91				9.23			
Phosphate (mg/l)			<0.1	UJ			<0.1	UJ		
Elec. Cond. (umho/cm)			306.4				119.5			
pH			7.76				7.36			
TDS (mg/l)			221				89			
Turbidity (mg/l)			0.88				1.7			
Alkalinity (mg/l)			80.8	J			52.3	J		

9 2 1 2 6 4 3 1 3 3 8

Appendix C: Water Chemistry

Site Identification	090-1	090-1-R	092-2	092-2	092-2-R
Sample Area	100N	100N	100N	100N	100N
Sample Source	spring	river	spring	spring	river
Discharge river/spring (cfs)	2.90E-01	8.16E+04	5.90E-01	5.90E-01	8.16E+04
Coordinates E (m)	571300	571300	571465	571465	571465
Coordinates N (m)	149920	149920	150150	150150	150150
River Mile (nearest 0.1 mi.)	9.0	9.0	9.2	9.2	9.2
Date	10/15/91	10/15/91	10/15/91	10/15/91	10/15/91
Time Interval	11:00 - 12:30	11:10 - 12:00	14:02 - 15:07	14:02 - 15:07	14:15 - 14:42
OSM Sample No.	B06KT9	Q B06KV1	Q B06KV4	Q B06KV3	Q B06KV6
Quality Control Sample					
Sample Comments			filtered		filtered
Aluminum (ug/l)	384.00	60.10 U	48.80 U	314.00	34.40 U
Antimony (ug/l)	14.00 U				
Barium (ug/l)	35.30 B	25.90 B	19.60 B	19.60 B	23.90 B
Beryllium (ug/l)	1.00 U				
Cadmium (ug/l)	1.00 U				
Calcium (ug/l)	25600.00	17200.00	26400.00	26400.00	17000.00
Chromium (ug/l)	2.30 U	2.00 U	2.00 U	2.60 U	2.00 U
Cobalt (ug/l)	2.00 U				
Copper (ug/l)	2.10 U	2.00 U	2.00 U	2.00 U	2.00 U
Iron (ug/l)	405.00	43.10 U	35.50 B	474.00	93.50 U
Magnesium (ug/l)	4410.00 B	3810.00 B	4540.00 B	4600.00 B	3770.00 B
Manganese (ug/l)	13.70 U	5.40 U	1.00 U	14.00 U	2.40 U
Nickel (ug/l)	5.00 U				
Potassium (ug/l)	1270.00 J	675.00 B	1320.00 J	1410.00 J	658.00 J
Silver (ug/l)	5.00 U				
Sodium (ug/l)	2640.00 B	1830.00 J	2570.00 J	2560.00 J	1800.00 J
Vanadium (ug/l)	3.50 U	2.00 U	2.00 U	3.20 U	2.00 U
Zinc (ug/l)	13.40 U	5.00 U	5.00 U	17.50 U	27.20 U
TOC (mg/l)	0.75	1.3		0.5 U	
COD (mg/l)	<60	<60		<60	
Ammonia (mg/l)	<0.5	<0.5		<0.5	
Fluoride (mg/l)	0.14	0.13		0.42	
Chloride (mg/l)	1.28	0.86		1.7	
Nitrite (mg/l)	<0.05 UJ	<0.05 UJ		<0.05 UJ	
Nitrate (mg/l)	1.42 J	0.5 J		2.36 J	
Sulfate (mg/l)	15.96	9.06		11.36	
Phosphate (mg/l)	<0.1 UJ	<0.1 UJ		<0.1 UJ	
Elec. Cond. (umho/cm)	148.5	99.6		152.3	
pH	7.72	8.01		7.91	
TDS (mg/l)	118	75		120	
Turbidity (mg/l)	3.4	1.2		4.3	
Alkalinity (mg/l)	66.5 J	53.2 J		72.2 UJ	

9 2 1 2 6 4 3 1 3 3 9

Appendix C: Water Chemistry

Site Identification	092-2-R		092-3		092-3		092-3-R		092-3-R	
Sample Area	100N		100N		100N		100N		100N	
Sample Source	river		spring		spring		river		river	
Discharge river/spring (cfs)	8.16E+04		2.20E-02		2.20E-02		9.08E+04		9.08E+04	
Coordinates E (m)	571465		571480		571480		571480		571480	
Coordinates N (m)	150150		150170		150170		150170		150170	
River Mile (nearest 0.1 mi.)	9.2		9.2		9.2		9.2		9.2	
Date	10/15/91		10/18/91		10/18/91		10/18/91		10/18/91	
Time Interval	14:15 - 14:42		12:12 -13:28		12:12 -13:28		12:37 - 12:50		12:37 - 12:50	
OSM Sample No.	B06KV5	Q	B06KV9	Q	B06KV8	Q	B06KW1	Q	B06KW0	Q
Quality Control Sample										
Sample Comments			filtered				filtered			
Aluminum (ug/l)	67.70	U	89.00	U	127.00	U	17.00	U	62.20	U
Antimony (ug/l)	14.00	U	14.00	U	47.00	U	14.00	U	47.00	U
Barium (ug/l)	24.10	B	23.40	B	29.70	B	24.60	B	29.70	B
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	1.00	U	1.00	U	3.00	U	1.00	U	3.00	U
Calcium (ug/l)	16800.00		21700.00		20800.00		17500.00		16600.00	
Chromium (ug/l)	2.00	U	2.40	U	6.00	U	2.00	U	6.00	U
Cobalt (ug/l)	2.00	U	2.00	U	8.00	U	2.00	U	8.00	U
Copper (ug/l)	2.00	U	2.00	U	5.00	U	2.00	U	5.00	U
Iron (ug/l)	55.20	U	126.00		138.00		16.60	U	329.00	
Magnesium (ug/l)	3720.00	B	5570.00	J	5340.00		3860.00	J	3690.00	B
Manganese (ug/l)	5.60	U	1.40	U	6.40	B	1.00	U	4.40	B
Nickel (ug/l)	5.00	U	5.00	U	9.00	U	5.00	U	9.00	U
Potassium (ug/l)	707.00	J	2260.00	B	2050.00	B	683.00	B	665.00	U
Silver (ug/l)	5.00	U	5.00	U	4.00	U	5.00	U	4.00	U
Sodium (ug/l)	1780.00	J	4170.00	J	4060.00	J	1800.00	J	1610.00	J
Vanadium (ug/l)	2.00	U	16.50	U	15.30	B	2.60	U	5.00	U
Zinc (ug/l)	5.00	U	5.00	U	7.00	U	24.40	U	7.00	U
TOC (mg/l)	1.3				0.5	U			1.1	
COD (mg/l)	<60				<60				<60	
Ammonia (mg/l)	<0.5				<0.5				<0.5	
Fluoride (mg/l)	0.38				0.16				0.41	
Chloride (mg/l)	0.88				1.77				0.86	
Nitrite (mg/l)	<0.05	UJ			<0.05	UJ			<0.05	UJ
Nitrate (mg/l)	0.5	J			1.63	J			0.5	J
Sulfate (mg/l)	9.1				14.23				8.88	
Phosphate (mg/l)	<0.1	UJ			<0.1	UJ			<0.1	UJ
Elec. Cond. (umho/cm)	98.5				167.2				117.1	
pH	8.24				7.75				7.83	
TDS (mg/l)	70				114				81	
Turbidity (mg/l)	0.9				1.5				1.8	
Alkalinity (mg/l)	55.1	J			64.6	J			52.3	J

9 2 1 2 6 4 3 1 3 4 0

Appendix C: Water Chemistry

Site Identification	093-1		093-1		093-1-R		093-1-R		094-1	
Sample Area	100N		100N		100N		100N		100N	
Sample Source	spring		spring		river		river		spring	
Discharge river/spring (cfs)	4.50E-03		4.50E-03		9.08E+04		9.08E+04		2.20E-02	
Coordinates E (m)	571500		571500		571500		571500		571680	
Coordinates N (m)	150185		150185		150185		150185		150465	
River Mile (nearest 0.1 mi.)	9.3		9.3		9.3		9.3		9.4	
Date	10/18/91		10/18/91		10/18/91		10/18/91		10/17/91	
Time Interval	10:30 - 11:30		10:30 - 11:30		10:41 - 11:09		10:41 - 11:09		10:05 - 11:45	
OSM Sample No.	B06KW4	Q	B06KW3	Q	B06KW6	Q	B06KW5	Q	B06KW9	Q
Quality Control Sample										
Sample Comments	filtered				filtered				filtered	
Aluminum (ug/l)	17.00	U	177.00	U	17.00	U	60.40	U	17.00	U
Antimony (ug/l)	14.00	U	47.00	U	14.00	U	47.00	U	15.60	B
Barium (ug/l)	30.40	B	33.40	B	24.50	B	29.70	B	26.20	B
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	1.00	U	3.00	U	1.00	U	3.00	U	1.00	U
Calcium (ug/l)	22400.00		21400.00		17400.00		16600.00		21000.00	
Chromium (ug/l)	3.10	U	6.00	U	2.00	U	6.00	U	2.10	U
Cobalt (ug/l)	2.00	U	8.00	U	2.00	U	8.00	U	2.00	U
Copper (ug/l)	2.00	U	5.00	U	2.00	U	5.00	U	2.00	U
Iron (ug/l)	7.00	U	202.00		7.00	U	43.90	U	13.30	U
Magnesium (ug/l)	5970.00	J	5810.00		3850.00	J	3720.00	B	4830.00	J
Manganese (ug/l)	1.00	U	10.80	B	1.00	U	4.40	B	1.00	U
Nickel (ug/l)	5.00	U	9.00	U	5.00	U	9.00	U	5.00	U
Potassium (ug/l)	2230.00	B	2180.00	B	688.00	B	703.00	U	1650.00	B
Silver (ug/l)	5.00	U	4.00	U	5.00	U	4.00	U	5.00	U
Sodium (ug/l)	4620.00	J	4510.00	J	1710.00	J	1660.00	J	2970.00	J
Vanadium (ug/l)	15.00	U	15.30	B	3.50	U	5.00	U	10.60	U
Zinc (ug/l)	5.00	U	8.70	U	5.00	U	7.00	U	5.00	U
TOC (mg/l)			0.5	U			1.1			
COD (mg/l)			<60				<60			
Ammonia (mg/l)			<0.5				<0.5			
Fluoride (mg/l)			0.16				0.13			
Chloride (mg/l)			1.93				0.86			
Nitrite (mg/l)			<0.05	UJ			<0.05	UJ		
Nitrate (mg/l)			1.78	J			0.53	J		
Sulfate (mg/l)			15.89				9.14			
Phosphate (mg/l)			<0.1	UJ			<0.1	UJ		
Elec. Cond. (umho/cm)			172.6				118.2			
pH			7.73				7.9			
TDS (mg/l)			130				72			
Turbidity (mg/l)			6.2				2.6			
Alkalinity (mg/l)			66.5	J			53.2	J		

9 2 1 2 6 4 3 1 3 4 1

Appendix C: Water Chemistry

Site Identification	094-1		094-1-R		094-1-R		110-1		110-1						
Sample Area	100N		100N		100N		100D		100D						
Sample Source	spring		river		river		spring		spring						
Discharge river/spring (cfs)	2.20E-02		1.16E+05		1.16E+05		1.50E-02		1.50E-02						
Coordinates E (m)	571680		571680		571680		573480		573480						
Coordinates N (m)	150465		150465		150465		152375		152375						
River Mile (nearest 0.1 mi.)	9.4		9.4		9.4		11.0		11.0						
Date	10/17/91		10/17/91		10/17/91		33500		33500						
Time Interval	10:05 - 11:45		10:30 - 11:22		10:30 - 11:22		12:20 - 13:46		12:20 - 13:46						
OSM Sample No.	B06KW8		Q	B06KX1		Q	B06KX0		Q	B06KX4		Q	B06KX3		Q
Quality Control Sample															
Sample Comments			filtered				filtered								
Aluminum (ug/l)	45.30		U	20.00		U	42.30		U	20.00		U	47.40		U
Antimony (ug/l)	47.00		U	14.00		U	47.00		U	8.00		U	8.00		UJ
Barium (ug/l)	29.70		B	25.00		B	29.70		B	52.50		B	52.50		B
Beryllium (ug/l)	1.00		U	1.00		U	1.00		U	1.00		U	1.00		U
Cadmium (ug/l)	3.00		U	1.00		U	3.00		U	1.00		U	1.00		U
Calcium (ug/l)	19900.00			17200.00			16400.00			37000.00			35400.00		
Chromium (ug/l)	6.00		U	2.00		U	6.00		U	75.80			71.70		
Cobalt (ug/l)	8.00		U	2.00		U	8.00		U	3.00		U	3.00		U
Copper (ug/l)	5.00		U	2.00		U	5.00		U	3.00		UJ	3.00		UJ
Iron (ug/l)	58.10		U	11.30		U	47.00		U	12.20		U	42.10		U
Magnesium (ug/l)	4650.00		B	3810.00		J	3660.00		B	7290.00			6940.00		
Manganese (ug/l)	2.00		U	1.00		U	4.80		B	1.00		U	1.00		B
Nickel (ug/l)	9.00		U	5.00		U	9.00		U	4.00		U	4.00		U
Potassium (ug/l)	1590.00		B	675.00		B	698.00		U	1930.00		B	1860.00		J
Silver (ug/l)	4.00		U	5.00		U	4.00		U	2.00		U	2.00		U
Sodium (ug/l)	2880.00		J	1760.00		J	1600.00		J	5570.00			5320.00		
Vanadium (ug/l)	9.70		B	3.20		U	5.00		U	4.60		U	5.30		J
Zinc (ug/l)	7.00		U	5.00		U	7.00		U	6.30		U	6.30		J
TOC (mg/l)	0.65						1.3								
COD (mg/l)	<60						<60						<30		
Ammonia (mg/l)	<0.5						<0.5						0.1		J
Fluoride (mg/l)	0.11						0.38						0.2		J
Chloride (mg/l)	1.49						0.87								
Nitrite (mg/l)	<0.05		UJ				<0.05		UJ				<0.1		R
Nitrate (mg/l)	1.28		J				0.49		J				3		J
Sulfate (mg/l)	11.91						8.85						34		J
Phosphate (mg/l)	<0.1		UJ				<0.1		UJ						
Elec. Cond. (umho/cm)	144.2						114.9						227		
pH	7.64						7.85						7.9		
TDS (mg/l)	90						70						171		
Turbidity (mg/l)	1.2						1.2						2		
Alkalinity (mg/l)	62.7		J				53.2		J				70		

9 2 1 2 6 4 3 1 3 1 2

Appendix C: Water Chemistry

Site Identification	110-2	110-2	110-2-R	110-2-R	144-1
Sample Area	100D	100D	100D	100D	100H
Sample Source	spring	spring	river	river	spring
Discharge river/spring (cfs)	2.90E-04	2.90E-04	9.48E+04	9.48E+04	1.20E-03
Coordinates E (m)	571597	571597	573597	573597	577080
Coordinates N (m)	152470	152470	152470	152470	153770
River Mile (nearest 0.1 mi.)	11.0	11.0	11.0	11.0	14.4
Date	9/26/91	9/26/91	9/26/91	9/26/91	9/20/91
Time Interval	9:25 - 10:55	9:25 - 10:55	10:55 - 11:15	10:55 - 11:15	9:15 - 11:17
OSM Sample No.	B06KX7 Q	B06KX6 Q	B06KX9 Q	B06KX8 Q	B06KY2 Q
Quality Control Sample					
Sample Comments	filtered		filtered		filtered
Aluminum (ug/l)	17.00 U	77.00 B	18.20 B	58.80 U	31.00 U
Antimony (ug/l)	14.00 U	47.00 U	14.00 U	14.00 U	47.00 U
Barium (ug/l)	53.20 J	55.40 B	24.40 B	26.00 J	40.80 B
Beryllium (ug/l)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cadmium (ug/l)	1.00 U	3.00 U	1.00 U	1.00 U	3.00 U
Calcium (ug/l)	43300.00	42900.00	16900.00	17300.00	38900.00
Chromium (ug/l)	123.00	124.00	2.40 B	8.80 U	43.30
Cobalt (ug/l)	2.00 U	8.00 U	2.00 U	2.00 U	8.00 U
Copper (ug/l)	3.10 U	5.00 U	2.00 U	2.00 UJ	5.00 UJ
Iron (ug/l)	7.00 U	72.10 J	22.90 B	102.00	39.30 B
Magnesium (ug/l)	7170.00	7140.00	3770.00 B	3790.00 B	8690.00
Manganese (ug/l)	1.00 U	4.30 B	1.00 U	7.20 U	2.00 U
Nickel (ug/l)	5.00 U	9.00 U	5.00 U	5.00 U	9.00 U
Potassium (ug/l)	2570.00 B	2630.00 B	653.00 J	675.00 J	2830.00 B
Silver (ug/l)	5.00 U	4.00 U	5.00 U	5.00 UJ	4.00 U
Sodium (ug/l)	5740.00 J	5760.00 J	1720.00 J	1740.00 J	9250.00
Vanadium (ug/l)	2.80 U	5.00 U	2.00 U	2.70 U	7.10 B
Zinc (ug/l)	7.00 B	8.40 B	5.00 U	6.40 B	7.00 U
TOC (mg/l)		1.6		1.8	
COD (mg/l)		<60		<60	
Ammonia (mg/l)		<0.5 UJ		<0.5 UJ	
Fluoride (mg/l)		0.4		0.42	
Chloride (mg/l)		20.16		0.74	
Nitrite (mg/l)		<0.05 UJ		<0.05 UJ	
Nitrate (mg/l)		3.99 J		<0.1 J	
Sulfate (mg/l)		44.43		8.54	
Phosphate (mg/l)		<0.1 UJ		<0.1 UJ	
Elec. Cond. (umho/cm)		308 J		122 J	
pH		7.49		7.97	
TDS (mg/l)		246		90	
Turbidity (mg/l)		2		<0.2	
Alkalinity (mg/l)		71 J		51 J	

