WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Spokane River/Aquifer Interaction Project Results, May – November 1999

July 2001

Publication No. 01-03-024

printed on recycled paper

This report is available on the Department of Ecology home page on the World Wide Web at http://www.ecy.wa.gov/biblio/0103024.html

For additional copies of this publication, please contact:

Department of Ecology Publications Distributions Office
Address: PO Box 47600, Olympia WA 98504-7600
E-mail: ecypub@ecy.wa.gov
Phone: (360) 407-7472

Refer to Publication Number 01-03-024

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Spokane River/Aquifer Interaction Project Results, May – November 1999

by
Pamela B. Marti
and
Robert S. Garrigues

Environmental Assessment Program
Olympia, Washington 98504-7710

July 2001

Waterbody No. WA-57-1010

Publication No. 01-03-024
printed on recycled paper

This page is purposely blank for duplex printing

Table of Contents

List of Figures

List of Tables

This page is purposely blank for duplex printing

Abstract

The Spokane River/Aquifer Interaction Study was intended to provide baseline data of the physical and chemical influences of the Spokane River on the upper Spokane Valley aquifer. Of particular interest is the influence of dissolved metals (cadmium, lead, zinc) that have exceeded water quality criteria in the river. The study encompassed the spring high-flow period through the fall low-flow period (May – November) of 1999.

The Washington State Department of Ecology, in cooperation with Spokane County, sampled 12 monitoring wells monthly between the Washington/Idaho state line (RM 96) and Sullivan Road (RM 87). Six of the wells were part of two three-well transects that were 100-200 feet from the river at Sullivan Road and Barker Road. The remaining six wells were located throughout the Spokane Valley portion of the aquifer within ¼ mile to 1¼ mile of the river. Groundwater samples were collected for major cations, major anions, nitrate-nitrite, and select dissolved metals. Surface water data from four stations between Post Falls, Idaho (RM 100) and Sullivan Road were provided by the U.S. Geological Survey.

The primary findings of this study support previous work in which the Spokane River has been identified as losing water to the aquifer in the area of the Barker Road. Water level elevations show the groundwater table sloping away from the river at Barker Road, indicating the river is recharging groundwater at this location. Water quality data collected from the Barker well set also correlate with data collected from the Spokane River. Overall, field measurements of temperature and specific conductance, as well as cation/anion concentrations, were much lower in the river and the Barker well set than those measured within the rest of the aquifer.

Dissolved cadmium, lead, and zinc were also most prominent in the Barker well set. Cadmium and zinc concentrations decreased substantially in the Barker well, 200 feet south of the river. These decreases in concentration generally suggest that dissolved metals entering the aquifer from the river are diluted as distance from the river increases. Dissolved cadmium, lead, and zinc concentrations detected in the monitoring wells were below the Maximum Contaminant Levels for drinking water.

To further understand the complex relation between the river and aquifer, a more comprehensive analysis of water levels, river flow data, and water quality should be considered.

Acknowledgements

Many people contributed to this report and associated groundwater monitoring work. We wish to thank:

- Jim Blake, formally with the Spokane County Utilities Department, for extraordinary help with all sampling events, providing the sampling pump, and valuable expertise.
- Reanette Boese, Spokane County Utilities Department, for providing historic data and well-head elevation information.
- Mike Terris and Gordy Fisette, Spokane County Utilities Department, for providing access to well SVA-1 and assisting with the sampling at that site.
- Rod Caldwell and Keith Hein, U.S. Geological Survey, for providing data and other technical information regarding groundwater and surface water sampling.
- Jeff Walkley, Eastern Washington University graduate student, for providing part of his masters thesis work: potassium data for the Spokane River.
- Washington State Department of Ecology, Eastern Regional Office, Spokane:
  - ◊ John Roland, Toxics Cleanup Program; David Knight, Water Quality Program; and John Covert, Water Resources Program; for assisting in the design of this project.
  - ◊ John Covert, Water Resources Program, for assisting with installation, maintenance, and periodic downloads of water-level data from two of the monitoring wells.
  - ◊ Kenneth Merrill, hydrogeologist, Water Quality Program, for providing technical peer review.
  - ◊ Sandra Treccani, Toxics Cleanup Program, and Reanette Boese for assisting with field work.
- Washington State Department of Ecology, Manchester Environmental Laboratory, Port Orchard:
  - ◊ Pam Covey for helpful assistance in coordinating the sample analysis work.
- Washington State Department of Ecology, Environmental Assistance Program, Olympia:
  - ◊ Kirk Sinclair, hydrogeologist, for providing technical peer review.
  - ◊ John Summers, Dave Rogowski, and Katina Kopantais for assisting with field work.
  - ◊ Joan LeTourneau for formatting and editing the final report.

Introduction

The upper reaches of the Spokane River, from its origins at the outlet of Coeur d'Alene Lake to its confluence with the Little Spokane River, flows westward through the Spokane River valley, a lowland area about 30 miles long and three to eight miles wide (Molenaar, 1988). The Spokane Valley-Rathdrum Prairie Aquifer (Spokane Valley aquifer) lies under the Spokane River valley. Groundwater flow direction generally parallels the axis of the valley. The Spokane Valley aquifer is an exceptionally transmissive, unconfined aquifer formed in the predominately coarse sand, gravel, cobbles, and boulders deposited by the Spokane floods (Molenaar, 1988). The Spokane River loses water to the aquifer from the outlet of Coeur d'Alene Lake to the area of the Idaho/Washington state line. Further west the river alternately loses water to and gains water from the aquifer.

Because the Spokane Valley aquifer is a designated "sole source" aquifer (EPA, 1978), there is particular concern over surface water quality problems identified in the upper Spokane River that may impact groundwater quality. This includes the impairment of river water quality due to historic mining practices within the Coeur d'Alene River basin in Idaho. Elevated concentrations of cadmium, lead and zinc, which exceed water quality criteria to protect aquatic life, have been identified in the river (Pelletier, 1994).

Although it is recognized that there is much interaction between the Spokane River and the aquifer, significant data gaps exist which prevent an adequate understanding of the effect of aquifer recharge from the Spokane River on hydraulic heads and water quality of the aquifer.

Currently, the U.S. Environmental Protection Agency (EPA) is conducting an expanded remedial investigation and feasibility study of the Coeur d'Alene/Spokane Basin. The study includes an evaluation of the extent and magnitude of trace metals distributed into the environment along the Spokane/Coeur d'Alene River system. The remedial investigation work along the Spokane River includes enhanced flow gauging, river sediment analysis, and the evaluation of suspended and dissolved trace metal transport from Coeur d'Alene Lake to the mouth of the Spokane River.

Other related studies underway for the Spokane River/Aquifer include (1) the Washington State Department of Ecology (Ecology) Total Maximum Daily Load (TMDL) study for dissolved oxygen in the Spokane River, which includes quantifying the groundwater phosphate loads to the river, and (2) as part of the National Ambient Water-Quality Assessment (NAWQA) program, a U.S. Geological Survey (USGS) evaluation of river water exchange with the aquifer. Spokane County is evaluating aquifer water resources under the Washington State Watershed Planning Act. Aquifer and river interaction is a fundamental consideration of their watershed planning process.

This page is purposely blank for duplex printing

Project Description

The primary objective of the Spokane River/Aquifer Interaction Study was to provide baseline data on the physical and chemical influences, in particular the influence of dissolved metals, of the Spokane River on the upper Spokane Valley aquifer. The study encompassed the spring runoff period through the fall low-flow season (May-November) of 1999 to determine the upper aquifer response to river flow patterns. Preliminary monitoring of the aquifer was conducted to assess the influence by the river on upper-aquifer water quality.

The project study area lies between the Washington/Idaho state line (river mile 96) and Sullivan Road (RM 87). Ecology, in cooperation with Spokane County, sampled 12 monitoring wells monthly from May to November 1999. Six of the wells were part of two three-well transects that were 100-200 feet from the river at Sullivan Road and Barker Road. The remaining six wells were located throughout the Spokane Valley portion of the aquifer within ¼ mile to 1¼ mile from the river (Figure 1). Surface water data from four stations between Post Falls, Idaho (RM 100) and Sullivan Road in Washington were provided by the USGS. The USGS data are used for comparison with groundwater data for this project. Sample dates for both the groundwater and surface water projects are listed in Table 1 and are shown in more detail in Appendix A:

Table 1: Sample Dates for Groundwater and Surface Water, May – November 1999

Groundwater[1]	Spokane River, Washington[2]	Spokane River, Post Falls, Idaho[2]
May 19-21	May 13	May 11 (metals) May 19 (cations/anions)[3]
June 16-17	June 17	June 7 (metals) June 23 (cations/anions)[3]
July 13-14 & 22	July 15	July 12 (metals) July 27(cations/anions)[3]
August 16-17	August 9 & 11	August 9 (metals only)
September 13-14	September 9	September 7 (metals, cations/anions[3])
October 12-13	---	---
November 16-17	---	---

[1] Samples collected by Ecology and Spokane County.
[2] Samples collected by USGS.
[3] Cations (calcium, magnesium, sodium)/anions (alkalinity, chloride, sulfate).

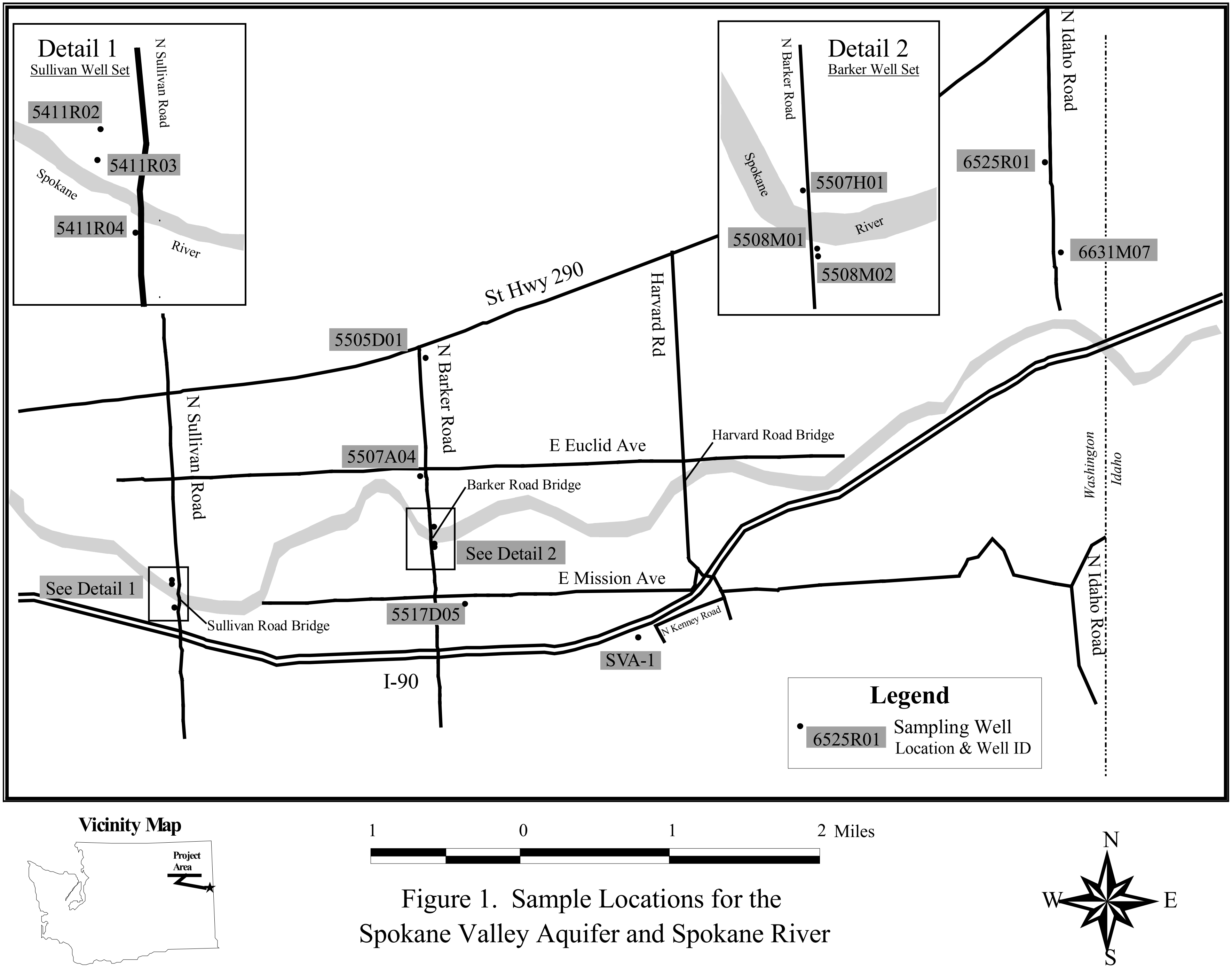


Figure 1. Sample Locations for the Spokane Valley Aquifer and Spokane River

Methods

Twelve monitoring wells and four surface water stations were sampled during this project. Ecology, in cooperation with Spokane County, sampled the wells monthly from May to November 1999. The USGS sampled four surface water stations along the Spokane River monthly for most of the analytes. Sample site details are shown in Tables 2 and 3. Sampling site areal distribution is shown on Figure 1. Latitude/longitude and elevation, as well as other location information for each monitoring well, is included as Appendix B.

Groundwater Stations

In the fall of 1998, Spokane County installed two networks of three monitoring wells each: one near Sullivan Road and the other near Barker Road, east of Spokane (Figure 1, Details 1 and 2). These wells were specifically placed to provide data for addressing river/aquifer interaction questions. The other six monitoring wells were selected based on availability of previously installed monitoring wells.

Table 2: Well Descriptions, Spokane Valley Aquifer, May - November 1999

Station ID	Station Name	Screened Interval (ft below LSD[1])	Ground Surface Elevation[2] (ft) MSL[3]	Top of Casing (ft) MSL	Approximate Distance from River
Sullivan Well Set					
5411R02	Sullivan Rd, 200' N	26.2 – 66.2	1967.2	1968.4	200 ft N
5411R03	Sullivan Rd, 100' N	27.3 – 67.3	1965.9	1967.2	100 ft N
5411R04	Sullivan Rd, 100' S	47.8 – 87.8	1987.4	1989.9	100 ft S
Barker Well Set					
5507H01	Barker Rd, 100' N	39.5 – 79.5	2001.5	2001.1	100 ft N
5508M01	Barker Rd, 100' S	64.1 - 97	2017.5	2019.7	100 ft S
5508M02	Barker Rd, 200' S	63.3 – 98.5	2018.0	2019.6	200 ft S
5517D05	CID #4, Mission & Barker Rd	85.2 – 115.2	2035.6	2037.8	½ mi S
5507A04	CID #5, Barker Rd & Euclid	69.5 – 99.5	2021.7	2023.5	¼ mi N
5505D01	Trent & Barker Rd	87 – 127	2045.2	2047.5	1 mi N
6525R01	Idaho Rd & Pipeline	97 – 142	2080.3	2082.4	1¼ mi N
6631M07	CID #11, Idaho Rd – East Farms	112 – 147	2090.2	2091.9	½ mi N
SVA-1	SVA-1 @ Green Acres Landfill	114 – 124	2050.0	2052.0	¾ mi S

1 LSD: Land Surface Datum
2 NGVD29: Elevation measured from National Geodetic Vertical Datum of 1929
3 MSL: Mean Sea Level

Groundwater Water Level Surveys and Sampling

All wells except SVA-1 (Green Acres Landfill) were purged and sampled using a Grundfos Redi-Flo2 portable submersible pump. The Grundfos pump was rinsed between wells with deionized water. Well SVA-1 has a dedicated bladder pump which was used for sampling at this site.

Prior to well purging and sampling, water levels were measured using an electric sounding tape. Water levels and temperature were also measured and recorded at one-hour intervals using pressure transducers and data loggers in all 12 wells. All wells were purged at a rate of 2-to-3 gpm. Wells were purged until a minimum of three well-volumes had been removed from the casing and until specific conductance, dissolved oxygen (DO), and water temperature stabilized (changes of 10% or less of the mean value of three consecutive measurements). Field measurements were also collected for pH.

Sampling methods described in EPA Method 1669 sampling guidance (EPA, 1995) were applied for the collection of groundwater trace metals. All samples were collected from a "T" placed at the pump outlet. Dissolved samples were filtered in the field through a pre-cleaned 0.45 µm Nalgene filter unit (#450-0045, type S). All metals samples were preserved in the field by acidification with nitric acid to pH≤2. Nitrate-nitrite samples were preserved using sulfuric acid to a pH≤2. Sample bottles from each well were packed in a plastic bag and held on ice for shipping to the Ecology/EPA Manchester Environmental Laboratory (MEL).

Chain-of-custody procedures were followed in accordance with MEL (1994). Sampling procedures are discussed in more detail in Appendix C.

Surface Water Stations and Sampling

The USGS collected river-stage, flow data, and water samples from fixed sites along the Spokane River, approximately monthly during the project interval. Three of the four surface water stations were located within the project area at Harvard, Barker, and Sullivan Road bridges. Although it is outside the project area, the USGS Post Falls station in Idaho has been included in the data analysis because of the expanded analytical work conducted at this station. Sample stations along the Spokane River are listed in Table 3 and shown on Figure 1.

Table 3: Surface Water Stations, Spokane River, May - September 1999

Station ID	Station Name	River Mile	Reference Elevation (ft) MSL
12419000	Post Falls Dam	100.0	---
12419500	Harvard Road Bridge	92.5	---
12420500	Barker Road Bridge	90.3	1973.74[1]
12420800	Sullivan Road Bridge	87.7	1900.00[1]

[1] Elevation of wire gage.

Surface water samples collected and analyzed for the major cations/anions, as well as select metals (cadmium, lead, zinc), were of most interest to this project. Potassium was not included in the USGS cation analyses for the surface water stations in Washington.

There were differences between surface water and groundwater sample processing; therefore, not all data are directly comparable. Major cation (calcium, magnesium, sodium) samples for surface water were filtered and acidified with nitric acid, while major anion (alkalinity, chloride, sulfate) and nutrient samples were filtered and chilled. This differs from the groundwater samples where the anion and nutrient samples were not filtered. Data collected by the different sampling procedures should be comparable for most purposes. This is discussed further under data quality objectives in Appendix D.

