IDAHO MINING ASSOCIATION

SELENIUM SUBCOMMITTEE

Fall 1997 Interim Surface Water Survey Report

Southeast Idaho Phosphate Resource Area

Selenium Project

February 1998

Prepared by

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Summary

As an initial effort under the Southeast Idaho Phosphate Resource Area Selenium Project, Montgomery Watson conducted an interim surface water survey within the resource area. The sampling for this survey was conducted from September 15 to 23, 1997, and the laboratory analytical data were validated on December 12, 1997. The survey was not designed to provide any conclusions about the distribution of selenium in the resource area; as such, no conclusions are drawn. Several observations, however, have been made:

- The selenium data generated by the University of Idaho's Analytical Sciences Laboratory are of high quality in terms of accuracy and precision.

- Background concentrations of selenium appear very low. The upper confidence limit of the 95th percentile of the background distribution of selenium is 0.00094 milligrams per liter.

- The observed selenium concentrations ranged from 0 to 1.55 milligrams per liter. The magnitude of these results is within the range of observations previously reported by or to the Forest Service.

- Selenium can often be detected in surface water above background values when surface water is directly associated with phosphate mining at Southeastern Idaho sites sampled during this survey. Several stations had selenium concentrations in excess of the upper range of veterinary advisory levels for livestock drinking water, 0.05 milligrams per liter; two stations had concentrations in excess of the lower range known to have caused chronic selenosis in mammals, 0.5 milligrams per liter.

- The observed selenium concentrations vary considerably from location to location, and there appears to be no obvious pattern to this variability. Although the survey was not designed to predict spatial variation, it does not appear that selenium concentrations can be predicted from the type or location of a water body or from the type, location, or age of the mining facility associated with a water body.

- The sampling results indicate that, with one exception, water bodies supporting fisheries—Spring Creek, Slug Creek, Angus Creek, Blackfoot River, Little Blackfoot River, and North Fork Sage Creek in Caribou County; and, Ross Fork and Lincoln Creek in Bingham County—do not appear to be adversely impacted. The selenium concentrations in these waters were well within the State of Idaho's water quality standard for the protection of fish. The one exception is Mill Creek, a known spawning stream, which had a concentration well in excess of the water quality standard.

- The survey results support the proposal for further study. Planning for a detailed investigation of surface water, sediment, groundwater, soil, vegetation, and source rock is underway. The observations made here will be regarded as working hypotheses for the upcoming study. Montgomery Watson Americas, Inc. expects to submit a draft work plan to the Interagency/Phosphate Industry Selenium Working Group by March 1, 1998, to finalize the plan by April 1, 1998 and, if so approved, to initiate the field work in May 1998.

- The survey results have implications for the sampling design of the 1998 study. This is particularly true in terms of how random samples will be allocated and whether samples should be replicated for statistical analysis.

Table of Contents

SECTION PAGE

SUMMARY i

1.0 INTRODUCTION 1-1

1.1 Project Background 1-2
1.2 Interim Surface Water Survey Objectives 1-3

2.0 SURVEY METHODS 2-1

2.1 Sample Station Locations and Sampling Frequencies 2-1
2.2 General Sampling Procedures 2-1
2.3 Sample Storage and Shipping Procedures 2-22
2.4 Statistical Analyses 2-22

3.0 SURVEY RESULTS 3-1

3.1 Selenium Concentrations 3-1
3.2 Filterable Residue Concentrations 3-12

4.0 DISCUSSION 4-1

5.0 REFERENCES 5-1

LIST OF TABLES

Table 2-1 Sample Stations for the Fall 1997 Interim Surface Water Survey
Table 3-1 Analytical Results - Selenium by ICP using Hydride Digestion
Table 3-2 Analytical Results - Selenium by ICP using Hydride Digestion (Averaged and Sorted by Concentration)
Table 3-3 Analytical Results - Total Dissolved Solids by EPA Method 160.1
Table 3-4 Field Data
Table 3-5a Correlation Coefficient Factors Using Untransformed Values
Table 3-5b Correlation Coefficient Factors Using Natural Log Transformed Values

APPENDICES

Appendix A Statistical Analyses
Appendix B Data Validation and Quality Control Summary Report

List of Abbreviations and Acronyms

EPA	United States Environmental Protection Agency
FS	United States Department of Agriculture, Forest Service
IDEQ	Idaho Department of Health, Division of Environmental Quality
IMA	Idaho Mining Association
ln	natural logarithm
MCL	maximum contaminant level
mg/L	milligrams per liter
MW	Montgomery Watson Americas, Inc.
QA	Quality assurance
QAPP	Quality Assurance Project Plan
TDS	Total dissolved solids

1.0 Introduction

Selenium is a naturally occurring element that is widely but unevenly distributed in the natural environment. Selenium is an essential nutrient for humans and animals; however, excessive concentrations can be harmful. Two incidents of chronic selenosis in several horses pastured below historic phosphate mines in the past year have prompted concern regarding the potential for selenium being released as a result of phosphate-mining activities. Therefore, various responsible state and federal agencies, in conjunction with the Idaho Mining Association (IMA) Selenium Subcommittee, a group of phosphate production companies, have formed the Southeast Idaho Selenium Working Group to respond to the issue in a thorough, consistent, and cost-effective manner. As an initial step, the IMA Selenium Subcommittee has retained Montgomery Watson to conduct an interim surface water survey on behalf of the Working Group to generate limited, but high-quality, data and to provide preliminary information relative to the selenium issue.

The primary objective of this report is to assess the surface water quality at selected locations resulting from potential selenium releases from phosphate-mining operations in southeast Idaho. The second objective of the interim surface water survey is to provide an initial indication as to whether livestock health could be impacted by selenium releases from phosphate-mining operations. The third objective of this survey is to obtain high quality preliminary surface water data and background data and to evaluate the need for replicate sampling for future work. As such, the survey has functioned as an initial, investigatory planning step for what will be a substantial investigation that is proposed to resume in May 1998. The lessons learned from this initial study will be factored into sampling designs for future investigations.

The *Fall 1997 Interim Surface Water Survey Report* is presented in four sections. Section 1.0, Introduction, provides a brief history and rationale behind the interim surface water survey as well as documents the three objectives of the survey. Section 2.0, Survey Methods, describes how sample locations were selected and provides both a list and maps of the sample locations. Section 3.0, Survey Results, presents field observations and laboratory analyses of samples collected during the survey; results from initial hypothetical testing are also presented. Section 4.0, Discussion, summarizes survey results and provides a basis for the future work.

Work documented in this report was conducted using protocols detailed in the September 1997 *Field Sampling Plan* and its two companion plans—the *Quality Assurance Program Plan* (QAPP), and the *Health and Safety Plan*—the three of which comprise the *Sampling and Analysis Plan*. The three component plans were used by field personnel and should be referred to regarding details for sampling protocols, laboratory requirements, and data management.

1.1 PROJECT BACKGROUND

Toward the end of 1996, one phosphate mining company operating in southeastern Idaho informed a rancher with pasture on nearby land that his horses appeared to be ill. The rancher, with the help of a local veterinarian and employees from the University of Idaho and the University of Wyoming, learned that six of his horses were suffering from chronic selenosis (selenium poisoning). Four of the horses were immediately euthanized, and, several months later, a fifth horse was euthanized. In the summer of 1997, another mining company discovered two horses pastured on its land to be suffering from selenosis. One horse was purchased by the company and shipped to the University of Idaho where it was euthanized for the purpose of veterinary toxicological training.

This event prompted public concern about the potential for selenium being released as a result of phosphate mining activities. Five companies that currently or formerly mine(d) phosphate in Caribou, Bear Lake, Bingham, or Bannock counties—FMC Corporation (FMC); Nu-West Industries, Inc., and Nu-West Mining, Inc., (Nu-West); Rhodia, Inc. (Rhodia); J. R. Simplot Company (Simplot) and, Solutia Inc (Solutia)—comprise the phosphate mining contingent of the IMA. In response to selenium concerns, these five companies formed an IMA Selenium Subcommittee to participate in the Interagency/Phosphate Industry Selenium Working Group and to respond to the issue in a thorough, consistent, and cost-effective manner. The Interagency/Phosphate Industry Selenium Working Group is comprised of the IMA Selenium Subcommittee and the following government agencies with primary responsibility for the administration of public or tribal lands: United States Department of Agriculture, Forest Service (FS), United States Department of Interior, Bureau of Indian Affairs, Shoshone-Bannock Tribes, United States Department of Interior, Bureau of Land Management, Idaho Department of Fish and Game, Idaho Department of Lands, and Idaho Department of Health, Division of Environmental Quality (IDEQ). A local citizen also participates as a community representative.

The IMA Selenium Subcommittee retained Montgomery Watson Americas, Inc., (MW) to conduct an investigation of selenium in the environment associated with historic and current phosphate mining operations in Caribou, Bear Lake, Bingham, and Bannock counties that were or are operated by the five companies or their predecessors. The planning for this effort, termed the Southeast Idaho Phosphate Resource Area Selenium Project (Selenium Project), is currently underway. Evaluation of existing data indicates that the Meade Peak Member of the Phosphoria Formation is a potential source of selenium.

The Selenium Project is being performed on behalf of and is being overseen by the Interagency/Phosphate Industry Selenium Working Group. The Selenium Project is a phased, scientific characterization of phosphate mining-related facilities. Random sampling of various facilities—mine pits, overburden areas, French drains, seeps, stormwater runoff control ponds,

dewatering ponds, and water-supply wells—will be conducted to effectively evaluate potential sources of selenium and release mechanisms. Potentially affected drainages containing or adjacent to past and present mining operations will also be sampled.