9 2 1 2 6 4 3 1 3 4 3

Appendix C: Water Chemistry

Site Identification	144-1		144-1-R		144-1-R		145-1		145-1	
Sample Area	100H		100H		100H		100H		100H	
Sample Source	spring		river		river		spring		spring	
Discharge river/spring (cfs)	1.20E-03		8.24E+04		8.24E+04		nr		nr	
Coordinates E (m)	577080		577080		577080		577255		577255	
Coordinates N (m)	153770		153770		153770		153660		153660	
River Mile (nearest 0.1 mi.)	14.4		14.4		14.4		14.5		14.5	
Date	9/20/91		9/20/91		9/20/91		9/20/91		9/20/91	
Time Interval	9:15 - 11:17		10:30 - 11:17		10:30 - 11:17		11:48 - 13:40		11:48 - 13:40	
OSM Sample No.	B06KY1	Q	B06L44	Q	B06L43	Q	B06L47	Q	B06L46	Q
Quality Control Sample										
Sample Comments			filtered				filtered			
Aluminum (ug/l)	169.00	B	31.00	U	115.00	B	31.00	U	77.00	B
Antimony (ug/l)	47.00	U	47.00	U	47.00	U	47.00	U	47.00	U
Barium (ug/l)	41.90	B	25.80	J	31.10	B	32.20	B	33.30	B
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	3.00	U	3.00	U	3.00	U	3.00	U	3.00	U
Calcium (ug/l)	38400.00		17600.00		17400.00		36700.00		38500.00	
Chromium (ug/l)	46.30		6.00	U	6.00	U	46.90		46.90	
Cobalt (ug/l)	8.00	U	8.00	U	8.00	U	8.00	U	2.00	U
Copper (ug/l)	5.00	UJ	5.00	UJ	5.00	UJ	5.00	UJ	5.00	UJ
Iron (ug/l)	223.00		12.00	U	158.00		39.80	B	114.00	
Magnesium (ug/l)	8650.00		3970.00	B	3950.00	B	8650.00		9090.00	
Manganese (ug/l)	11.80	B	2.00	U	12.40	B	2.00	U	2.50	B
Nickel (ug/l)	9.00	U	9.00	U	9.00	U	9.00	U	9.00	U
Potassium (ug/l)	2790.00	B	665.00	B	677.00	B	1790.00	B	1710.00	B
Silver (ug/l)	4.00	U	4.00	U	4.00	U	4.00	U	4.00	U
Sodium (ug/l)	9310.00		1830.00	B	2030.00	B	10500.00		11000.00	
Vanadium (ug/l)	6.70	B	5.00	U	5.00	U	5.00	U	5.00	U
Zinc (ug/l)	7.00	U	7.00	U	7.00	U	7.00	U	7.00	U
TOC (mg/l)	0.74				1.6				0.94	
COD (mg/l)	<60				<60				<60	
Ammonia (mg/l)	<0.5	UJ			<0.5	UJ			<0.5	UJ
Fluoride (mg/l)	0.17	J			0.15	J			0.18	J
Chloride (mg/l)	9.3	J			0.99	J			8.36	J
Nitrite (mg/l)	<0.05	UJ			<0.05	UJ			<0.05	UJ
Nitrate (mg/l)	4.58	J			0.54	J			4.57	J
Sulfate (mg/l)	45.74	J			9.65	J			46.65	J
Phosphate (mg/l)	<0.1	UJ			<0.1	UJ			<0.1	UJ
Elec. Cond. (umho/cm)	291	J			123	J			293	J
pH	7.57				8.1				7.26	
TDS (mg/l)	207				70				228	
Turbidity (mg/l)	1.3				1.3				1	
Alkalinity (mg/l)	79	J			56	J			82	J

9 2 1 2 6 4 3 1 3 1 4

Appendix C: Water Chemistry

Site Identification	145-1-R		145-1-R		145-2		145-2		145-2-R	
Sample Area	100H		100H		100H		100H		100H	
Sample Source	river		river		spring		spring		river	
Discharge river/spring (cfs)	8.24E+04		8.24E+04		1.80E-03		1.80E-03		9.09E+04	
Coordinates E (m)	577255		577255		577330		577330		577330	
Coordinates N (m)	153660		153660		153615		153615		153615	
River Mile (nearest 0.1 mi.)	14.5		14.5		14.5		14.5		14.5	
Date	9/20/91		9/20/91		9/25/91		9/25/91		9/25/91	
Time Interval	12:55 - 13:20		12:55 - 13:20		11:22 - 13:00		11:22 - 13:00		13:00 - 13:25	
OSM Sample No.	B06L49	Q	B06L48	Q	B06L52	Q	B06L51	Q	B06L54	Q
Quality Control Sample										
Sample Comments	filtered				filtered				filtered	
Aluminum (ug/l)	38.50	B	69.60	B	137.00	B	677.00		17.00	U
Antimony (ug/l)	47.00	U	47.00	U	14.00	U	14.00	U	14.00	U
Barium (ug/l)	29.00	B	29.00	B	27.90	B	37.30	J	26.00	B
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	3.00	U	3.00	U	1.00	U	1.00	U	1.00	U
Calcium (ug/l)	17200.00		16900.00		34900.00		35200.00		17300.00	
Chromium (ug/l)	6.00	U	6.00	U	47.40		51.60		2.00	U
Cobalt (ug/l)	8.00	U	8.00	U	2.00	U	2.00	U	2.00	U
Copper (ug/l)	5.00	UJ	5.00	UJ	2.00	U	2.00	UJ	2.00	U
Iron (ug/l)	35.40	B	115.00		137.00		924.00		7.00	U
Magnesium (ug/l)	3910.00	B	3790.00	B	8760.00		8500.00		3840.00	B
Manganese (ug/l)	2.00	U	8.20	B	1.00	U	37.90		1.00	U
Nickel (ug/l)	9.00	U	9.00	U	5.00	U	5.00	U	5.00	U
Potassium (ug/l)	723.00	B	627.00	B	3430.00	J	3340.00	J	739.00	J
Silver (ug/l)	4.00	U	4.00	U	5.00	U	5.00	UJ	5.00	U
Sodium (ug/l)	1760.00	B	1870.00	B	11000.00	J	10900.00	J	1860.00	J
Vanadium (ug/l)	5.00	U	5.00	U	6.70	U	10.40	U	2.00	U
Zinc (ug/l)	7.00	U	7.00	U	6.00	B	27.30		8.00	B
TOC (mg/l)			1.5				0.74			
COD (mg/l)			<60				<60			
Ammonia (mg/l)			<0.5	UJ			<0.5	UJ		
Fluoride (mg/l)			0.44	J			0.21			
Chloride (mg/l)			0.79	J			6.43			
Nitrite (mg/l)			<0.05	UJ			<0.05	UJ		
Nitrate (mg/l)			<0.1	UJ			4.35	J		
Sulfate (mg/l)			8.57	J			38.23			
Phosphate (mg/l)			<0.1	UJ			<0.1	UJ		
Elec. Cond. (umho/cm)			124	J			255	J		
pH			8.1				7.37			
TDS (mg/l)			27				188			
Turbidity (mg/l)			0.3				<0.2			
Alkalinity (mg/l)			53	J			80	J		

9 2 1 2 6 4 3 1 3 4 5

Appendix C: Water Chemistry

Site Identification	145-2		150-1		150-1		150-1-R		150-1-R	
Sample Area	100H		100H		100H		100H		100H	
Sample Source	river		spring		spring		river		river	
Discharge river/spring (cfs)	9.09E+04		3.00E-04		3.00E-04		9.48E+04		9.48E+04	
Coordinates E (m)	577330		577885		577885		577885		577885	
Coordinates N (m)	153615		153160		153160		153160		153160	
River Mile (nearest 0.1 mi.)	14.5		15.0		15.0		15.0		15.0	
Date	9/25/91		9/26/91		9/26/91		9/26/91		9/26/91	
Time Interval	13:00 - 13:25		12:05 - 13:35		12:05 - 13:35		14:00 - 14:30		14:00 - 14:30	
OSM Sample No.	B06L53	Q	B06L57	Q	B06L56	Q	B06L59	Q	B06L58	Q
Quality Control Sample										
Sample Comments			filtered				filtered			
Aluminum (ug/l)	109.00	U	17.00	U	413.00		17.00	U	60.90	U
Antimony (ug/l)	15.50	U	14.00	U	14.00	U	14.00	U	14.00	U
Barium (ug/l)	28.80	J	42.90	B	54.00	J	24.40	B	26.30	J
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	1.10	U	1.00	U	1.00	U	1.00	U	1.00	U
Calcium (ug/l)	17800.00		28800.00		30500.00		16800.00		17500.00	
Chromium (ug/l)	2.00	U	21.20		35.30		2.00	U	2.00	U
Cobalt (ug/l)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
Copper (ug/l)	2.00	UJ	2.00	U	2.00	UJ	2.00	U	2.00	UJ
Iron (ug/l)	136.00		13.40	B	792.00		7.00	U	83.40	U
Magnesium (ug/l)	3920.00	B	6570.00		6800.00		3720.00	B	3820.00	B
Manganese (ug/l)	10.60	B	2.90	B	31.00		1.00	U	8.00	U
Nickel (ug/l)	5.00	U	5.00	U	6.00	B	5.00	U	5.00	U
Potassium (ug/l)	788.00	J	2450.00	J	2530.00	J	625.00	J	655.00	J
Silver (ug/l)	5.00	UJ	5.00	U	5.00	UJ	5.00	U	5.00	UJ
Sodium (ug/l)	2130.00	J	7460.00	J	7650.00	J	1670.00	J	1980.00	J
Vanadium (ug/l)	2.90	U	2.40	U	7.20	U	2.00	U	2.60	B
Zinc (ug/l)	13.60	B	5.00	U	32.10		261.00		8.00	B
TOC (mg/l)	1.8				0.84				1.4	
COD (mg/l)	<60				<60				<60	
Ammonia (mg/l)	<0.5	UJ			<0.5	UJ			<0.5	UJ
Fluoride (mg/l)	0.45				0.2				0.42	
Chloride (mg/l)	0.75				2.72				0.71	
Nitrite (mg/l)	<0.05	UJ			<0.05	UJ			<0.05	UJ
Nitrate (mg/l)	<0.1	UJ			1.97	J			<0.1	UJ
Sulfate (mg/l)	8.6				21.24				8.35	
Phosphate (mg/l)	<0.1	UJ			<0.1	UJ			<0.1	UJ
Elec. Cond. (umho/cm)	120	J			226	J			105	J
pH	7.9				7.47				8.03	
TDS (mg/l)	79				122				34	
Turbidity (mg/l)	<0.2				<0.2				<0.2	
Alkalinity (mg/l)	51	J			87	J			51	J

9 2 1 2 6 4 3 1 3 4 6

Appendix C: Water Chemistry

Site Identification	153-1	153-1	153-1-R	153-1-R	187-1
Sample Area	100H	100H	100H	100H	100F
Sample Source	spring	spring	river	river	spring
Discharge river/spring (cfs)	4.70E-03	4.70E-03	8.75E+04	8.75E+04	2.30E-03
Coordinates E (m)	578235	578235	578235	578235	580820
Coordinates N (m)	152660	152660	152660	152660	148275
River Mile (nearest 0.1 mi.)	15.3	15.3	15.3	15.3	18.7
Date	10/21/91	10/21/91	10/21/91	10/21/91	9/27/91
Time Interval	11:35 - 13:10	11:35 - 13:10	12:38 - 13:10	12:38 - 13:10	10:40 - 12:01
OSM Sample No.	B06L62 Q	B06L61 Q	B06L64 Q	B06L63 Q	B06L67 Q
Quality Control Sample					
Sample Comments	filtered		filtered		filtered
Aluminum (ug/l)	31.00 U	104.00 U	370.00	160.00 U	32.60 B
Antimony (ug/l)	47.00 U	47.00 U	47.00 U	47.00 U	14.00 U
Barium (ug/l)	25.00 B	22.50 B	35.00 B	28.80 B	24.20 B
Beryllium (ug/l)	1.00 U				
Cadmium (ug/l)	3.00 U	3.00 U	3.00 U	3.00 U	1.00 U
Calcium (ug/l)	23700.00	24100.00	16700.00	16300.00	40900.00
Chromium (ug/l)	15.70	20.90	6.00 U	6.00 U	2.70 B
Cobalt (ug/l)	8.00 U	8.00 U	8.00 U	8.00 U	2.00 U
Copper (ug/l)	5.00 U	5.00 U	5.00 U	5.00 U	2.00 U
Iron (ug/l)	21.30 U	144.00	415.00	183.00	18.90 B
Magnesium (ug/l)	4240.00 B	4480.00 B	4220.00 B	3830.00 B	9590.00
Manganese (ug/l)	2.00 U	4.40 B	3.20 B	4.20 B	1.00 U
Nickel (ug/l)	9.00 U	9.00 U	9.00 U	9.00 U	5.00 U
Potassium (ug/l)	1100.00 B	1230.00 B	952.00 B	820.00 B	1970.00 J
Silver (ug/l)	4.00 U	4.00 U	4.00 U	4.00 U	5.00 U
Sodium (ug/l)	3380.00 J	3470.00 J	1610.00 J	1520.00 J	6500.00 J
Vanadium (ug/l)	5.00 U	5.00 U	5.00 U	5.00 U	2.00 U
Zinc (ug/l)	7.00 U	7.00 U	7.00 U	7.00 U	5.00 U
TOC (mg/l)		0.83		1.2	
COD (mg/l)		<60		<60	
Ammonia (mg/l)		<0.5		<0.5	
Fluoride (mg/l)		0.11		0.12	
Chloride (mg/l)		1.56		0.78	
Nitrite (mg/l)		<.05 UJ		<.05 UJ	
Nitrate (mg/l)		1.65 J		0.49 J	
Sulfate (mg/l)		14.92		8.72	
Phosphate (mg/l)		<0.1 UJ		<0.1 UJ	
Elec. Cond. (umho/cm)		134.1		89.8	
pH		7.59		8.09	
TDS (mg/l)		113		75	
Turbidity (mg/l)		0.6		1.5	
Alkalinity (mg/l)		67		52	

9 2 1 2 6 4 3 1 3 4 7

Appendix C: Water Chemistry

Site Identification	187-1		187-1-R		187-1-R		190-4		190-4		190-4-R	
Sample Area	100F		100F		100F		100F		100F		100F	
Sample Source	spring		river		river		spring		spring		river	
Discharge river/spring (cfs)	2.30E-03		8.55E+04		8.55E+04		1.20E-03		1.20E-03		8.55E+04	
Coordinates E (m)	580820		580820		580820		581230		581230		581230	
Coordinates N (m)	148275		148275		148275		147940		147940		147940	
River Mile (nearest 0.1 mi.)	18.7		18.7		18.7		19.0		19.0		19.0	
Date	9/27/91		9/27/91		9/27/91		9/27/91		9/27/91		9/27/91	
Time Interval	10:40 - 12:01		12:20 - 12:37		12:20 - 12:37		8:00 - 9:35		8:00 - 9:35		9:50 - 10:10	
OSM Sample No.	B06L66	Q	B06L69	Q	B06L68	Q	B06L72	Q	B06L71	Q	B06L74	Q
Quality Control Sample												
Sample Comments			filtered				filtered				filtered	
Aluminum (ug/l)	112.00	U	17.00	U	36.40	U	21.90	B	55.10	U	27.20	B
Antimony (ug/l)	18.10	U	14.00	U	14.00	U	14.00	U	18.20	U	14.00	U
Barium (ug/l)	25.40	J	24.50	B	26.90	U	26.40	B	26.80	J	24.40	B
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Calcium (ug/l)	42400.00		17000.00		17800.00		25600.00		25800.00		17000.00	
Chromium (ug/l)	7.40	U	2.00	U	6.30	U	2.00	U	2.00	U	2.00	U
Cobalt (ug/l)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
Copper (ug/l)	2.00	UJ	2.00	U	2.00	UJ	2.00	U	2.00	UJ	2.00	U
Iron (ug/l)	102.00		10.90	B	71.30	U	10.70	B	66.40	U	7.00	U
Magnesium (ug/l)	9710.00		3820.00	B	3870.00	B	5650.00		5530.00		3770.00	B
Manganese (ug/l)	6.80	U	1.10	B	7.20	U	1.00	U	4.10	U	1.00	U
Nickel (ug/l)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
Potassium (ug/l)	2010.00	J	697.00	J	698.00	J	1000.00	J	1030.00	J	685.00	J
Silver (ug/l)	5.00	UJ	5.00	U	5.00	UJ	5.00	U	5.00	UJ	5.00	U
Sodium (ug/l)	6690.00	J	1850.00	J	2070.00	J	2370.00	J	2560.00	J	1690.00	J
Vanadium (ug/l)	3.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
Zinc (ug/l)	11.20	B	12.00	B	13.60	B	6.80	B	12.80	B	5.00	U
TOC (mg/l)	0.79				1.6				0.79			
COD (mg/l)	<60				<60				<60			
Ammonia (mg/l)	<0.5				<0.5	UJ			<0.5			
Fluoride (mg/l)	0.13				0.39	J			0.39			
Chloride (mg/l)	8.19				0.93	J			1.29			
Nitrite (mg/l)	<0.05	UJ			<0.05	UJ			<0.05	UJ		
Nitrate (mg/l)	2.66	J			<0.1	UJ			1.8	J		
Sulfate (mg/l)	33.82				8.81	J			17.92			
Phosphate (mg/l)	<0.1	UJ			<0.1	UJ			<0.1	UJ		
Elec. Cond. (umho/cm)	310				97.2	J			178			
pH	8.11				8.2				7.47			
TDS (mg/l)	175				88				99			
Turbidity (mg/l)	5.3				1.1				<0.2			
Alkalinity (mg/l)	102	J			54.2	J			66	J		