Potassium was not analyzed for as part of the USGS river sampling program. Potassium data used in this report for the Washington surface water samples were provided by Walkley (2001). These samples were collected in the fall of 1998 and spring of 1999.

This page is purposely blank for duplex printing

Data Analysis

Analytes, analytical methods, and detection limits for groundwater samples are listed in Table 4 for both field and laboratory parameters.

Table 4: Analytical Methods for Groundwater Samples, May - November 1999

Analytes	Method	Detection Limit
Field		
Water Level	Slope Indicator Well Probe	0.01 feet
pH	Orion 25A Field Meter[1]	± 0.1 Standard Units
Temperature	YSI T-L-C 3000 Meter[1]	± 0.1° C
Specific Conductance	YSI T-L-C 3000 Meter[1]	± 2% of reading, in umhos/cm
Dissolved Oxygen (DO)	YSI Model 57	± 0.2 mg/L
Turbidity	HF Scientific DRT 15C	± 0.1 NTU
Laboratory		
Alkalinity	EPA 310.1	1 mg/L
Chloride	EPA 300.0	0.1 mg/L
Nitrate + Nitrite	EPA 353.2	0.01 mg/L
TDS	EPA 160.1	1 mg/L
Sulfate	EPA 300.0	0.5 mg/L
Calcium	ICAP[2] (EPA 200.7)	25 ug/L
Potassium	ICAP[2] (EPA 200.7)	400 ug/L
Magnesium	ICAP[2] (EPA 200.7)	25 ug/L
Sodium	ICAP[2] (EPA 200.7)	25 ug/L
Silica	ICAP[2] (EPA 200.7)	20 ug/L
Iron	ICAP[2] (EPA 200.7)	20 ug/L
Cadmium	ICP/MS[3] (EPA 200.8)	0.02 ug/L
Lead	ICP/MS[3] (EPA 200.8)	0.02 ug/L
Zinc	ICP/MS[3] (EPA 200.8)	0.5 ug/L

[1] Operated in accordance with operators manual or WAS (1993).
[2] Inductively Coupled Argon Plasma method (MEL, 2000).
[3] Inductively Coupled Plasma Mass Spectrometry method (MEL, 2000).

Analyses for groundwater samples were conducted at the Ecology/EPA Manchester Laboratory (MEL). The qualitative and quantitative accuracy, validity, and usefulness of data were reviewed by MEL staff. All data are considered usable with the following exception: zinc was not detected as frequently after August. This may be due to instrumentation problems at the laboratory which is indicated by the use of a higher detection limit.

Laboratory quality control (QC) followed standard MEL guidelines and included procedural blanks, duplicate matrix spikes, and laboratory control samples. All procedural blanks associated with these samples showed no significant analytical levels of the requested analytes. All duplicate matrix spike recoveries met the acceptance criteria of ±25%. Precision estimates based on duplicate spikes were within the acceptance criteria for duplicate analysis of ±20%. All laboratory control samples were within the acceptance criteria for the individual analytes. Laboratory reporting sheets are available upon request.

In addition to laboratory QC samples, field quality assurance (QA) samples consisted of duplicate samples during each sample event, and filter blanks. A duplicate sample consisted of blind field duplicate samples, which were obtained from wells 5507H01 (May and June), 6525R01 (July), 5508M02 (August and September), and 5508M01 (October and November). The numeric comparison of duplicate results is expressed as the relative percent difference (RPD). The data indicate that overall precision of the data set was excellent, with an RPD within 5% for May, June, and July. Precision decreased slightly for the remainder of the study period (August through November) with a RPD within 15%. There were a few exceptions in which RPDs were especially high, but these occurred infrequently throughout the data set. Most parameters analyzed for in the filter blanks were not detected. Zinc is the only analyte detected in one of the filter blanks at a concentration of 0.6 ug/L; this is far below any of the reported values in the samples.

Results

For discussion purposes, project data have been divided into field observations and analytical results. Field observations include water level data and field parameters measured during sampling. Analytical results have been divided into major cations and anions, nutrients, and metals.

Field Observations

Water Levels

Table 5 lists static water levels measured prior to well purging for each monitoring well.

Table 5: Static Water Levels[1] (feet), Spokane Valley Aquifer, May - November 1999

Monitoring Well	Ground Surface Elevation (ft) MSL	Measuring Point Height (ft)	May	June	July	August	Sept	Oct	Nov	Water Table Fluctuation[2] (ft)
Sullivan Well Set										
5411R02	1967.2	1.15	25.99	25.4	31.23	34.37	35.45	34.37	33.73	10.05
5411R03	1965.9	1.30	25.12	24.49	30.39	33.69	34.72	33.64	32.95	10.23
5411R04	1987.4	2.46	47.35	46.64	52	54.96	56.13	55.15	54.67	9.49
Barker Well Set										
5507H01	2001.5	-0.45	42.82	41.71	46.08	48.95	50.35	49.47	49.52	8.64
5508M01	2017.5	2.17	61.37	60.31	64.64	---	69.09	68.11	68.11	8.78
5508M02	2018.0	1.58	62.23	61.12	65.46	68.45	69.86	68.92	68.94	8.74
5517D05	2035.6	2.15	78.95	77.85	82.15	85.09	86.54	85.59	85.63	8.69
5507A04	2021.7	1.79	64.48	63.46	67.63	70.55	71.97	71.05	71.1	8.51
5505D01	2045.2	2.34	87.52	86.44	90.48	93.33	94.69	93.83	93.93	8.25
6525R01	2080.3	2.10	99.15	98.31	100.87	102.97	104	103.65	104.1	5.79
6631M07	2090.2	1.70	110.1	109.29	112	114.15	115.22	114.8	115.23	5.94
SVA-1	2050.0	2.0	92.78	91.8	---	99	100.24	99.35	99.72	8.44

[1] As measured from top of the PVC casing.
[2] Difference between the lowest and highest water level measurement.

Completion depths for the 12 monitoring wells used for this study ranged from approximately 66 to 147 feet below ground surface, with screen lengths of 30 to 45 feet (Table 2). Water levels in the wells ranged from 24.49 to 115.23 feet below the measuring point (bmp). Water levels along Idaho Road (the eastern edge of the study area) ranged from 98.31 to 115.23 feet bmp, decreasing to a range of 24.49 to 56.13 feet bmp in the three wells adjacent to the river at Sullivan Road (the western edge of the study area). The water table fluctuated from approximately six feet at the eastern edge of the study area to approximately ten feet at the western edge of the study area. The highest water levels occurred in June for all the wells, while the lowest water levels occurred in September for most of the wells, with the exception of the two wells along Idaho Road which occurred in November, the last month of this study.

Table 6 lists river flows for the Spokane River at the time that the USGS collected their surface water samples.

Table 6: Spokane River Flows (cfs), May - September 1999

Station ID	May	June	July	August	September
Post Falls	13,800	12,500	1,850	---	807
Harvard	14,600	14,800	3,700	1,740	633
Barker	14,500	14,800	4,000	1,820	444
Sullivan	15,000	14,800	4,300	1,900	444

Table 7 and Figure 2 shows water level elevations for the two well sets at Sullivan and Barker Roads, as well as for the Spokane River in May and September 1999. Elevations represent high (May) and low (September) flow periods in the river.

Table 7: Water Level Elevations for Sullivan and Barker Road Well Sets and Spokane River Stage, May and September 1999

Station ID	Ground Surface Elevation (ft) MSL	May Water Level Elevation (MSL)	September Water Level Elevation (MSL)
5411R02	1967.2	1943.03	1932.34
5411R03	1965.9	1942.88	1931.8
5411R04	1987.4	1943.13	1933.31
Spokane R @ Sullivan Rd Br	---	1943.08	1930.5
5507H01	2001.5	1958.65	1950.61
5508M01	2017.5	1958.62	1950.5
5508M02	2018.0	1958.43	1950.47
Spokane R @ Barker Rd Br	---	1983.55	1977.3

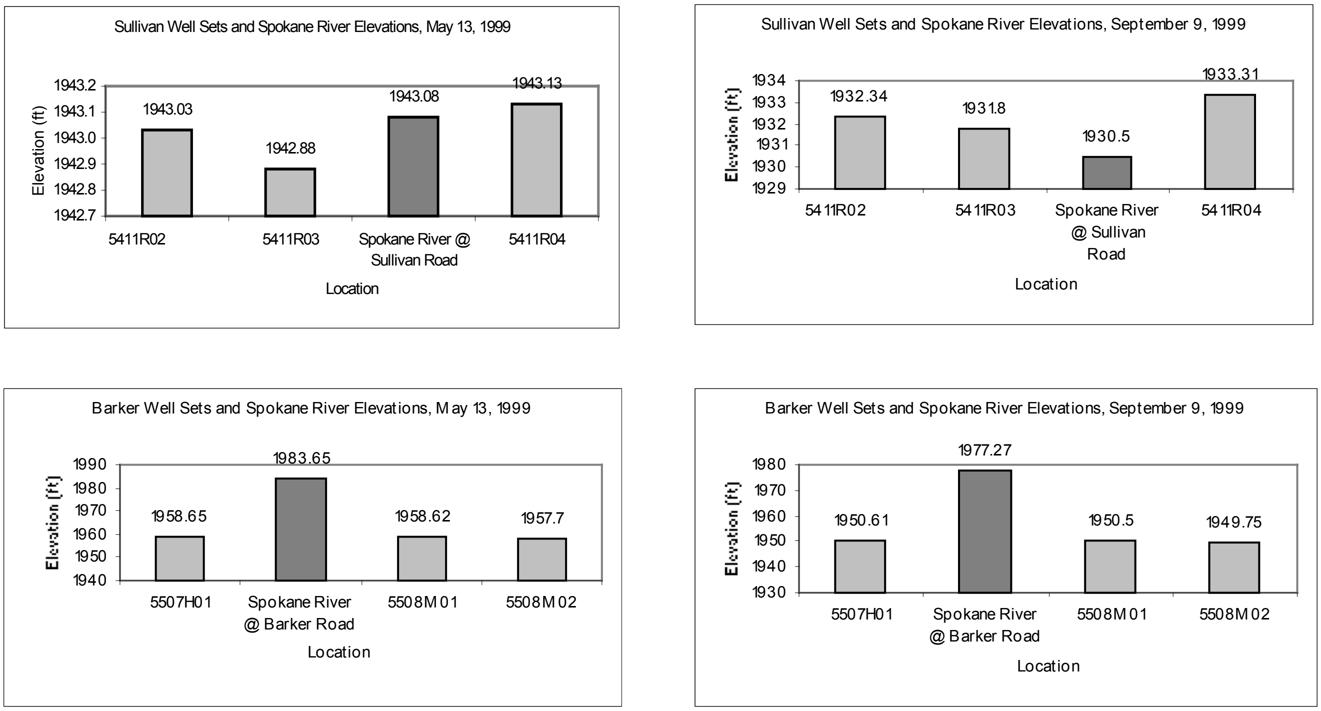


Figure 2: Water Level Elevations for Sullivan and Barker Well Sets and Spokane River, May and September 1999

In May during the river's high flow, the water table elevation in the two near-river wells north of the Spokane River at Sullivan Road (5411R02, 5411R03) have slightly lower elevations (less than one-foot) than the river. In September during the river's low flow, water level elevations indicate that the Spokane River gains water from the aquifer at Sullivan Road. Water level elevations for the Barker well set were evaluated from May through September; all results are presented in Appendix E. A large difference in water level elevations between the river and the three Barker Road wells indicate that this stretch of the river is losing water to the aquifer. On average an elevation difference of 26 feet between the river and the water table surface was maintained over the five-month period, May to September, with the groundwater table sloping away from the river. This supports previous work that had already interpreted this area as a losing reach of the river (Bolke and Vaccaro, 1979).

A more recent aquifer/river interaction study was conducted between December 1998 and July 1999 (Gearhart, 2000). Groundwater and river stage elevations were collected weekly over the study period. Because of the large elevation difference between the river and monitoring well, groundwater elevations from the state line to Barker Road, Gearhart interpreted the recharge zone between the river bottom and water table as unsaturated. At Sullivan Road, Gearhart also found water level elevation differences between groundwater and the river to be generally within one foot from December 1998 to July 1999. However, the relationship between groundwater and river elevations varied depending on flow at the time. Gearhart defined the stretch of river between Barker Road and Sullivan Road as a transitional reach between the unsaturated conditions upstream and saturated flow downstream.

Field Parameters

Table 8 lists field parameters measured prior to sampling for each monitoring well, including temperature, pH, specific conductance, turbidity, and dissolved oxygen. For comparison, surface water field parameters measured by the USGS have also been included. All field data are presented in Appendices F2 through F6.

Table 8: Summary of Field Parameter Results for Spokane Valley Aquifer and River, May - November 1999

Station ID	Temperature (°C) (range)	Difference	pH (s.u.) (range)	Mean	Specific Conductance (umhos/cm) (range)	Mean	Turbidity (NTU) (range)	Dissolved Oxygen (mg/L) (range)
Sullivan Well Set								
5411R02	10.5-12.2	1.7	7.4-7.9	7.7	199-275	251	0.4-9	6.4-8.1
5411R03	10.5-12.2	1.7	7.3-7.9	7.8	206-278	257	0.06-6	5.9-7.8
5411R04	10.6-12.4	1.8	7.8-8.1	7.9	213-276	242	1.5-4.3	6.8-9.4
Barker Well Set								
5507H01	8.0-21.2	13.2	6.4-7.3	6.7	50-74	56	0.7-6	3.1-8.1
5508M01	6.9-18.6	11.7	6.5-7.5	6.8	46-58	51	0.4-3	1.9-8.3
5508M02	7.3-17.8	10.5	6.6-7.4	6.9	49-57	53	0.8-47	2-9.4
5517D05	12.1-14.3	2.2	6.9-7.7	7.4	112-136	126	0.3-11	6.0-8.3
5507A04	9.8-11.2	1.4	7.4-7.7	7.6	341-370	351	0.2-21	7.8-9.9
5505D01	10.8-12.2	1.4	7.5-8.1	7.8	351-374	363	2-9.7	6.8-8.8
6525R01	10-11.3	1.3	7.7-8.1	7.9	299-311	304	2.9-8.3	7.1-9.4
6631M07	12.7-14.1	1.4	7.6-8.1	7.9	277-290	285	1.1-7	5.7-7.5
SVA-1	10.2-11.7	1.5	7.6-8.0	7.8	258-305	272	-0.1-0.15	7.2-8.4
Spokane River								
Post Falls	8.4-19.6	11.2	7.0-7.6	7.2	41-53	46	---	---
Harvard	7.9-22.5	14.6	7.7-8.3	7.9	45-50	47	---	---
Barker	7.8-22.0	14.2	7.7-8.2	7.8	44-52	48	---	---
Sullivan	7.8-23.6	15.8	7.7-8.1	7.9	45-119	63	---	---

Groundwater temperatures for the majority of the monitoring wells ranged from 9.8ºC to 14.4ºC, with a fluctuation of 1.3 to 2.2ºC over the monitoring period. Groundwater temperatures for the three wells adjacent to the river at Barker Road varied more, with a low of 6.9ºC to a high of 21.2ºC. Temperatures fluctuated 10.5 to 13.2ºC. This correlates with Spokane River temperatures measured from the Barker Road bridge which ranged from 7.8 to 22.0ºC, with a temperature fluctuation of 14.2ºC (Figure 3). The large fluctuations in temperature in the three Barker Road wells (5507H01, 5508M01, 5508M02) indicate that river is recharging this area of the aquifer.

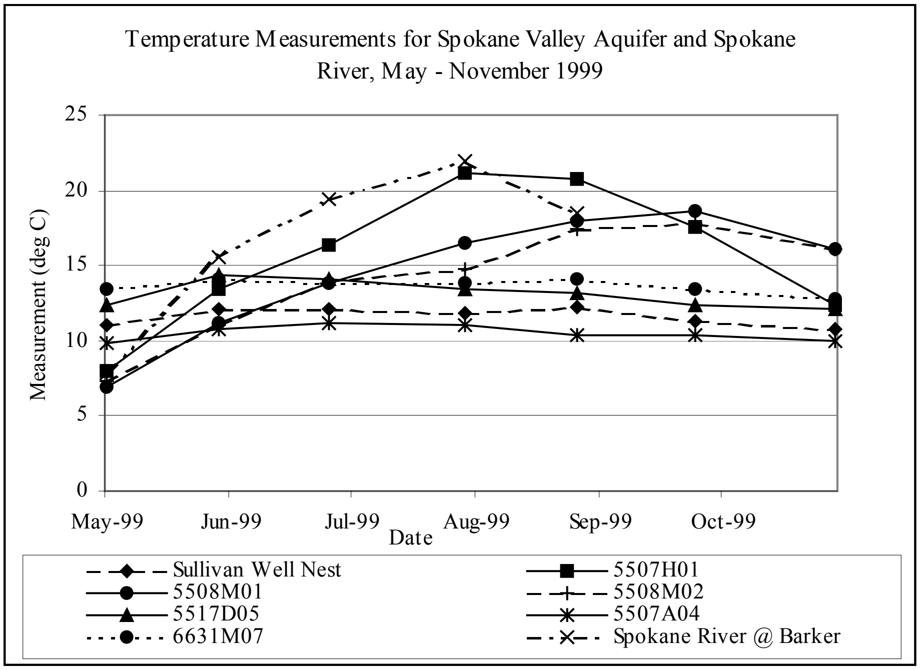


Figure 3: Temperature Measurements (°C) for Spokane Valley Aquifer and Spokane River

The pH of groundwater in the majority of the monitoring wells had an average range of 7.4 to 7.9. Average pH measurements from the three Barker Road wells were lower, ranging from 6.7 to 6.9. Average pH measurements for the Spokane River ranged from 7.2 to 7.9.