Given that the past and current mining operations within the scope of the Selenium Project span approximately eight decades of activity over a large geographic area, it was not possible to complete planning for the main investigation in time to collect data during the 1997 field season. Additional potential drainage sampling stations and mine facilities have been tentatively identified for consideration of future sampling; these sampling stations and mine facilities will need to be carefully inventoried to allow for the development of a high-quality sampling design.

Therefore, the Interagency/Phosphate Industry Selenium Working Group implemented an interim surface water survey during September 1997 so as to generate limited, but high-quality, data to satisfy a need for information and to accelerate response to the selenium issue. Planning for the main investigation has continued concurrent with the interim surface water survey so as to allow implementation of the main investigation, which is to be initiated in May of 1998.

1.2 INTERIM SURFACE WATER SURVEY OBJECTIVES

The primary although by no means exclusive objective of the interim surface water survey is to address the following question: "Is water quality impacted by potential selenium releases from phosphate-mining operations?" While a significant proportion of the project area drainages adjacent to or within phosphate mine operations do not naturally support and potentially can never support a fishery, some tributaries of rivers and larger streams that drain mining operations do have documented fish populations. Perhaps the most significant stream in the project area is the Blackfoot River. The Blackfoot River supports a significant cutthroat trout fishery managed under special regulations. Other streams within the project area that support fisheries include Ross Fork, Little Blackfoot River, Slug Creek, Angus Creek, Sage Creek and it's tributaries, and Lincoln Creek, Spring Creek, and Mill Creek.

The U.S. Environmental Protection Agency (EPA), pursuant to its authority under the Clean Water Act, has established a selenium chronic water quality criterion for the protection of freshwater life at 0.005 milligrams per liter (mg/L). This criterion is expressed as a total recoverable concentration. The IDEQ has adopted the EPA selenium water quality criterion as a state water quality standard for the protection of cold-water biota. Water quality criteria developed by the EPA are highly conservative for many locations, given that they are intended to apply to a wide variety of waters in the United States. For this interim survey the state cold-water biota standard of 0.005 mg/L serves as a preliminary, risk-based benchmark concentration for an initial screening of the health of the aquatic systems surveyed. Preliminary, risk-based benchmark concentrations are not used for any definitive decision making during the interim

survey. Rather, they are used simply as initial reference points. Such benchmarks are typically conservative. For the main investigation, the standard will be carefully evaluated to see if it is applicable to southeastern Idaho waters; if not, state regulations allow it to be refined on a site-specific basis.

Another important objective of the interim surface water survey is to address the question which several ranchers grazing livestock in the vicinity of phosphate mining operations have: "Could the health of livestock be impacted by selenium releases from phosphate-mining operations?" Member companies of the IMA Selenium Subcommittee have past or present operations where livestock graze or water on or below reclaimed waste-rock dumps, run-off control ponds receiving drainage from areas covered by mine overburden, pit ponds or lakes, streams or ponds downstream of such facilities, or ponds constructed specifically for stock watering.

There are no federal or state regulatory standards or criteria for selenium concentrations in water used by livestock or terrestrial or avian wildlife. As an initial benchmark, the EPA primary maximum contaminant level (MCL) for selenium, promulgated under the Safe Drinking Water Act, is 0.05 mg/L. This human drinking water standard applies to community potable water-supply systems and is presented for reference only.

The EPA assumed in deriving the selenium MCL that a person receives approximately 28 percent of the required daily selenium intake from community water-supply systems. For humans, the majority of ingested selenium is thus assumed to come from food and dietary supplements; the same is assumed to be also true for wildlife. Veterinary literature (Howard, 1986) suggests a range of 0.01 to 0.05 mg/L as a drinking water advisory concentration for livestock, but the literature confirms that the majority of selenium ingested by livestock is generally derived from food and dietary supplements. Therefore, when the advisory concentration is exceeded, the appropriate course of action is to examine an animal's total selenium uptake to evaluate the potential for adverse effects. A Fish and Wildlife Service report states that chronic selenosis can be induced by dietary exposure to selenium at selenium concentrations in feed between 1 mg/kg (in rats) and 44 mg/kg (in horses), or in water between 0.5 to 2.0 mg/L (Eisler, 1985). Although the food exposure pathway was not characterized during this interim survey, it will be during the main investigation.

The final objective of this survey, and perhaps the most important one from a technical perspective, is to obtain limited but high quality data for use in planning the main investigation and in refining the Working Group's conceptual understanding of the selenium issue. The survey allows for comparisons to be made between selected historic data that have been generated by some of the mining companies and government agencies using standard sampling and analysis procedures compared to the state-of-the-art procedures used in this interim survey.

For example, some samples collected prior to September 1997 have not been filtered, have not been appropriately preserved and handled, and have been analyzed with test methods now known to be potentially inaccurate and imprecise. During the interim survey both unfiltered and, as appropriate, filtered samples were collected and properly preserved and handled. In addition, a modified analytical method for selenium analysis was used that has been found to be much more accurate and precise than standard methods.

2.0 Survey Methods

2.1 SAMPLE STATION LOCATIONS AND SAMPLING FREQUENCIES

Members of the Interagency/Phosphate Industry Selenium Working Group submitted stations for inclusion in the interim surface water survey. A total of 72 stations were identified and are tabulated in Table 2-1 by associated mining company, mine operation, and surface water body. In addition, Table 2-1 includes, as necessary, a location description and a station number. These stations are plotted on Maps 2 through 15; a key to the relative location of the various maps is provided in Map 1. Each station was sampled once during the survey which was conducted from September 15 to September 23, 1997.

2.2 GENERAL SAMPLING PROCEDURES

Each two-man sampling crew used a global positioning system receiver to determine the location of a surface water station. A painted wooden stake was placed at each sampling station with the station number marked in permanent, waterproof ink.

Sample identifications were designated in accordance with the September 1997 QAPP. Field personnel described any unusual conditions at or near each sampling station such as the presence of livestock within the water body immediately upstream and extreme weather conditions at the time. A qualitative indication of whether or not the water body being sampled is being used by livestock, wildlife, or fish, and, if so, to what extent, was also recorded. Use of the water body was gauged by the actual presence of livestock or game, or the presence or absence of hoof prints and scat. Use by avian species was gauged by actual sightings of birds, categorized as either waterfowl, shore birds, or marsh-dwelling passerines, or the presence or absence of suitable bird habitat. The absence of fish can be difficult to ascertain, but sightings of fish at a station were recorded, as well as any impression by the crew as to whether a water body is sufficiently isolated or has a quantity of water so as to make the presence of fish at the time unlikely. These qualitative observations were documented on forms and in field notebooks.

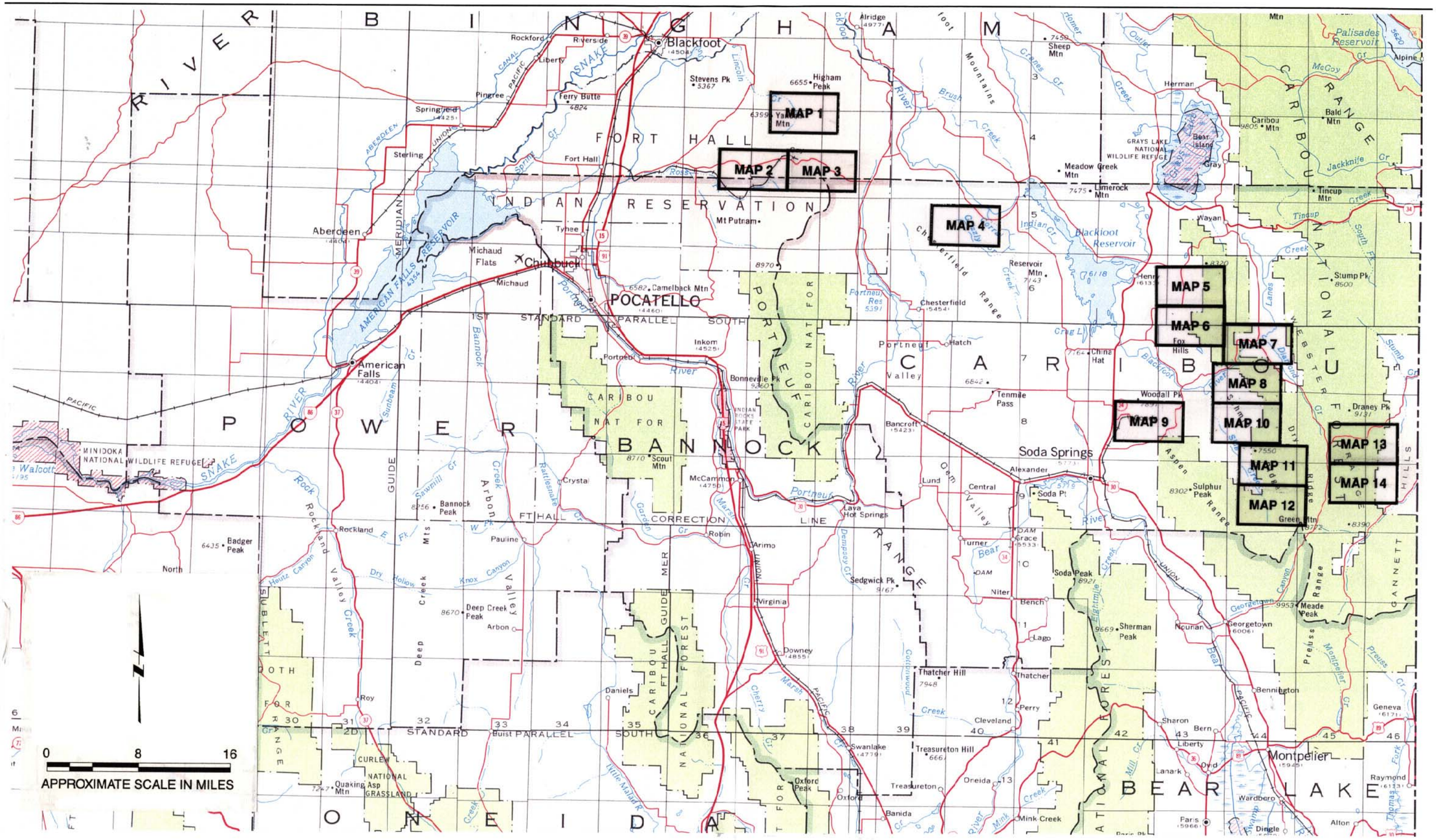
TABLE 2-1
Fall 1997 Interim Surface Water Sampling Stations