9 2 1 2 5 4 3 1 3 1 8

Appendix C: Water Chemistry

Site Identification	190-4-R		207-1		207-1		207-1-R		207-1-R	
Sample Area	100F		100F		100F		100F		100F	
Sample Source	river		spring		spring		river		river	
Discharge river/spring (cfs)	8.55E+04		2.20E-02		2.20E-02		8.57E+04		8.57E+04	
Coordinates E (m)	581230		582621		582621		582621		582621	
Coordinates N (m)	147940		145597		145597		145597		145597	
River Mile (nearest 0.1 mi.)	19.0		20.7		20.7		20.7		20.7	
Date	9/27/91		9/30/91		9/30/91		9/30/91		9/30/91	
Time Interval	9:50 - 10:10		9:10 - 11:15		9:10 - 11:15		11:50 - 12:20		11:50 - 12:20	
OSM Sample No.	B06L73	Q	B06L77	Q	B06L76	Q	B06L79	Q	B06L78	Q
Quality Control Sample										
Sample Comments			filtered				filtered			
Aluminum (ug/l)	68.00	U	17.80	U	334.00		17.00	U	36.00	B
Antimony (ug/l)	18.70	U	14.00	U	47.00	U	16.10	U	47.00	U
Barium (ug/l)	27.50	J	41.60	J	50.80	B	27.40	J	27.70	B
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	1.40	U	1.00	U	3.00	U	1.00	U	3.00	U
Calcium (ug/l)	17800.00		42400.00		42300.00		17500.00		18100.00	
Chromium (ug/l)	2.20	U	3.00	B	9.60	B	2.00	U	6.00	U
Cobalt (ug/l)	2.00	U	2.00	U	8.00	U	2.00	U	8.00	U
Copper (ug/l)	2.00	UJ	2.00	U	5.00	U	2.00	U	5.00	U
Iron (ug/l)	65.90	U	7.00	U	1370.00	J	9.00	U	54.40	J
Magnesium (ug/l)	3870.00	B	8780.00		9040.00		3870.00	B	4040.00	B
Manganese (ug/l)	7.20	U	1.00	U	45.00		1.70	U	8.70	B
Nickel (ug/l)	5.00	U	5.00	U	9.00	U	5.00	U	9.00	U
Potassium (ug/l)	689.00	J	2410.00	B	2480.00	B	592.00	B	717.00	B
Silver (ug/l)	5.00	UJ	5.00	U	4.00	U	5.00	U	4.00	U
Sodium (ug/l)	1970.00	J	9040.00	J	8970.00	J	1910.00	J	2060.00	J
Vanadium (ug/l)	2.00	B	2.00	U	5.00	U	2.00	U	5.00	U
Zinc (ug/l)	6.40	B	8.60	B	18.00	B	5.00	U	7.00	U
TOC (mg/l)	1.5				0.59				1.5	
COD (mg/l)	<60				71				79	
Ammonia (mg/l)	<0.5				<0.5	UJ			<0.5	UJ
Fluoride (mg/l)	0.43				0.13	J			0.12	J
Chloride (mg/l)	0.71				9.8	J			1.02	J
Nitrite (mg/l)	<0.05	UJ			<0.05	UJ			<0.05	UJ
Nitrate (mg/l)	<0.1	UJ			4.33	J			<0.1	UJ
Sulfate (mg/l)	8.38				40.05	J			9.65	J
Phosphate (mg/l)	<0.1	UJ			<0.1	UJ			<0.1	UJ
Elec. Cond. (umho/cm)	120				266.4	J			97	J
pH	8.16				7.8				9.17	
TDS (mg/l)	56				194				61	
Turbidity (mg/l)	<0.2				0.35				1.2	
Alkalinity (mg/l)	52	J			94.1	J			54.2	J

9 2 1 2 6 4 3 1 3 1 9

Appendix C: Water Chemistry

Site Identification	211-1		211-1		211-1-R		211-1-R		211-1	
Sample Area	100F		100F		100F		100F		100F	
Sample Source	spring		spring		river		river		spring	
Discharge river/spring (cfs)	nr		nr		7.11E+04		7.11E+04		1.80E-03	
Coordinates E (m)	582864		582864		582864		582864		582864	
Coordinates N (m)	145130		145130		145130		145130		145130	
River Mile (nearest 0.1 mi.)	21.1		21.1		21.1		21.1		21.1	
Date	9/29/91		9/29/91		9/29/91		9/29/91		9/29/91	
Time Interval	8:35 - 10:17		8:35 - 10:17		11:30 - 12:02		11:30 - 12:02		10:20 - 11:10	
OSM Sample No.	B06L82	Q	B06L81	Q	B06L86	Q	B06L85	Q	B06L84	Q
Quality Control Sample									Dup. B06L82	
Sample Comments	filtered				filtered				filtered	
Aluminum (ug/l)	17.00	U	121.00	U	19.80	B	85.40	U	17.00	U
Antimony (ug/l)	14.00	U	14.00	U	14.00	U	14.00	U	14.00	U
Barium (ug/l)	42.90	B	45.10	J	26.00	B	28.00	J	43.20	B
Berytium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Calcium (ug/l)	45500.00		46400.00		18100.00		18800.00		45500.00	
Chromium (ug/l)	2.00	U	5.20	U	2.00	U	2.20	U	2.00	U
Cobalt (ug/l)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
Copper (ug/l)	2.00	U	2.00	UJ	2.00	U	2.00	UJ	2.00	U
Iron (ug/l)	7.00	U	231.00		25.10	B	88.20	U	7.00	U
Magnesium (ug/l)	9020.00		9000.00		3980.00	B	4070.00	B	9010.00	
Manganese (ug/l)	1.00	U	6.30	U	1.10	B	7.50	U	1.00	U
Nickel (ug/l)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
Potassium (ug/l)	2910.00	J	2970.00	J	795.00	J	728.00	J	2890.00	J
Silver (ug/l)	5.00	U	5.00	UJ	5.00	U	5.00	UJ	5.00	U
Sodium (ug/l)	10100.00	J	10100.00	J	1960.00	J	2220.00	J	10100.00	J
Vanadium (ug/l)	2.30	U	5.00	B	2.00	U	2.90	U	3.10	U
Zinc (ug/l)	5.00	U	11.20	B	6.00	B	10.80	B	5.20	B
TOC (mg/l)			0.94				1.5			
COD (mg/l)			63				71			
Ammonia (mg/l)			<0.5	UJ			<0.5	UJ		
Fluoride (mg/l)			0.15	J			0.42	J		
Chloride (mg/l)			9.71	J			1.02	J		
Nitrite (mg/l)			<.05	UJ			<.05	UJ		
Nitrate (mg/l)			5.5	J			0.51	J		
Sulfate (mg/l)			47.3	J			9.31	J		
Phosphate (mg/l)			<0.1	UJ			<0.1	UJ		
Elec. Cond. (umho/cm)			230.9	J			100.1	J		
pH			7.58				8.24			
TDS (mg/l)			232				63			
Turbidity (mg/l)			1.1				1.8			
Alkalinity (mg/l)			90.25	J			53.2	J		

9 2 1 2 6 4 3 1 3 5 0

Appendix C: Water Chemistry

Site Identification	211-1		211-1-R		211-1-R		213-1		213-1	
Sample Area	100F		100F		100F		100F		100F	
Sample Source	spring		river		river		spring		spring	
Discharge river/spring (cfs)	1.80E-03		7.11E+04		7.11E+04		2.30E-03		2.30E-03	
Coordinates E (m)	582864		582864		582864		582962		582962	
Coordinates N (m)	145130		145130		145130		144813		144813	
River Mile (nearest 0.1 mi.)	21.1		21.1		21.1		21.3		21.3	
Date	9/29/91		9/29/91		9/29/91		9/28/91		9/28/91	
Time interval	10:20 - 11:10		12:11 - 12:42		12:11 - 12:42		10:56 - 12:10		10:56 - 12:10	
OSM Sample No.	B06L83	Q	B06L88	Q	B06L87	Q	B06L92	Q	B06L91	Q
Quality Control Sample	Dup. B06L81		Dup. B06L86		Dup. B06L85					
Sample Comments			filtered				filtered			
Aluminum (ug/l)	859.00		17.00	U	146.00	U	24.90	B	128.00	U
Antimony (ug/l)	19.90	U	14.00	U	14.00	U	14.00	U	14.00	U
Barium (ug/l)	57.60	J	25.60	B	28.20	J	43.20	B	44.60	J
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Calcium (ug/l)	46900.00		18600.00		18900.00		45600.00		46300.00	
Chromium (ug/l)	4.20	U	2.00	U	4.70	U	2.40	B	6.90	U
Cobalt (ug/l)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
Copper (ug/l)	2.00	UJ	2.00	U	2.00	UJ	2.00	U	2.00	UJ
Iron (ug/l)	1850.00		7.00	U	219.00		24.50	B	184.00	
Magnesium (ug/l)	9280.00		4060.00	B	4100.00	B	8880.00		8810.00	
Manganese (ug/l)	46.40		1.00	U	17.90		1.00	U	7.10	U
Nickel (ug/l)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
Potassium (ug/l)	2990.00	J	760.00	J	793.00	J	2970.00	J	2960.00	J
Silver (ug/l)	5.00	UJ	5.00	U	5.00	UJ	5.00	U	5.00	UJ
Sodium (ug/l)	10000.00	J	2050.00	J	2220.00	J	9690.00	J	9700.00	J
Vanadium (ug/l)	7.90	U	2.00	U	2.10	B	4.00	U	4.70	U
Zinc (ug/l)	79.90		5.20	B	11.60	B	5.00	U	7.60	B
TOC (mg/l)	1.1				1.6				0.69	
COD (mg/l)	63				<60				71	
Ammonia (mg/l)	0.6	J			<0.5	UJ			<0.5	UJ
Fluoride (mg/l)	0.16	J			0.11	J			0.15	J
Chloride (mg/l)	9.78	J			0.96	J			9.6	J
Nitrite (mg/l)	<.05	UJ			<.05	UJ			<.05	UJ
Nitrate (mg/l)	5.52	J			0.51	J			4.93	J
Sulfate (mg/l)	47.35	J			9.3	J			49.39	J
Phosphate (mg/l)	<0.1	UJ			<0.1	UJ			<0.1	UJ
Elec. Cond. (umho/cm)	270.8	J			99.5	J			263.1	J
pH	7.48				8.28				7.47	
TDS (mg/l)	225				58				215	
Turbidity (mg/l)	1.5				2.5				0.75	
Alkalinity (mg/l)	89.3	J			53.2	J			92.15	J

9 2 1 2 6 4 3 1 3 5 1

Appendix C: Water Chemistry

Site Identification	213-1-R		213-1-R		216-1		216-1		216-1-R	
Sample Area	100F		100F		100F		100F		100F	
Sample Source	river		river		spring		spring		river	
Discharge river/spring (cfs)	7.00E+04		7.00E+04		nr		nr		7.00E+04	
Coordinates E (m)	582962		582962		583132		583132		583132	
Coordinates N (m)	144813		144813		144317		144317		144317	
River Mile (nearest 0.1 mi.)	21.3		21.3		21.6		21.6		21.6	
Date	9/28/91		9/28/91		9/28/91		9/28/91		9/28/91	
Time Interval	12:37 - 12:58		12:37 - 12:58		8:30 - 10:08		8:30 - 10:08		10:10 - 10:35	
OSM Sample No.	B06L94	Q	B06L93	Q	B06L97	Q	B06L96	Q	B06L99	Q
Quality Control Sample										
Sample Comments	filtered				filtered				filtered	
Aluminum (ug/l)	17.00	U	57.10	U	17.00	U	43.90	B	17.00	U
Antimony (ug/l)	14.00	U	14.00	U	15.00	U	47.00	U	14.00	U
Barium (ug/l)	24.00	B	25.70	J	37.20	J	38.10	B	23.90	B
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	1.00	U	1.00	U	1.00	U	3.00	U	1.00	U
Calcium (ug/l)	16800.00		17500.00		38600.00		39500.00		17200.00	
Chromium (ug/l)	2.00	U	11.30	U	32.10		6.00	B	2.00	U
Cobalt (ug/l)	2.00	U	2.00	U	2.00	U	8.00	U	2.00	U
Copper (ug/l)	2.00	U	2.00	UJ	2.00	U	5.00	U	2.00	U
Iron (ug/l)	7.00	U	110.00		119.00		31.10	J	7.00	U
Magnesium (ug/l)	3710.00	B	3820.00	B	7290.00		7550.00		3810.00	B
Manganese (ug/l)	1.00	U	7.60	U	2.10	U	2.00	U	1.00	U
Nickel (ug/l)	5.00	U	5.50	B	11.80	B	9.00	U	5.00	U
Potassium (ug/l)	637.00	J	692.00	J	2560.00	B	2630.00	B	632.00	J
Silver (ug/l)	5.00	U	5.00	UJ	5.00	U	4.00	U	5.00	U
Sodium (ug/l)	1700.00	J	1960.00	J	7870.00	J	8170.00	J	1700.00	J
Vanadium (ug/l)	2.00	U	3.00	U	4.20	U	5.00	U	2.00	U
Zinc (ug/l)	5.00	U	9.60	B	5.00	U	10.10	B	5.00	U
TOC (mg/l)			1.5				0.69			
COD (mg/l)			71				71			
Ammonia (mg/l)			<0.5	UJ			<0.5	UJ		
Fluoride (mg/l)			0.4	J			0.15	J		
Chloride (mg/l)			1	J			6.99	J		
Nitrite (mg/l)			<.05	UJ			<0.05	UJ		
Nitrate (mg/l)			<0.1	UJ			3.53	J		
Sulfate (mg/l)			9.2	J			38.92	J		
Phosphate (mg/l)			<0.1	UJ			<0.1	UJ		
Elec. Cond. (umho/cm)			105.7	J			228.7	J		
pH			8.44				7.57			
TDS (mg/l)			94				193			
Turbidity (mg/l)			1				0.8			
Alkalinity (mg/l)			52.25	J			78.85	J		

9 2 1 2 6 4 3 1 3 5 2

Appendix C: Water Chemistry

Site Identification	216-1-R		241-1		241-1		241-1-R		241-1-R	
Sample Area	100F		HAN		HAN		HAN		HAN	
Sample Source	river		spring		spring		river		river	
Discharge river/spring (cfs)	7.00E+04		3.30E-02		3.30E-02		9.51E+04		9.51E+04	
Coordinates E (m)	583132		584986		584986		584986		584986	
Coordinates N (m)	144317		140838		140838		140838		140838	
River Mile (nearest 0.1 mi.)	21.6		24.1		24.1		24.1		24.1	
Date	9/28/91		10/2/91		10/2/91		10/2/91		10/2/91	
Time Interval	10:10 - 10:35		13:10 - 15:05		13:10 - 15:05		16:07 - 16:37		16:07 - 16:37	
OSM Sample No.	B06L98	Q	B06LB2	Q	B06LB1	Q	B06LJ6	Q	B06LJ5	Q
Quality Control Sample										
Sample Comments			filtered				filtered			
Aluminum (ug/l)	44.90	U	17.00	B	158.00	B	19.80	U	82.40	B
Antimony (ug/l)	14.00	U	14.00	U	47.00	U	14.00	U	47.00	U
Barium (ug/l)	25.50	J	30.80	J	38.10	B	28.80	J	27.70	B
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	1.00	U	1.00	U	3.00	U	1.00	U	3.00	U
Calcium (ug/l)	17100.00		34300.00		32800.00		21400.00		19800.00	
Chromium (ug/l)	11.90	U	2.00	U	6.00	U	2.00	U	6.00	U
Cobalt (ug/l)	2.00	U	2.00	U	8.00	U	2.00	U	8.00	U
Copper (ug/l)	2.00	UJ	2.00	U	5.00	U	2.00	U	5.00	U
Iron (ug/l)	93.90	U	17.20	U	224.00	J	16.30	U	148.00	J
Magnesium (ug/l)	3750.00	B	7190.00		7000.00		4660.00	B	4390.00	B
Manganese (ug/l)	9.50	B	1.90	U	7.80	B	2.40	U	10.60	B
Nickel (ug/l)	5.00	U	5.00	U	9.00	U	5.00	U	9.00	U
Potassium (ug/l)	646.00	J	3810.00	B	3890.00	B	1440.00	B	1280.00	B
Silver (ug/l)	5.00	UJ	5.00	U	4.00	U	5.00	U	4.00	U
Sodium (ug/l)	1890.00	J	16000.00	J	15900.00	J	5600.00	J	4340.00	J
Vanadium (ug/l)	2.00	U	7.30	U	5.90	B	3.50	U	5.00	U
Zinc (ug/l)	6.00	B	5.00	U	10.60	B	5.00	U	12.00	B
TOC (mg/l)	1.6				0.5	U			1.9	
COD (mg/l)	71				<60				71	
Ammonia (mg/l)	<0.5	UJ			<0.5	UJ			<0.5	UJ
Fluoride (mg/l)	0.38	J			0.22	J			0.13	J
Chloride (mg/l)	0.9	J			6.09	J			1.62	J
Nitrite (mg/l)	<0.05	UJ			<0.05	UJ			<0.05	UJ
Nitrate (mg/l)	<0.1	UJ			1.58	J			0.56	J
Sulfate (mg/l)	8.84	J			26.47	J			11.62	J
Phosphate (mg/l)	<0.1	UJ			<0.1	UJ			<0.1	UJ
Elec. Cond. (umho/cm)	96.9	J			243.1	J			125.4	J
pH	7.79				7.93				8.25	
TDS (mg/l)	93				206				109	
Turbidity (mg/l)	0.38				2.1				3.4	
Alkalinity (mg/l)	49.4	J			110.2	J			62.7	J