Specific conductance measurements for all of the monitoring wells had a mean range of 51 to 363 umhos/cm as shown in Figure 4. Well 5517D05, south of the Spokane River, had an average specific conductance of 126 umhos/cm. Mean specific conductance measurements for the two well sets at Sullivan and Barker Roads were 250 and 53 umhos/cm, respectively. In general, specific conductance readings for wells along Barker Road increased with distance from the river, with a low of 51 umhos/cm next to the river to a high of 363 umhos/cm at the northern edge of the aquifer. Average specific conductance readings for the river ranged from 46 umhos/cm at Post Falls to 63 umhos/cm at Sullivan Road. As with groundwater temperature,

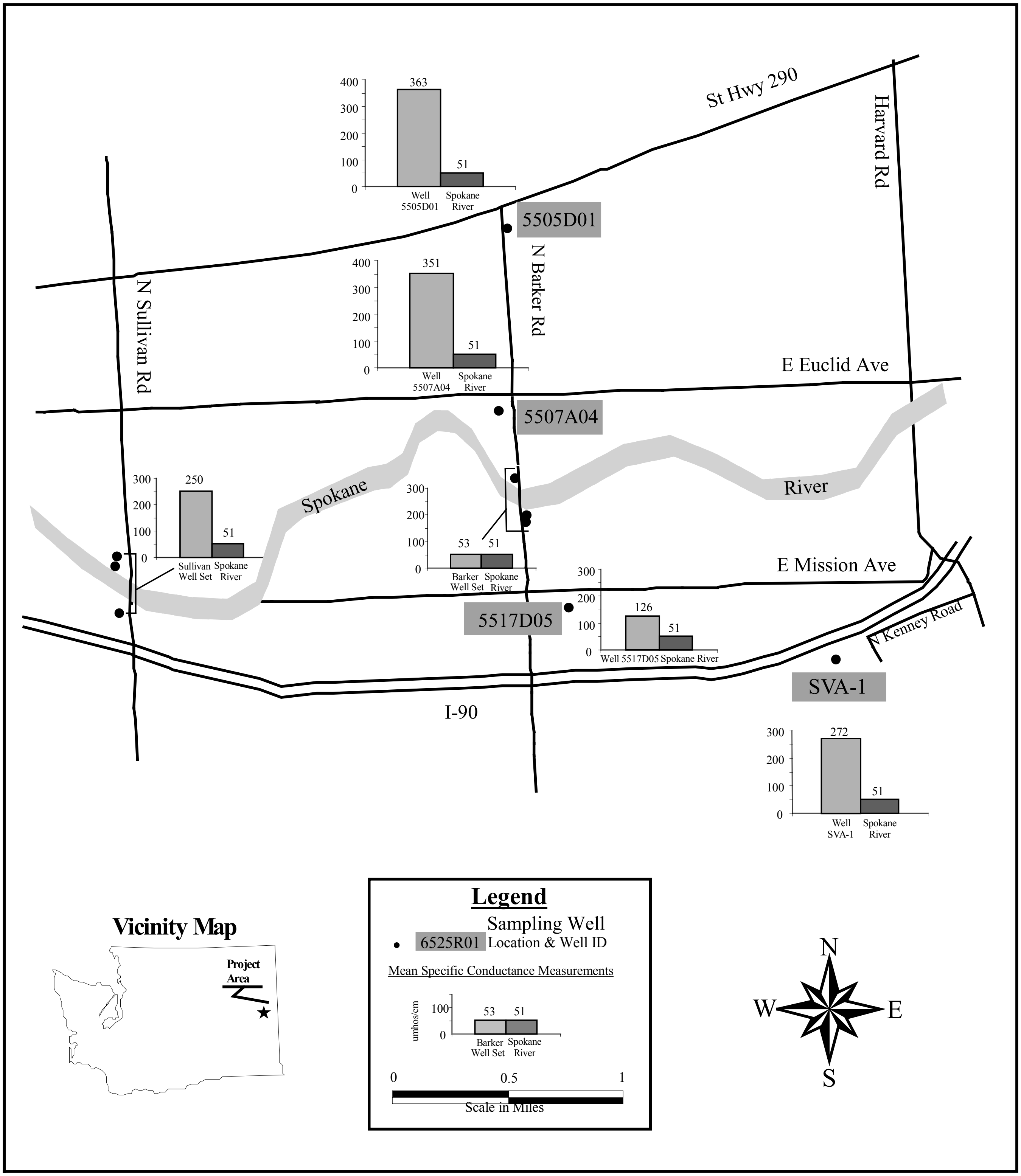


Figure 4. Mean Specific Conductance Measurements (umhos/cm) for the Spokane Valley Aquifer and Spokane River

specific conductance measurements at the three Barker Road wells adjacent to the river indicate that the river is recharging the aquifer in this portion of the study area.

Turbidity measurements at the time of sampling ranged from -0.1 to 47 NTUs. Half of the wells consistently started with high turbidity readings, which usually decreased quickly during the purge cycle. High turbidity could be the result of disturbance to the water column during pump placement.

Dissolved oxygen (DO) measurements for the majority of the wells ranged from 5.7 to 9.9 mg/L. The range of DO measurements for the Barker Road wells was larger, from 1.9 to 9.4 mg/L. For most of the wells, higher DO levels occurred in May during the river's high flows, and lower DO levels occurred in August and September during the river's low flows. Sullivan wells 5411R02 and 5411R03, which are within 200 feet north of the river, had lower DO measurements in May, during high flows.

Analytical Results

Major Cations/Anions and Total Dissolved Solids

A summary of the major cations and anions in the Spokane Valley aquifer and river is presented in Table 9. Results presented in the table are average values for data collected over the study period. Mean concentrations in groundwater have been divided into the following subsets: wells away from the river, well 5517D05 which is approximately ½ mile south of the river, and the two well sets adjacent to the river at Sullivan and Barker Roads. The complete data set of the cations, anions, and total dissolved solids are presented in Appendix F. In addition, graphs showing concentrations for all major cations and anions are also presented in Appendix G.

Table 9: Summary of Mean Cation/Anion and Total Dissolved Solid Results (mg/L) for Spokane Valley Aquifer and River, May - November 1999

Station ID	Calcium	Magnesium	Potassium	Sodium	Chloride	Sulfate	Total Alkalinity	TDS
Sullivan Well Set								
5411R02	29.63	13.6	1.84	2.95	1.55	12.65	119	150
5411R03	30.19	13.93	1.81	2.9	1.51	12.8	122	150
5411R04	28.83	12.66	1.76	2.67	1.56	12.17	114	147
Barker Well Set								
5507H01	5.99	1.77	1.03	1.84	1.0	4.05	23	43
5508M01	5.53	1.59	1.06	1.71	0.87	4.17	21	41
5508M02	5.81	1.63	0.92	1.76	0.89	4.11	21	45
5517D05	14.9	5.38	1.5	2.01	1.26	6.4	56	78
5507A04	41.76	18.27	2.19	2.98	1.57	16.63	171	206
5505D01	48.39	14.2	2.5	6.05	4.14	11.81	171	216
6525R01	33.89	17.99	2.17	3.02	1.24	15.56	146	178
6631M07	33.0	15.34	2.37	2.82	2.49	12.53	132	170
SVA-1	40.1	8.46	1.97	4.32	2.14	8.03	132	167
Spokane River								
Post Falls	5.5	1.7	0.8	1.9	0.7[2]	2.5[2]	17.4[3]	--
Harvard	4.8	1.4	---	1.6	1.1[2]	3.5[2]	18[3]	--
Barker	4.9	1.4	0.64[1]	1.6	0.9[2]	3.5[2]	18.2[3]	--
Sullivan	6.5	2.2	0.66[1]	1.6	0.95[2]	4.5[2]	24.6[3]	--

[1] Data collected by Walkley (2001) between September 1998 and June 1999.

[2] Results from filtered samples.

[3] Results from filtered samples and titrated in the field.

Sources: Ecology for all groundwater data; USGS for surface water data except potassium which is from Walkley (2001). Ecology groundwater data were collected in 1999; USGS data were collected in 1999; Walkley data were collected 1998-1999.

Calcium is the primary cation in groundwater. The mean calcium concentration in groundwater for the aquifer was 39.4 mg/L for wells away from the river. Well 5517D05 had a much lower mean calcium concentration of 14.9 mg/L. Mean calcium concentrations for the two well sets at Sullivan and Barker Roads were 29.6 and 5.8 mg/L, respectively. Figure 5 shows calcium concentrations for most of the wells and the Spokane River over the monitoring period. All calcium data are presented as Appendix F7.

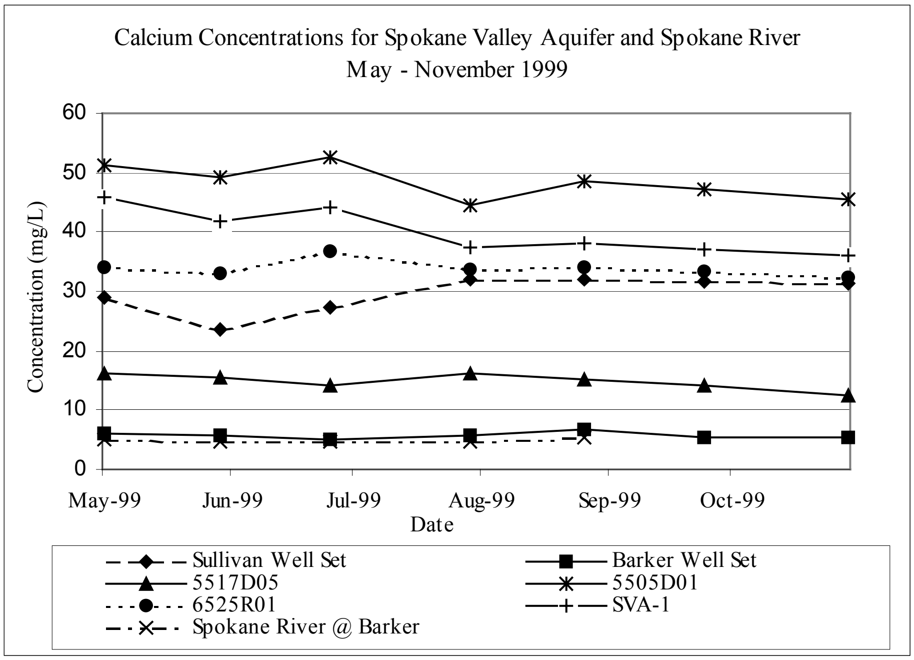


Figure 5: Calcium Concentrations (mg/L) for Spokane Valley Aquifer and Spokane River

The remaining cation total is mostly accounted for by magnesium with a mean concentration of 14.9 mg/L. As with calcium, the magnesium concentration in well 5517D05 was much lower, with a mean concentration of 5.4mg/L. Mean magnesium concentrations for the Sullivan and Barker well sets were 13.4 and 1.7 mg/L, respectively. All magnesium data are presented in a table and a graph as Appendices F8 and G3, respectively.

Potassium and sodium concentrations were more constant among the monitoring wells, with mean concentrations of 1.8 mg/L and 2.9 mg/L, respectively. Data tables and graphs for potassium are presented as Appendices F9 and G4, and for sodium as Appendices F10 and G5.

Cation concentrations reported for the Spokane River are similar to results detected in the three Barker Road wells, with mean concentrations of 5.4 mg/L (calcium), 1.7 mg/L (magnesium), 0.7 mg/L (potassium), and 1.7 mg/L (sodium). Mean concentrations for the Barker Road wells for all the cations were 5.8 mg/L (calcium), 1.7 mg/L (magnesium), 1.0 mg/L (potassium) and 1.8 mg/L (sodium).

The major anion in groundwater is bicarbonate. The bicarbonate values presented in Table 9 were not directly measured but are estimated from the alkalinity results. Alkalinity is primarily a measure of the carbon dioxide dissolved in the water. Between a pH of 6.4 and 8.3, the dissolved carbon dioxide species is predominately bicarbonate (Hem, 1989). Samples from all of the wells had a pH greater than 6.4 (average pH values ranged from 6.7 to 7.9), indicating that bicarbonate predominates.

Groundwater bicarbonate concentrations had a mean concentration of 150 mg/L for wells ¼ to 1¼ mile away from the river. The Sullivan well set had a mean bicarbonate concentration of 118 mg/L. As with the cations, bicarbonate concentrations in well 5517D05 and the three Barker Road wells were much lower, with mean concentrations of 56 and 22 mg/L, respectively. Figure 6 shows total alkalinity concentrations for most of the wells and the Spokane River over the monitoring period. All alkalinity data are presented as Appendix F11.

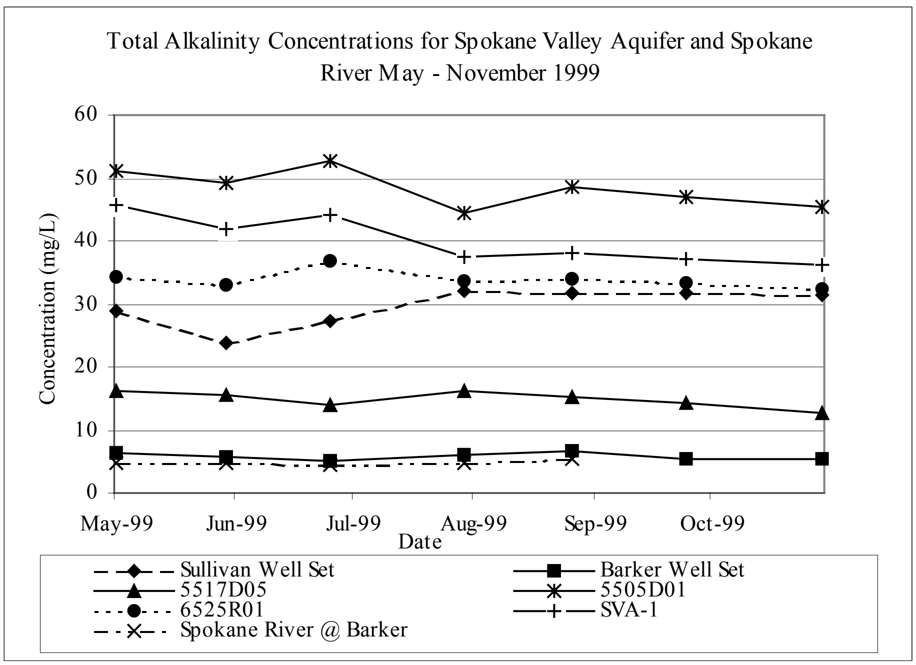


Figure 6: Total Alkalinity Concentrations (mg/L) for Spokane Valley Aquifer and Spokane River

Concentrations of the other anions, chloride and sulfate were also much lower than the bicarbonate. The mean sulfate concentration in groundwater for the aquifer was 12.9 mg/L for wells away from the river. Well 5517D05 had a mean concentration of 6.4mg/L. The mean sulfate concentrations for the Sullivan and Barker well sets were 12.5 mg/L and 4.1 mg/L, respectively. Chloride concentrations were more constant with a mean concentration of 1.7 mg/L for all the wells. Data tables and graphs for chloride are presented as Appendices F12 and G6, and for sulfate as Appendices F13 and G7.

Anion concentrations reported for the Spokane River are similar to results detected in the three Barker Road wells, with mean concentrations of 20 mg/L (bicarbonate), 0.9 mg/L (chloride), and 3.5 mg/L (sulfate). The Barker Road wells had a mean concentration of 22 mg/L (bicarbonate), 0.9 mg/L (chloride) and 4.1 mg/L (sulfate).

Total dissolved solids (TDS) concentrations in groundwater ranged from a mean of 167 to 216 mg/L for wells away from the river. The Sullivan well set had a mean TDS of 149 mg/L. Well 5517D05 and the three Barker Road wells had much lower TDS concentrations, with a mean of 78 and 43 mg/L, respectively. This was expected since the total concentration of the major cation/anions normally comprise more than 90% of the TDS in water. The complete TDS data set is presented as Appendix F14.

As noted by Vaccaro and Bolke (1983), the Spokane Valley aquifer is calcium/bicarbonate dominant. As with field parameters, cation/anion concentrations in the Barker well set are much lower than concentrations measured in the rest of the aquifer, and correlate with measurements from the Spokane River. However, the relative cation/anion percentages of milli-equivalents remain constant, and calcium/bicarbonate also describes the water type of the Barker well set and the Spokane River. Although the aquifer and river are classified as the same water type, Figure 7 presents Stiff patterns that better emphasize the difference in concentrations between the various ions. Stiff patterns for the Barker well set and the Spokane River at Harvard, Barker, and Sullivan Roads illustrate the lower ion concentrations for these sample stations as compared to the rest of the aquifer, including the Sullivan well set. The Stiff patterns for the Barker well set and the Spokane River are very comparable and is further evidence that the river does influence the groundwater quality in this portion of the aquifer.