Company	Mine	Water Body	Location	Station	Map
Nu-West	North Maybe Mine	Mill Creek	Below East Mill Dump Seep at FS station C-B&M-1	1	7
		Spring Creek	Above confluence with Mill Creek at FS station C-B-2	2	7
			Below confluence with Mill Creek and above confluence with Blackfoot River at FS station C-B-1	3	7
		North Dry Ridge Creek	Headwaters spring at FS station C-B&M-2	4	7
		Big Draw	Below Upper Big Draw Dump Seep	5	8
	Mountain Fuel Mine	New Spring #1		6	12
		New Spring #2		7	12
		New Spring #3		8	12
		Stock Pond		9	12
	Champ Mine	Goodheart Creek	Headwaters spring below Champ Mine dumps	10	11
			Upper reach at FS stat. C-B&M-3	11	11
		Slug Creek	Above confluence with Goodheart Creek	12	11
			Below confluence with Goodheart Creek	13	11
FMC	Dry Valley Mine	Maybe Creek	Above confluence with Dry Valley Creek at FMC station MB2	14	10
		Dry Valley Creek	Above Dry Valley Mine at FMC station DV7	15	10
			Above confluence with Maybe Creek at FMC station DV6	16	10
			Below confluence with Maybe Creek at FMC station DV3	17	8
			Below Dry Valley Mine at FMC station DV2	18	8
		Blackfoot River	Above confluence with Dry Valley Creek at FMC station BF2 (FS station F-B&M-2)	19	8
			Below confluence with Dry Valley Creek at FMC station BF1 (FS station F-B&M-1)	20	8

FMC (continued)	Dry Valley Mine (continued)	Pit Dewatering Pond	FMC station PD1	21	8
		Chicken Creek	Above confluence with Dry Valley Creek at FMC station CC1	72	8
Solutia	Ballard Mine	Dredge Pond		22	6
	Henry Mine	Little Blackfoot River	Above Henry Mine	23	5
			Below Henry Mine	24	5
		Henry Pond		25	5
		Smith Pond		26	5
		Center Henry Pond		27	5
		Pasture #3 Seep	Below South Pit Overburden Dump	28	6
		Coarse Rock Fill Seep	Below South Pit Overburden Dump	29	6
	Enoch Valley Mine	Shop Pond		30	5
		Stock Pond		31	5
		Bat Cave Pond		32	5
		West Pond		33	5
		South Pond		34	6
		Tipple Pond		35	5
		Haul Road Pond		36	5
		North Pond		37	5
		Center Fork Angus Creek	At FS station M-B&M-1	38	6
Rhodia	Wooley Valley Mine	Large Haul Road Pond		39	6
		Unit III Panel E Pond		40	6
		Unit III Panel F Pond		41	6
		Unit III Overburden Dump Seep		42	6
		Upper Angus Creek Reservoir	FS station R-B&M-12	43	6
Simplot	Conda Mine	SL3 French Drain		44	9
		Hoorah Hollow	Flow from underground mine	45	9
			Pond	69	9
		SW3 Perennial Seep		46	9
		Camp G Creek	Above Camp G Waste Dump	47	9
			Below Camp G Waste Dump	48	9
		NL4 Pond		71	9

Simplot (continued)	Smoky Canyon Mine	Pole Creek	Above Pole Canyon Waste Dump at FS station S-B&M-8	65	13
		Pole Creek	Below Pole Canyon Waste Dump at FS station S-B&M-9	66	13
		North Fork Sage Creek	Above confluence with Pole Creek	67	14
			Below confluence with Pole Creek	68	14
		Tailings Pond #1	Upper tailings pond on Roberts Creek	70	13
FMC/Simplot	Gay Mine	Ross Fork	above South 40	49	3
			below South 40	50	2
		Lincoln Creek	above North Limb	51	1
			below North Limb	52	1
		Pond #1	above A-12 Pit	53	3
		Pond #2	above A-12 Pit	54	3
		JF Lake	in JF Pit	55	2
		A-12 Lake	in A-12 Pit	56	3
		W Lake	in W Pit	57	3
		Z Lake	in Z Pit	58	3
Background	Eastern District	South Fork Sage Creek	above Phosphoria Formation	59	14
			below Phosphoria Formation	60	14
	Central District	Caldwell Creek	above Phosphoria Formation	61	10
			below Phosphoria Formation	62	10
	Western District	Grizzly Creek	above Phosphoria Formation	63	4
			below Phosphoria Formation	64	4

*The references to FS stations are to those which are now, or in the past have been, sampled by companies, per agreement with the FS, and which are identified by the stations numbers given on a map maintained by the FS.



SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS STATE OF IDAHO MAP (1976)

KEY MAP

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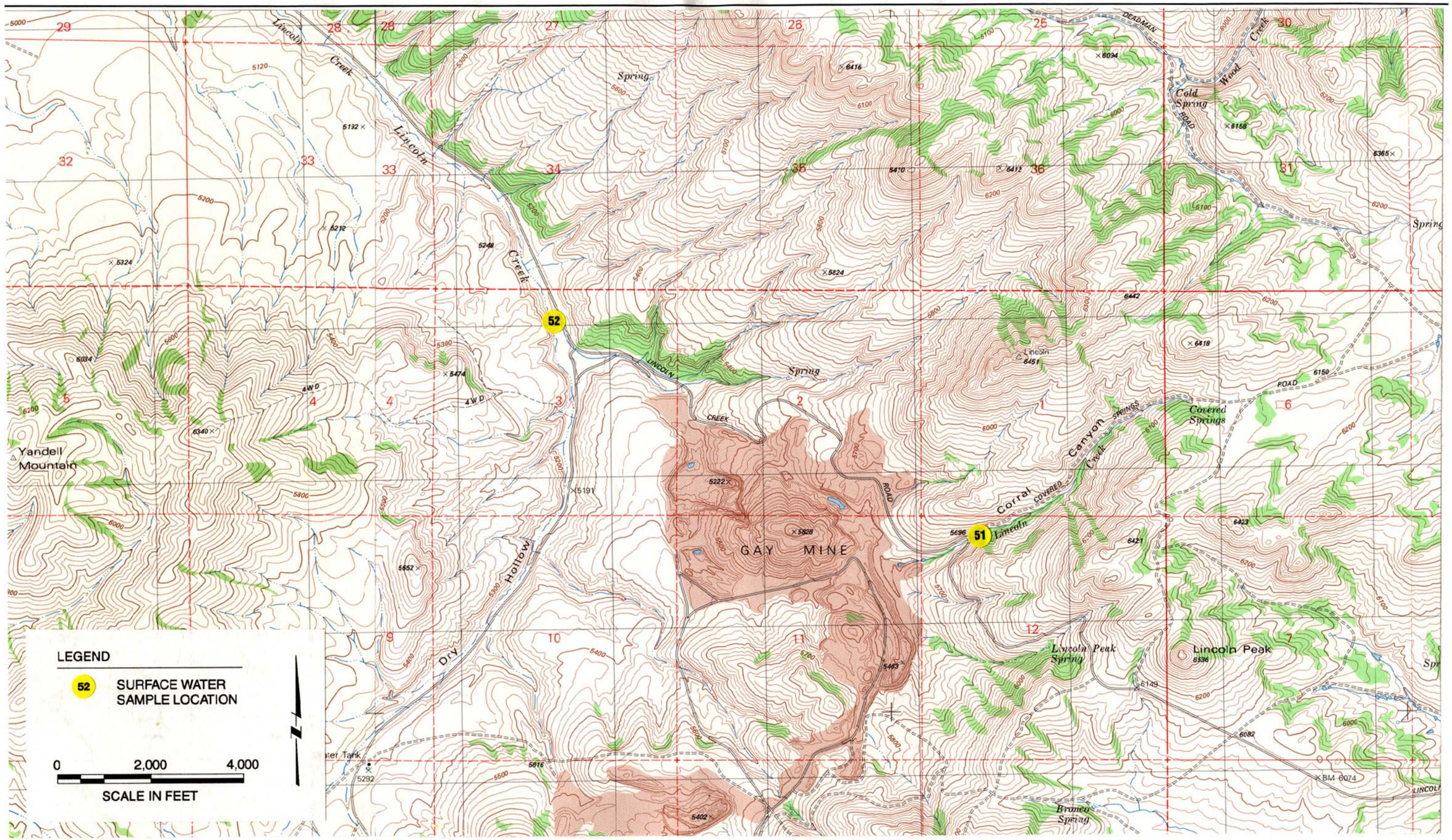

SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS YANDELL SPRINGS, IDAHO, AND LINCOLN PEAK, IDAHO, QUADRANGLE TOPOGRAPHIC MAPS (1981)

MAP 1

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SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS YANDELL SPRINGS, IDAHO, AND LINCOLN PEAK, IDAHO, QUADRANGLE TOPOGRAPHIC MAPS (1981)