9 2 1 2 6 4 3 1 3 5 3

Appendix C: Water Chemistry

Site Identification	241-1		241-1		241-1-R		241-1-R		247-1	
Sample Area	HAN		HAN		HAN		HAN		HAN	
Sample Source	spring		spring		river		river		spring	
Discharge river/spring (cfs)	3.30E-02		3.30E-02		9.51E+04		9.51E+04		4.70E-03	
Coordinates E (m)	585059		585059		585059		585059		585729	
Coordinates N (m)	140777		140777		140777		140777		140070	
River Mile (nearest 0.1 mi.)	24.1		24.1		24.1		24.1		24.7	
Date	10/2/91		10/2/91		10/2/91		10/2/91		10/2/91	
Time interval	15:10 - 15:20		15:10 - 15:20		15:35 - 16:00		15:35 - 16:00		9:25 - 11:37	
OSM Sample No.	B06LJ4 Q		B06LJ3 Q		B06LJ8 Q		B06LJ7 Q		B06LK2 Q	
Quality Control Sample	Dup. B06LB2		Dup. B06LB1		Dup. B06L6		Dup. B06LJ5			
Sample Comments	filtered				filtered				filtered	
Aluminum (ug/l)	17	U	111	B	35.7	U	137	B	17	U
Antimony (ug/l)	14	U	47	U	16	U	47	U	14	U
Barium (ug/l)	30.7	J	38.1	B	29.1	J	27.7	B	30.7	J
Beryllium (ug/l)	1	U	1	U	1	U	1	U	1	U
Cadmium (ug/l)	1	U	3	U	1	U	3	U	1	U
Calcium (ug/l)	33600		32900		20400		18000		19700	
Chromium (ug/l)	2	U	6	U	2	U	6	U	2	U
Cobalt (ug/l)	2	U	8	U	2	U	8	U	2	U
Copper (ug/l)	2	U	5	U	2	U	5	U	2	U
Iron (ug/l)	7	U	157	J	75.9	B	192	J	7	U
Magnesium (ug/l)	7070		7040		4510	B	4020	B	4750	B
Manganese (ug/l)	1.9	U	5.4	B	2.1	U	12.1	B	1	U
Nickel (ug/l)	5	U	9	U	5	U	9	U	5	U
Potassium (ug/l)	3740	B	3810	B	1270	B	1070	B	940	B
Silver (ug/l)	5	U	4	U	5	U	4	U	5	U
Sodium (ug/l)	15700	J	15700	J	4800	J	3260	J	2700	J
Vanadium (ug/l)	6.4	U	5	U	2.3	U	5	U	2	U
Zinc (ug/l)	5	U	10.9	B	6.1	B	10.6	B	5	U
TOC (mg/l)			0.64				2			
COD (mg/l)			95				71			
Ammonia (mg/l)			<0.5	UJ			<0.5	UJ		
Fluoride (mg/l)			0.22	J			0.12	J		
Chloride (mg/l)			6.08	J			1.31	J		
Nitrite (mg/l)			<0.05	UJ			<0.05	UJ		
Nitrate (mg/l)			1.57	J			0.5	J		
Sulfate (mg/l)			26.54	J			10.44	J		
Phosphate (mg/l)			<0.1	UJ			<0.1	UJ		
Elec. Cond. (umho/cm)			243.1	J			106.7	J		
pH			7.91				8.42			
TDS (mg/l)			212				94			
Turbidity (mg/l)			2.5				2.9			
Alkalinity (mg/l)			110.2	J			58.9	J		

9 2 1 2 6 4 3 1 3 5 4

Appendix C: Water Chemistry

Site Identification	247-1		247-1-R		247-1-R	
Sample Area	HAN		HAN		HAN	
Sample Source	spring		river		river	
Discharge river/spring (cfs)	4.70E-03		9.51E+04		9.51E+04	
Coordinates E (m)	585729		585729		585729	
Coordinates N (m)	140070		140070		140070	
River Mile (nearest 0.1 mi.)	24.7		24.7		24.7	
Date	10/2/91		10/2/91		10/2/91	
Time Interval	9:25 - 11:37		12:09 - 12:31		12:09 - 12:31	
OSM Sample No.	B06LK1	Q	B06LK4	Q	B06LK3	Q
Quality Control Sample						
Sample Comments			filtered			
Aluminum (ug/l)	92.30	B	17.00	U	42.90	B
Antimony (ug/l)	47.00	U	14.40	U	47.00	U
Barium (ug/l)	27.70	B	26.50	J	27.70	B
Beryllium (ug/l)	1.00	U	1.00	U	1.00	U
Cadmium (ug/l)	3.00	U	1.00	U	3.00	U
Calcium (ug/l)	19200.00		16800.00		17000.00	
Chromium (ug/l)	6.00	U	2.00	U	6.00	U
Cobalt (ug/l)	8.00	U	2.00	U	8.00	U
Copper (ug/l)	5.00	U	2.00	U	5.00	U
Iron (ug/l)	96.10	J	7.00	U	84.40	J
Magnesium (ug/l)	4670.00	B	3710.00	B	3820.00	B
Manganese (ug/l)	4.50	B	1.50	U	6.50	B
Nickel (ug/l)	9.00	U	5.00	U	9.00	U
Potassium (ug/l)	1070.00	B	587.00	B	726.00	B
Silver (ug/l)	4.00	U	5.00	U	4.00	U
Sodium (ug/l)	2670.00	J	1640.00	J	1820.00	J
Vanadium (ug/l)	5.00	U	2.00	U	5.00	U
Zinc (ug/l)	7.00	U	5.00	U	11.20	B
TOC (mg/l)	0.94				1.6	
COD (mg/l)	79				<60	
Ammonia (mg/l)	<0.5	UJ			<0.5	UJ
Fluoride (mg/l)	0.12	J			0.12	J
Chloride (mg/l)	1.17	J			0.83	J
Nitrite (mg/l)	<0.05	UJ			<0.05	UJ
Nitrate (mg/l)	0.68	J			<0.1	UJ
Sulfate (mg/l)	10.53	J			8.76	J
Phosphate (mg/l)	<0.1	UJ			<0.1	UJ
Elec. Cond. (umho/cm)	119.8	J			101.8	J
pH	7.36				8.16	
TDS (mg/l)	349				68	
Turbidity (mg/l)	0.76				1.2	
Alkalinity (mg/l)	60.8	J			52.3	J

9 2 1 2 5 4 3 1 3 5 5

APPENDIX D
RADIOLOGICAL ANALYSES OF WATER SAMPLES

9 2 1 2 6 4 3 1 3 5 6

APPENDIX D
EXPLANATION OF TERMS

- Site Identification: Identifies the specific sample site. The first three digits, e.g., 037, identify the location using the Hanford River Mile (HRM) system. A location at 037 is at HRM 3.7 miles. The next digit 037-1 identifies sites in an upstream to downstream order at that river mile. The letter R indicates a river sample location, e.g., 037-1-R. The letter S denotes a sediment sample location, e.g., 037-1-S.
- Sample Area: This identifier denotes the specific reactor area or general position of the associated sample.
- Discharge river/spring (ft³/s): Identifies the average discharge of the Columbia River for the day of sampling or the estimated discharge of the individual spring at the time of sampling. Discharges are in ft³/s.
- Coordinates E (m)
Coordinates N (m): Identifies the location of the sample location according to the NAD 1983 Washington State South Zone Coordinates in Meters .
- River Mile (nearest 0.1 mi.): Identifies the approximate Hanford River Mile. Hanford River Mile 0.0 is at the Vernita Bridge. Measurements are scaled from the 1:2000 maps of the Hanford Site.
- Date: Day on which the specific sample was collected.
- Time Interval: The sampling interval, starting with the initiation of presampling measurements for the springs. For river samples, the interval denotes the actual time during which the sample was collected.
- OSM Sample No.: The sample tracking number assigned to a specific set of samples. Each spring/sediment sample had a single number; the adjacent river sample was assigned a separate number. All numbers were supplied by Westinghouse Hanford OSM.
- Q (Qualifier): Data qualifiers for radiological analyses are statistical evaluations of counting errors and are provided as plus or minus two times the standard deviation (sigma).
- N/A: Not/Analyzed

9 2 1 2 6 4 3 1 3 5 7

Site Identification	037-1		037-1-R		038-3		039-2		057-3		057-3-R		074-1	
Sample Area	100B		100B		100B		100B		100K		100K		100K	
Sample Type	spring		river		spring		spring		spring		river		spring	
Discharge river/spring (cfs)	5.90E-04		9.35E+04		3.30E-03		2.00E-03		2.90E-04		9.30E+04		1.80E-02	
Coordinates E (m)	564540		564940		564675		56444940		567585		567585		569680	
Coordinates N (m)	145275		145350		145275		145350		146210		146210		148070	
River Mile (nearest 0.1 mi.)	3.7		3.7		3.8		3.9		5.7		5.7		7.7	
Date	9/18/91		9/18/91		9/17/91		9/19/91		9/25/91		9/25/91		10/16/91	
Time Interval	9:45 - 11:45		10:48 - 11:45		13:25 - 16:19		9:20-11:06		7:25 - 9:05		9:15 - 9:50		12:30 - 13:30	
OSM Sample No.	B06KR3		B06KR5		B06KR8		B06KS1		B06KS4		B06KS6		B06KS9	
Quality Control Sample														
Concentration in pCi/L	2σ		2σ		2σ		2σ		2σ		2σ		2σ	
Gross Alpha	0	1	1	1	2	2	2	2	0	2	0	1	1	1
Gross Beta	5	1(J)	7	2(J)	15	2(J)	42	3(J)	11	2(J)	1	2(J)	18	1(J)
H(3)	13000	700(J)	300	200(J)	20600	900(J)	3100	200	1400	300(J)	<300	(J)	400	100
Sr(90)	<0.4	(UJ)	0.6	0.4(J)	0.96	0.29(J)	6.3	0.7	<1	(J)	0.4	0.2(J)	8.8	0.6
Tc(99)	N/A		N/A		N/A				N/A		N/A		5.2	1.6
Total Uranium	1.6	0.2	0.4	0.04	1.6	0.2	1.45	0.05	1	0.1	0.39	0.04	0.24	0.02
Gamma Scan														
K(40)	<134.1		<288.3		<146.9		<152.6		<138.3		<257.7		<247.6	
Cr(51)	<312.0		<346.9		<259.8		<5528		<381.7		<387.9		<498.4	
Co(60)	<18.63		<17.68		<16.24		<18.00		<16.45		<15.74		<15.25	
Zn(65)	<23.88		<30.35		<25.76		<42.73		<28.73		<36.27		<38.45	
Cs(134)	<12.61		<16.24		<10.97		<13.87		<12.35		<15.93		<15.75	
Cs(137)	<11.70	(UJ)	<15.25	(UJ)	<10.16	(UJ)	<12.27		<10.88	(UJ)	<12.91	(UJ)	<14.51	
Ra(226)	<23.39		<30.46		<35.54		<21.06		<26.12		<23.49		<28.44	
Th(228)	<20.42		<22.51		<17.58		<20.95		(UJ) <19.67		<21.08		<22.27	
Th(232)	<47.24		<61.35		<48.71		<50.10		<44.66		<65.51		<94.88	
Sb (125)	N/A		N/A		N/A		N/A		N/A		N/A		N/A	

D-3

Site Identification	077-1-R		082-2		082-2-R		090-1		090-1-R		092-2		092-2-R		
Sample Area	100K		100K		100K		100N		100N		100N		100N		
Sample Type	river		spring		river		spring		river		spring		river		
Discharge river/spring (cfs)	7.62E+04		2.20E-02		9.08E+04		2.90E-01		8.16E+04		5.90E-01		8.16E+04		
Coordinates E (m)	569680		570415		570415		571300		571300		571465		571465		
Coordinates N (m)	148070		148780		148780		149920		149920		150150		150150		
River Mile (nearest 0.1 mi.)	7.7		8.3		8.3		9.0		9.0		9.2		9.2		
Date	10/16/91		10/18/91		10/18/91		10/15/91		10/15/91		10/15/91		10/15/91		
Time Interval	12:40 - 13:26		14:10 - 16:05		15:25 - 15:55		11:00 - 12:30		11:10 - 12:00		14:02 - 15:07		14:15 - 14:42		
OSM Sample No.	B06KT1		B06KT4		B06KT6		B06KT9		B06KV1		B06KV3		B06KV5		
Quality Control Sample															
Concentration in pCi/L	2σ		2σ		2σ		2σ		2σ		2σ		2σ		
Gross Alpha	0	1	1	1	2	1	0	3	0	1	1	1	0	1	
Gross Beta	2	1(J)	4	1(J)	1	1(J)	6830	22(J)	6	1(J)	5	1(R)	2	1(J)	
H(3)	<200		8900	500	<200		15900	800	300	100	3400	200	200	100	
Sr(90)	0.7	0.2(J)	<0.5	(U)	<0.4	(U)	3210	70	8.1	1.2	395	12	3	1(J)	
Tc(99)	2	1	<2		<3		2.5	2.2	<2.4		3.6	1.3	3.9	1.6	
Total Uranium	0.29	0.03	1.1	0.1	0.49	0.04	0.32	0.03	0.32	0.03	0.24	0.02	0.29	0.03	
Gamma Scan															
K(40)	<128.8		<307		<101		<142		<249.8		<129.1		<232.4		
Cr(51)	<435.9		<477.1		<315.7		<415.8		<495.5		<467.3		<546.3		
Co(60)	<17.94		<14.10		<15.51		<17.98		44.73		17.8	<23.32		<19.47	
Zn(65)	<30.79		<37.28		<19.99		<26.01		<41.25		<21.85		<32.69		
Cs(134)	<11.55		<14.33		<9.093		<12.56		<15.18		<16.01		<14.86		
Cs(137)	<11.54		<14.44		<8.608		<11.79		<13.82		<12.25		<15.06		
Ra(226)	<29.61		<25.13		<17.10		<25.16		<28.24		<39.49		<32.49		
Th(228)	<20.50		<20.80		<14.88		<20.32		<20.64		<20.79		<22.12		
Th(232)	<54.78		<58.27		<40.49		<47.72		<61.49		<66.83		<63.31		
Sb (125)	N/A		N/A		N/A		N/A		N/A		31.01		24.86	N/A	

D-4

9 2 1 2 6 4 3 1 3 6 0

Site Identification	092-3		092-3-R		093-1		093-1-R		094-1		0941-1-R	
Sample Area	100N		100N		100N		100N		100N		100N	
Sample Type	spring		river		spring		river		spring		river	
Discharge river/spring (cfs)	2.20E-02		9.08E+04		4.50E-03		9.08E+04		2.20E-02		1.16E+05	
Coordinates E (m)	571480		571480		571500		571500		571680		571680	
Coordinates N (m)	150170		150170		150185		150185		150465		150465	
River Mile (nearest 0.1 mi.)	9.2		9.2		9.3		9.3		9.4		9.4	
Date	10/18/91		10/18/91		10/18/91		10/18/91		10/17/91		10/17/91	
Time Interval	12:12 - 13:28		12:37 - 12:50		10:30 - 11:30		10:41 - 11:09		10:05 - 11:45		10:30 - 11:22	
OSM Sample No.	B06KV8		B06KW0		B06KW3		B06KW5		B06KW8		B06KX0	
Quality Control Sample												
Concentration in pCi/L	2σ		2σ		2σ		2σ		2σ		2σ	
Gross Alpha	1	1	0	1	1	1	0	1	1	1	0	1
Gross Beta	7	1(J)	1	1(J)	6	2(J)	2	1(J)	5	1(J)	2	1(J)
H(3)	24300	1200	<200		23900	1200	800	100	20300	1000	<200	
Sr(90)	<0.3	(U)	<0.4	(U)	<0.2	(U)	<0.4	0.2(U)	<1	<1.0(U)	0.9	.8(J)
Tc(99)	3.6	1.6	<3		6.2	3	<5		5	3	1.7	1.2
Total Uranium	0.41	0.04	0.3	0.03	0.36	0.03	0.28	0.03	0.274	0.024	0.283	0.025
Gamma Scan												
K(40)	<219.8		<121.2		<252.9		111.7	102.1	<278.5		<174.7	
Cr(51)	<434.1		<490.6		<502.1		<369.4		<476.1		<472.4	
Co(60)	<13.19		<16.21		<20.49		<15.19		<14.58		<18.48	
Zn(65)	<26.37		<33.98		<33.01		<21.67		<31.09		<22.76	
Cs(134)	<12.23		<13.84		<16.42		<10.22		<16.38		<15.92	
Cs(137)	<12.26		<11.68		<14.95		<9.389		<12.67		<11.90	
Ra(226)	<21.62		<24.47		<29.22		<19.74		<25.04		22.58	21.93
Th(228)	<17.58		<20.43		<21.31		<16.90		<21.34		<20.20	
Th(232)	<49.67	(J)	<51.37		<63.85		<35.89		<58.11		<50.80	
Sb (125)	N/A		N/A		N/A		N/A		N/A		N/A	