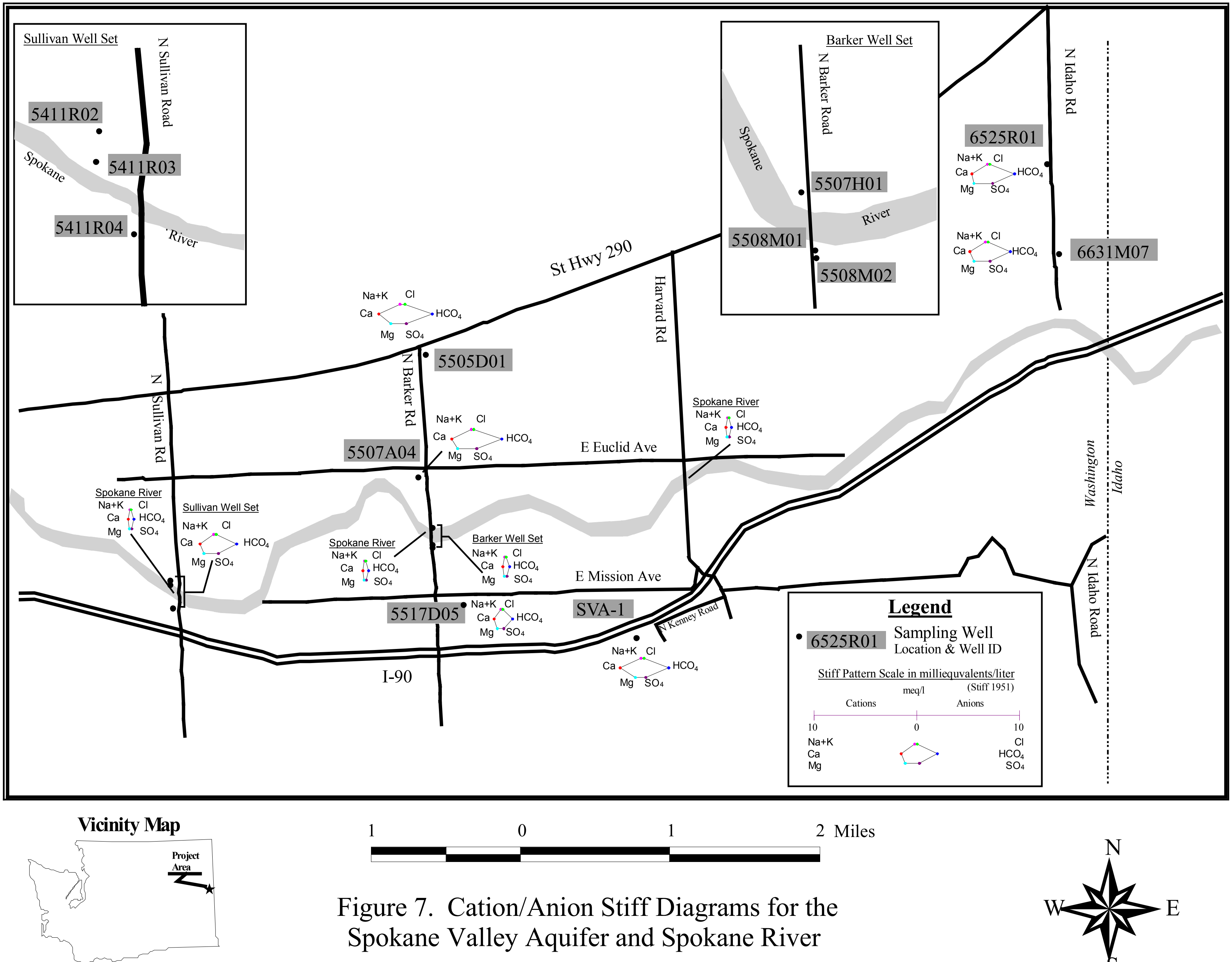


Figure 7. Cation/Anion Stiff Diagrams for the Spokane Valley Aquifer and Spokane River

Nitrogen

Water samples were analyzed for nitrogen in the form of nitrate+nitrite (NO_3+NO_2 as N). Table 10 shows a summary of average nitrate concentrations for the groundwater sample sites and the Spokane River. Complete results are included in Appendix F.

Table 10: Summary of Mean Nitrate+Nitrite Results (mg/L) for Spokane Valley Aquifer and River, May - November 1999

Monitoring Well	Nitrate-Nitrite
Sullivan Well Set	
5411R02	0.94
5411R03	0.95
5411R04	1.31
Barker Well Set	
5507H01	0.20
5508M01	0.18
5508M02	0.22
5517D05	0.66
5507A04	1.42
5505D01	2.74
6525R01	1.05
6631M07	1.77
SVA-1	1.17

Surface Water Station	Nitrate-Nitrite (Dissolved)
Post Falls	0.045
Harvard	0.041
Barker	0.042
Sullivan	0.099

Average nitrate+nitrite concentrations in groundwater ranged from 0.66 to 2.74 mg/L, with concentrations decreasing to an average of 0.20 mg/L for the three Barker Road wells. In August nitrate+nitrite concentrations increased in wells 5411R04, 5508M02, and 5517D05 (Appendix F15).

Nitrate+nitrite results for the Spokane River were an order of magnitude lower than those detected in the groundwater, with average concentrations of 0.041 to 0.099 mg/L. Samples from the Spokane River were field filtered, which is standard practice for surface water samples.

Metals

Groundwater samples were analyzed for dissolved cadmium, iron, lead, silicon, and zinc. Metal concentrations for cadmium, lead, and zinc are presented in Tables 11, 14, and 17, respectively.

Cadmium, lead, and zinc are of most interest since these metals have exceeded water quality criteria to protect aquatic life in the Spokane River. All metal results are presented in Appendix F. Metal results for the Spokane River were collected by the USGS as part of the EPA Coeur d'Alene Basin Superfund mining legacy investigation. Surface water results for cadmium, lead, and zinc are presented in Tables 12, 15 and 18, respectively.

Cadmium

Dissolved cadmium was not detected in any of the monitoring wells other than the three Barker Road wells located 100-200 feet from the river (Table 11). All cadmium data are presented as Appendix F16.

Table 11: Summary of Dissolved Cadmium Results (ug/L) for Spokane Valley Aquifer, May - November 1999

Monitoring Well	May	June	July	August	September	October	November
Barker Well Set							
5507H01	0.25	0.148	0.229	0.28	0.544	0.381	0.364
5508M01	0.232	0.209	0.203	0.22	0.25	0.247	0.2
5508M02	0.021	0.023	0.024	0.04 U	0.05	0.047	0.02 U

U = Analyte was not detected at or above the reported value.

Cadmium concentrations in groundwater ranged from the detection limit (0.02 ug/L) to 0.54 ug/L, with average concentrations in the three wells being 0.31 ug/L (5507H01), 0.22 ug/L (5508M01), and 0.03 ug/L (5508M02). A substantial decrease in cadmium concentration occurs in well 5508M02, which is 200 feet from the south bank of the river. Cadmium concentrations did not exceed the Maximum Contaminant Level (MCL) for drinking water of 5 ug/L.

As shown in Table 12, dissolved cadmium was not detected in most of the Spokane River samples in May and June, due to the high detection limit (1 ug/L).

Table 12: Summary of Dissolved Cadmium Results (ug/L) for Spokane River, May - September 1999

Station ID	May	June	July	August	September	October	November
Post Falls	<1	0.264	0.219	0.137	0.15	--	--
Harvard	<1	<1	0.18	0.15	0.081	--	--
Barker	<1	<1	0.173	<1	0.094	--	--
Sullivan	<1	<1	0.174	0.122	0.073	--	--

Dissolved cadmium was detected at Post Falls in June with a concentration of 0.264 ug/L. From July through September, cadmium concentrations in the Spokane River ranged from 0.073 to 0.219 ug/L. Average concentrations from the four stations decreased from 0.19 ug/L in July to 0.1 ug/L in September. No samples were collected in October or November.

For comparison, results collected by Ecology in 1997 (Hopkins and Johnson, 1997) have been included in Table 13. It should be noted that these samples were collected during a period of unusually high flow. River flows in 1997 are twice the volume of flows in the 1999 study, which may have resulted in increased cadmium concentrations in the river. During the spring of 1997, dissolved cadmium concentrations slightly exceeded water quality criteria to protect aquatic life in the upper portion of the river (at the state line, RM 96). A Total Maximum Daily Load (TMDL) study conducted in 1992/93 also found that dissolved cadmium concentrations exceeded water quality criteria at the state line during the high-flow season (Pelletier, 1994). Criteria for cadmium, as well as for lead and zinc, vary with hardness concentration.

Table 13: Summary of Dissolved Cadmium Results (ug/L) for Spokane River, May - September 1997

Surface Water Station	May	June	July	August	September
State line (RM 96)	0.326	0.337	0.160	0.160	0.093

Source: Ecology Ambient Monitoring Program. Metals Data for Spokane River May – September 1997

Dissolved cadmium concentrations in the Spokane River at the state line ranged from 0.09 to 0.34 ug/L in 1997 (Hopkins and Johnson, 1997) and 0.061 to 0.346 ug/L in 1992/93 (Pelletier, 1994).

Lead

As shown in Table 14, dissolved lead was primarily detected in the Sullivan and Barker Road wells, which are 100-200 feet from the river. Lead was intermittently detected at well 5517D05. Complete lead results are included as Appendix F17.

Lead concentrations in groundwater ranged from the detection limit (0.02 ug/L) to 0.97 ug/L. Barker well 5507H01, 100 feet north of the river and screened nearest the river bottom, is the only well in which lead was consistently detected with concentrations ranging from 0.023 to 0.072 ug/L. Lead concentrations did not exceed the MCL for drinking water of 15 ug/L in the 1999 samples.

As with cadmium, dissolved lead was not detected in most of the Spokane River samples in May and June (Table 15) due to the high detection limit (1 ug/L).

Table 14: Summary of Dissolved Lead Results (ug/L) for Spokane Valley Aquifer, May - November 1999

Monitoring Well	May	June	July	August	September	October	November
Sullivan Well Set							
5411R02	0.02 U	0.02 U	0.487	0.02 U	0.045	0.06 U	0.02 U
5411R03	0.02 U	0.02	0.02 U	0.02 U	0.02 U	0.06 U	0.02 U
5411R04	0.02 U	0.1	0.13	0.02 U	0.02 U	0.06 U	0.02 U
Barker Well Set							
5507H01	0.062	0.054	0.04	0.043	0.049	0.072	0.023
5508M01	0.021	0.02 U	0.02 U	0.02 U	0.02 U	0.06 U	0.02 U
5508M02	0.02 U	0.021	0.02 U	0.02 U	0.02 U	0.06 U	0.02 U
5517D05	0.023	0.02 U	0.971	0.02 U	0.02 U	0.06 U	0.02 U

U = Analyte was not detected at or above the reported value.
Underline = Detected values

Table 15: Summary of Dissolved Lead Results (ug/L) for Spokane River, May - September 1999

Station ID	May	June	July	August	September	October	November
Post Falls	<1	0.772	0.182	0.076	0.211	--	--
Harvard	<1	<1	0.197	0.14	0.188	--	--
Barker	<1	<1	0.22	<1	0.183	--	--
Sullivan	<1	<1	0.178	0.163	0.111	--	--

Dissolved lead was detected at Post Falls in June, with a concentration of 0.772 ug/L. From July through September, dissolved lead concentrations in the Spokane River ranged from 0.076 to 0.22 ug/L. Whole water recoverable lead samples were also analyzed for the same period. Results were much higher, ranging from 6.3 ug/L in June to 0.67 in September. Average concentrations from the four stations for whole water recoverable results decreased from 4.67 ug/L in May to 1.07 ug/L in September. No samples were collected in October or November.

Results collected by Ecology in 1997 have been included for comparison in Table 16. Like cadmium, lead concentrations may be elevated due to the higher flow levels in 1997. During the spring of 1997, dissolved lead concentrations measured in the Spokane River from above the state line (RM 93.5) to Riverside State Park (RM 66.2) exceeded water quality criteria (Hopkins and Johnson, 1997). Analysis of total recoverable metals was also conducted in the 1997 study from samples collected at the state line and found that most of the lead was in particulate form (Hopkins and Johnson, 1997). During the 1992/93 TMDL, dissolved lead concentrations exceeded water quality criteria from river mile 96.0 to 64.5 during the high-flow season (Pelletier, 1994).

Table 16: Summary of Dissolved Lead Results (ug/L) for Spokane River, May - September 1997

Surface Water Station	May	June	July	August	September
State line (RM 96)	2.5	1.65	0.377	0.13	0.12

Source: Ecology Ambient Monitoring Program. Metals Data for Spokane River May – September 1997.

Dissolved lead concentrations in the Spokane River in 1997 ranged from 0.12 to 2.5 ug/L (Hopkins and Johnson, 1997). Total recoverable lead concentrations in 1997 ranged from 1.0 to 9.1 ug/L. In 1992/93 dissolved lead concentrations detected at the state line ranged from 0.184 to 0.724 ug/L (Pelletier, 1994).

Zinc

As shown in Table 17, dissolved zinc was detected in all of the wells, but primarily in the Barker well set adjacent to the river. Figure 8 shows dissolved zinc concentrations for the month of May in the monitoring wells and Spokane River.

Table 17: Summary of Dissolved Zinc Results (ug/L) for Spokane Valley Aquifer, May - November 1999

Monitoring Well	May	June	July	August[1]	September[1]	October[1]	November[1]
Sullivan Well Set							
5411R02	0.4 U	0.63	1.7	1 U	1 U	1.3	1 U
5411R03	0.92	0.55	1.7	1 U	1 U	1 U	1 U
5411R04	0.4 U	0.54	1.2	1 U	2.3	1.1	1 U
Barker Well Set							
5507H01	33.9	17.1	27.2	29.4	37.9	30.3	45.8
5508M01	43.5	33.4	30.9	35.2	23.4	23.5	29.2
5508M02	7.14	5.5	5.83	5.1	6.9	6.0	3.5
5517D05	4.0	0.59	15.5	1 U	1 U	1 U	1 U
5507A04	1.3	0.82	1.1	1.9	1.6	1 U	1 U
5505D01	0.84	0.80	1.8	1 U	1 U	1 U	1 U
6525R01	1.4	0.81	1.6	1 U	1 U	1 U	1 U
6631M07	2.0	0.82	0.6	1 U	1 U	1 U	4.1
SVA-1	1.7	0.4 U	1.9 J	1.7	1.1	1 U	1 U

U = Analyte was not detected at or above the reported value.
J = Analyte was positively identified. The result is an estimate.
Underline = Detected values
[1] Change in detection limit due to instrumentation problem.

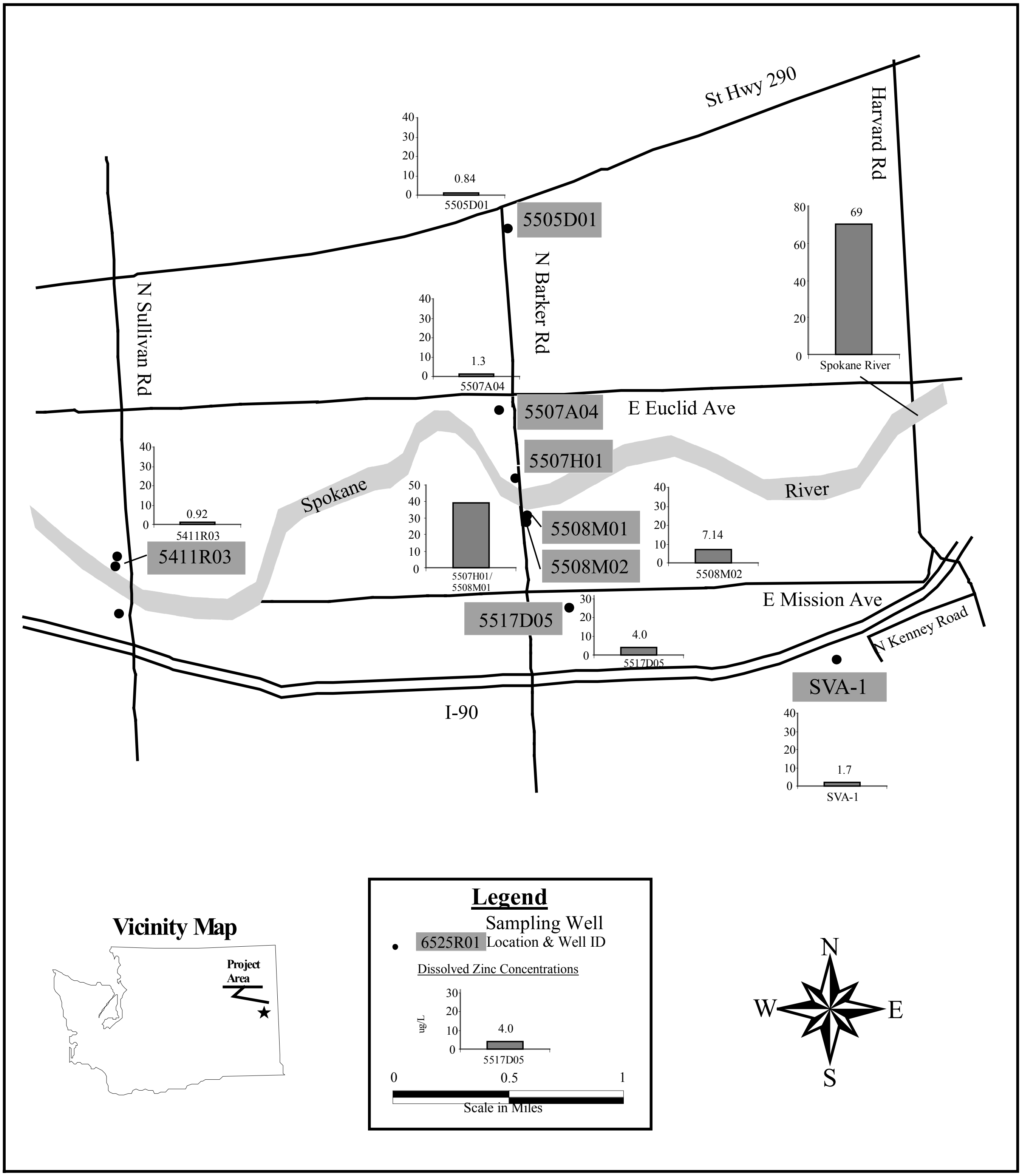


Figure 8. Dissolved Zinc Results (ug/L) for May 1999 for the Spokane Valley Aquifer and Spokane River

Zinc was detected in all of the monitoring wells, with a range in concentration of 0.54 to 45.8 ug/L. Elevated zinc concentrations occurred in the two Barker wells within 100 feet of the river, with a mean concentration of 31.5 ug/L. The zinc concentrations decreases substantially in well 5508M02, which is 200 feet south of the river, with a mean concentration of 5.7 ug/L. Mean zinc concentrations for well 5517D05 and the Sullivan well set were 2.3 and 1.2 ug/L, respectively, excluding the July detection of 15.5 ug/L. The mean zinc concentrations for the remainder of the wells was 1.4 ug/L. Zinc was not detected as frequently after August; this may be due to instrumentation problems at the laboratory which is indicated by the use of a higher detection limit. Zinc concentrations did not exceed the MCL for drinking water of 5,000 ug/L.

Dissolved zinc was detected in the USGS Spokane River samples from May through September, as shown in Table 18. The highest concentrations occurred in May, with an average concentration of 70 ug/L and gradually decreased to an average concentration of 26 ug/L in September. Surface water samples were not collected in October and November.

Table 18: Summary of Dissolved Zinc Results (ug/L) for Spokane River, May - September 1999

Station ID	May	June	July	August	September	October	November
Post Falls	71.89	61.8	44.8	37.3	31.7	--	--
Harvard	68.7	48.8	38.7	33.1	23.7	--	--
Barker	70.68	49.4	37.8	37.21	28.6	--	--
Sullivan	70.8	48.3	39.8	26.3	22.3	--	--

Whole water recoverable zinc samples were also analyzed for the same period. Results were similar to the dissolved concentrations, ranging from a high of 76 ug/L in May and decreasing to 24 ug/L in September.