MAP 2

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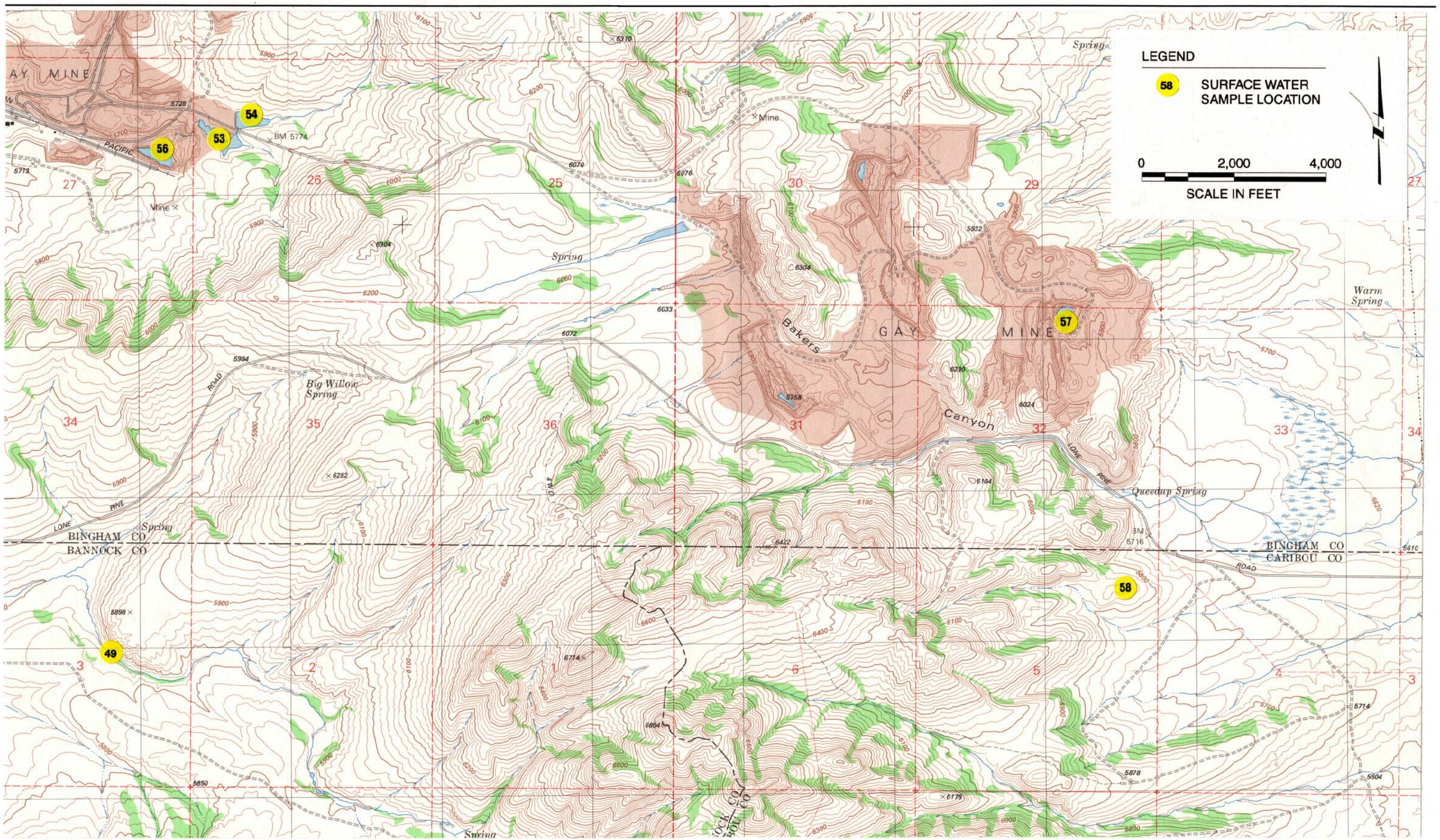
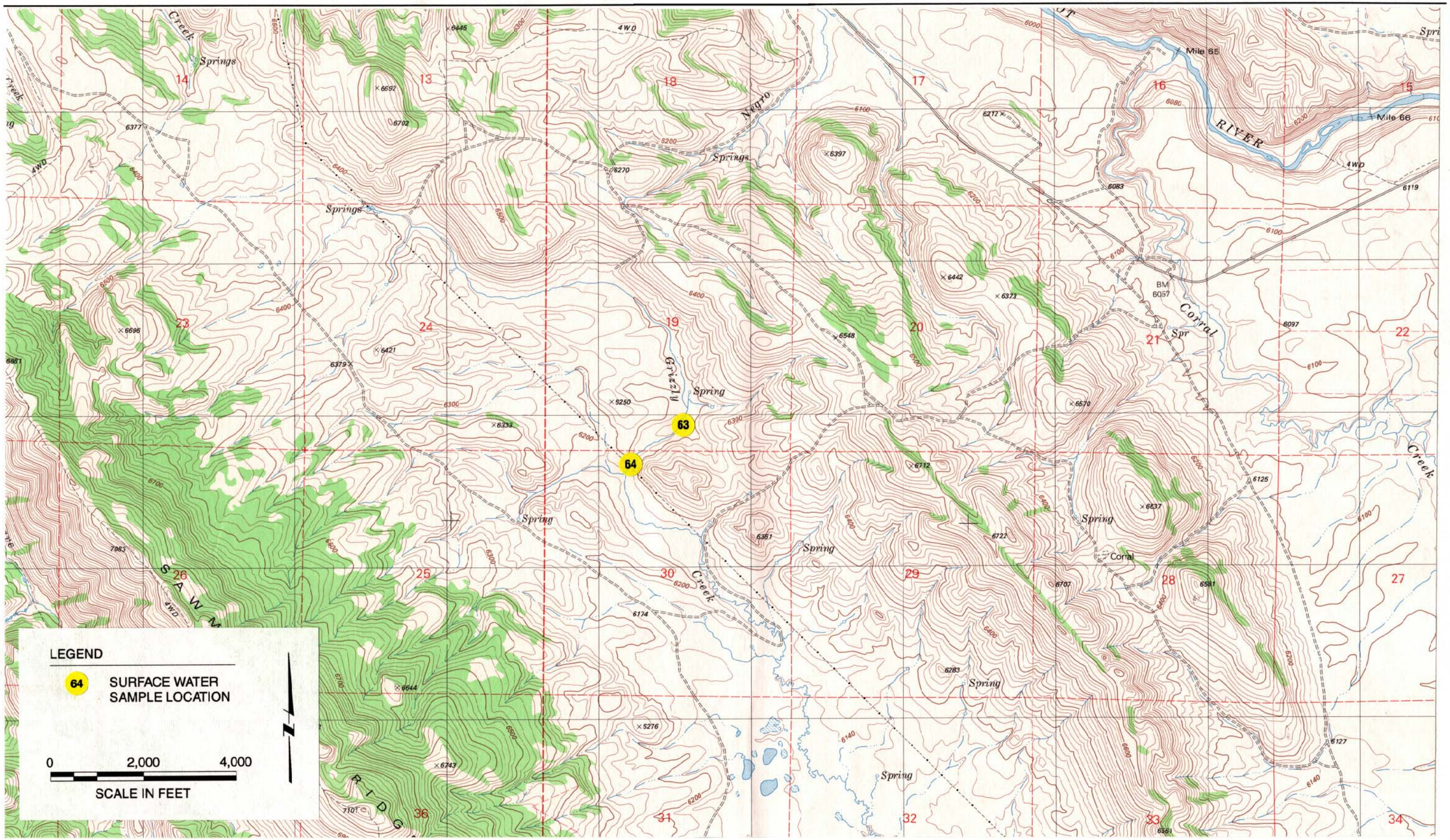


SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS LINCOLN PEAK, IDAHO, QUADRANGLE TOPOGRAPHIC MAP (1981)

MAP 3

MONTGOMERY WATSON



SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS GRIZZLY PEAK, IDAHO, QUADRANGLE TOPOGRAPHIC MAP (1981)