D-5

DOE/RL-92-12, Rev. 1

Site Identification	110-1		110-2-R		110-2		144-1		144-1-R		145-1		145-1-R	
Sample Area	100D		100D		100D		100H		100H		100H		100H	
Sample Type	spring		river		spring		spring		river		spring		river	
Discharge river/spring (cfs)	1.50E-02		9.48E+04		2.90E-04		1.20E-03		8.24E+04		nr		8.24E+04	
Coordinates E (m)	573480		573597		571597		577080		577080		577255		577255	
Coordinates N (m)	152375		152470		152470		153770		153770		153660		153660	
River Mile (nearest 0.1 mi.)	11.0		11.0		11.0		14.4		14.4		14.5		14.5	
Date	9/19/91		9/26/91		9/26/91		9/20/91		9/20/91		9/20/91		9/20/91	
Time Interval	12:20 - 13:46		10:55 - 11:15		9:25 - 10:55		9:15 - 11:17		10:30 - 11:17		11:48 - 13:40		12:55 - 13:20	
OSM Sample No.	B06KX3		B06KX8		B06KX6		B06KY1		B06L43		B06L46		B06L48	
Quality Control Sample														
Concentration in pCi/L	2σ		2σ		2σ		2σ		2σ		2σ		2σ	
Gross Alpha	0	1	0	1	0	1	1	1	0	1	0	2	1	1
Gross Beta	9	2(J)	3	1(J)	9	1(J)	3	1(J)	1	1(J)	0	2(J)	0	1(J)
H(3)	1200	200	<200		3100	400	2900	400(J)	300	200(J)	2900	400(J)	400	200(J)
Sr(90)	4.5	0.3	<1		1.8	1	0.4	0.2(J)	<0.1	(J)	0.6	0.2(J)	0.4	0.3(J)
Tc(99)	0.3	.1(U)	<1		4.9	1.1	<6		<3		<1		2	1
Total Uranium	0.88	0.03	0.33	0.03	1	0.1	1	0.1	0.37	0.04	1.0	0.1	0.36	0.03
Gamma Scan														
K(40)	<126.7		<119		<146.6		<128.9		<235.6		<152.1		<239.9	
Cr(51)	<5559		<614.2		<411.7		<275.9		<608.0		<581.9		<660.1	
Co(60)	<10.99		<16.42		<19.31		<8.432		<13.39		<21.89		<15.11	
Zn(65)	<34.45		<23.62		<30.38		<17.01		<31.97		<37.08		<35.77	
Cs(134)	<13.36		<14.11		<14.20		<7.97		<13.45 (UJ)		<12.29		<15.13	
Cs(137)	<11.06		<12.91		<13.84		<7.522 (UJ)		<13.84		<13.18 (UJ)		<14.00 (UJ)	
Ra(226)	<23.51		<30.25		<27.48		<14.03		<23.70		<27.17		<26.27	
Th(228)	<23.46 (UJ)		<20.06		<18.93		<11.63		<21.00		<20.83 20.17		<21.28	
Th(232)	<47.87		<58.95		<53.53		<32.62 (J)		56.31		<48.60		<60.60	
Sb(125)			N/A		N/A		N/A		N/A		N/A		N/A	

D-6

9 2 1 2 5 4 3 1 3 6 2

Site Identification	145-2		145-2-R		150-1		150-1-R		153-1		153-1-R		187-1	
Sample Area	100H		100H		100H		100H		100H		100H		100F	
Sample Type	spring		river		spring		river		spring		river		spring	
Discharge river/spring (cfs)	1.80E-03		9.09E+04		3.00E-04		9.48E+04		4.70E-03		8.75E+04		2.30E-03	
Coordinates E (m)	577330		577330		577885		577885		578235		578235		580820	
Coordinates N (m)	153615		153615		153160		153160		152660		152660		148275	
River Mile (nearest 0.1 mi.)	14.5		14.5		15.0		15.0		15.3		15.3		18.7	
Date	9/25/91		9/25/91		9/26/91		9/26/91		10/21/91		10/21/91		9/27/91	
Time Interval	11:22 - 13:00		13:00 - 13:25		12:05 - 13:35		14:00 - 14:30		11:35 - 13:10		12:38 - 13:10		10:40 - 12:01	
OSM Sample No.	B06L51		B06L53		B06L55		B06L58		B06L61		B06L63		B06L66	
Quality Control Sample														
Concentration in pCi/L	2σ		2σ		2σ		2σ		2σ		2σ		2σ	
Gross Alpha	1	2	0	1	0	1	0	1	1	1	0	1	1	1
Gross Beta	3	1(J)	2	1(J)	3	1(J)	2	1(J)	35	3(J)	2	1(J)	3	2(J)
H(3)	3800	500(J)	<300	(J)	1100	300	<200		400	100	<200		<400	
Sr(90)	3	2(UJ)	<1	(UJ)	<1		<2		12.7	1.4	0.7	0.2(J)	46	25
Tc(99)	<3		2	1	<2		3.4	1.5	12	2	2.6	1.4	N/A	
Total Uranium	1.22	0.22	0.53	0.05	0.8	0.1	0.34	0.03	0.66	0.06	0.3	0.03	2.6	0.2
Gamma Scan														
K(40)	<67.62		<226.6		268.3		<138.5		<197.8		<157.1		<200.1	
Cr(51)	<210.9		<339.7		<640.7		<635.9		<385.8		<152.1		<513.9	
Co(60)	<10.19		<15.14		<16.62		<19.59		<12.57		<10.89		<13.74	
Zn(65)	<15.42		<30.30		<30.20		<31.18		<28.26		<20.03		<28.92	
Cs(134)	<6.664		<14.25		<17.40		<12.81		<12.28		<8.774		<12.01	
Cs(137)	<6.289		(UJ)		<13.61		(UJ)		<10.84		<8.863		<11.74	
Ra(226)	<12.79		25.82		22.29		<26.50		<25.02		<19.15		<17.17	
Th(228)	12.46		10.87		<20.35		<34.73		<18.84		<16.06		<13.48	
Th(232)	<27.64		<57.14		<56.44		<53.84		<46.72		<38.77		<49.38	
Sb(125)	N/A		N/A		N/A		N/A		N/A		N/A		N/A	

D-7

DOE/RL-92-12, Rev. 1

Site Identification	187-1-R		190-4		190-4-R		207-1		207-1-R		211-1		211-1-R	
Sample Area	100F		100F		100F		100F		100F		100F		100F	
Sample Type	river		spring		river		spring		river		spring		river	
Discharge river/spring (cfs)	8.55E+04		1.20E-03		8.55E+04		2.20E-02		8.57E+04		nr		7.11E+04	
Coordinates E (m)	580820		581230		581230		582621		582621		582864		582864	
Coordinates N (m)	148275		147940		147940		145597		145597		145130		145130	
River Mile (nearest 0.1 mi.)	18.7		19.0		19.0		20.7		20.7		21.1		21.1	
Date	9/27/91		9/27/91		9/27/91		9/30/91		9/30/91		9/29/91		9/29/91	
Time Interval	12:20 - 12:37		8:00 - 9:35		9:50 - 10:10		9:10 - 11:15		11:50 - 12:20		8:35 - 10:17		11:30 - 12:02	
OSM Sample No.	B06L68		B06L71		B06L73		B06L76		B06L78		B06L81		B06L85	
Quality Control Sample														
Concentration in pCi/L	2σ		2σ		2σ		2σ		2σ		2σ		2σ	
Gross Alpha	1	1	0	1	0	1	1	1	0	1	1	1	0	1
Gross Beta	1	1(J)	6	1(J)	1	1(J)	4	1(J)	1	1(J)	5	1(J)	1	1(J)
H(3)	<200		<200		<200		590 150		110 130		<200		<300	
Sr(90)	<1		2.5 0.4		<2		0.24 0.07		-0.4 0.4		<1		<1	
Tc(99)	N/A		N/A		N/A						N/A		N/A	
Total Uranium	0.37	0.04	0.31	0.03	0.32	0.03	1.92	0.07	0.41	0.01	2.2	0.2	0.46	0.04
Gamma Scan														
K(40)	<147.5		<240.9		<131.3		<129		<118.6		<196.3		<115.6	
Cr(51)	<646.7		<723.2		<628.4		<4027		<4354		<519.7		<614.8	
Co(60)	<19.09		<15.18		<14.61		<12.67		<20.07		<12.64		<19.49	
Zn(65)	<24.23		<30.30		<28.50		<31.84		<32.27		<26.41		<28.05	
Cs(134)	<11.92		<14.95		<13.46		<14.43		<15.10		<13.68		<12.13	
Cs(137)	<10.85		<15.35		<10.92		<11.8		<10.87		<12.47		<11.39	
Ra(226)	<22.73		<27.26		<21.32		<24.98		23.55 18.91		<20.37		<23.72	
Th(228)	<24.58		<21.22		<18.22		<39.37 (UJ)		<23.77 (UJ)		<16.93		<20.63	
Th(232)	<51.74		<63.90		<45.93		<51.05		<40.93		<48.65		<51.25	
Sb(125)	N/A		N/A		N/A		N/A		N/A		N/A		N/A	

9 2 1 2 6 4 3 1 3 6 4

Site Identification	211-1		211-1-R		213-1		213-1-R		216-1		216-1-R		241-1-R
Sample Area	100F		100F		100F		100F		100F		100F		HAN
Sample Type	spring		river		spring		river		spring		river		river
Discharge river/spring (cfs)	1.80E-03		7.11E+04		2.30E-03		7.00E+04		nr		7.00E+04		9.51E+04
Coordinates E (m)	582864		582864		582962		582962		583132		583132		584986
Coordinates N (m)	145130		145130		144813		144813		144317		144317		140838
River Mile (nearest 0.1 mi.)	21.1		21.1		21.3		21.3		21.6		21.6		24.1
Date	9/29/91		9/29/91		9/28/91		9/28/91		9/28/91		9/28/91		10/2/91
Time Interval	10:20 - 11:10		12:11 - 12:42		10:56 - 12:10		12:37 - 12:58		8:30 - 10:08		10:10 - 10:35		16:07 - 16:37
OSM Sample No.	B06L83		B06L87		B06L91		B06L93		B06L96		B06L98		B06LJ5
Quality Control Sample	Dup. B06L81		Dup. B06L85										
Concentration in pCi/L		2 σ		2 σ		2 σ		2 σ		2 σ		2 σ	
Gross Alpha	2	2	0	1	1	2	2	1	2	2	1	1	0
Gross Beta	5	1(J)	2	1(J)	2	2(J)	1	1(J)	3	1(J)	1	1(J)	4
H(3)	<200		-46	126	<300		<200		<200		<200		<270
Sr(90)	<1		0.1	0.2	40	30	<1		<1		<40		<1
Tc(99)	N/A				N/A		N/A		N/A		N/A		N/A
Total Uranium	2.4	0.2	0.38	0.01	1.9	0.2	0.31	0.03	1.2	0.1	0.37	0.04	0.49
Gamma Scan													
K(40)	<238.9		<143.8		<269.1		<118.7		<249.3		<140.5		<91.41
Cr(51)	<682.1		<4781		<731.2		<558.4		<728.5		<591.5		<532.1
Co(60)	<14.65		<19.86		<17.16		<17.85		<17.08		<16.99		<17.94
Zn(65)	<32.64		<34.62		<31.60		<23.37		<35.66		<25.78		<26.99
Cs(134)	<16.57		<13.98		<17.29		<12.48		<16.23		<12.27		<13.69
Cs(137)	<13.97		<12.99		<14.77		<10.71		<13.78		<12.51		<14.13
Ra(226)	<26.01		<21.03		<25.78		<20.59		<24.70		<25.83		35.71
Th(228)	<21.33		<21.20	(UJ)	<22.79		<19.61		<21.98		<21.14		<20.34
Th(232)	<61.38		<52.14		<63.15		<44.70		<60.57		<47.81		<44.19
Sb(125)	N/A				N/A		N/A		N/A		N/A		N/A

D-9

DOE/RL-92-12, Rev. 1

Site Identification		241-1		241-1		241-1-R		247-1		247-1-R	
Sample Area		HAN		HAN		HAN		HAN		HAN	
Sample Type		spring		spring		river		spring		river	
Discharge river/spring (cfs)		3.30E-02		3.30E-02		9.51E+04		4.70E-03		9.51E+04	
Coordinates E (m)		584986		585059		585059		585729		585729	
Coordinates N (m)		140838		140777		140777		140070		140070	
River Mile (nearest 0.1 mi.)		24.1		24.1		24.1		24.7		24.7	
Date		10/2/91		10/2/91		10/2/91		10/2/91		10/2/91	
Time Interval		13:10 - 15:05		15:10 - 15:20		15:35 - 16:00		9:25 - 11:37		12:09 - 12:31	
OSM Sample No.		B06LB1		B06LJ3		B06LJ7		B06LK1		B06LK3	
Quality Control Sample				Dup. B06LB1		Dup. B06LJ5					
Concentration in pCi/L	2σ		2σ		2σ		2σ		2σ		2σ
Gross Alpha	1	0	1	1	1	1	1	0	1	0	1
Gross Beta	1(J)	4	2(J)	6	2(J)	2	1(J)	3	1(J)	2	1(J)
H(3)		<240		<190		<170		<260		<170	
Sr(90)		<0.3		<.04		0.4	0.2	<.4		<0.8	
Tc(99)		N/A		N/A		N/A		N/A		N/A	
Total Uranium	0.05	1.69	0.16	1.61	0.15	0.69	0.07	0.26	0.02	0.3	0.03
Gamma Scan											
K(40)		<215.5		<268.2		<212.3		<207.2		<111.7	
Cr(51)		<511.4		<543.5		<468.1		<458.6		<463.5	
Co(60)		<15.60		<16.66		<12.69		<14.00		<16.95	
Zn(65)		<32.51		<38.87		<28.65		<28.30		<24.72	
Cs(134)		<15.65		<15.29		<11.91		<14.03		<11.52	
Cs(137)		<14.03		<14.43		<13.02		<13.26		<10.00	
Ra(226)	25.59	<25.77		<25.25		<23.23		<25.16		<24.39	
Th(228)		<20.47		<22.12		<18.20		<19.80		<19.24	
Th(232)		<54.82		<59.99		<49.00		<51.49		<51.09	
Sb(125)		N/A		N/A		N/A		N/A		N/A	

APPENDIX E
CHEMICAL AND RADIOLOGICAL ANALYSES OF SEDIMENTS.

9 2 1 2 6 4 3 1 3 6 6

APPENDIX E
EXPLANATION OF TERMS

Site Identification: Identifies the specific sample site. The first three digits, e.g., 037, identify the location using the Hanford River Mile (HRM) system. A location at 037 is at HRM 3.7 miles. The next digit 037-1 identifies sites in an upstream to downstream order at that river mile. The letter R indicates a river sample location, e.g., 037-1-R. The letter S denotes a sediment sample location, e.g., 037-1-S.

Sample Area: This identifier denotes the specific reactor area or general position of the associated sample.

Sample Type: All samples are sediments

Coordinates E (m)
Coordinates N (m): Identifies the location of the sample location according to the NAD 1983 Washington State South Zone Coordinates in Meters.

River Mile (nearest 0.1 mi.): Identifies the approximate Hanford River Mile. Hanford River Mile 0.0 is at the Vernita Bridge. Measurements are scaled from the 1:2000 maps of the Hanford Site.

Date: Day on which the specific sample was collected.

OSM Sample No.: The sample tracking number assigned to a specific set of samples. Each spring/sediment sample had a single number. All numbers were supplied by Westinghouse Hanford OSM.

nr: Data not recorded in the field.

Q (Qualifier): Qualifier codes were supplied through the data validation process:
U - none detected; numerical value is sample quantitation limit
J - estimated value (less than quantitation limit)
B - analyte found in associated blank as well as in sample
E - concentration exceeds calibration range
Q - not analyzed
D - compound identified at secondary dilution factor
N - Presumptive evidence of presence of material
NJ - Presumptive evidence of presence of material at estimated quantity
UJ - not detected; quantitation limit is estimated
R - data unusable; compound may/may not be present
<blank> - positive
DIL/C - diluted out

9 2 1 2 5 4 3 1 3 6 7

Data qualifiers for radiological analyses are statistical evaluations of counting errors and are provided as plus or minus two times the standard deviation (sigma).
N/A - not analyzed

9 2 1 2 6 4 3 1 3 6 8

Appendix E. Chemical and Radiological Analyses of Sediments.