For comparison, results collected by Ecology in 1997 have been included in Table 19. During the spring of 1997, dissolved zinc concentrations measured in the Spokane River from above the state line (RM 98.7) to Riverside State Park (RM 66.2) exceeded water quality criteria (Hopkins and Johnson, 1997). Analysis of total recoverable metals was also conducted in the 1997 study from samples collected at the state line, and found that most of the zinc in the river was dissolved (Hopkins and Johnson, 1997). During the 1992/93 TMDL, dissolved zinc concentrations in the river exceeded water quality criteria from river mile 96.0 to 64.5 during the high- and low-flow seasons (Pelletier, 1994).

Table 19: Summary of Dissolved Zinc Results (ug/L) for Spokane River, May - September 1997

Surface Water Station	May	June	July	August	September
State line (RM 96)	74.1	78.9	40.4	45.3	39.4

Source: Ecology Ambient Monitoring Program. Metals Data for Spokane River May – September 1997.

Dissolved zinc concentrations in the Spokane River at the state line ranged from 39.4 to 78.9 ug/L in 1997 (Hopkins and Johnson, 1997) and from 19.3 to 139 ug/L in 1992/93 (Pelletier 1994). Total recoverable zinc concentrations in 1997 ranged from 44 to 91 ug/L.

Discussion and Conclusions

The Spokane River/Aquifer Interaction Study was intended to provide baseline data of the physical and chemical influences by the Spokane River on the upper Spokane Valley aquifer. The influence of dissolved metals was of particular interest. Data indicate that the Spokane River is steadily losing water to the aquifer in the area of Barker Road. This supports previous work that had identified this area as a losing reach of river (Bolke and Vaccaro, 1979). The installation of the three shallow wells adjacent to the river at Barker Road (5507H01, 5508M01, 5508M02) provides additional data that show the influence of the river on both the groundwater gradient and groundwater quality in this portion of the aquifer. Water table measurements, field parameters, and analytical data clearly indicate that the Spokane River is losing water to the aquifer in this stretch of the river.

Water level elevations were evaluated for the Barker well set, as well as for the Spokane River, from May through September 1999 (Appendix E). A large difference in water level elevations between the river and the aquifer was maintained over the five-month period from the river's high- flow (May) to low-flow (September) seasons. On average, the elevation difference was 26 feet, with the groundwater table sloping away from the river. This corresponds to another interaction study conducted between the Washington/Idaho state line and the city of Spokane from December 1998 to July 1999 (Gearhart, 2000).

Aquifer and river interaction at Sullivan Road for May and September 1999 is more complex. In May during the river's high flow, the water table elevation in the two wells north of the river (5411R03, 5411R02) had slightly lower elevations (less than one foot) than the river. Conversely, in September during the river's low flow, water level elevations indicate that the Spokane River gains water from the aquifer in the area of Sullivan Road. Gearhart (2000) observed that river and groundwater water level elevations at Sullivan Road were generally within one foot from December 1998 to July 1999. However, the relationship between groundwater and river elevations varied depending on flow at the time. Because of this, Gearhart defined this stretch of the river as a transitional reach between unsaturated conditions upstream and saturated flow downstream.

Data collected from the river and the Barker well set also indicate that the Spokane River is losing water to, or recharging, the aquifer in this stretch of the river. Overall, field measurements of temperature and specific conductance, as well as cation/anion concentrations, were much lower in the river and the Barker well set than those measured within the rest of the aquifer. Because the stretch of river at Sullivan Road has been identified as a transitional area between a losing reach upstream and a gaining reach downstream, data collected from the Sullivan well set do not indicate the same river influence on the groundwater quality in this portion of the aquifer as seen at Barker Road.

The extent of the river's influence on groundwater quality is more difficult to define for wells that are farther away from the river. Well 5517D05, approximately ½ mile to the south of the river, consistently had field measurements, cation/anion concentrations, and other analytical concentrations between those reported for the Barker well set and the rest of the aquifer wells. These concentrations suggest that groundwater at this location may be influenced by river recharge. Well 5517D05 is a monitoring well associated with a drinking water production well; therefore, it is important to understand the relationship between this well and the river.

Of the metals analyzed, data for dissolved cadmium, lead, and zinc were of most interest since these metals have exceeded water quality criteria to protect aquatic life in the Spokane River.

- Cadmium was detected only in the three Barker Road wells, 100-200 feet from the river.
- Lead was detected in more wells, but not as consistently as cadmium and zinc. Lead was primarily detected in Barker Road well 5507H01, 100 feet north of the river.
- Zinc was detected in all wells, but primarily in the Barker Road well set.

Both cadmium and zinc concentrations decreased substantially in well 5508M02, which is 200 feet south of the river. The decrease in cadmium and zinc concentrations 200 feet from the river indicates that dissolved metals entering the aquifer from the river in this area are not migrating far beyond the river bank or are being quickly diluted by aquifer water.

Dissolved cadmium, lead, and zinc concentrations detected in the monitoring wells were far below the Maximum Contaminant Levels for drinking water of 5 ug/L, 15 ug/L and 5,000 ug/L, respectively. This study did not analyze for total recoverable metal concentrations in the monitoring wells. Previous studies (Pelletier, 1994; Hopkins and Johnson, 1997) have confirmed that dissolved concentrations of cadmium, lead, and zinc have exceeded water quality criteria for the protection of aquatic life in the Spokane River in the past.

- Dissolved cadmium concentrations exceeded the criteria at the state line during the high-flow season.
- Dissolved lead concentrations exceeded the criteria from the state line to the city of Spokane during the high-flow season. Analysis of total recoverable metals conducted in 1997 from samples collected at the state line also found that most of the lead was in particulate form.
- Dissolved zinc concentrations in the river exceeded water quality criteria from the state line to the city of Spokane during the high- and low-flow seasons. Analysis of total recoverable metals conducted in 1997 from samples collected at the state line also found that most of the zinc in the river was dissolved.

Data from this current study indicate that the Spokane River does lose water to the aquifer. Because of this, the water quality of the river does affect the groundwater quality. To further understand the complex relation between the river and aquifer, more comprehensive analyses of water levels, river flow data, and water quality should be considered. Water levels were measured and recorded at one-hour intervals from May through November 1999 throughout the project area using pressure transducers and data loggers. However, evaluating the large quantity of transducer water level data was beyond the scope of this project. As seen from the preliminary data, gaining a better understanding of the physical interaction between the river and aquifer is essential to gaining a better understanding of water quality.

Recommendations

- Groundwater levels were recorded at one-hour intervals using pressure transducers and data loggers. Evaluating the large quantity of water level data collected over the study period was beyond the scope of this project. However, these data will be important in understanding the complex relation between the river and aquifer under different flow conditions. Therefore, it is recommended that these data be evaluated in the future. The groundwater/surface water modeling program, *Analytical Solutions and Computer Programs for Hydraulic Interaction of Stream-Aquifer Systems* (Barlow, 1998), may be useful for evaluating these data.

- An accurate surveyed elevation needs to be obtained for the measuring point or staff gage at the Harvard Road bridge on the Spokane River. This elevation information would aid in the interpretation of the groundwater level information.

- Data collected for this project were intended to provide baseline information on the chemical influences of the Spokane River on the upper portion of the Spokane Valley aquifer. For future sampling, higher resolution may be achieved if samples are collected from the Spokane River at the same time that samples are collected from the monitoring wells. This is because concentrations of some analytes, such as metals, appear to be linked to river flow levels and to exceedance of surface water quality criteria. In addition, samples should be collected for dissolved and total recoverable metals, since previous data indicate that some metals are predominately found in the dissolved phase while others are predominately found in particulate form.

- The two sets of three shallow wells adjacent to the river at Sullivan and Barker Roads provided data that showed the influence of the river on both groundwater gradient and groundwater quality in that portion of the aquifer. Since these wells provided such useful data, installation of additional wells having more limited screen intervals along the river should be considered for future projects.

This page is purposely blank for duplex printing

References Cited

Barlow, P. M. and Moench, A. F., 1998, Analytical Solutions and Computer Programs for Hydraulic Interaction of Stream-Aquifer Systems: U.S. Geological Survey Open-File Report 98-415-A, 85 p.

Bolke, E. L. and Vaccaro, J. J., 1979, Selected Hydrologic Data for Spokane Valley, Spokane, Washington, 1977-78, U.S. Geological Survey Open-File Report 79-333, 98 p.

Caldwell, R., 2001, Personal communication, U.S. Geological Survey, Helena, MT.

EPA, 1978, Safe Drinking Water Act, Title 42 Section 1424e. U.S. Environmental Protection Agency, Washington, DC.

EPA, 1986, Test Methods for Evaluating Solid Waste, SW-846. Office of Emergency Response, U.S. Environmental Protection Agency, Washington, DC.

EPA, 1995, Method 1669, Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels. U.S. Environmental Protection Agency, Washington, DC, 36 p.

Gearhart. C., 2000, The Hydraulic Connection Between the Spokane River and the Spokane Aquifer: Gaining and Losing Reaches of the Spokane River from State Line to Spokane, Washington. Graduate Thesis prepared for Spokane County Water Quality Management Program as part of EPA Wellhead Protection Demonstration Project Grant No. X-000465-05.

Hem, J. D., 1989, Study and Interpretation of the Chemical Characteristics of Natural Water, Third edition, U.S. Geological Survey Water Supply Paper 2254, 263 p.

Hopkins, B. and Johnson, A., 1997, Metal Concentrations in the Spokane River During Spring 1997. Publication No. 97-e02, Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA.

Kammin, W. R., Cull, S., Knox, R., Ross, J., McIntosh, M., and Thomson, D., 1995, Labware cleaning protocols for the determination of low-level metals by ICP-MS: American Environmental Laboratory 7(9).

MEL, 2000, Laboratory Users Manual, Fifth Edition, Washington State Department of Ecology, Manchester Environmental Laboratory, Port Orchard, WA.

Molenaar, D., 1988, The Spokane Aquifer, Washington: Its Geologic Origin and Water-bearing and Water-quality Characteristics: U.S. Geological Survey Water-Supply Paper 2265, 74 p.

Pelletier, G.J., 1994, Cadmium, Copper, Mercury, Lead and Zinc in the Spokane River: Comparisons with Water Quality Standards and Recommendations for Total Maximum Daily Loads. Publication No. 94-99. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA.

Stiff, H.A., 1951, The Interpretation of Chemical Water Analysis by Means of Patterns: Journal of Petroleum Technology, v.3, no 10, October 1951, p.15-17.

Vaccaro, J. J. and Bolke, E. L., 1983, Evaluation of Water-quality Characteristics of Part of the Spokane Aquifer, Washington and Idaho: U.S. Geological Survey Water-Resources Investigations Open-File Report 82-0769, 69 p.

Walkley, J., 2001, Personal communication, Graduate-study data, Eastern Washington University, Cheney, WA.

WAS, 1993, Field Sampling and Measurement Protocols for the Watershed Assessment Section. Publication No. 97-e02, Watershed Assessment Section, Environmental Investigations and Laboratory Services Program, Washington State Department of Ecology, Olympia, WA.

Additional References

Buchanan, J., 1997, Personal communication, Eastern Washington University, Geology Department, Cheney, WA.

Covert, J., 1998, Personal communication, Water Resources Program, Eastern Regional Office, Washington State Department of Ecology, Spokane, WA.

Drost, B. W. and Seitz, H. R., 1978, Spokane Valley-Rathdrum Prairie aquifer, Washington and Idaho, U.S. Geological Survey Open-File Report 77-829, 79 p.

Ebbert, J. C., 1984, The quality of ground water in the principle aquifers of northeastern-north central Washington: U.S. Geological Survey Water-Resources Investigations Report 83-4102.

Esvelt, L. A., 1978, Spokane aquifer cause and effect report, Spokane County Engineers Office, Spokane, WA, 88 p., 2 plates.

Jensen, J. R. and Eckart, C. M., 1989, The Spokane Aquifer, *in* Engineering Geology in Washington, Vol. II: Washington Division of Geology and Earth Resources Bulletin 78, p. 975-982.

Miller, S., 1997, Personal communication, Spokane County Engineer's Office, Spokane, WA.

Roland, J., 1999, Personal communication, Toxics Cleanup Program, Eastern Regional Office, Washington State Department of Ecology, Spokane, WA.

Spokane County Engineers, 1979, Spokane Aquifer Water Quality Management Plan: Spokane County Engineers Office, Spokane, WA, 127 p., 6 plates.

Stoffel, K. L., Joseph, N. L., Zurenko-Waggoner, S., Gulick, C. W., Korosec, M. A., and Bunning, B. B., 1991, Geologic map of Washington - northeast quadrant: Washington Division of Geology and Earth Resources Geologic Map GM-39, 36 p. + 3 plates.

This page is purposely blank for duplex printing

Appendices

This page is purposely blank for duplex printing

Appendix A

Sample Dates for Spokane Valley Aquifer and Spokane River May – November 1999

This page is purposely blank for duplex printing

Table A1. Sample Dates for Groundwater and Surface Water

Station ID	May	June	July	August	September	October	November
Sullivan Well Set							
5411R02	19	16	13	16	13	12	16
5411R03	19	16	13	16	13	12	16
5411R04	19	16	13	16	13	12	16
Barker Well Set							
5507H01	20	16	14	16	13	12	16
5508M01	20	16	13	16	13	12	16
5508M02	20	16	13	16	13	12	16
5517D05	20	16	13	16	13	12	16
5507A04	21	17	13	16	14	12	16
5505D01	21	17	14	17	14	12	17
6525R01	21	17	14	17	14	13	17
6631M07	21	17	14	17	14	13	17
SVA-1	19	17	22	17	13	13	17
Spokane River							
Post Falls	11 (metals) 19 (cation/anion)	7 (metals) 23 (cation/anion)	12 (metals) 27 (cation/anion)	9 (metals)	7 (metals, cation/anion)	---	---
Harvard	13	17	15	11	9	---	---
Barker	13	17	15	11	9	---	---
Sullivan	13	17	15	9	9	---	---

This page is purposely blank for duplex printing

Appendix B

Well Locations and Elevations

This page is purposely blank for duplex printing

Table B1. Well Locations and Elevations

Station ID	Station Name	Latitude/Longitude in Deg/min/sec					
		Latitude			Longitude		
		Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
5411R02	SULLIVAN RD., 200' NORTH	47	40	27.2	117	11	53.5
5411R03	SULLIVAN RD, 100' NORTH	47	40	26.1	117	11	53.6
5411R04	SULLIVAN RD, 100' SOUTH	47	40	19.1	117	11	48
5507H01	BARKER RD, 100' NORTH	47	40	45.2	117	9	15.5
5508M01	BARKER ROAD, 100' SOUTH	47	40	38.65	117	9	13.07
5508M02	BARKER RD, 200' SOUTH	47	40	37.74	117	9	13.56
5517D05	CID #4, MISSION & BARKER RD	47	40	15.96	117	8	55.89
5507A04	CID #5, BARKER RD & EUCLID	47	41	8.6	117	9	17.8
5505D01	TRENT & BARKER RD	47	41	55.6	117	9	16.3
6525R01	IDAHO RD & PIPELINE	47	43	3.84	117	2	51.68
6631M07	CID #11, IDAHO ROAD - EAST FARMS	47	42	25.4	117	2	48.48
SVA-1	SVA-1 @ GREEN ACRES LANDFILL	47	40	2.6	117	7	8.2

Station ID	Station Name	Decimal Lat/Long		State Plane Coordinates		Surface Elevation at Well (feet above MSL)	Measuring Point Height (ft)
		Latitude	Longitude	X Coordinate	Y		
5411R02	SULLIVAN RD., 200' NORTH	47.67454	117.19813	2,813,600	870,900	1,967.2	1.15
5411R03	SULLIVAN RD, 100' NORTH	47.67386	117.19817	2,813,600	870,650	1,965.9	1.30
5411R04	SULLIVAN RD, 100' SOUTH	47.67204	117.19706	2,813,900	870,000	1,987.4	2.46
5507H01	BARKER RD, 100' NORTH	47.6793	117.15416	2,824,350	873,090	2,001.5	-0.45
5508M01	BARKER ROAD, 100' SOUTH	47.67744	117.15375	2,824,480	872,415	2,017.5	2.17
5508M02	BARKER RD, 200' SOUTH	47.67715	117.15377	2,824,480	872,310	2,018.0	1.58
5517D05	CID #4, MISSION & BARKER RD	47.67095	117.14888	2,825,780	870,100	2,035.6	2.15
5507A04	CID #5, BARKER RD & EUCLID	47.68566	117.15486	2,824,080	875,400	2,021.7	1.79
5505D01	TRENT & BARKER RD	47.69888	117.1546	2,823,940	880,220	2,045.2	2.34
6525R01	IDAHO RD & PIPELINE	47.71773	117.04769	----	----	2,080.3	2.10
6631M07	CID #11, IDAHO ROAD - EAST FARMS	47.70706	117.0468	----	----	2,090.2	1.70
SVA-1	SVA-1 @ GREEN ACRES LANDFILL	47.66711	117.1206	2,832,800	869,000	2,050.0	2.0

This page is purposely blank for duplex printing

Appendix C

Sampling Procedures

This page is purposely blank for duplex printing

Sampling Procedures

Each sampling-well site was described in the field notes and photographed.

All wells except SVA-1 (Green Acres Landfill) were purged and sampled using a Grundfos Redi-Flo2 portable submersible pump. The Grundfos pump was rinsed between wells with de-ionized water. Well SVA-1 has a dedicated bladder pump which was used for sampling at this site.

Prior to well purging and sampling, water levels were measured using an electric sounding tape. Water levels, as well as temperature, were also measured and recorded at 1-hour intervals using pressure transducers and data loggers in all 12 wells. The transducers and data loggers were supplied jointly by Spokane County, USGS and Ecology. All wells were purged at a rate of 2-to-3 gpm. Wells were purged until a minimum of three well-volumes had been removed from the casing and until specific conductance, dissolved oxygen (DO), and water temperature stabilized (changes of 10% or less of the mean value of three consecutive measurements). Field measurements were also collected for pH. During May, June and July sample events, temperature, conductivity, and DO were measured by placing the probes in the bottom of a five-gallon plastic bucket along with the outlet of the purge hose. The purge water flows around the probes, without introducing entrained air to the system. In August, September, October and November, field measurements were recorded using a Geo-Tech flow-through cell. pH was measured from a small grab bucket throughout the study.