MAP 4

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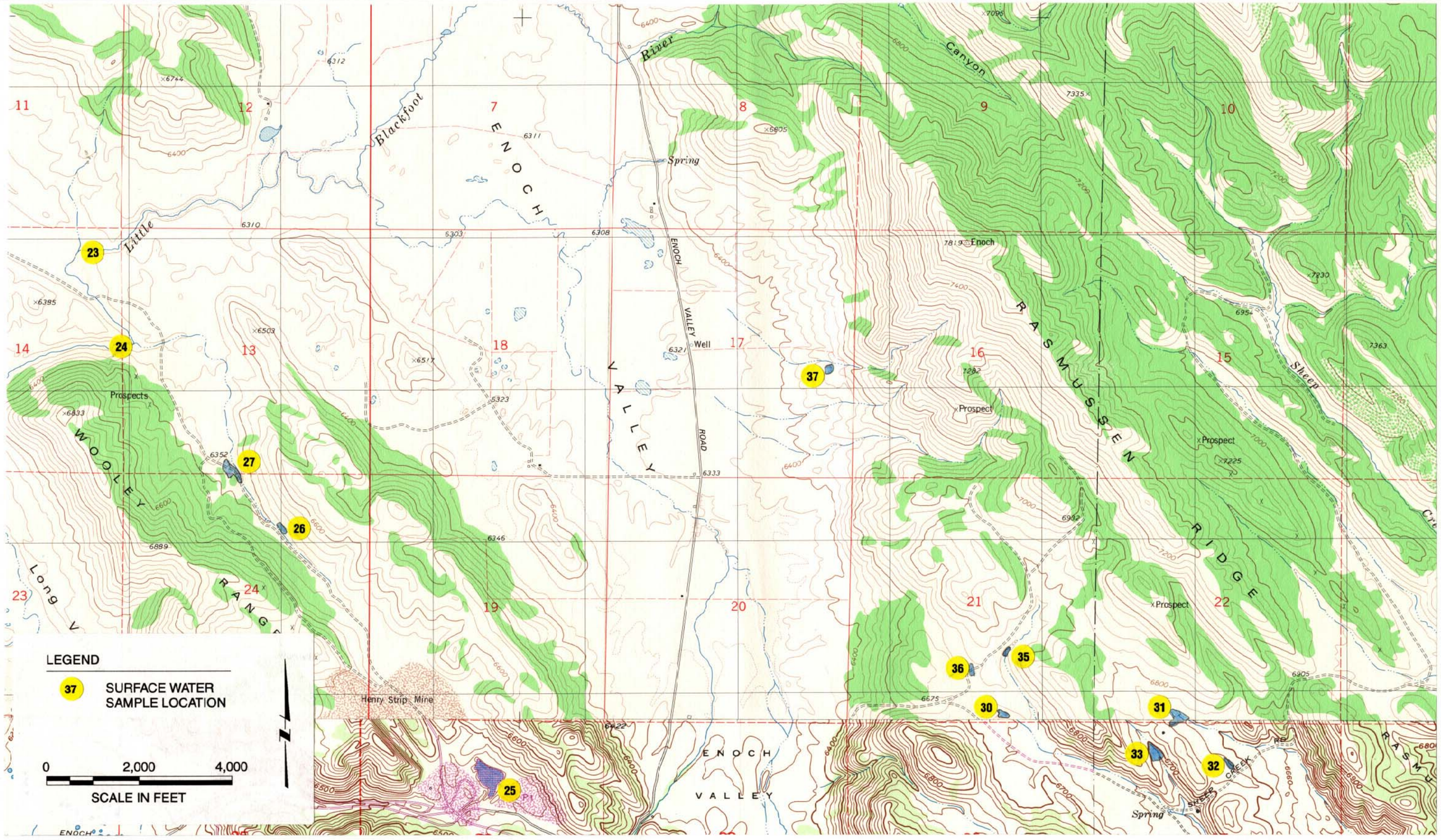

SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS WAYAN WEST, IDAHO, AND LOWER VALLEY, IDAHO, QUADRANGLE TOPOGRAPHIC MAPS (1980 AND 1984, RESPECTIVELY)

MAP 5

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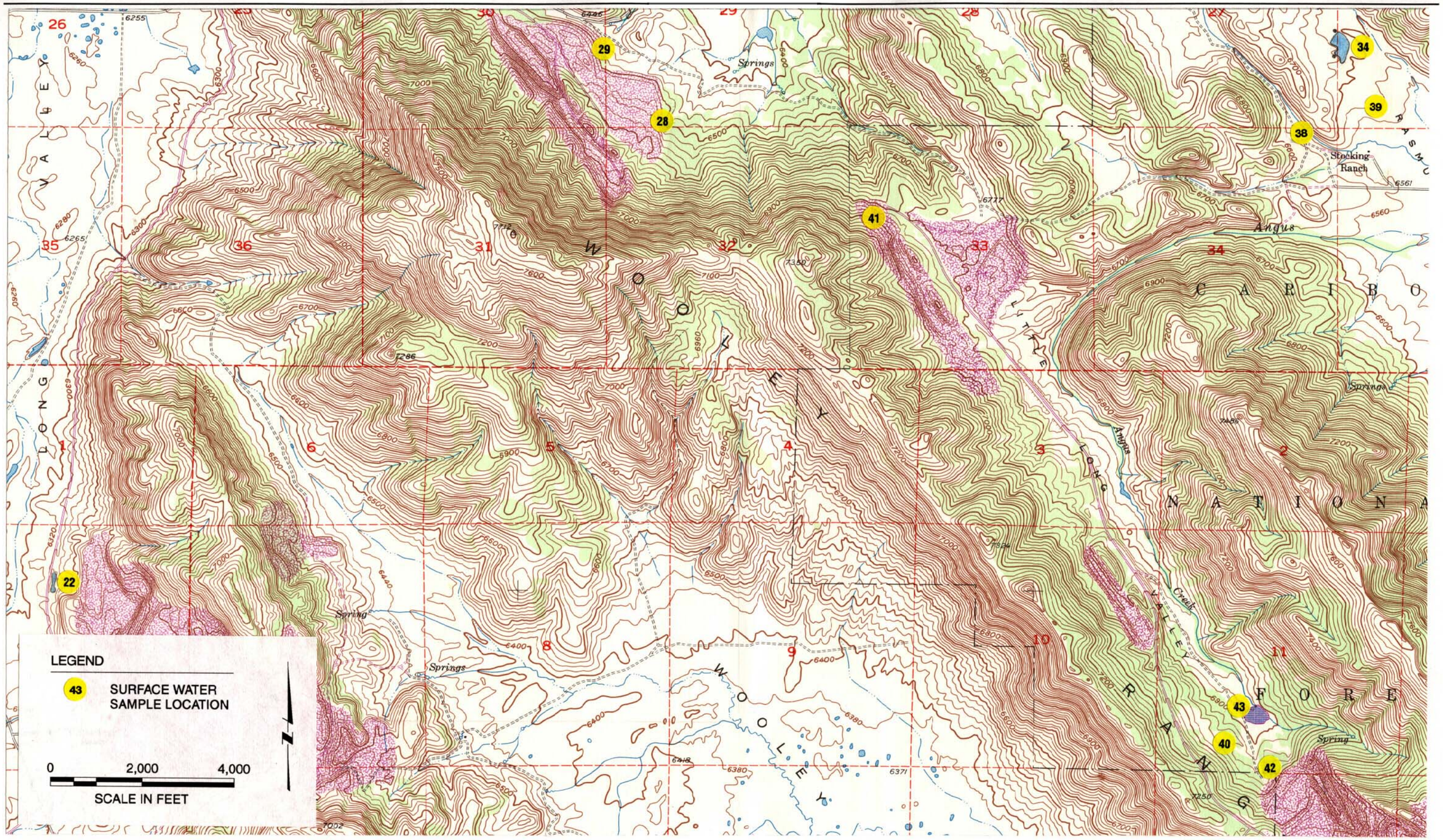

SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS LOWER VALLEY, IDAHO, QUADRANGLE TOPOGRAPHIC MAP (1984)

MAP 6

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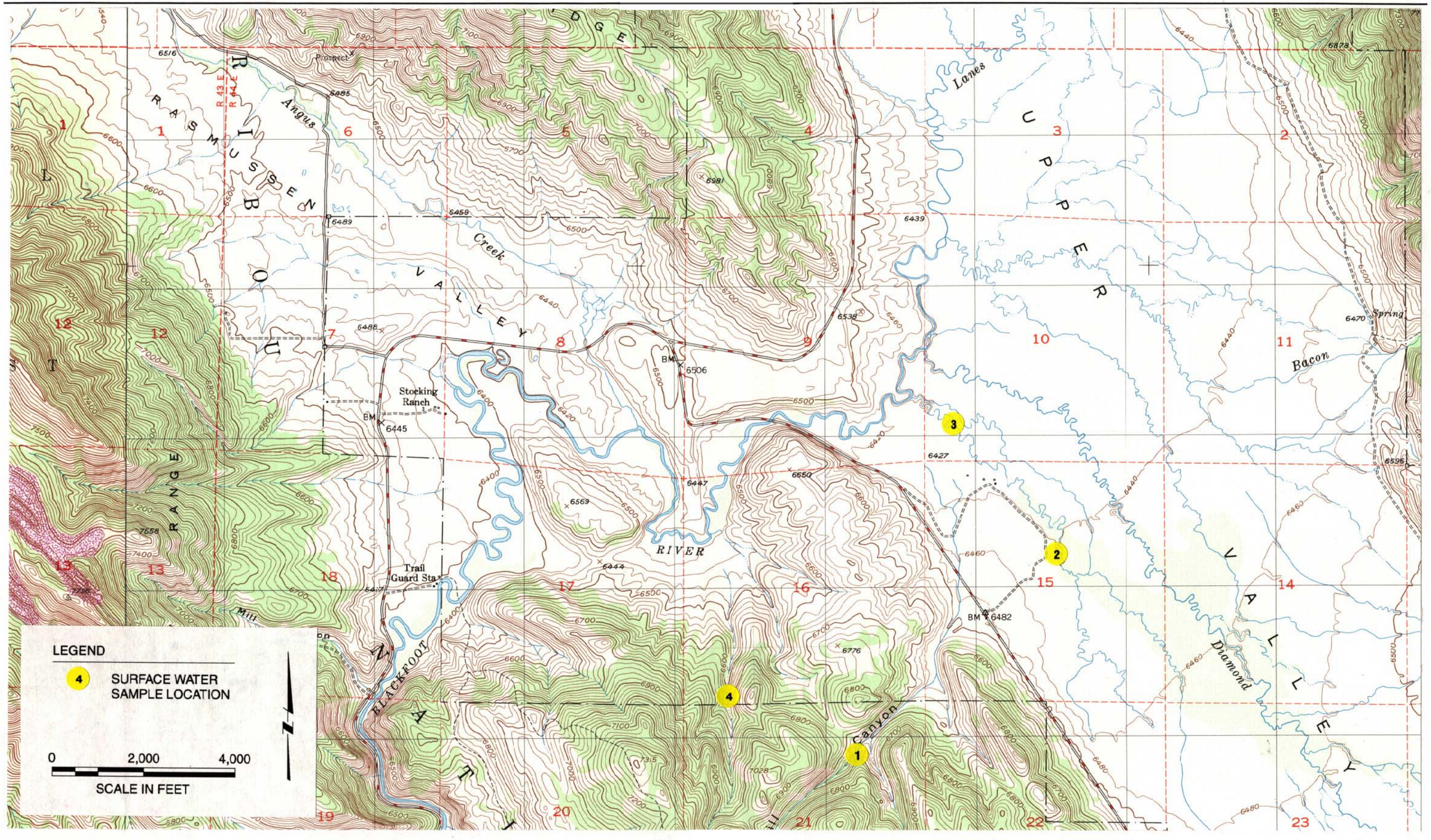

SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS LOWER VALLEY, IDAHO, AND UPPER VALLEY, IDAHO, QUADRANGLE TOPOGRAPHIC MAPS (1984 AND 1951, RESPECTIVELY)

MAP 7

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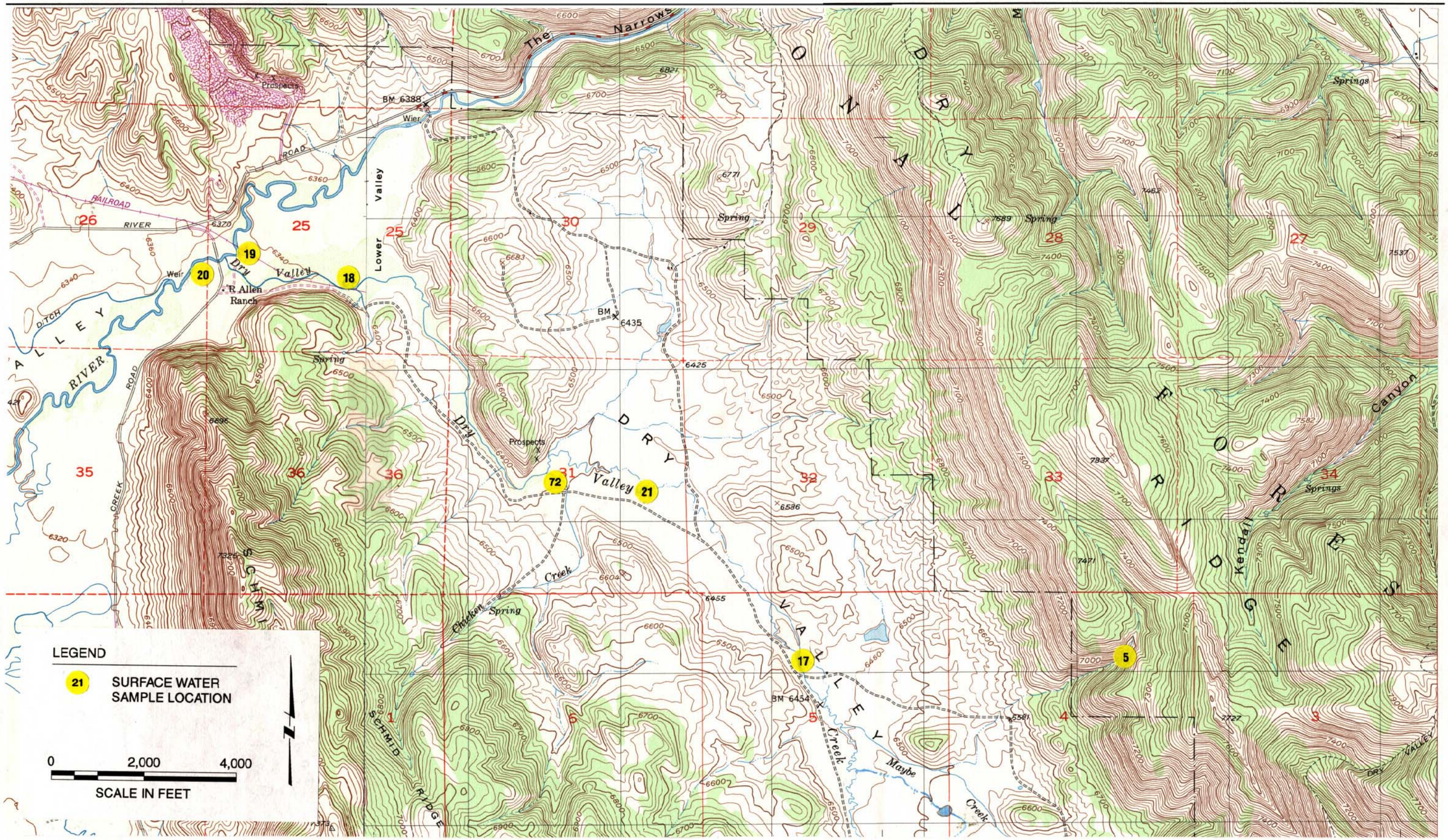

SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS LOWER VALLEY, IDAHO, AND UPPER VALLEY, IDAHO, QUADRANGLE TOPOGRAPHIC MAPS (1984 AND 1951, RESPECTIVELY)

MAP 8

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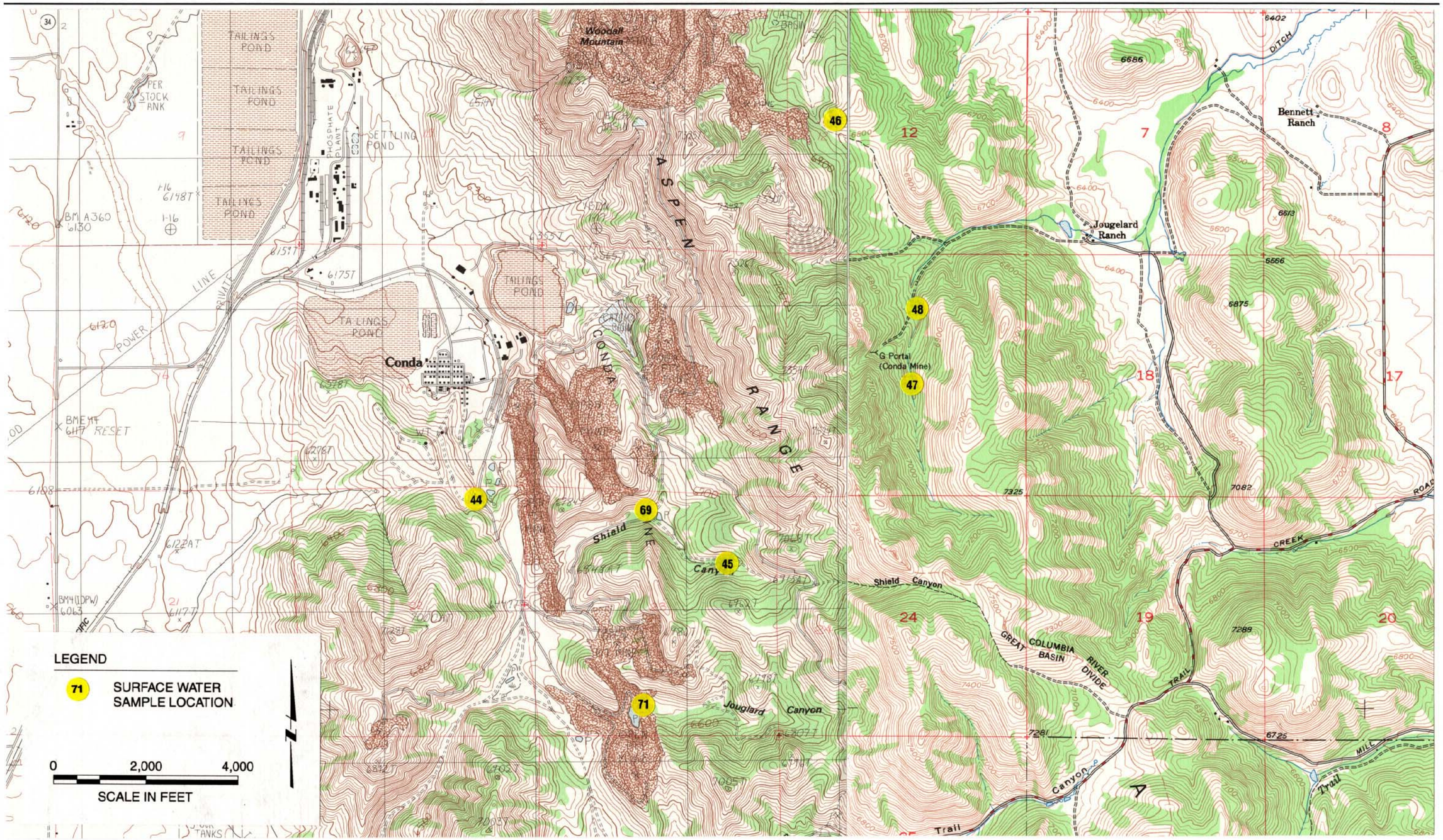

SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS SODA SPRINGS, IDAHO, AND JOHNSON CREEK, IDAHO, QUADRANGLE TOPOGRAPHIC MAPS (1982 AND 1949, RESPECTIVELY)