Site Identification	037-1-S		038-3-S		039-2-S		057-3-S		077-1-S	
Sample Area	100B		100B		100B		100K		100K	
Coordinates E (m)	564540		564675		564940		567585		569680	
Coordinates N (m)	145275		145275		145350		146210		148070	
River Mile (nearest 0.1 mi.)	3.7		3.8		3.9		5.7		7.7	
Date	9/18/91		9/17/91		9/19/91		9/25/91		10/16/91	
OSM Sample No.	B06KR7		B06KS0		B06KS3		B06KS8		B06KT3	
Quality Control Sample	Q		Q		Q		Q		Q	
Aluminum (mg/kg)	6180		6060		5510		6030		5390	
Antimony (mg/kg)	22.2 UJ		14 UJ		1.9 U		11.6 UJ		11.9 UJ	
Barium (mg/kg)	61.7 B		52.1 B		51.8		102 J		59.5	
Beryllium (mg/kg)	0.47 U		0.28 U		0.23 U		0.36 B		0.25 U	
Cadmium (mg/kg)	1.4 U		0.85 U		0.23 UJ		0.74 U		0.76 U	
Calcium (mg/kg)	3780		2550		3120		3500		3090	
Chromium (mg/kg)	52.1 J		51.7 J		35.6		29.3 J		39.6	
Cobalt (mg/kg)	6.8 J		5.4 J		5.1 B		7.1 B		6.5 B	
Copper (mg/kg)	18.2		15.8		11.8		19.1		17.5 J	
Iron (mg/kg)	11700		11500		14900		21500		14400	
Magnesium (mg/kg)	3530		3420		3270		2940		3310	
Manganese (mg/kg)	154		135		252 J		335 J		238 J	
Nickel (mg/kg)	12.1 B		12.5		9.8		13.6		11	
Potassium (mg/kg)	1180 B		1050 B		732 B		707 B		670 B	
Silver (mg/kg)	1.9 U		1.1 U		0.47 U		0.98 U		1 U	
Sodium (mg/kg)	188 J		117 J		139 B		242 J		152 J	
Vanadium (mg/kg)	26.7		23.2		26.4 J		37.2		29.6	
Zinc (mg/kg)	208		79.6		99.5		280		173 J	
	2σ		2σ		2σ		2σ		2σ	
Gross Alpha	4		4		11		4		0 3(R)	
Gross Beta	15		3		20		3		10 2	
Sr(90)	0.3		0.1		0.4		0.2(J)		0.19 0.18	
Tc(99)	N/A		N/A		N/A		N/A		0.2 0.1(J)	
Gamma Scan	N/A		N/A		N/A		N/A		0.61 0.3(J)	
K(40)	13.91 0.66		13.03 0.53		12.45 1.01		11.44 0.43		14.18 0.5	
Cr(51)	<1.446		<1.129		<25.46		<85.09		<0.684	
Mn(54)	N/A		N/A		N/A		N/A		N/A	
Co(60)	<0.040		<0.026		<0.067		<0.023		0.042 0.021	
Zn(65)	<0.093		<0.067		<0.244		<0.053		<0.065	
Sb(124)	N/A		N/A		N/A		N/A		N/A	
Cs(134)	<0.040		<0.027		<0.076		<0.024		<0.029	
Cs(137)	0.146 0.03(J)		0.033 0.014(J)		<0.0631		0.148 0.015(J)		0.214 0.029	
Ce (141)	N/A		N/A		N/A		N/A		N/A	
Eu(152)	N/A		N/A		N/A		N/A		0.126 0.038	
Eu(154)	N/A		N/A		N/A		N/A		N/A	
Eu(155)	N/A		N/A		N/A		N/A		0.050 0.048	
Pa(226)	0.776 0.067		0.446 0.041		0.719 0.107		0.727 0.046		0.817 0.046	
Th(228)	1.024 0.04(J)		0.776 0.031(J)		1.813 0.121		0.791 0.027		0.933 0.029	
Th(232)	0.955 0.143		0.673 0.088		1.288 0.247		0.776 0.091		1.051 0.099	
U(235)	N/A		N/A		N/A		N/A		N/A	

9 2 1 2 3 4 3 1 3 5 9

Appendix E. Chemical and Radiological Analyses of Sediments.

Site Identification	092-2-S		090-1-S		092-2-S		092-3-S		093-1-S	
Sample Area	100K		100N		100N		100N		100N	
Coordinates E (m)	570415		571300		571465		571480		571500	
Coordinates N (m)	148780		149920		150150		150170		150185	
River Mile (nearest 0.1 mi.)	8.3		9.0		9.2		9.2		9.3	
Date	10/18/91		10/15/91		10/15/91		10/18/91		10/18/91	
OSM Sample No.	B06KT8	Q	B06KV2	Q	B06KV7	Q	B06KW2	Q	B06KW7	Q
Quality Control Sample										
Aluminum (mg/kg)	5970		4800		5870		6910		4850	
Antimony (mg/kg)	9.2	UJ	6.3	J	2.9	UJ	10.9	UJ	10.9	UJ
Barium (mg/kg)	79.5		54.2		57.1		111		81.7	
Beryllium (mg/kg)	0.2	U	0.24	B	0.21	U	0.23	U	0.23	U
Cadmium (mg/kg)	0.59	U	0.22	U	0.5	B	0.7	U	0.9	B
Calcium (mg/kg)	2980		3160		2710		3300		3680	
Chromium (mg/kg)	34.9		10.3		13.4		14.5		9.1	
Cobalt (mg/kg)	6.1	B	7.3	B	6.8	B	8.2	B	8.9	B
Copper (mg/kg)	17.9	J	16.7	J	13.1	J	18	J	17.4	J
Iron (mg/kg)	14200		15400		14500		18300		16400	
Magnesium (mg/kg)	3410		3270		3110		3960		3130	
Manganese (mg/kg)	493	J	239	J	360	J	487	J	578	J
Nickel (mg/kg)	13		9.1		12		16.2		11	
Potassium (mg/kg)	697	B	657	J	586	J	811	B	551	B
Silver (mg/kg)	0.78	U	1.1	U	1	U	0.93	U	0.93	U
Sodium (mg/kg)	131	J	137	J	137	J	148	J	192	J
Vanadium (mg/kg)	32.8		35.2		31.8		44.5		38.4	
Zinc (mg/kg)	80.3		77.4		98		99.7		168	
		2 σ								
Gross Alpha	5	5	0	5	8	5	16	6	11	5
Gross Beta	23	3	317	8	51	3	30	3	19	2
Sr(90)	<0.6	(U)	207	42	24.5	2.3	<0.6	(U)	<0.4	(U)
Tc(99)	N/A									
Gamma Scan										
K(40)	14.58	0.51	12	0.51	12.67	0.48	14.05	0.52	12.61	0.47
Cr(51)	<0.741		<1.321		<1.156		<0.833		<0.752	
Mn(54)	N/A									
Co(60)	0.036	0.027	2.757	0.079	4.973	0.092	1.061	0.050	0.821	0.043
Zn(65)	<0.071		<0.105		<0.137		<0.077		<0.085	
Sb(124)	N/A		1.238	0.086	0.645	0.074	N/A		0.075	0.053
Cs(134)	<0.034		<0.044		<0.050		<0.036		<0.034	
Cs(137)	0.187	0.028	0.104	0.041	0.147	0.038	0.077	0.025	0.310	0.026
Ce(141)	N/A									
Eu(152)	0.100	0.048	N/A		0.114	0.072	N/A		0.235	0.037
Eu(154)	N/A									
Eu(155)	0.077	0.047	N/A		N/A		N/A		N/A	
Ra(226)	1.019	0.058	0.796	0.569	0.750	0.072	0.903	0.053	0.910	0.047
Th(228)	1.516	0.035	0.844	0.042	0.938	0.035	1.225	0.037	0.844	0.029
Th(232)	1.419	0.113	0.739	0.170	0.886	0.211	1.100	0.140	0.879	0.126
U(235)	N/A		N/A		N/A		0.108	0.083	N/A	

9 2 1 2 6 4 3 1 3 7 0

Appendix E. Chemical and Radiological Analyses of Sediments.

Site Identification	094-1-S		110-1-S		110-2-S		144-1-S		145-1-S	
Sample Area	100N		100D		100D		100H		100H	
Coordinates E (m)	571680		573480		573597		577080		577255	
Coordinates N (m)	150465		152375		152470		153770		153660	
River Mile (nearest 0.1 mi.)	9.4		11.0		11.0		14.4		14.5	
Date	10/17/91		9/19/91		9/26/91		9/20/91		9/20/91	
OSM Sample No.	B06KX2		B06KX5		B06KY0		B06L45		B06L50	
Quality Control Sample	Q		Q		Q		Q		Q	
Aluminum (mg/kg)	5590		6090		6310		6360		5410	
Antimony (mg/kg)	10		2		7.1		12.4		12	
Barium (mg/kg)	61.3		61.9		80.3		60.7		45.4	
Beryllium (mg/kg)	0.21		0.25		0.25		0.25		0.26	
Cadmium (mg/kg)	0.64		0.25		1.9		0.76		0.77	
Calcium (mg/kg)	2910		5220		3840		3660		5660	
Chromium (mg/kg)	10.9		30.1		122		19.7		107	
Cobalt (mg/kg)	7.3		6.1		7.6		8.4		7.3	
Copper (mg/kg)	17.3		11		17.8		29.5		24.6	
Iron (mg/kg)	15200		14200		171000		15100		17000	
Magnesium (mg/kg)	2870		3350		3770		3900		3280	
Manganese (mg/kg)	376		315		425		296		253	
Nickel (mg/kg)	11.2		9.3		10.5		9.2		11.4	
Potassium (mg/kg)	671		562		774		784		626	
Silver (mg/kg)	0.85		0.5		1.1		1		1	
Sodium (mg/kg)	150		149		192		223		210	
Vanadium (mg/kg)	38.5		28.5		34.9		28.5		26.1	
Zinc (mg/kg)	142		91		195		217		204	
	2σ		2σ		2σ		2σ		2σ	
Gross Alpha	10		4		7		7		6	
Gross Beta	18		19		18		18		22	
Sr(90)	<0.6 (U)		-0.04		<0.3		0.3		0.2	
Tc(99)	N/A		0.5		<0.3		0.2		0.2	
Gamma Scan										
K(40)	11.94		10.68		10.62		12.18		13.32	
Cr(51)	<0.878		<19.48		<1.345		<1.118		<1.107	
Mn(54)	N/A						N/A		N/A	
Co(60)	1.389		0.290		0.110		0.177		0.037	
Zn(65)	<0.083		<.181		<.071		<0.066		<0.059	
Sb(124)	0.062		0.057				N/A		N/A	
Cs(134)	<0.035		<.059		<.300		<0.028		<0.028	
Cs(137)	0.156		0.221		0.270		0.249		0.187	
Ce (141)	N/A		0.030		0.045		0.028(J)		0.017(J)	
Eu(152)	N/A				0.266		N/A		N/A	
Eu(154)	0.102		0.039		0.047		N/A		N/A	
Eu(155)	N/A						N/A		N/A	
Ra(226)	0.701		0.421		0.603		0.656		0.762	
Th(228)	0.753		0.656		0.735		0.822		1.156	
Th(232)	0.735		0.584		0.696		0.783		1.070	
U(235)	N/A		0.132		0.193		0.116		0.105	
U(238)	N/A						N/A		N/A	

9 2 1 2 5 4 3 1 3 7 1

Appendix E. Chemical and Radiological Analyses of Sediments.

Site Identification	145-2-S		150-1-S		153-1-S		187-1-S		190-4-S	
Sample Area	100H		100H		100H		100F		100F	
Coordinates E (m)	577330		577885		578235		580820		581230	
Coordinates N (m)	153615		153160		152660		148275		147940	
River Mile (nearest 0.1 mi.)	14.5		15.0		15.3		18.7		19.0	
Date	9/25/91		9/26/91		10/21/91		9/27/91		9/27/91	
OSM Sample No.	B06L55 Q		B06L60 Q		B06L65 Q		B06L70 Q		B06L75 Q	
Quality Control Sample										
Aluminum (mg/kg)	9150		6540		5700		5460		6120	
Antimony (mg/kg)	16	UJ	12.7	UJ	11.3	UJ	11.2	UJ	11.1	UJ
Barium (mg/kg)	76.5	J	53.5	J	69.1		49.9	J	67.9	J
Beryllium (mg/kg)	0.63	B	0.3	B	0.24	U	0.26	U	0.43	B
Cadmium (mg/kg)	1	U	0.81	U	0.72	U	0.72	U	0.71	U
Calcium (mg/kg)	4810	J	3690	J	3460		3300	J	2770	J
Chromium (mg/kg)	45.6	J	23.9	J	47.3	J	10	J	20.7	J
Cobalt (mg/kg)	8.4	B	6.3	B	8.1	B	6.1	B	5.9	B
Copper (mg/kg)	31.6		23.4		24.9		20.1		16.4	
Iron (mg/kg)	18200	J	13500	J	16400	J	13700	J	13100	J
Magnesium (mg/kg)	4890		3870		3680		3640		3760	
Manganese (mg/kg)	457	J	180	J	285		283	J	236	J
Nickel (mg/kg)	17.4		11.7		11.2		10		11.8	
Potassium (mg/kg)	1160	B	837	B	569	B	648	B	554	B
Silver (mg/kg)	1.4	U	1.1	U	0.96	U	0.96	U	0.94	U
Sodium (mg/kg)	311	J	256	J	169	J	186	J	137	J
Vanadium (mg/kg)	40.8		28.7		37.5		31		30.6	
Zinc (mg/kg)	364	J	226	J	174		109	J	58.9	J
		2 σ								
Gross Alpha	6	4	7	3	8	5	8	5	8	5
Gross Beta	13	2	23	2	19	2	20	3	20	2
Sr(90)	<0.3	(UJ)	<2		0.9	0.3(J)	<1		20	10
Tc(99)	0.4	0.1(J)	<0.2		0.23	0.09	N/A		N/A	
Gamma Scan										
K(40)	13.65	0.48	15.17	0.63	12.28	0.49	13.85	0.46	12.61	0.52
Cr(51)	<1.165		<1.429		<0.702		<0.977		<1.267	
Mn(54)	N/A									
Co(60)	0.184	0.030	0.047	0.033	0.069	0.020	0.095	0.024	0.153	0.036
Zn(65)	<0.084		<0.088		<0.066		<0.061		<0.094	
Sb(124)	N/A									
Cs(134)	<0.044		<0.034		<0.030		<0.024		<0.037	
Cs(137)	0.520	0.036(J)	0.169	0.033	0.168	0.030	0.150	0.024	0.186	0.029
Ce(141)	N/A									
Eu(152)	0.636	0.049	N/A		0.212	0.044	N/A		0.758	0.055
Eu(154)	0.093	0.064	N/A		N/A		N/A		0.164	0.078
Eu(155)	0.076	0.048	0.084	0.058	0.059	0.048	0.326	0.035	0.066	0.053
Ra(226)	0.769	0.051	0.743	0.063	0.784	0.006	0.552	0.047	0.759	0.057
Th(228)	1.092	0.032	0.927	0.035	1.159	0.035	0.748	0.027	1.238	0.036
Th(232)	1.123	0.102	0.953	0.117	1.196	1.106	0.670	0.087	1.228	0.128
U(235)	0.084	0.072	N/A		N/A		N/A		N/A	

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Appendix E. Chemical and Radiological Analyses of Sediments.

Site Identification	207-1-S		211-1-S		211-1-S		213-1-S		216-1-S	
Sample Area	100F		100F		100F		100F		100F	
Coordinates E (m)	582621		582864		582864		582962		583132	
Coordinates N (m)	145597		145130		145130		144813		144317	
River Mile (nearest 0.1 mi.)	20.74		21.1		21.1		21.3		21.6	
Date	9/30/91		9/29/91		9/29/91		9/28/91		9/28/91	
OSM Sample No.	B06L80	Q	B06L89	Q	B06L90	Q	B06L95	Q	B06L80	Q
Quality Control Sample					Dup. B06L89					
Aluminum (mg/kg)	5200		6920		6790		6630		5240	
Antimony (mg/kg)	6.9	U	13.6	UJ	12.8	UJ	11.6	UJ	4.3	J
Barium (mg/kg)	50.9		65.5		66		53.4		65.1	
Beryllium (mg/kg)	0.35	B	0.53	B	0.3	B	0.25	U	0.23	U
Cadmium (mg/kg)	1.8		0.87		0.82		0.74		0.99	
Calcium (mg/kg)	4180		4030		5320		4230		10000	
Chromium (mg/kg)	12.8		20		17.4		17.1		10.2	
Cobalt (mg/kg)	11	B	7.1	B	6.9	B	8.2	B	7.5	B
Copper (mg/kg)	19.2		21		20.9		19.8		15.1	
Iron (mg/kg)	252000		16500		16100		18800		16200	
Magnesium (mg/kg)	4530		4320		4080		4370		3690	
Manganese (mg/kg)	338		217		201		276		308	
Nickel (mg/kg)	11		12.6		12.2		14		10.3	
Potassium (mg/kg)	622	B	951	B	977	B	847	B	641	B
Silver (mg/kg)	1.1	U	1.2	U	1.1	U	0.99	U	1.1	U
Sodium (mg/kg)	219	B	229	J	247	J	232	J	225	J
Vanadium (mg/kg)	70.8		33.9		32.4		46.7		40.2	
Zinc (mg/kg)	98.7		252		244		160		148	
		2σ		2σ		2σ		2σ		2σ
Gross Alpha	2	4(R)	2	4	6	4	14	5	6	4
Gross Beta	12	2	23	3	23	3	24	3	24	3
Sr(90)	-0.2	2	<40		<0.1		<0.4		<0.1	
Tc(99)	0.2	0.1	N/A		N/A		N/A		N/A	
Gamma Scan										
K(40)	7.93	0.77	14.63	0.58	15.6	0.62	13.4	0.53	13.45	0.49
Cr(51)	<16.07		<1.514		<1.376		<1.434		<1.347	
Mn(54)			N/A		N/A		N/A		N/A	
Co(60)	0.059	0.041	0.063	0.033	0.075	0.043	0.080	0.024	0.250	0.034
Zn(65)	<.194		<0.083		<0.100		<0.074		<0.089	
Sb(124)			N/A		0.115	0.109	N/A		N/A	
Cs(134)	<.061		<0.038		<0.050		<0.035		<0.034	
Cs(137)	0.167	0.051	0.439	0.038	0.487	0.030	0.259	0.033	0.590	0.026
Ce (141)			N/A		N/A		N/A		N/A	
Eu(152)			0.312	0.056	0.275	0.059	0.289	0.039	0.737	0.051
Eu(154)			N/A		N/A		N/A		0.088	0.070
Eu(155)			0.076	0.070	N/A		N/A		0.085	0.050
Ra(226)	0.547	0.099	0.803	0.049	0.802	0.070	0.827	0.054	0.857	0.052
Th(228)	0.926	0.092	1.181	0.042	1.127	0.039	1.559	0.043	1.510	0.035
Th(232)	0.700	0.208	1.073	0.150	1.110	0.128	1.497	0.111	1.563	0.124
U(235)			N/A		N/A		N/A		N/A	

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Appendix E. Chemical and Radiological Analyses of Sediments.