Sampling methods described in EPA Method 1669 sampling guidance (EPA, 1995) were used as appropriate for groundwater sampling of trace metals. Samples were collected from a sampling "T" at the pump outlet. Dissolved samples were filtered in the field through a pre-cleaned 0.45 µm Nalgene filter unit (#450-0045, type S). Sample bottles, preservatives, and holding times for each parameter are listed in the following table. Teflon sample bottles and Nalgene filters were obtained from Manchester Lab. They were cleaned as described in Kammin, et al (1995), and individually sealed in plastic bags. Samples were kept on ice until analyzed by Manchester Lab.

Nitrile gloves were worn by all personnel collecting and filtering the samples. Samples were filtered, transferred to sample bottles, and preserved in the back of the sampling vehicle to minimize chances of contamination from wind-blown contaminants. After June low-level metal samples were filtered and collected in a portable sampling chamber to minimize wind-blown contaminants. Sample bottles from each well were packed in a plastic bag and held on ice for shipping to Manchester Lab. Additionally, each low-level metals sample bottle was sealed in the original, zip-lock-type, plastic bag in which the cleaned bottle was packed. The double-sealed sample was then packaged in the plastic bag with the other samples from the well and held on ice. All metals samples were preserved in the field by adding nitric acid to $\leq$pH 2. The low-level (ICP/MS) metals were preserved using high-purity nitric acid supplied by Manchester Lab in specially cleaned Teflon vials. The ICP-scan metal samples were preserved using commercially available 1 mL nitric acid (70% HNO_3) ampules.

Table C1. Sample containers, preservatives, and holding times.

Parameter	Holding Time	Bottle Index No.	Bottle type	Preservative
Alkalinity	14 days	22	500 ml w/m poly	
Chloride	28 days	22	500 ml w/m poly	On ice
Sulfate	28 days	22	500 ml w/m poly	
Nitrate + Nitrite	28 days	19	125 ml clear w/m poly, pre-preserved	H_2SO_4 to pH <2, On ice
TDS	7 days	23	1000 ml w/m poly	On ice
Calcium	6 months	16	1 L HDPE bottle	
Iron	6 months	16	1 L HDPE bottle	
Magnesium	6 months	16	1 L HDPE bottle	
Potassium	6 months	16	1 L HDPE bottle	Filter in field then HNO_3 to pH <2, store on ice
Silica	6 months	16	1 L HDPE bottle	
Sodium	6 months	16	1 L HDPE bottle	
Cadmium	6 months	S.O.[1]	500 ml teflon FEP bottle	
Lead	6 months	S.O.[1]	500 ml teflon FEP bottle	Filter in field then HNO_3 to pH <2, store on ice
Zinc	6 months	S.O.[1]	500 ml teflon FEP bottle	
Total Phosphorus (dissolved, low level)	28 days	22	New 500 ml w/m poly, pre-preserved	On ice @ 4° C
Orthophosphate, low-level	48 hours	20	125 ml amber w/m poly	Filter in field, store on ice, ship by air to lab

[1] Special order bottles

Appendix D

Data Quality Objectives

This page is purposely blank for duplex printing

Data Quality Objectives

All data quality objectives for both field and laboratory were met for this project. Laboratory data quality objectives and quality control procedures are documented in the Manchester Environmental Laboratory's *Lab Users Manual* (MEL, 2000).

Precision/Bias

Sources of bias from groundwater sampling procedures and sample handling were minimized by adhering to standard sampling procedures.

Groundwater levels were measured with an electrical tape and recorded to the nearest 0.01 feet. Because of errors in the instrument, the true accuracy of any measurement may be considered to be 0.1 feet. Relative differences between water levels over large areas are the desired result and will be adequately represented by these measurements.

In this study, the intent was to characterize the concentrations of several analytes in the groundwater. No special laboratory considerations were needed and the precision and bias routinely obtained with the methods selected were adequate.

Representativeness

Wells were selected to represent the variability in groundwater near the Spokane River and away from the river. All of the wells were constructed as environmental monitoring wells. The six wells placed adjacent to the river were designed to provide data to address the river/aquifer interaction questions. Samples collected from all wells are assumed to be representative of the groundwater quality during the study period.

Completeness

The data set for this project is complete. With the exception of some field measurements, all the planned samples were collected.

Comparability

Ecology, with Spokane County and the USGS, collected data for this project. As discussed previously not all sampling procedures were the same, therefore not all data is directly comparable. Data provided by the USGS for the Spokane River samples were field filtered. Ecology did not filter the anion (chloride, sulfate, and alkalinity) groundwater samples. Data for alkalinity, chloride, sulfate, and potassium should be compared with some caution. Chloride is fairly conservative in natural waters and most reactions are through physical processes (Hem, 1989). However, the chemical behavior of sulfur is related strongly to redox properties of the aqueous system. The most highly oxidized and stable form of sulfur is the sulfate anion (Hem, 1989). As for alkalinity, review of preliminary groundwater data provided by the USGS appears to indicate that filtering of the anion samples does not affect alkalinity concentrations (Caldwell, 2001). Data collected by the different sampling procedures should be comparable for most purposes. Potassium was not analyzed for as part of the USGS river sampling program. Potassium data used in this report for the Washington surface water samples were provided by Walkley (2001). These samples were collected in the fall of 1998 and spring of 1999.

Appendix E

Water Level Elevations for the Barker and Sullivan Well Sets and the Spokane River, May – September 1999

This page is purposely blank for duplex printing

Figure E1. Water Level Elevations for Barker Well Sets and Spokane River, May - September 1999

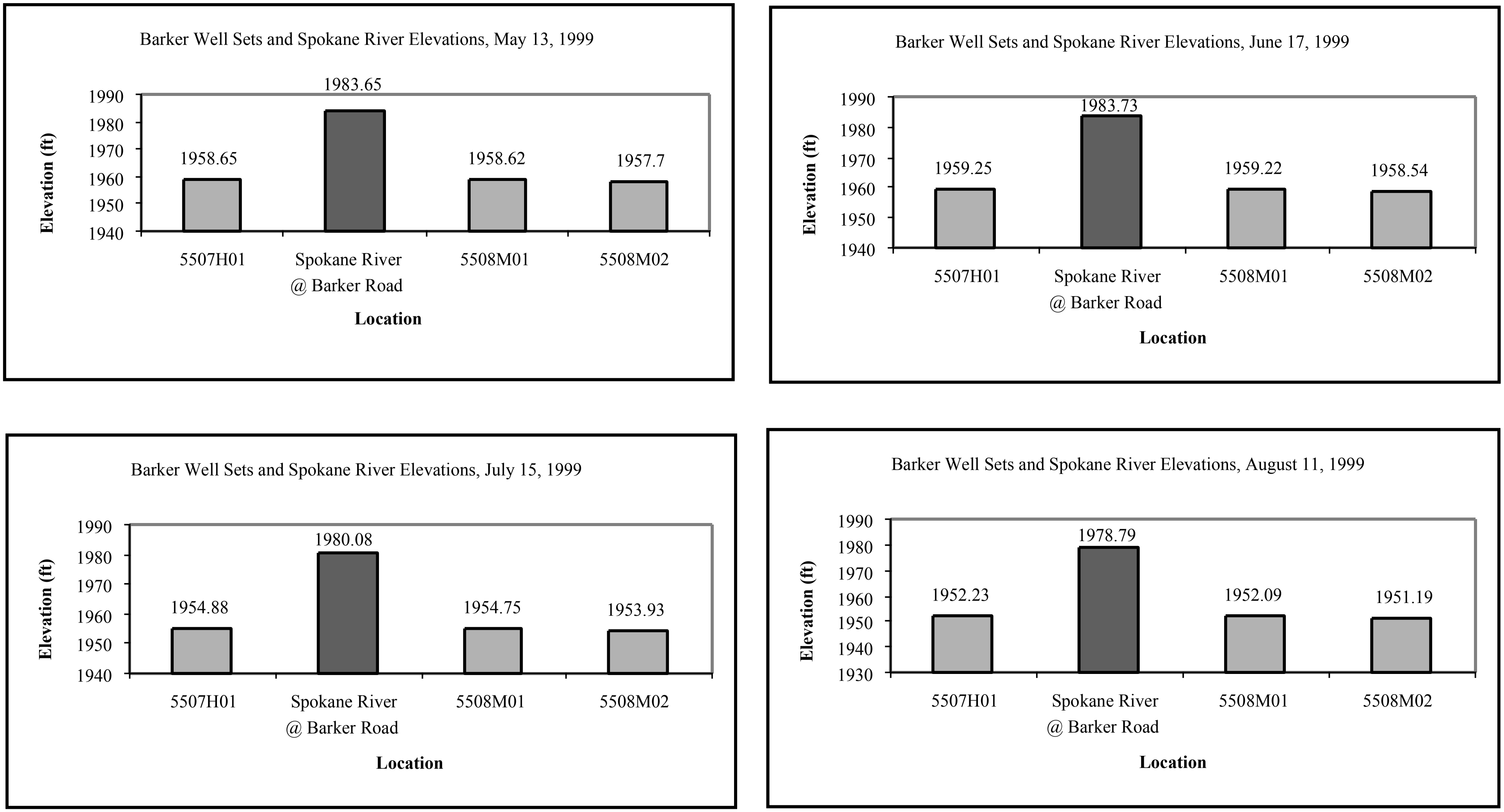


Figure E2. Water Level Elevations for Barker Well Sets and Spokane River, May - September 1999 (cont'd)

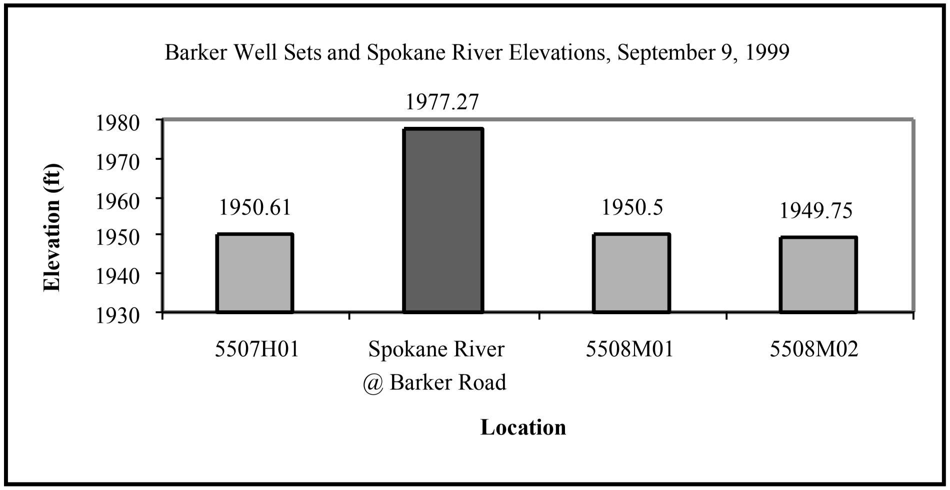
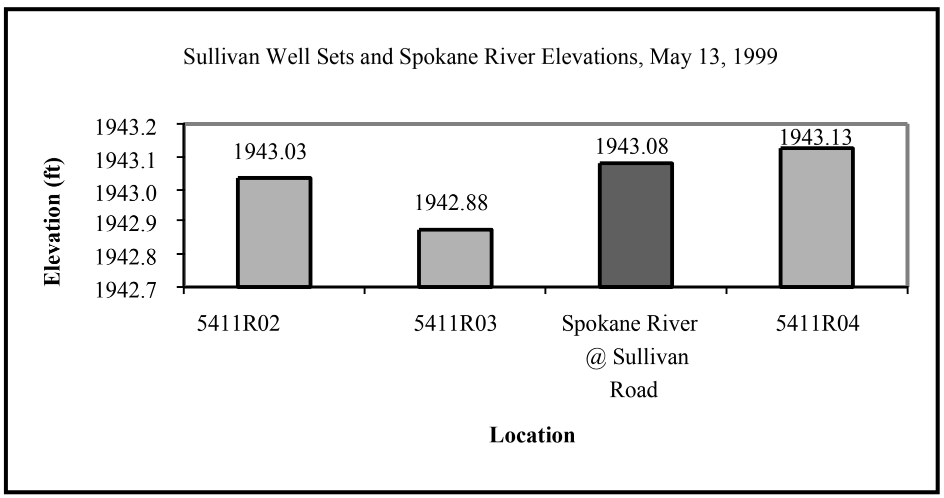
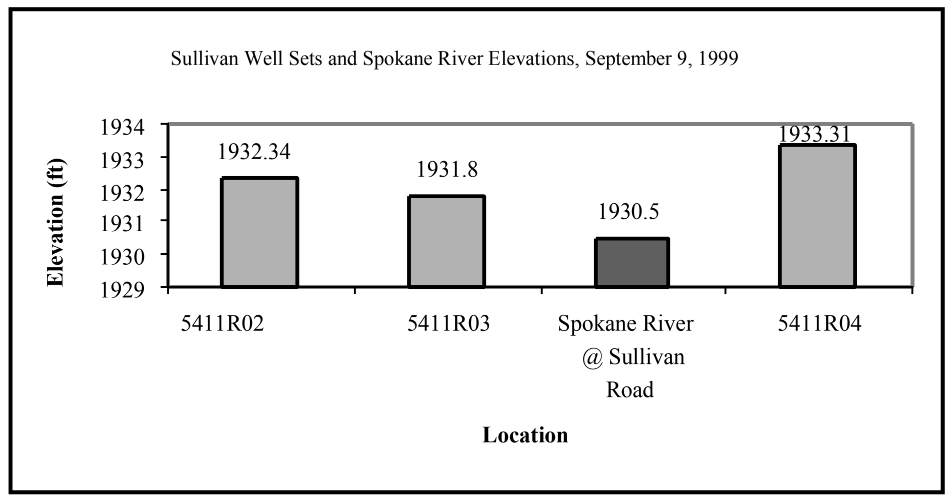


Figure E3. Water Level Elevations for Sullivan Well Sets and Spokane River, May and September 1999





Appendix F

Complete Analytical Data Sets
May – November 1999

This page is purposely blank for duplex printing

Table F1. Static Water Levels[1] (feet) for Spokane Valley Aquifer, May–November 1999

Monitoring Well	Ground Surface Elevation (ft) MSL	Measuring Point Height (ft)	May	June	July	August	Sept	Oct	Nov	Water Table Fluctuation[2] (ft)
Sullivan Well Set										
5411R02	1967.2	1.15	25.99	25.4	31.23	34.37	35.45	34.37	33.73	10.05
5411R03	1965.9	1.30	25.12	24.49	30.39	33.69	34.72	33.64	32.95	10.23
5411R04	1987.4	2.46	47.35	46.64	52	54.96	56.13	55.15	54.67	9.49
Barker Well Set										
5507H01	2001.5	-0.45	42.82	41.71	46.08	48.95	50.35	49.47	49.52	8.64
5508M01	2017.5	2.17	61.37	60.31	64.64	---	69.09	68.11	68.11	8.78
5508M02	2018.0	1.58	62.23	61.12	65.46	68.45	69.86	68.92	68.94	8.74
5517D05	2035.6	2.15	78.95	77.85	82.15	85.09	86.54	85.59	85.63	8.69
5507A04	2021.7	1.79	64.48	63.46	67.63	70.55	71.97	71.05	71.1	8.51
5505D01	2045.2	2.34	87.52	86.44	90.48	93.33	94.69	93.83	93.93	8.25
6525R01	2080.3	2.10	99.15	98.31	100.87	102.97	104	103.65	104.1	5.79
6631M07	2090.2	1.70	110.1	109.29	112	114.15	115.22	114.8	115.23	5.94
SVA-1	2050.0	2.0	92.78	91.8	---	99	100.24	99.35	99.72	8.44

[1] As measured from top of the PVC casing.

[2] Difference between the lowest and highest water level measurement.