Site Identification	241-1-S		241-1-S		247-1-S	
Sample Area	HAN		HAN		HAN	
Coordinates E (m)	584986		585059		585729	
Coordinates N (m)	140838		140777		140070	
River Mile (nearest 0.1 mi.)	24.1		24.1		24.7	
Date	10/2/91		10/2/91		10/2/91	
OSM Sample No.	B06LJ9	Q	B06LK0	Q	B06LK5	Q
Quality Control Sample			Dup. B06LJ9			
Aluminum (mg/kg)	9350		9220		6410	
Antimony (mg/kg)	6.9	UJ	6.7	UJ	5	J
Barium (mg/kg)	87	B	98.8		74.2	
Beryllium (mg/kg)	0.49	U	0.48	U	0.24	U
Cadmium (mg/kg)	2.7		1.9	B	0.79	U
Calcium (mg/kg)	5060		5140		4200	
Chromium (mg/kg)	22.1		21.9		12.1	
Cobalt (mg/kg)	10.2	B	11.5	B	8.3	B
Copper (mg/kg)	29	J	26	J	14.3	J
Iron (mg/kg)	24600		30400		19200	
Magnesium (mg/kg)	4650		4620		3900	
Manganese (mg/kg)	313	J	338	J	373	J
Nickel (mg/kg)	19.7		19.3		12.2	
Potassium (mg/kg)	1300	B	1160	B	715	B
Silver (mg/kg)	2.5	U	2.4	U	1.2	U
Sodium (mg/kg)	293	J	275	J	148	J
Vanadium (mg/kg)	70		82.2		46.7	
Zinc (mg/kg)	333		291		163	
		2σ		2σ		2σ
Gross Alpha	12	5	8	5	12	5
Gross Beta	21	2	20	3	25	3
Sr(90)	<2		<2		<0.1	
Tc(99)	N/A		N/A		N/A	
Gamma Scan						
K(40)	12.17	0.58	12.73	0.6	11.46	0.55
Cr(51)	<1.444		<1.481		<1.273	
Mn(54)	0.026	0.021	N/A		N/A	
Co(60)	0.077	0.033	0.071	0.033	0.220	0.039
Zn(65)	<0.086		<0.1		<0.092	
Sb(124)	N/A		N/A		N/A	
Cs(134)	<0.060		<0.043		<0.045	
Cs(137)	0.257	0.025	0.344	0.040	0.477	0.029
Ce (141)	N/A		0.151	0.123	N/A	
Eu(152)	0.377	0.060	0.342	0.070	0.755	0.060
Eu(154)	N/A		N/A		N/A	
Eu(155)	0.087	0.078	N/A		N/A	
Ra(226)	1.273	0.073	1.184	0.076	1.108	0.072
Th(228)	1.913	0.050	1.760	0.048	1.185	0.042
Th(232)	1.708	0.143	1.649	0.165	1.185	0.144
U(235)	N/A		0.1069	0.87	N/A	

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APPENDIX F
SHORELINE SAMPLING LOCATIONS AND SAMPLE NUMBERS

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Location Identifiers

Shoreline sampling locations are identified using the Hanford River Mile (HRM) system. The first number group in the sample location identifier indicates the Hanford river mile to the nearest tenth, multiplied by ten. The second number group indicates multiple, closely-spaced seep locations. For example, 037-1 and 037-2 indicate two seeps located at approximately HRM 3.7. Numerous seeps sampled during previous investigations are not included in this table; hence the second number group is not always sequential. The final suffix indicates sample type, if other than a water sample from riverbank seepage.

Hanford River Miles

Hanford River Miles are measured along the south shoreline of the Columbia River, starting at Vernita Bridge and proceeding downstream (see Figure 1). HRM's were scaled on USGS 7 1/2-min quadrangle maps, and generally follow the shoreline as shown on the maps. Where sloughs and peninsulas complicate the scaling process (e.g. immediately south of 100-F and 100-H areas), scaling ignores the islands and peninsulas, and follows the main channel bank as indicated by topography. The HRM associated with samples collected for this study were revised slightly from the initial scaling done during field activities.

Permanent milepost markers are present along the south shoreline of the river, although not for each mile. The locations of these mileposts do not exactly match the scaling system described above, especially at HRM 6, but they are close enough for field identification purposes. For this project, the discrepancy at HRM 6 has been equally split between mileposts HRM 5 and HRM 7.

Efforts are in progress to establish a more formal and reproducible reference system for identifying seep locations. Part of that effort involves attempting to determine the actual seeps sampled during previous field investigations, so that comparisons between historical data and Fall 1991 sampling results can be made. Locations during former seep sampling activities were identified only by their position relative to the HRM system, and the scaling used is not consistent among the various reports.

Sample Numbers

A sample number is assigned to each individual sample that is submitted for analysis. These sample numbers are used in the Hanford Environmental Information System (HEIS) to keep track of all analytical data. A unique number is assigned to each sample, including a separate number for filtered water samples, unfiltered water samples, river samples, and bank seepage samples, and sediment samples.

The original sample number assignments contained ambiguities with regard to filtered versus unfiltered samples, and to water versus sediment samples. An interim sample number was created to temporarily accommodate the ambiguities during preparation of the report. A final, revised sample number was subsequently assigned, and all references to sample numbers in the report reflect the final revised number assignments.

Shoreline Sampling Locations and Sample Numbers Conversion Table

A table showing the evolution of shoreline sampling locations for riverbank seepage, nearshore river water, and sediments associated with bank seepage is included in this Appendix.

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SHORELINE SAMPLING LOCATIONS AND SAMPLE NUMBERS

Location ID (Orig)	Location ID (Rev)	Revised HRM	Original Sample No.	Interim Sample No.	Revised Sample No.	Sample Type	Comments
037-1	037-1	3.67	B01579	B01579	B06KR3	Seep	
037-1	037-1	3.67	B01579-f	B01579-f	B06KR4	Seep	
037-1-R	037-1-R	3.67	B01580	B01580	B06KR5	River	
037-1-R	037-1-R	3.67	B01580-f	B01580-f	B06KR6	River	
037-1-S	037-1-S	3.67	B01579	B01579S	B06KR7	Sediment	
038-3	038-3	3.76	B01578	B01578	B06KR8	Seep	
038-3	038-3	3.76	B01578-f	B01578-f	B06KR9	Seep	
038-3-S	038-3-S	3.76	B01578	B01578S	B06KS0	Sediment	
039-2	039-2	3.92	B01583	B01583	B06KS1	Seep	
039-2	039-2	3.92	B01583-f	B01583-f	B06KS2	Seep	
039-2-S	039-2-S	3.92	B01583	B01583S	B06KS3	Sediment	
056-3	057-3	5.70	B01589	B01589	B06KS4	Seep	
056-3	057-3	5.70	B01589-f	B01589-f	B06KS5	Seep	
056-3-R	057-3-R	5.70	B01590	B01590	B06KS6	River	
056-3-R	057-3-R	5.70	B01590-f	B01590-f	B06KS7	River	
056-3-S	057-3-S	5.70	B01589	B01589S	B06KS8	Sediment	
074-1	077-1	7.65	B015D2	B015D2	B06KS9	Seep	
074-1	077-1	7.65	B015D2-f	B015D2-f	B06KT0	Seep	
074-1-R	077-1-R	7.65	B015D3	B015D3	B06KT1	River	
074-1-R	077-1-R	7.65	B015D3-f	B015D3-f	B06KT2	River	
074-1-S	077-1-S	7.65	B015D2	B015D2S	B06KT3	Sediment	
080-2	082-2	8.25	B015F2	B015F2	B06KT4	Seep	
080-2	082-2	8.25	B015F2-f	B015F2-f	B06KT5	Seep	
080-2-R	082-2-R	8.25	B015F3	B015F3	B06KT6	River	
080-2-R	082-2-R	8.25	B015F3-f	B015F3-f	B06KT7	River	
080-2-S	082-2-S	8.25	B015F2	B015F2S	B06KT8	Sediment	
090-1	090-1	8.96	B015C8	B015C8	B06KT9	Seep	
090-1	090-1	8.96	B015C8-f	B015C8-f	B06KV0	Seep	
090-1-R	090-1-R	8.96	B015C9	B015C9	B06KV1	River	
090-1-S	090-1-S	8.96	B015C8	B015C8S	B06KV2	Sediment	
091-2	092-2	9.21	B015D0	B015D0	B06KV3	Seep	
091-2	092-2	9.21	B015D0-f	B015D0-f	B06KV4	Seep	
091-2-R	092-2-R	9.21	B015D1	B015D1	B06KV5	River	
091-2-R	092-2-R	9.21	B015D1-f	B015D1-f	B06KV6	River	
091-2-S	092-2-S	9.21	B015D0	B015D0S	B06KV7	Sediment	
092-1	092-3	9.24	B015F0	B015F0	B06KV8	Seep	
092-1	092-3	9.24	B015F0-f	B015F0-f	B06KV9	Seep	
092-1-R	092-3-R	9.24	B015F1	B015F1	B06KW0	River	
092-1-R	092-3-R	9.24	B015F1-f	B015F1-f	B06KW1	River	
092-1-S	092-3-S	9.24	B015F0	B015F0S	B06KW2	Sediment	
092-2	093-1	9.27	B015D8	B015D8	B06KW3	Seep	
092-2	093-1	9.27	B015D8-f	B015D8-f	B06KW4	Seep	
092-2-R	093-1-R	9.27	B015D9	B015D9	B06KW5	River	
092-2-R	093-1-R	9.27	B015D9-f	B015D9-f	B06KW6	River	
092-2-S	093-1-S	9.27	B015D8	B015D8S	B06KW7	Sediment	
094-1	094-1	9.41	B015D4	B015D4	B06KW8	Seep	
094-1	094-1	9.41	B015D4-f	B015D4-f	B06KW9	Seep	

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SHORELINE SAMPLING LOCATIONS AND SAMPLE NUMBERS

Location ID (Orig)	Location ID (Rev)	Revised HRM	Original Sample No.	Interim Sample No.	Revised Sample No.	Sample Type	Comments
094-1-R	094-1-R	9.41	B015D5	B015D5	B06KX0	River	
094-1-R	094-1-R	9.41	B015D5-f	B015D5-f	B06KX1	River	
094-1-S	094-1-S	9.41	B015D4	B015D4S	B06KX2	Sediment	
110-1	110-1	10.96	B01585	B01585	B06KX3	Seep	
110-1	110-1	10.96	B01585-f	B01585-f	B06KX4	Seep	
110-1-S	110-1-S	10.96	B01585	B01585S	B06KX5	Sediment	
110-2	110-2	11.03	B01593	B01593	B06KX6	Seep	
110-2	110-2	11.03	B01593-f	B01593-f	B06KX7	Seep	
110-2-R	110-2-R	11.03	B01594	B01594	B06KX8	River	
110-2-R	110-2-R	11.03	B01594-f	B01594-f	B06KX9	River	
110-2-S	110-2-S	11.03	B01593	B01593S	B06KY0	Sediment	
143-1	144-1	14.38	B01581	B01581	B06KY1	Seep	
143-1	144-1	14.38	B01581-f	B01581-f	B06KY2	Seep	
143-1-R	144-1-R	14.38	B01582	B01582	B06L43	River	
143-1-R	144-1-R	14.38	B01582-f	B01582-f	B06L44	River	
143-1-S	144-1-S	14.38	B01581	B01581S	B06L45	Sediment	
144-1	145-1	14.48	B01587	B01587	B06L46	Seep	
144-1	145-1	14.48	B01587-f	B01587-f	B06L47	Seep	
144-1-R	145-1-R	14.48	B01588	B01588	B06L48	River	
144-1-R	145-1-R	14.48	B01588-f	B01588-f	B06L49	River	
144-1-S	145-1-S	14.48	B01587	B01587S	B06L50	Sediment	
146-1	145-2	14.54	B01591	B01591	B06L51	Seep	
146-1	145-2	14.54	B01591-f	B01591-f	B06L52	Seep	
146-1-R	145-2-R	14.54	B01592	B01592	B06L53	River	
146-1-R	145-2-R	14.54	B01592-f	B01592-f	B06L54	River	
146-1-S	145-2-S	14.54	B01591	B01591S	B06L55	Sediment	
149-1	150-1	15.02	B01595	B01595	B06L56	Seep	
149-1	150-1	15.02	B01595-f	B01595-f	B06L57	Seep	
149-1-R	150-1-R	15.02	B01596	B01596	B06L58	River	
149-1-R	150-1-R	15.02	B01596-f	B01596-f	B06L59	River	
149-1-S	150-1-S	15.02	B01595	B01595S	B06L60	Sediment	
154-1	153-1	15.34	B015D6	B015D6	B06L61	Seep	
154-1	153-1	15.34	B015D6-f	B015D6-f	B06L62	Seep	
154-1-R	153-1-R	15.34	B015D7	B015D7	B06L63	River	
154-1-R	153-1-R	15.34	B015D7-f	B015D7-f	B06L64	River	
154-1-S	153-1-S	15.34	B015D6	B015D6S	B06L65	Sediment	
187-1	187-1	18.71	B01599	B01599	B06L66	Seep	
187-1	187-1	18.71	B01599-f	B01599-f	B06L67	Seep	
187-1-R	187-1-R	18.71	B01580	B01580	B06L68	River	
187-1-R	187-1-R	18.71	B01580-f	B01580-f	B06L69	River	
187-1-S	187-1-S	18.71	B01599	B01599S	B06L70	Sediment	
190-4	190-4	19.02	B01597	B01597	B06L71	Seep	
190-4	190-4	19.02	B01597-f	B01597-f	B06L72	Seep	
190-4-R	190-4-R	19.02	B01598	B01598	B06L73	River	
190-4-R	190-4-R	19.02	B01598-f	B01598-f	B06L74	River	
190-4-S	190-4-S	19.02	B01597	B01597S	B06L75	Sediment	
208-1	207-1	20.74	B015C0	B015C0	B06L76	Seep	
208-1	207-1	20.74	B015C0-f	B015C0-f	B06L77	Seep	

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SHORELINE SAMPLING LOCATIONS AND SAMPLE NUMBERS

Location ID (Orig)	Location ID (Rev)	Revised HRM	Original Sample No.	Interim Sample No.	Revised Sample No.	Sample Type	Comments
208-1-R	207-1-R	20.74	B015C1	B015C1	B06L78	River	
208-1-R	207-1-R	20.74	B015C1-f	B015C1-f	B06L79	River	
208-1-S	207-1-S	20.74	B015C0	B015C0S	B06L80	Sediment	
216-1	211-1	21.06	B015B5	B015B5	B06L81	Seep	
216-1	211-1	21.06	B015B5-f	B015B5-f	B06L82	Seep	
216-1	211-1	21.06	B015B7	B015B7	B06L83	Seep	Duplicate of B015B5/B06L81
216-1	211-1	21.06	B015B7-f	B015B7-f	B06L84	Seep	Duplicate of B015B5-f/B06L82
216-1-R	211-1-R	21.06	B015B6	B015B6	B06L85	River	
216-1-R	211-1-R	21.06	B015B6-f	B015B6-f	B06L86	River	
216-1-R	211-1-R	21.06	B015B9	B015B9	B06L87	River	Duplicate of B015B6/B06L85
216-1-R	211-1-R	21.06	B015B9-f	B015B9-f	B06L88	River	Duplicate of B015B6-f/B06L86
216-1-S	211-1-S	21.06	B015B5	B015B5S	B06L89	Sediment	
216-1-S	211-1-S	21.06	B015B7	B015B7S	B06L90	Sediment	Duplicate of B015B5S/B06L89
218-1	213-1	21.28	B015B3	B015B3	B06L91	Seep	
218-1	213-1	21.28	B015B3-f	B015B3-f	B06L92	Seep	
218-1-R	213-1-R	21.28	B015B4	B015B4	B06L93	River	
218-1-R	213-1-R	21.28	B015B4-f	B015B4-f	B06L94	River	
218-1-S	213-1-S	21.28	B015B3	B015B3S	B06L95	Sediment	
221-1	216-1	21.61	B015B1	B015B1	B06L96	Seep	
221-1	216-1	21.61	B015B1-f	B015B1-f	B06L97	Seep	
221-1-R	216-1-R	21.61	B015B2	B015B2	B06L98	River	
221-1-R	216-1-R	21.61	B015B2-f	B015B2-f	B06L99	River	
221-1-S	216-1-S	21.61	B015B1	B015B1S	B06L80	Sediment	
246-1	241-1	24.06	B015C4	B015C4	B06LB1	Seep	
246-1	241-1	24.06	B015C4-f	B015C4-f	B06LB2	Seep	
246-1	241-1	24.06	B015C6	B015C6	B06LJ3	Seep	Duplicate of B015C4/B06LB1
246-1	241-1	24.06	B015C6-f	B015C6-f	B06LJ4	Seep	Duplicate of B015C4-f/B06LB2
246-1-R	241-1-R	24.06	B015C5	B015C5	B06LJ5	River	
246-1-R	241-1-R	24.06	B015C5-f	B015C5-f	B06LJ6	River	
246-1-R	241-1-R	24.06	B015C7	B015C7	B06LJ7	River	Duplicate of B015C5/B06LJ5
246-1-R	241-1-R	24.06	B015C7-f	B015C7-f	B06LJ8	River	Duplicate of B015C5-f/B06LJ6
246-1-S	241-1-S	24.06	B015C4	B015C4S	B06LJ9	Sediment	
246-1-S	241-1-S	24.06	B015C6	B015C6S	B06LK0	Sediment	Duplicate of B015C4S/B06LJ9
252-1	247-1	24.71	B015C2	B015C2	B06LK1	Seep	
252-1	247-1	24.71	B015C2-f	B015C2-f	B06LK2	Seep	
252-1-R	247-1-R	24.71	B015C3	B015C3	B06LK3	River	
252-1-R	247-1-R	24.71	B015C3-f	B015C3-f	B06LK4	River	
252-1-S	247-1-S	24.71	B015C2	B015C2S	B06LK5	Sediment	

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APPENDIX G

VALIDATION OF 100 AREA SPRINGS RADIOCHEMICAL DATA

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The 100 Area Springs Radiochemical Validation was performed to the requirements outlined in the draft procedure titled "Data Validation Procedure for Radiological Analysis, Rev. 0, June 18, 1991." The 100 Area Springs project is the first case where the Westinghouse Hanford OSM validated radiological data to the guidelines described in the above referenced procedure. The validation using this procedure is also a user test, with recommendations for improvements that should be applied in future radiological data validation.