Table F2. Temperature Measurements (°C) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Difference
Sullivan Well Set								
5411R02	11.3	12.2	12.1	12.1	12.2	11.2	10.5	1.7
5411R03	11.1	11.8	11.9	11.8	12.2	11.1	10.5	1.7
5411R04	10.6	12.4	12.4	11.7	12.2	11.5	11.4	1.8
Barker Well Set								
5507H01	8.0	13.4	16.3	21.2	20.7	17.6	12.4	13.2
5508M01	6.9	11.2	13.8	16.5	18.0	18.6	16.1	11.7
5508M02	7.3	11.1	13.9	14.8	17.4	17.8	16.1	10.5
5517D05	12.4	14.3	14.1	13.4	13.2	12.4	12.1	2.2
5507A04	9.8	10.8	11.2	11.0	10.4	10.4	10.0	1.4
5505D01	10.9	11.6	11.2	12.2	11.6	11.3	10.8	1.4
6525R01	10.9	11.3	11.0	11.1	11.0	10.8	10.0	1.3
6631M07	13.4	14.1	13.8	13.8	14.1	13.4	12.7	1.4
SVA-1	10.8	11.3	---	11.7	11.4	11.1	10.2	1.5
Spokane River								
Post Falls	8.4	15.0	19.6	---	18.4	---	---	11.2
Harvard	7.9	15.6	19.7	22.5	19.0	---	---	14.6
Barker	7.8	15.6	19.4	22.0	18.5	---	---	14.2
Sullivan	7.8	15.8	18.6	23.6	15.0	---	---	15.8

Table F3. pH Measurements (std. units) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	7.41	7.47	7.59	7.72	7.85	7.83	7.88	7.7
5411R03	7.28	7.9	7.78	7.74	7.84	7.88	7.93	7.8
5411R04	7.82	8.06	7.84	7.79	7.82	7.86	7.92	7.9
Barker Well Set								
5507H01	6.4	6.95	7.31	6.65	6.43	6.46	6.6	6.7
5508M01	6.51	7.45	7.38	6.79	6.58	6.51	6.66	6.8
5508M02	6.61	7.22	7.41	6.89	6.74	6.74	6.91	6.9
5517D05	6.9	7.75	7.66	7.36	7.27	7.32	7.4	7.4
5507A04	7.38	7.64	7.73	7.62	7.7	7.66	7.74	7.6
5505D01	7.53	7.67	7.6	8.13	7.88	7.84	7.87	7.8
6525R01	7.68	8.02	7.83	8.12	7.95	7.93	7.93	7.9
6631M07	7.58	7.84	7.88	8.06	7.87	7.88	7.94	7.9
SVA-1	7.69	7.6	---	8.02	7.89	7.88	7.94	7.8
Spokane River								
Post Falls	7.1	7.6	7.2	---	7.0	---	---	7.2
Harvard	7.8	7.7	7.8	7.7	8.3	---	---	7.9
Barker	7.8	7.7	7.7	7.7	8.2	---	---	7.8
Sullivan	7.9	7.7	7.8	8.0	8.1	---	---	7.9

Table F4. Specific Conductance Measurements (umhos/cm) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	252	199	246	252	269	275	267	251
5411R03	256	206	257	259	274	278	269	257
5411R04	219	213	214	241	275	276	258	242
Barker Well Set								
5507H01	58	55	53	50	74	52	53	56
5508M01	52	46	49	52	58	54	49	51
5508M02	57	53	49	53	57	54	51	53
5517D05	136	132	123	125	130	124	112	126
5507A04	341	342	343	349	366	370	348	351
5505D01	373	374	358	351	367	362	354	363
6525R01	304	300	301	302	311	310	299	304
6631M07	289	290	285	277	289	288	280	285
SVA-1	305	281	---	258	264	264	258	272
Spokane River								
Post Falls	47	41	43	---	53	---	---	46
Harvard	50	46	45	45	50	---	---	47
Barker	51	46	44	46	52	---	---	48
Sullivan	55	47	45	50	119	---	---	63

Table F5. Turbidity Measurements (NTU) in Groundwater

Station ID	May	June	July	August	September	October	November	Range
Sullivan Well Set								
5411R02	---	---	9	0.7	0.59	0.4	2.2	0.4-9
5411R03	---	---	6	0.3	0.06	0.3	0.6	0.06-6
5411R04	---	---	3.8	2.5	1.6	1.53	4.3	1.5-4.3
Barker Well Set								
5507H01	---	---	4	6	1.6	3.5	0.7	0.7-6
5508M01	---	---	0.5	3	0.4	0.93	1	0.4-3
5508M02	---	---	47	2.7	0.8	3.6	0.8	0.8-47
5517D05	---	---	11	7.5	0.28	8.5	6	0.3-11
5507A04	---	---	21	2.3	0.22	1.6	1	0.2-21
5505D01	---	---	9	2	2	7.4	9.7	2-9.7
6525R01	---	---	3	4.8	4.4	8.3	2.9	2.9-8.3
6631M07	---	---	7	1.8	1.1	4.2	2.2	1.1-7
SVA-1	---	---	---	0.15	0.0	-0.05	-0.1	-0.1-0.15

Table F6. Dissolved Oxygen Measurements (mg/L) in Groundwater

Station ID	May	June	July	August	September	October	November	Range
Sullivan Well Set								
5411R02	6.4	7.9	8.0	7.1	7.8	7.96	8.08	6.4-8.1
5411R03	5.9	7.4	7.7	7.1	7.55	7.75	7.97	5.9-7.8
5411R04	9.4	8.0	8.0	7.0	6.77	7.36	7.1	6.8-9.4
Barker Well Set								
5507H01	8.1	6.3	4.3	3.1	4.16	5.27	7.4	3.1-8.1
5508M01	8.3	6.5	4.1	2.5	1.95	2.82	4.73	1.9-8.3
5508M02	9.4	7.5	4.8	2.7	2.02	3.67	5.32	2-9.4
5517D05	8.3	7.8	7.5	6.9	6.01	6.86	6.26	6.0-8.3
5507A04	8.3	9.3	8.3	7.8	7.89	8.31	9.91	7.8-9.9
5505D01	7.8	8.8	7.1	6.8	6.84	7.05	7.68	6.8-8.8
6525R01	9	9.4	7.8	7.6	7.1	8.02	8.76	7.1-9.4
6631M07	6.8	7.5	6.2	6.0	5.66	6.11	6.07	5.7-7.5
SVA-1	8.0	8.4	---	7.6	8.4	7.2	8.1	7.2-8.4

Table F7. Calcium Concentrations (mg/L) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	30.3	22.9	28.2	32	31.4	31.3	31.3	29.63
5411R03	30.4	23.5	29.2	32.9	31.9	31.6	31.8	30.19
5411R04	26.1	24.61	24.8	30.9	32.3	32.2	30.9	28.83
Barker Well Set								
5507H01	6.26	5.99	5.37	5.58	7.75	5.35	5.64	5.99
5508M01	5.75	5.37	4.95	6.04	6.07	5.47	5.04	5.53
5508M02	6.63	6.21	5.11	6.04	5.96	5.58	5.17	5.81
5517D05	16.3	15.6	14	16.3	15.3	14.2	12.6	14.9
5507A04	42.1	41.3	41	38.9	43.6	43.8	41.6	41.76
5505D01	51.1	49.3	52.7	44.5	48.5	47.1	45.5	48.39
6525R01	34.2	32.9	36.7	33.6	34	33.3	32.5	33.89
6631M07	34.2	33.3	35.9	31.9	32.5	32.4	30.8	33.0
SVA-1	45.8	41.9	44.1	37.5	38.1	37.1	36.2	40.1
Spokane River								
Post Falls	7.5	4.4	4.8	---	5.2	---	---	5.5
Harvard	4.9	4.7	4.6	4.8	5.2	---	---	4.8
Barker	4.9	4.7	4.6	4.8	5.3	---	---	4.9
Sullivan	4.9	4.8	4.7	5.3	13	---	---	6.5

Table F8. Magnesium Concentrations (mg/L) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	13.6	10.1	12.6	13	15.2	15.3	15.4	13.6
5411R03	13.9	10.6	13.2	13.4	15.4	15.4	15.6	13.93
5411R04	11.4	10.6	10.5	11.8	14.9	14.9	14.5	12.66
Barker Well Set								
5507H01	1.89	1.69	1.59	1.35	2.37	1.65	1.82	1.77
5508M01	1.71	1.51	1.45	1.45	1.79	1.64	1.56	1.59
5508M02	1.87	1.67	1.44	1.45	1.75	1.66	1.57	1.63
5517D05	5.99	5.71	4.97	5.09	5.74	5.37	4.82	5.38
5507A04	18.5	18.1	17.6	13.8	20	20.4	19.5	18.27
5505D01	15.8	15.2	13.6	10.6	15.2	14.6	14.4	14.2
6525R01	18.3	17.5	17.2	17.2	18.8	18.6	18.3	17.99
6631M07	15.8	15.3	14.8	14.6	15.8	15.9	15.2	15.34
SVA-1	9.85	8.98	8.48	6.65	8.56	8.43	8.3	8.46
Spokane River								
Post Falls	2.6	1.3	1.4	---	1.6	---	---	1.7
Harvard	1.6	1.4	1.3	1.4	1.5	---	---	1.4
Barker	1.6	1.4	1.3	1.4	1.5	---	---	1.4
Sullivan	1.6	1.4	1.4	1.6	5.1	---	---	2.2

Table F9. Potassium Concentrations (mg/L) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	1.9	1.6	1.5	2.4	1.9	1.8	1.8	1.84
5411R03	1.8	1.4	1.6	2.38	1.9	1.8	1.8	1.81
5411R04	1.7	1.6	1.4	2.2	1.8	1.8	1.8	1.76
Barker Well Set								
5507H01	1.1	0.94	0.67	1.4	1.5 U	1.5 U	1.5 U	1.03
5508M01	1.1	0.68	0.6 U	1.4	1.5 U	1.5 U	1.5 U	1.06
5508M02	0.92	0.63	0.6 U	1.2	1.5 U	1.5 U	1.5 U	0.92
5517D05	1.4	1.4	1	1.8	1.5 U	1.9	1.5 U	1.5
5507A04	2.1	1.9	1.8	2.3	2.9	2.2	2.1	2.19
5505D01	2.3	2.1	2.93	2.3	3.3	2.3	2.3	2.5
6525R01	2.3	1.9	2.7	2.1	2.1	2	2.1	2.17
6631M07	2.5	2.2	2.86	2.3	2.2	2.3	2.2	2.37
SVA-1	2	1.8	2.5	2	1.87	1.8	1.8	1.97
Spokane River								
Post Falls	0.77	0.57	1.0	---	0.82	---	---	0.8
Harvard	---	---	---	---	---	---	---	---
Barker[1]	0.61	0.55	---	---	---	---	---	0.64
Sullivan[1]	0.62	0.55	---	---	---	---	---	0.66

U = Analyte was not detected at or above the reported value.

[1] Data collected by Walkley (2001) between September 1998 to June 1999.

Table F10. Sodium Concentrations (mg/L) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	3.38	2.8	2.7	3.18	2.92	2.83	2.83	2.95
5411R03	3.28	2.71	2.7	3.12	2.86	2.84	2.82	2.9
5411R04	2.67	2.56	2.3	2.77	2.75	2.81	2.81	2.67
Barker Well Set								
5507H01	2.23	2.14	1.64	1.4	2.15	1.62	1.71	1.84
5508M01	1.76	1.67	1.52	1.69	1.9	1.78	1.63	1.71
5508M02	1.71	1.74	1.63	1.8	1.9	1.85	1.69	1.76
5517D05	2.23	2.12	1.8	2.09	2	2.01	1.83	2.01
5507A04	3.24	3.13	2.84	2.11	3.24	3.18	3.1	2.98
5505D01	6.5	6.19	6.31	4.71	6.38	6.11	6.17	6.05
6525R01	3.08	2.97	3.14	2.94	2.97	3	3.03	3.02
6631M07	2.95	2.94	2.96	2.69	2.72	2.76	2.73	2.82
SVA-1	4.77	4.5	4.68	3.36	4.27	4.3	4.36	4.32
Spokane River								
Post Falls	2.2	1.3	1.5	---	2.5	---	---	1.9
Harvard	1.7	1.4	1.4	1.4	2.1	---	---	1.6
Barker	1.7	1.4	1.3	1.5	2.2	---	---	1.6
Sullivan	1.6	1.4	1.3	1.5	2.2	---	---	1.6

Table F11. Total Alkalinity Concentrations (mg/L) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	123	92.4	116	122	125	127	129	119
5411R03	125	99.5	122	124	128	129	129	122
5411R04	105	103	98.1	114	126	126	124	114
Barker Well Set								
5507H01	24	23	21.1	20.5	28.7	20.1	21	23
5508M01	23	21	19.2	20.7	21.8	20.6	19.8	21
5508M02	23	23	19.2	21.2	21.7	21	20.7	21
5517D05	61	59.5	52.5	55.9	55.7	54.1	51.6	56
5507A04	169	169	164	172	175	177	173	171
5505D01	180	179	168	168	170	166	165	171
6525R01	149	147	142	145	146	146	144	146
6631M07	137	137	131	131	131	130	130	132
SVA-1	149	141	133	128	126	125	123	132
Spokane River								
Post Falls[1]	17	17	17	---	18	---	---	17.4
Harvard[1]	18	17	17	18	20	---	---	18
Barker[1]	19	18	17	18	19	---	---	18.2
Sullivan[1]	19	18	18	20	48	---	---	24.6

[1] Results from filtered samples and titrated in the field.

Table F12. Chloride Concentrations (mg/L) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	1.73	1.47	1.74	1.45	1.45	1.54	1.44	1.55
5411R03	1.63	1.45	1.67	1.44	1.43	1.45	1.48	1.51
5411R04	1.37	1.61	1.47	1.79	1.54	1.5	1.46	1.56
Barker Well Set								
5507H01	1.12	0.94	0.677	0.795	1.46	0.948	1.09	1.0
5508M01	0.876	0.747	0.719	0.796	1.17	0.874	0.885	0.87
5508M02	0.911	0.709	0.609	0.801	1.48	0.844	0.859	0.89
5517D05	1.31	1.4	1.25	1.3	1.25	1.19	1.12	1.26
5507A04	1.51	1.57	1.38	1.62	1.6	1.71	1.6	1.57
5505D01	4.01	4.26	3.75	4.26	4.48	4.15	4.08	4.14
6525R01	1.22	1.34	1.08	1.27	1.25	1.3	1.23	1.24
6631M07	2.42	2.67	2.29	2.52	2.46	2.56	2.52	2.49
SVA-1	1.59	2.52	2.25	2.17	2.13	2.21	2.14	2.14
Spokane River								
Post Falls[1]	0.19	0.5	0.71	---	1.5	---	---	0.7
Harvard[1]	2.0	0.59	---	0.62	1.2	---	---	1.1
Barker[1]	0.99	0.6	---	0.73	1.3	---	---	0.9
Sullivan[1]	0.91	0.63	---	---	1.3	---	---	0.95

[1] Results from filtered samples.

Table F13. Sulfate Concentrations (mg/L) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	12.7	9.88	12.5	13.1	12.9	13.7	13.8	12.65
5411R03	12.7	9.97	13	13.4	13.1	13.6	13.8	12.8
5411R04	10.7	10.4	10.8	13	13.7	13.6	13	12.17
Barker Well Set								
5507H01	4.99	4	3.46	3.5	4.11	3.98	4.3	4.05
5508M01	4.99	4.05	3.91	3.84	4.09	4.11	4.21	4.17
5508M02	5.21	4.05	3.79	3.69	3.88	4.02	4.1	4.11
5517D05	7	6.87	6.71	6.55	6.19	5.94	5.57	6.4
5507A04	16.3	16.4	16.9	17.3	16.4	16.8	16.3	16.63
5505D01	12.1	12.1	11.8	11.9	12	11.4	11.4	11.81
6525R01	14.9	15	15.5	16.4	15.7	16	15.4	15.56
6631M07	12.5	12.5	12.9	12.9	12.2	12.5	12.2	12.53
SVA-1	10.1	8.52	7.44	7.28	7.1	7.66	8.08	8.03
Spokane River								
Post Falls[1]	1.3	2.5	2.5	---	3.7	---	---	2.5
Harvard[1]	4.3	3.3	---	2.6	3.7	---	---	3.5
Barker[1]	4.3	3.2	---	2.7	3.7	---	---	3.5
Sullivan[1]	4.2	3.2	---	---	6.0	---	---	4.5

[1] Results from filtered samples.

Table F14. Total Dissolved Concentrations (mg/L) in Groundwater

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	145	131	154	3	156	161	152	150
5411R03	147	127	156	154	156	158	154	150
5411R04	126	136	124	144	191	156	155	147
Barker Well Set								
5507H01	42	55	42	42	55	38	30	43
5508M01	38	45	42	37	53	40	33	41
5508M02	43	70	46	37	48	41	31	45
5517D05	82	92	68	80	82	75	66	78
5507A04	193	214	205	206	214	208	200	206
5505D01	225	238	219	224	226	155	224	216
6525R01	170	181	182	181	188	173	168	178
6631M07	170	177	171	165	181	164	163	170
SVA-1	182	185	173	159	163	155	154	167

Table F15. Nitrite-Nitrate Concentrations (mg/L) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	0.937	0.733	0.925	0.988	0.945	1	1.02	0.94
5411R03	0.932	0.749	0.991	1	0.972	1.01	1.03	0.95
5411R04	0.821	0.767	0.868	3.78	1.01	0.984	0.96	1.31
Barker Well Set								
5507H01	0.305	0.221	0.172	0.159	0.28	0.123	0.16	0.20
5508M01	0.152	0.131	0.188	0.211	0.212	0.174	0.159	0.18
5508M02	0.128	0.104	0.142	0.628	0.219	0.161	0.15	0.22
5517D05	0.747	0.733	0.571	1.02	0.571	0.497	0.46	0.66
5507A04	1.35	1.43	1.53	1.39	1.4	1.39	1.37	1.42
5505D01	3.21	3.05	2.9	2.53	2.6	2.57	2.34	2.74
6525R01	1.09	1.03	1.17	1.14	0.976	0.959	0.951	1.05
6631M07	1.63	1.85	1.94	1.84	1.71	1.69	1.7	1.77
SVA-1	1.58	1.25	1.16	1.09	0.993	1.03	1.1	1.17
Spokane River								
Post Falls	0.038	0.006	0.015	---	0.123	---	---	0.045
Harvard	0.039	0.009	0.019	0.036	0.103	---	---	0.041
Barker	0.038	0.009	0.014	0.038	0.109	---	---	0.042
Sullivan	0.038	0.011	0.017	0.054	0.373	---	---	0.099

Table F16. Dissolved Cadmium Concentrations (ug/L) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	0.02 U	0.02 U	0.02 U	0.04 U	0.02 U	0.02 U	0.02 U	0.04 U
5411R03	0.02 U	0.02 U	0.02 U	0.04 U	0.02 U	0.02 U	0.02 U	0.04 U
5411R04	0.02 U	0.02 U	0.02 U	0.04 U	0.02 U	0.02 U	0.02 U	0.04 U
Barker Well Set								
5507H01	0.25	0.148	0.229	0.28	0.544	0.381	0.364	0.31
5508M01	0.232	0.209	0.203	0.22	0.25	0.247	0.2	0.22
5508M02	0.021	0.023	0.024	0.04 U	0.05	0.047	0.02 U	0.03
5517D05	0.02 U	0.02 U	0.02 U	0.04 U	0.02 U	0.02 U	0.02 U	0.04 U
5507A04	0.02 U	0.02 U	0.02 U	0.04 U	0.02 U	0.02 U	0.02 U	0.04 U
5505D01	0.02 U	0.02 U	0.02 U	0.04 U	0.02 U	0.02 U	0.02 U	0.04 U
6525R01	0.02 U	0.02 U	0.02 U	0.04 U	0.02 U	0.02 U	0.02 U	0.04 U
6631M07	0.02 U	0.02 U	0.02 U	0.04 U	0.02 U	0.02 U	0.02 U	0.04 U
SVA-1	0.02 U	0.02 U	0.02 U	0.04 U	0.02 U	0.02 U	0.02 U	0.04 U
Spokane River								
Post Falls	<1	0.264	0.219	0.137	0.15	---	---	0.193
Harvard	<1	<1	0.18	0.15	0.081	---	---	0.137
Barker	<1	<1	0.173	<1	0.094	---	---	0.134
Sullivan	<1	<1	0.174	0.122	0.073	---	---	0.123

U = Analyte was not detected at or above the reported value.