The 100 Area Springs Project consisted of a total of 82 samples contained within nine radiochemical sample delivery groups (SDGs). The samples represent both water and soil matrices. All samples were analyzed at the Thermo Analytical Norcal Laboratory (TMA Norcal). Radiological parameters of interest for the project were: total alpha, total beta, total uranium (on water samples only), gross gamma scan, tritium (on water samples only), strontium-90 and technetium-99.

The radiological validation process, in part, is a detailed and in-depth technical review of the laboratory counting systems, standards and quality control used in analyzing the samples. Review of chain-of-custody requirements, completeness of data reported and contract required detection limits are also part of the validation process. The initial technical review of the laboratory counting systems is applicable to all 100 Area Springs delivery groups analyzed. The analysis batch quality control (QC) and instrument performance are reviewed for each delivery group reported. The attached appendices taken from the radiological validation procedure document the review of the counting systems used and will not change other than QC and holding times pertaining to the individual data packages.

DELIVERY GROUP AND SAMPLE QUALIFIER REPORT

The laboratory analyzed the nine delivery groups in four processing groups. A processing group is defined as a set of samples that are prepared and analyzed together within the laboratory. The QC required for each delivery group could be spread over two or three delivery groups due to delivery groups being batched together in the processing groups. Each data package contains the individual QC evaluation used to qualify the data, with the same information being placed within the other data packages that were processed together. The purpose of the redundant information being placed within each data package processed in the same group, is to provide the end data user a complete explanation of the data qualification as it applies to the individual data package. The four processing groups with the associated sample delivery groups and samples are listed below. The original OSM sample numbers are followed by the revised OSM sample numbers. The associated sample matrix is listed in brackets for information only, e.g., spring water [SW], sediment [S], and river water [RW].

Processing Group Number 1:

Original Sample Number	SDG N1-10-035-9581 Revised Sample Numbers and Sample Matrix
B01583	B06KS1 [SW], B06KS3 [S]
B01585	B06KX3 [SW], B06KX5 [S]
B015B9	B06L87 [R]

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Original Sample Number SDG N1-10-200-9563
 Revised Sample Numbers and Sample Matrix
 B015F4 None - Quality Control Sample Bottle Blank

Original Sample Number SDG N1-10-035-9561
 Revised Sample Numbers and Sample Matrix
 B015C0 B06L76 [SW], B06L80 [S]
 B015C1 B06L78 [R]

Processing Group Number 2:

Original Sample Number SDG N1-10-126-9556
 Revised Sample Numbers and Sample Matrix
 B015D0 B06KV3 [SW], B06KV7 [S]
 B015D1 B06KV5 [R]
 B015C8 B06KT9 [SW], B06KV2 [S]
 B015C9 B06KV1 [R]
 B015D2 B06KS9 [SW], B06KT3 [S]
 B015D3 B06KT1 [R]
 B015D4 B06KW8 [SW], B06KX2 [S]
 B015D5 B06KX0 [R]
 B015D8 B06KW3 [SW], B06KW7 [S]
 B015D9 B06KW5 [R]
 B015F0 B06KV8 [SW], B06KW2 [S]
 B015F1 B06KW0
 B015F2 B06KT4 [SW], B06KT8 [S]
 B015F3 B06KT6 [R]
 B015D6 B06L61 [SW], B06L65 [S]
 B015D7 B06L63 [R]

Processing group Number 3:

Original Sample Number SDG N1-09-157-9543
 Revised Sample Numbers and Sample Matrix
 B01581 B06KY1 [SW], B06L45 [S]
 B01582 B06L43 [R]
 B01587 B06L46 [SW], B06L50 [S]
 B01588 B06L48 [R]

Original Sample Number SDG N1-10-012-9544
 Revised Sample Numbers and Sample Matrix
 B01589 B06KS4 [SW], B06KS8 [S]
 B01590 B06KS6 [R]
 B01591 B06L51 [SW], B06L55 [S]
 B01592 B06L53 [R]

Original Sample Number SDG N1-09-129-9536
 Revised Sample Numbers and Sample Matrix
 B01578 B06KR8 [SW], B06KS0 [S]
 B01579 B06KR3 [SW], B06KR7 [S]
 B01580 B06KR5 [R]

Processing Group Number 4:

Original Sample Number	Revised Sample Numbers and Sample Matrix
	SDG N1-10-037-9553
B015C2	B06LK1 [SW], B06LK5 [S]
B015C3	B06LK3 [R]
B015C4	B06LB1 [SW], B06LJ9 [S]
B015C5	B06LJ5 [R]
B015C6	B06LJ3 [SW], B06LK0 [S]
B015C7	B06LJ7 [R]

Original Sample Number	Revised Sample Numbers and Sample Matrix
	SDG N1-10-036-9552
B01593	B06KX6 [SW], B06KY0 [S]
B01594	B06KX8 [R]
B01595	B06L56 [SW], B06L60 [S]
B01596	B06L58 [R]
B01597	B06L71 [SW], B06L75 [S]
B01598	B06L73 [R]
B01599	B06L66 [SW], B06L70 [S]
B01580	B06L68 [R]
B015B1	B06L96 [SW], B06LB0 [S]
B015B2	B06L98 [R]
B015B3	B06L91 [SW], B06L95 [S]
B015B4	B06L93 [R]
B015B5	B06L81 [SW], B06L89 [S]
B015B6	B06L85 [R]
B015B7	B06L83 [SW], B06L90 [S]

Data limitations and explanation of qualifiers for SDG N1-10-035-9561
(Processing Group Number 1)

Gross Alpha : All soil matrix samples are qualified as unusable (R) due to the laboratory control sample recovery (48%) below the $100 \pm 20\%$ acceptable limits.

Gross Beta : Water matrix samples are qualified as estimated non-detectable (UJ) for all values less than the lower limit of detection (LLD), and estimated (J) for all values greater than the LLD. This qualification is due to duplicate relative percent difference exceeding the acceptable limits.

Tritium : The sample identified as the bottle blank was used as the duplicate sample. The matrix of the bottle blank and the actual samples is comparable. The instrument efficiency and quench for the samples and the blank are undistinguishable and qualification of the data is not needed.

Strontium-90 : The sample identified as the bottle blank was used as the duplicate sample. Due to the similar matrix of the blank and samples, no qualification is needed.

Technetium-99 : Water matrix samples a positive value was obtained for the blank. All water matrix samples are qualified as estimated (J) that are greater than the LLD. All water matrix sample

results that are above background, but below the LLD are qualified as non-detectable (U).

NOTE: The water matrix duplicate sample (B015F4) was calculated as a soil sample with a weight of 2 grams. The raw data sheet has been copied and the correct calculation written on the copy. The revised copy has been added to the data package.

Total Uranium : No qualification needed.

Gamma Spec. : Water matrix samples, the duplicate Relative Percent Difference (RPD) for Thorium 228 exceeded limits. All water matrix samples less than the LLD are qualified as (UJ) and all water matrix samples greater than the LLD are qualified as (J).

Data limitations and explanation of qualifiers for SDG NI-09-143-9581 (Processing Group Number 1)

Gross Alpha : All soil matrix samples are qualified as unusable (R) due to the laboratory control sample recovery (48%) below the $100 \pm 20\%$ acceptability.

Gross Beta : Water matrix samples are qualified as estimated non-detectable (UJ) for all values less than the lower limit of detection (LLD), and estimated (J) for all values greater than the LLD. This qualification is due to duplicate relative percent difference exceeding the acceptable limits.

Tritium : The sample identified as the bottle blank was used as the duplicate sample. The matrix of the bottle blank and the actual samples is comparable. The instrument efficiency and quench for the samples and the blank are undistinguishable and qualification of the data is not needed.

Strontium-90 : The sample identified as the bottle blank was used as the duplicate sample. Due to the similar matrix of the blank and samples, no qualification is needed.

Technetium-99 : Water matrix samples a positive value was obtained for the blank. All water matrix samples are qualified as estimated (J) that are greater than the LLD. All water matrix sample results that are above background but below the LLD are qualified as non-detectable (U).

NOTE: The water matrix duplicate Sample B015F4 and Sample B06KX5 (B01585) were calculated as soil samples with a weight of 2 grams. The raw data sheets have been copied and the correct calculation written on the copies. The revised copies have been added to the data packages.

Total Uranium : No qualification needed.

Gamma Spec. : Water matrix samples, the duplicate Relative Percent Difference (RPD) for ²²⁸Th exceeded limits. All water

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matrix samples less than the LLD are qualified as (UJ) and all water matrix samples greater than the LLD are qualified as (J).

Data limitations and explanation of qualifiers for SDG N1-10-200-9563
(Processing Group Number 1)

Gross Alpha : All soil matrix samples are qualified as unusable (R) due to the laboratory control sample recovery (48%) below the $100 \pm 20\%$ acceptability.

Gross Beta : Water matrix samples are qualified as estimated non-detectable (UJ) for all values less than the lower limit of detection (LLD), and estimated (J) for all values greater than the LLD. This qualification is due to duplicate relative percent difference exceeding the acceptable limits.

Tritium : The sample identified as the bottle blank was used as the duplicate sample. The matrix of the bottle blank and the actual samples is comparable. The instrument efficiency and quench for the samples and the blank are undistinguishable and qualification of the data is not needed.

Strontium-90 : The sample identified as the bottle blank was used as the duplicate sample. Due to the similar matrix of the blank and samples, no qualification is needed.

Technetium-99 : Water matrix samples a positive value was obtained for the blank. All water matrix samples are qualified as estimated (J) that are greater than the LLD. All water matrix sample results that are above background but below the LLD are qualified as non-detectable (U).

NOTE: The water matrix duplicate Sample B015F4 was calculated as a soil sample with a weight of 2 grams. The raw data sheet has been copied and the correct calculation written on the copy. The revised copy has been added to the data package.

Total Uranium : No qualification needed.

Gamma Spec. : Water matrix samples, the duplicate Relative Percent Difference (RPD) for ^{228}Th exceeded limits. All water matrix samples less than the LLD are qualified as (UJ) and all water matrix samples greater than the LLD are qualified as (J).

Data limitations and explanation of qualifiers for SDG N1-10-126-9556
(Processing Group Number 2)

Gross Alpha : No qualification needed.

Gross Beta : Water matrix samples, the duplicate RPD exceeded limits. All water matrix samples less than the LLD are qualified as (UJ) and all water matrix samples greater than the LLD are

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qualified as (J). The total beta result for Sample B06KV3 (B015D0) is qualified as unusable (R). See note below.

NOTE: Sample B06KV3 (B015D0), run in this processing group as the duplicate sample for the water matrix, was noted by the laboratory as having anomalous results. The laboratory initiated a rerun analysis of this sample and confirmed the initial value obtained. OSM directed the laboratory to reanalyze the sample one more time. The results of this rerun confirmed the duplicate result originally obtained. Four total beta results have now been obtained for this sample, two total beta results that are close to background and two other results that are 838 pCi/L and 886 pCi/L. OSM directed the laboratory to investigate this anomaly and report back with an explanation. The laboratory investigated sources of possible laboratory error which included sample aliquoting and cross contamination. The laboratory was able to eliminate these possible sources by extra attention that was placed on the sample rerun analysis. Other sources of error that could be investigated are related to sample collection and labeling. The two higher values are more consistent with the concentration of ⁹⁰Sr. Acceptance of this data can be made if the highest sample result is used for final reporting. Technical judgement qualifies this data point as unusable but this should not preclude this data point from being used as information only.

Tritium : No qualification needed

NOTE: The laboratory noted that all the sample aliquots for Tritium had been acidified in the field and that neutralization at the laboratory was required before the samples could be run. The affect this could have on the data is to induce a low bias in the results. Use of this data should take this potential bias into account.

Strontium-90 : Laboratory blank result exceeded the LLD. All sample results (both matrices) less than the LLD are qualified as (U). All sample results (both matrices) less the 4.6 pCi/l or 4.6 pCi/g but greater than the LLD are qualified as (J). All sample results (both matrices) that are greater than 4.6 pCi/l or 4.6 pCi/g, are greater than 10 times the level of contamination found in the blank and do not require qualification.

Technetium-99 : No qualification needed.

NOTE: Sample B06KW3 (B015D8) (spring water) did not have the summary calculation sheet within the data package. All the information needed to derive the result was provided from other sources within the data package. No qualification of this sample needed.

NOTE: The laboratory blank run with this processing group has a gravimetric yield less than 30%. This blank result would be rejected if it were a sample. Two other blanks were also run with this processing batch with acceptable recoveries.

Total Uranium : No qualification needed.

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Gamma Spec. : The ^{228}Th result for Sample B06KV8 (B015F0) is qualified as (J) due to the 5 channel resolution for the full width half max (FWHM) being exceeded. All other sample results acceptable.

Data limitations and explanation of qualifiers for SDG N1-09-57-9543
(Processing Group Number 3)

Total Alpha : No qualification needed.

Total Beta : No qualification needed.

Tritium : Duplicate sample was not run with this processing group. Qualify all sample results (J).

Strontium-90 : The duplicate results for this processing group exceed the acceptable limits of $\pm 2\text{xLLD}$. Qualify all sample results that are less than the LLD (UJ) and all sample results greater than the LLD (J).

Technetium-99 : Blank was not run with this processing group. Qualify all sample results that are greater than the LLD (J). Sample B06LBO (B015B1) (sediment) had the ^{99}Tc recovery of 25.8%, this sample is qualified as unusable (R).

Total Uranium : No qualification needed.

Gamma Spec. : The laboratory control sample for ^{137}Cs was below the lower limit for acceptability. Qualify all ^{137}Cs results that are less than the LLD as (UJ) and all ^{137}Cs results that are greater than the LLD as (J). The ^{232}Th result for Sample B06L96 (B015B1) is qualified as (J) due to the 5 channel resolution for the FWHM being exceeded. All other sample results acceptable.

Data limitations and explanation of qualifiers for SDG N1-09-129-9536
(Processing Group Number 3)

Total Alpha : No qualification needed.

Total Beta : No qualification needed.

Tritium : Duplicate sample was not run with this processing group. Qualify all sample results (J).

Strontium-90 : The duplicate results for this processing group exceed the acceptable limits of $\pm 2\text{xLLD}$. Qualify all sample results that are less than the LLD (UJ) and all sample results greater than the LLD (J).

Technetium-99 : No requested for this sample delivery group.

Total Uranium : No qualification needed.

NOTE: The original data package reported anomalous total uranium result for Sample B06KR8 (B01578). The result reported was significantly higher than expected. OSM requested the sample(s) affected be rerun and the cause of the evident problem be investigated. The rerun results matched the results reported for total alpha. The laboratory determined the cause of the problem to be glassware contamination from a previous batch of samples prepared using the same glassware. All samples within this processing batch were rerun and reported as replacements to the existing data packages. The rerun results are accepted as the data to be used.

Gamma Spec. : The laboratory control sample for ^{137}Cs was below the lower limit for acceptability. Qualify all ^{137}Cs results that are less than the LLD as (UJ) and all ^{137}Cs results that are greater than the LLD as (J).

The duplicate run for the soil matrix exceeds the limits for RPD. Qualify all soil matrix sample results less than the LLD as (UJ) and all soil matrix results greater than the LLD (J).

Data limitations and explanation of qualifiers for SDG NI-10-012-9544
(Processing Group Number 3)

Total Alpha : No qualification needed.

Total Beta : No qualification needed.

Tritium : Duplicate sample was not run with this processing group. Qualify all sample results (J).

Strontium-90 : The duplicate results for this processing group exceed the acceptable limits of $\pm 2x\text{LLD}$. Qualify all sample results that are less than the LLD (UJ) and all sample results greater than the LLD (J).

Technetium-99 : Blank was not run with this processing group. Qualify all sample results that are greater than the LLD (J). Sample B06LB0 (B015B1) (sediment) had the ^{99}Tc recovery of 25.8%, this sample is qualified as unusable (R).

Total Uranium : No qualification needed.

NOTE: The original data package reported anomalous total uranium result for Sample B06L51 (B01591). The result reported was significantly higher than expected. OSM requested the sample(s) affected be rerun and the cause of the evident problem investigated. The rerun results matched the results reported for total alpha. The laboratory determined the cause of the problem to be glassware contamination from a previous batch of samples prepared using the same glassware. All samples within this processing batch were rerun and reported as replacements to the existing data packages. The rerun results are accepted as the data to be used.

Gamma Spec. : The laboratory control sample for ^{137}Cs was below the lower limit for acceptability. Qualify all ^{137}Cs results that are less than the LLD as (UJ) and all ^{137}Cs results that are greater than the LLD as (J).

The ^{228}Th duplicate run for the soil matrix exceeds the limits for RPD. Qualify all soil matrix sample results less than the LLD as (UJ) and all soil matrix results greater than the LLD (J).

Data limitations and explanation of qualifiers for SDG N1-10-036-9552
(Processing Group Number 4)

Total Alpha : No qualification needed.

Total Beta : No qualification needed.

Tritium : No qualification needed.

Strontium-90 : No qualification needed.

Technetium-99 : No qualification needed.

Total Uranium : No qualification needed.

Gamma Spec. : No qualification needed.

Data limitations and explanation of qualifiers for SDG N1-10-037-9553
(Processing Group Number 4)

Total Alpha : No qualification needed.

Total Beta : No qualification needed.

Tritium : No qualification needed.

Strontium-90 : No qualification needed.

Technetium-99 : No qualification needed.

Total Uranium : No qualification needed.

Gamma Spec. : No qualification needed.

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