Table F17. Dissolved Lead Concentrations (ug/L) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	0.02 U	0.02 U	0.487	0.02 U	0.045	0.06 U	0.02 U	0.27
5411R03	0.02 U	0.02	0.02 U	0.02 U	0.02 U	0.06 U	0.02 U	0.02
5411R04	0.02 U	0.1	0.13	0.02 U	0.02 U	0.06 U	0.02 U	0.12
Barker Well Set								
5507H01	0.062	0.054	0.04	0.043	0.049	0.072	0.023	0.05
5508M01	0.021	0.02 U	0.02 U	0.02 U	0.02 U	0.06 U	0.02 U	0.02
5508M02	0.02 U	0.021	0.02 U	0.02 U	0.02 U	0.06 U	0.02 U	0.02
5517D05	0.023	0.02 U	0.971	0.02 U	0.02 U	0.06 U	0.02 U	0.50
5507A04	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.06 U	0.02 U	0.06 U
5505D01	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.06 U	0.02 U	0.06 U
6525R01	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.06 U	0.02 U	0.06 U
6631M07	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.06 U	0.02 U	0.06 U
SVA-1	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.06 U	0.02 U	0.06 U
Spokane River								
Post Falls	<1	0.772	0.182	0.076	0.211	---	---	0.31
Harvard	<1	<1	0.197	0.14	0.188	---	---	0.175
Barker	<1	<1	0.22	<1	0.183	---	---	0.20
Sullivan	<1	<1	0.178	0.163	0.111	---	---	0.151

U = Analyte was not detected at or above the reported value.

Table F18. Dissolved Zinc Concentrations (ug/L) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	0.4 U	0.63	1.7	1 U	1 U	1.3	1 U	1.21
5411R03	0.92	0.55	1.7	1 U	1 U	1 U	1 U	1.06
5411R04	0.4 U	0.54	1.2	1 U	2.3	1.1	1 U	1.29
Barker Well Set								
5507H01	33.9	17.1	27.2	29.4	37.9	30.3	45.8	32
5508M01	43.5	33.4	30.9	35.2	23.4	23.5	29.2	31
5508M02	7.14	5.5	5.83	5.1	6.9	6.0	3.5	5.71
5517D05	4.0	0.59	15.5	1 U	1 U	1 U	1 U	6.7
5507A04	1.3	0.82	1.1	1.9	1.6	1 U	1 U	1.34
5505D01	0.84	0.80	1.8	1 U	1 U	1 U	1 U	1.15
6525R01	1.4	0.81	1.6	1 U	1 U	1 U	1 U	1.27
6631M07	2.0	0.82	0.6	1 U	1 U	1 U	4.1	7.52
SVA-1	1.7	0.4 U	1.9 J	1.7	1.1	1 U	1 U	1.6
Spokane River								
Post Falls	71.89	61.8	44.8	37.3	31.7	---	---	49.5
Harvard	68.7	48.8	38.7	33.1	23.7	---	---	42.6
Barker	70.68	49.4	37.8	37.21	28.6	---	---	44.74
Sullivan	70.8	48.3	39.8	26.3	22.3	---	---	41.5

U = Analyte was not detected at or above the reported value.

Table F19. Dissolved Iron Concentrations (ug/L) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November
Sullivan Well Set							
5411R02	80	28	50 U	50 U	50 U	50 U	50 U
5411R03	76	34	50 U	50 U	50 U	50 U	50 U
5411R04	65	38	50 U	50 U	50 U	50 U	50 U
Barker Well Set							
5507H01	31	36	50 U	50 U	50 U	50 U	50 U
5508M01	21	20 U	50 U	50 U	50 U	50 U	50 U
5508M02	40	37	50 U	50 U	50 U	50 U	50 U
5517D05	38	20 U	50 U	50 U	50 U	50 U	50 U
5507A04	36	30	50 U	50 U	50 U	50 U	50 U
5505D01	39	48	50 U	50 U	50 U	50 U	50 U
6525R01	32	29	50 U	50 U	50 U	50 U	50 U
6631M07	32	29	50 U	50 U	50 U	50 U	50 U
SVA-1	60	28	50 U	50 U	50 U	50 U	50 U
Spokane River							
Post Falls	18	13	E 5.5	---	11	---	---
Harvard	20	11	13	E 5.4	E 7.2	---	---
Barker	19	11	E 8.7	E 5.2	E 5.7	---	---
Sullivan	26	12	E 9.4	E 6.4	<10	---	---

U = Analyte was not detected at or above the reported value.

Table F20. Dissolved Silicon Concentrations (ug/L) in Groundwater and Spokane River

Station ID	May	June	July	August	September	October	November	Mean
Sullivan Well Set								
5411R02	5650	5410	5020	5590	6100	5920	5830	5646
5411R03	5650	5430	4980	5500	6010	5990	5870	5633
5411R04	5490	5440	4810	5230	5900	5960	5900	5533
Barker Well Set								
5507H01	5480	5560	4690	4700	5070	4390	4390	4897
5508M01	4960	5000	4520	4920	5540	5170	4770	4983
5508M02	4790	5150	4760	5210	5890	5730	5330	5266
5517D05	5680	5440	4730	5250	5750	5580	5600	5433
5507A04	5660	5560	4980	4630	6110	6170	6220	5619
5505D01	9980	9680	9910	8380	10,800	10,700	10,800	10,036
6525R01	5570	5470	5480	5100	6000	5940	5990	5650
6631M07	6470	6330	6320	5810	6820	6880	7000	6519
SVA-1	7320	7110	7280	6220	7500	7480	7430	7191
Spokane River								
Post Falls	11	8.8	8.3	---	7.1	---	---	8.8
Harvard	12	11	---	8.3	6.7	---	---	9.5
Barker	12	11	---	8.5	6.5	---	---	9.5
Sullivan	12	11	---	---	8.2	---	---	10.4

This page is purposely blank for duplex printing

Appendix G

Graphs of Select Analytical Data Sets
May – September 1999

This page is purposely blank for duplex printing

Figure G1: Specific Conductance (umhos/cm) for Spokane Valley Aquifer and Spokane River May - November 1999

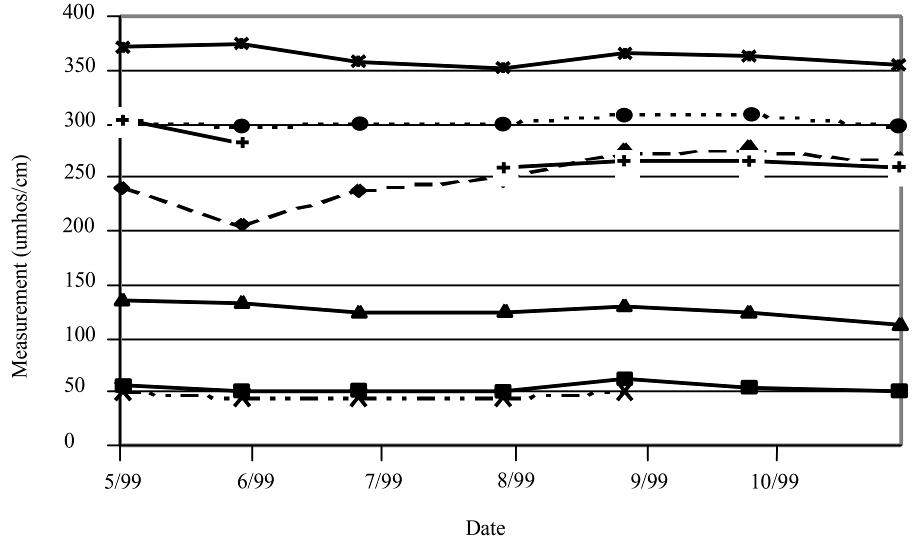


Figure G2: Calcium Concentrations (mg/L) for Spokane Valley Aquifer and Spokane River May - November 1999

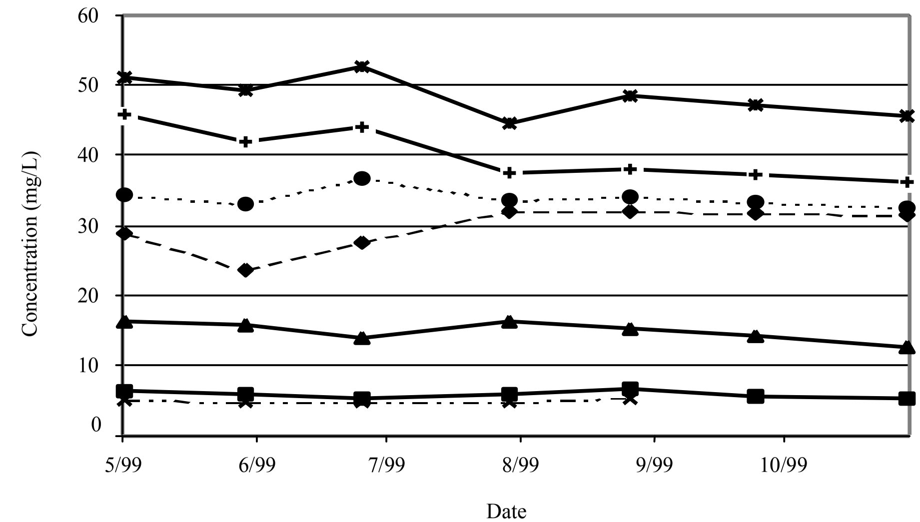


Figure G3: Magnesium Concentrations (mg/L) for Spokane Valley Aquifer and Spokane River May - November 1999

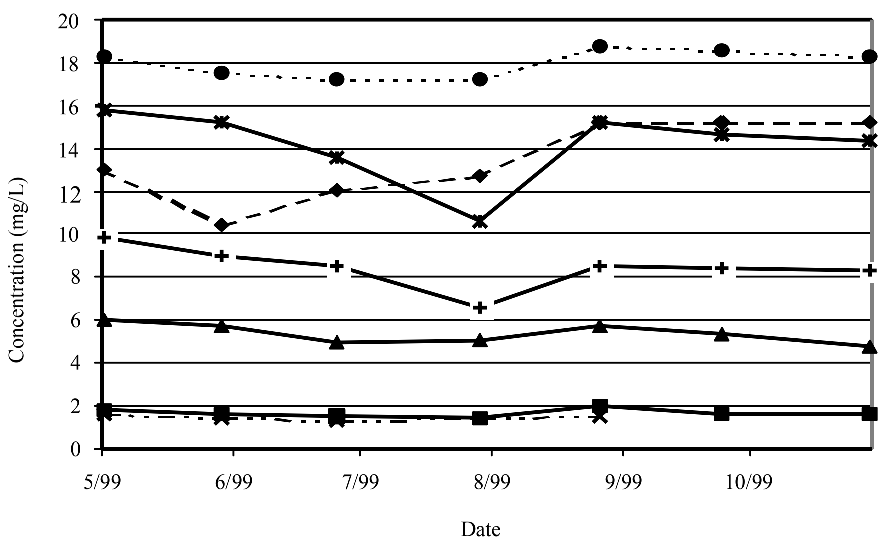
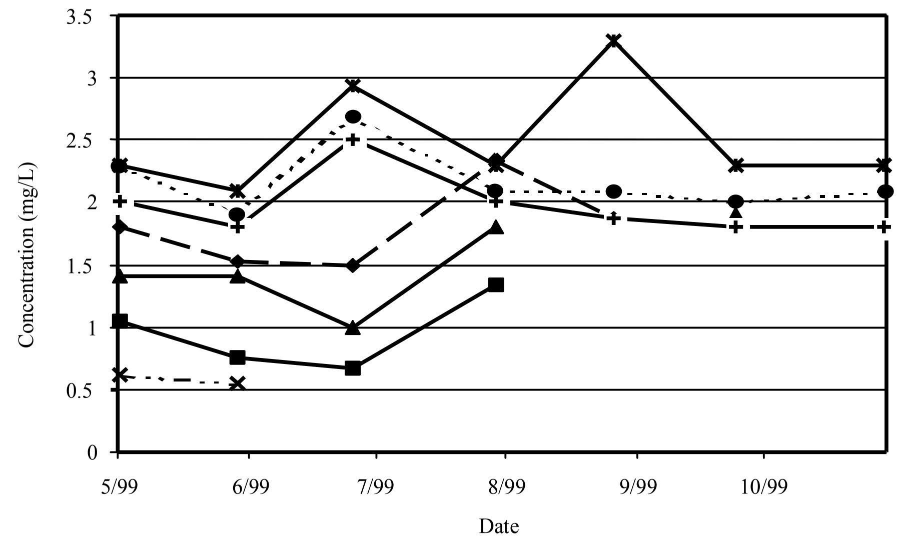


Figure G4: Potassium Concentrations (mg/L) for Spokane Valley Aquifer and Spokane River May - November 1999



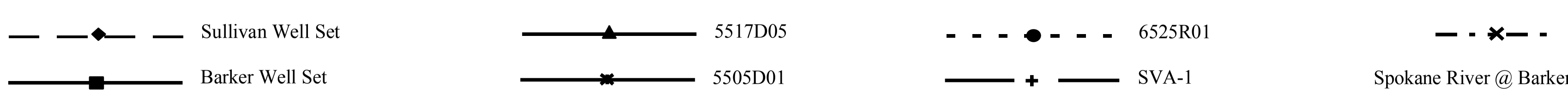


Figure G5: Sodium Concentrations (mg/L) for Spokane Valley Aquifer and Spokane River May - November 1999

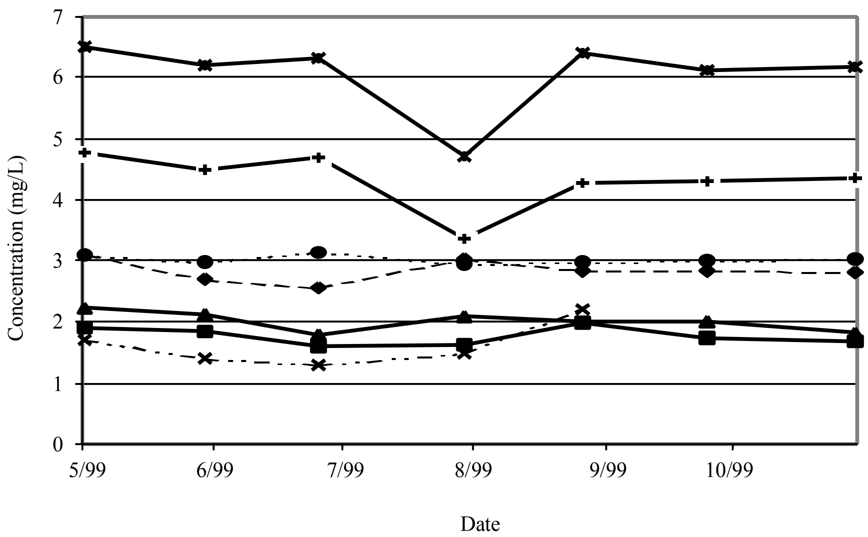


Figure G6: Chloride Concentrations (mg/L) for Spokane Valley Aquifer and Spokane River May - November 1999

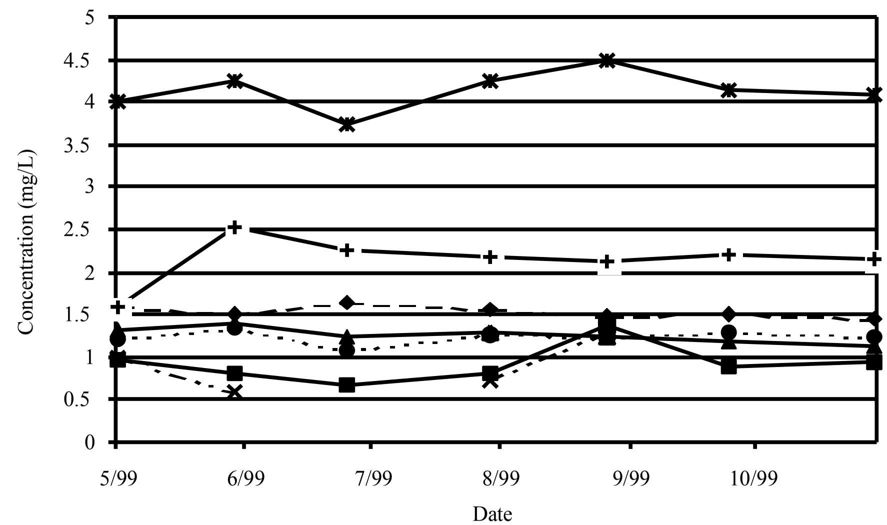


Figure G7: Sulfate Concentrations (mg/L) for Spokane Valley Aquifer and Spokane River May - November 1999

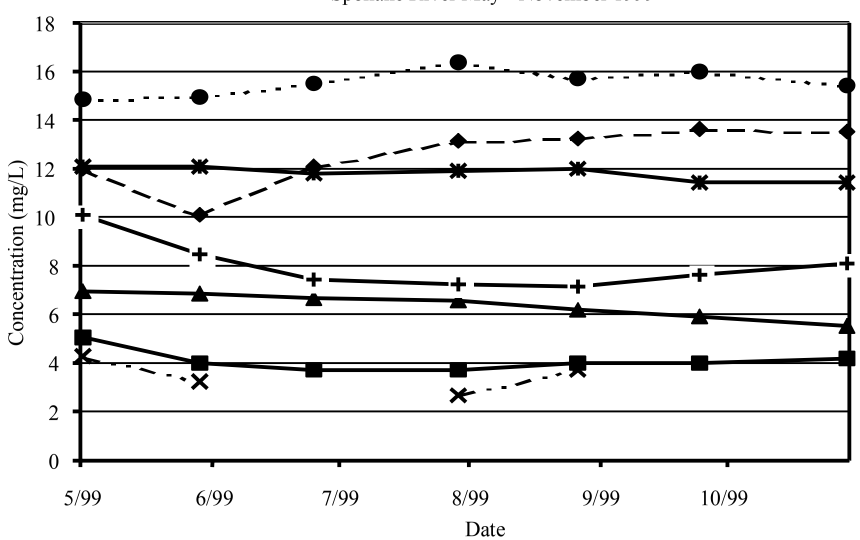


Figure G8: Total Alkalinity Concentrations (mg/L) for Spokane Valley Aquifer and Spokane River May - November 1999