MAP 9

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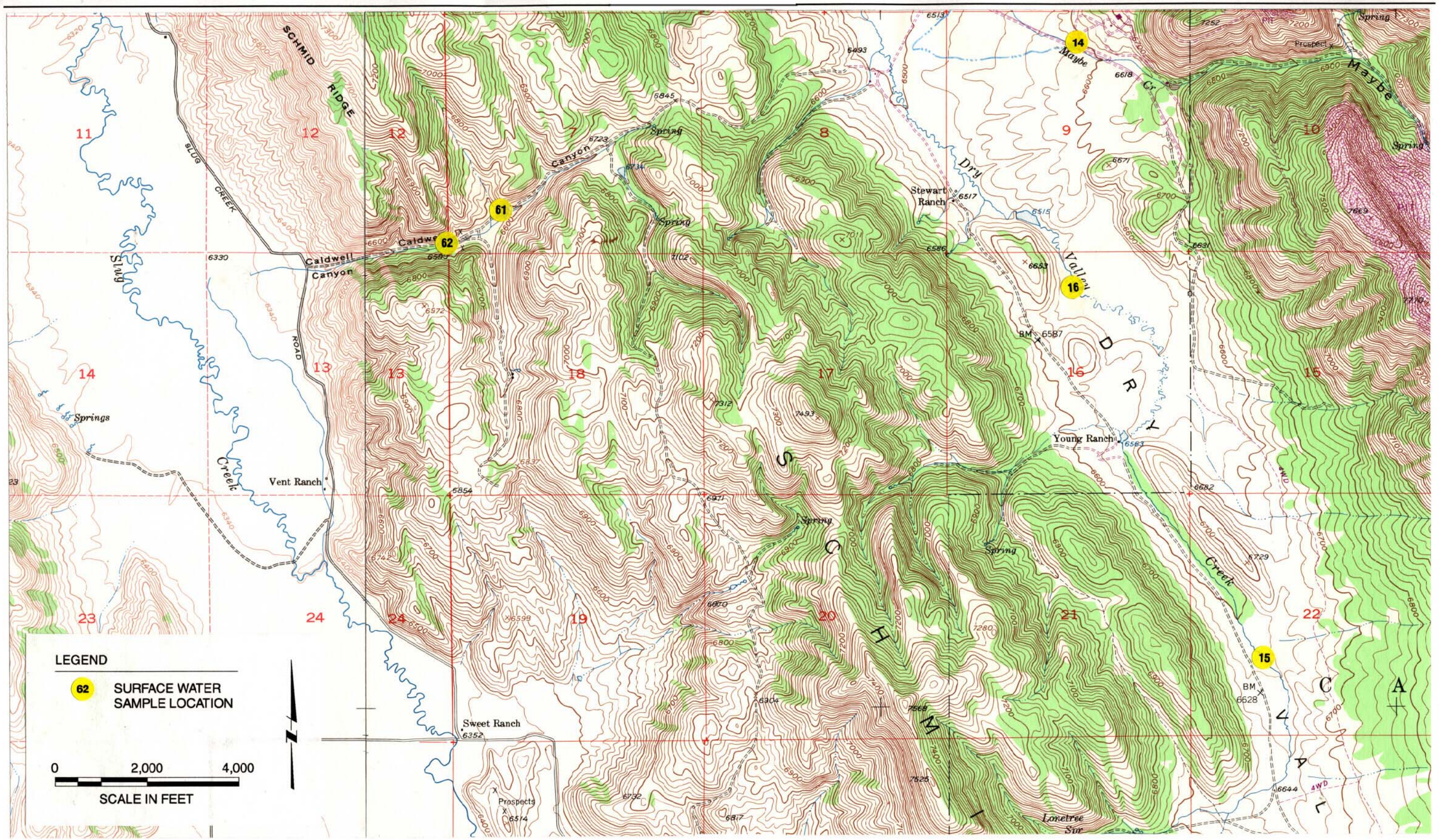

SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS JOHNSON CREEK, IDAHO, AND DRY VALLEY, IDAHO, QUADRANGLE TOPOGRAPHIC MAPS (1949 AND 1984, RESPECTIVELY)

MAP 10

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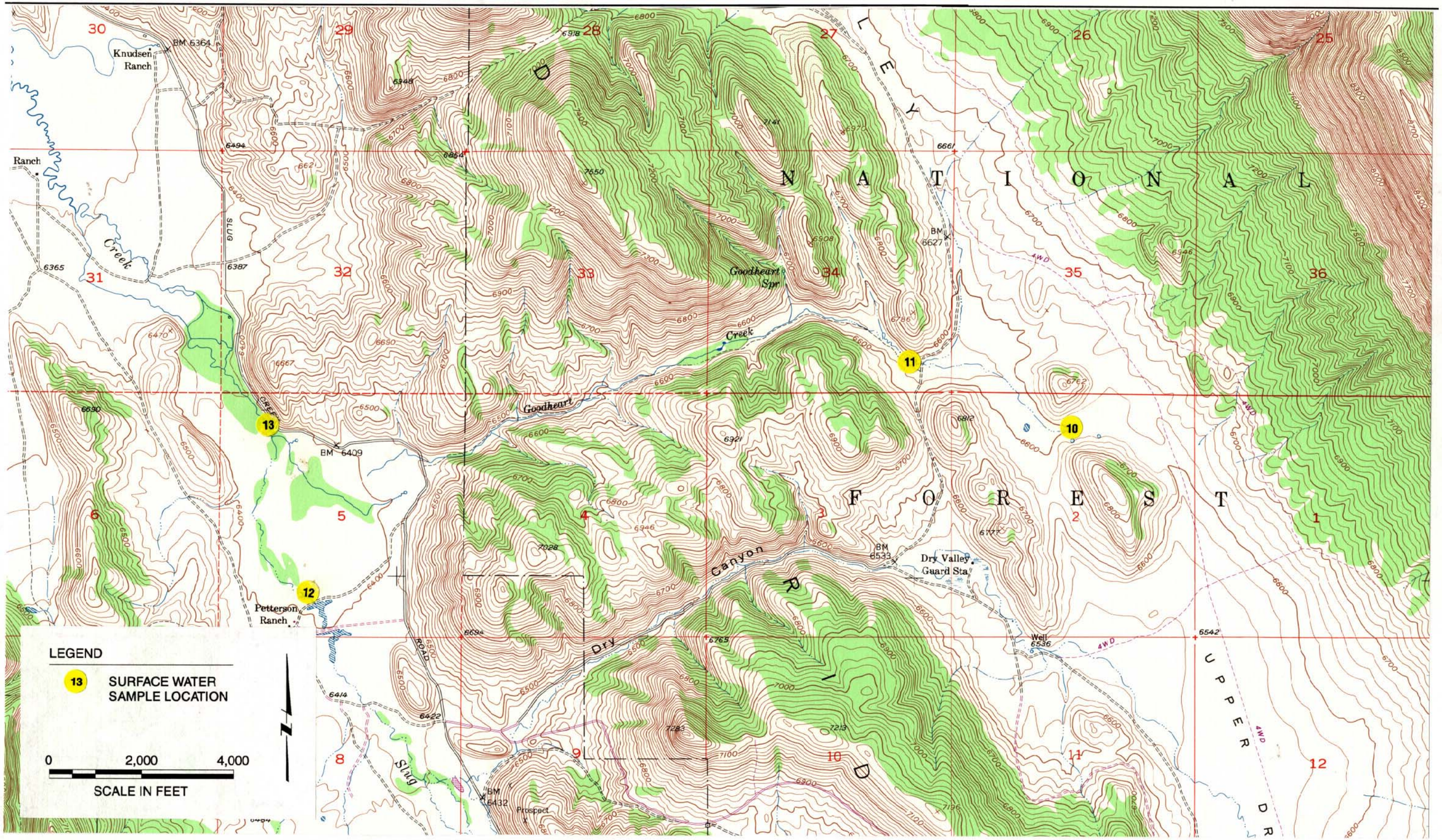
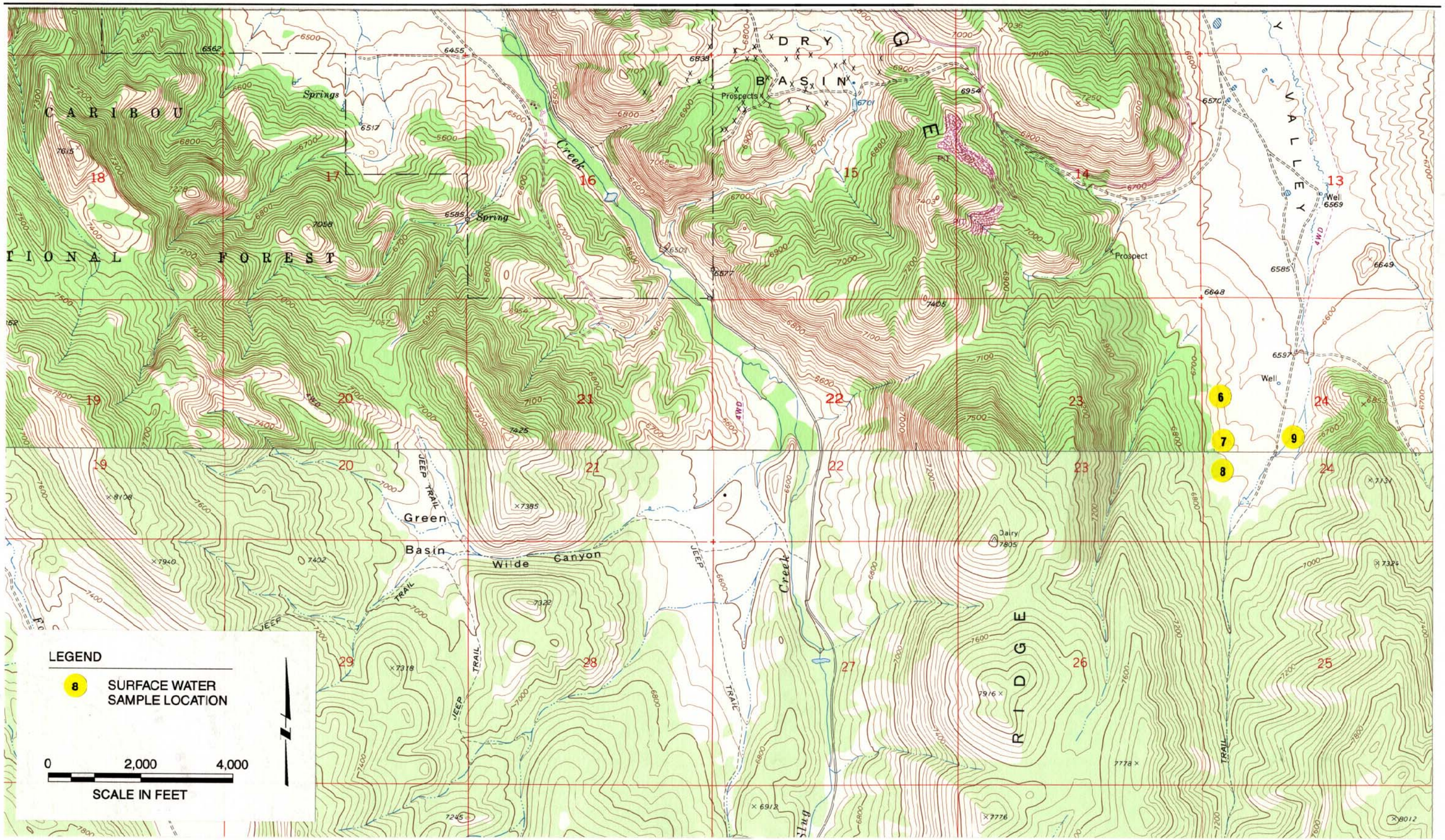


SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS DRY VALLEY, IDAHO, QUADRANGLE TOPOGRAPHIC MAP (1984)

MAP 11

MONTGOMERY WATSON

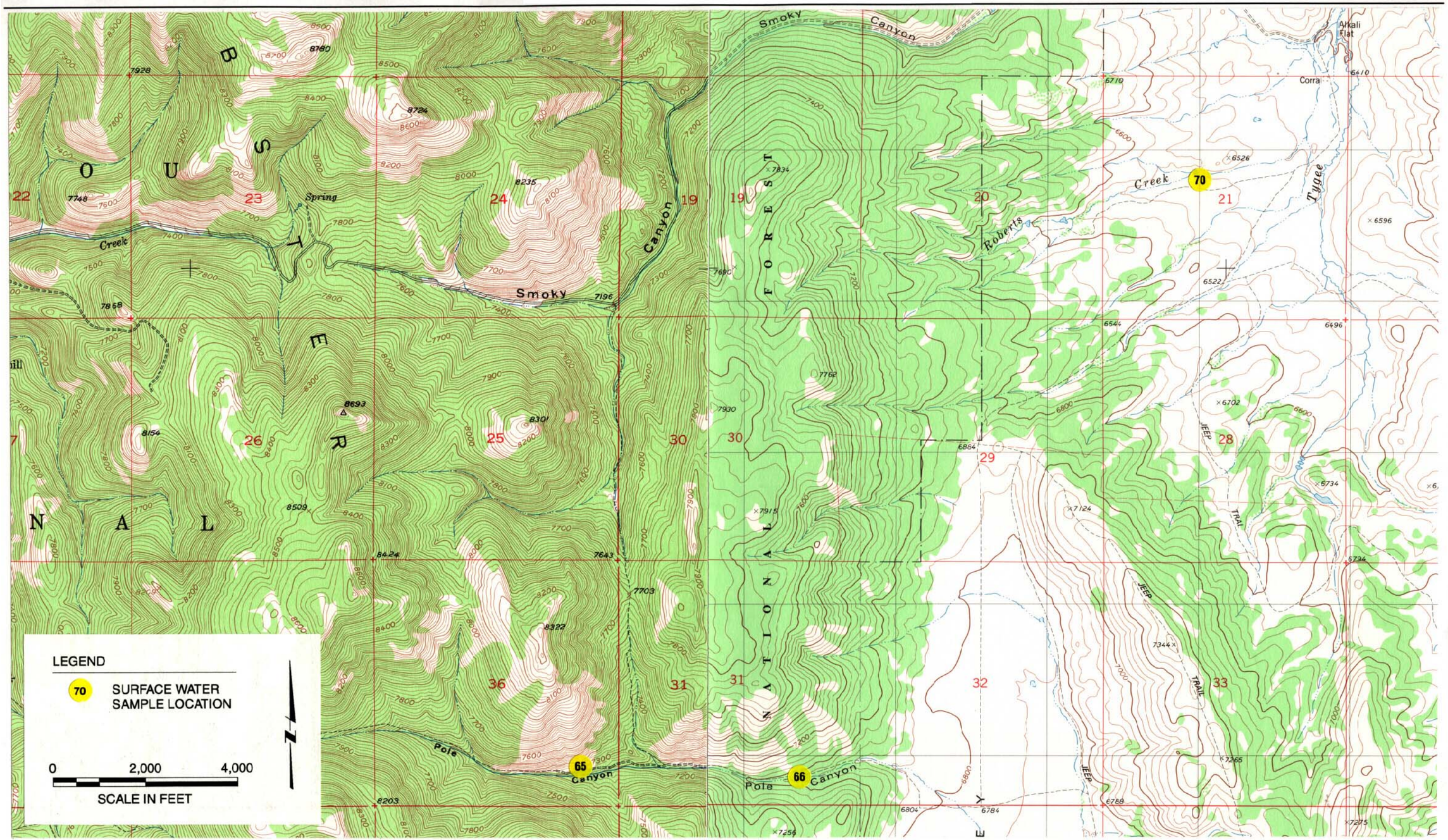


SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS DRY VALLEY, IDAHO, AND HARRINGTON PEAK, IDAHO, QUADRANGLE TOPOGRAPHIC MAPS (1984 AND 1980, RESPECTIVELY)

MAP 12

MONTGOMERY WATSON

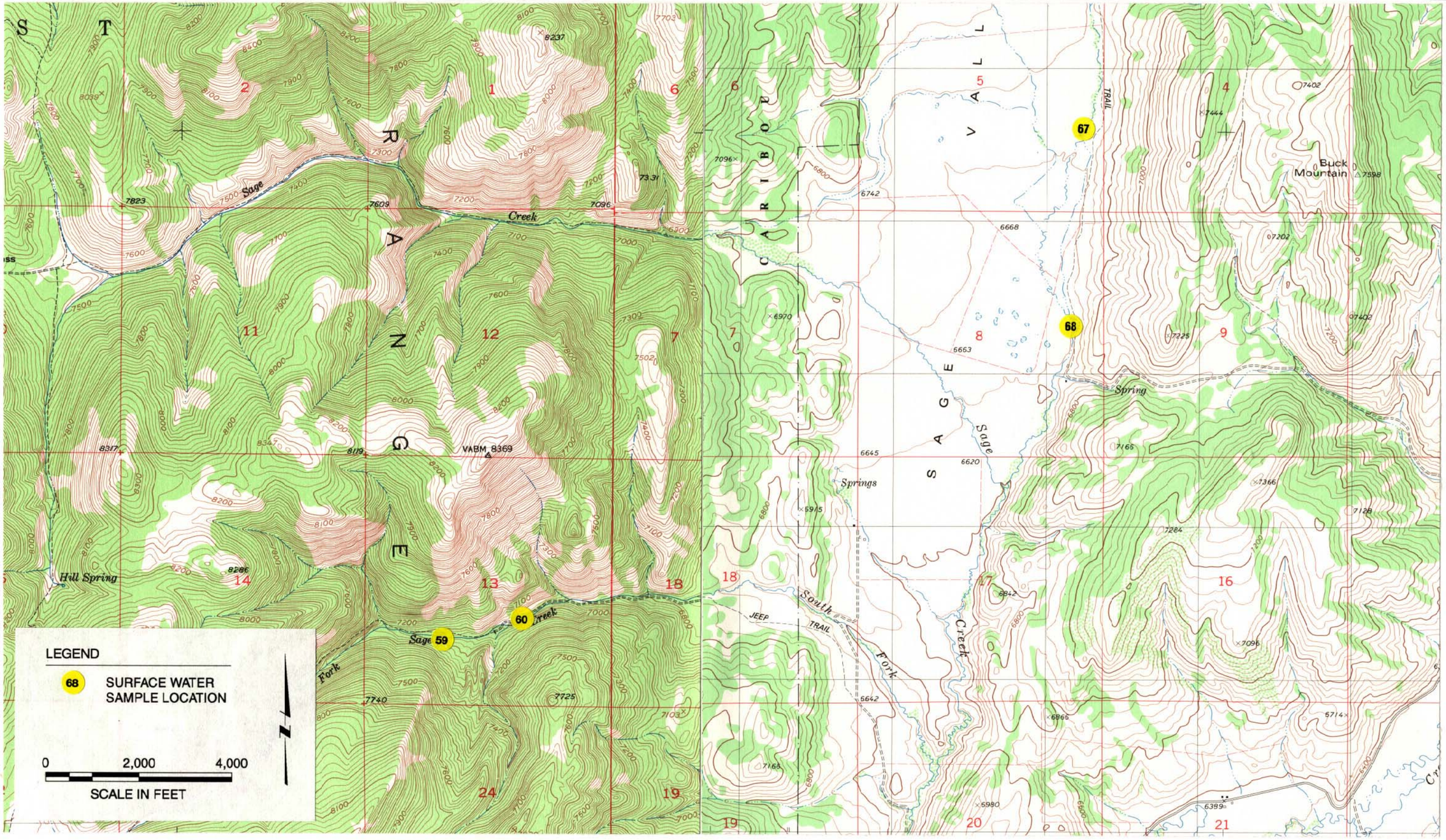


SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS STEWART FLAT, IDAHO, AND SAGE VALLEY, IDAHO-WYOMING, QUADRANGLE TOPOGRAPHIC MAPS (1949 AND 1980, RESPECTIVELY)

MAP 13

MONTGOMERY WATSON



SOUTHEAST IDAHO PHOSPHATE RESOURCE AREA—SELENIUM MONITORING PROJECT

SOURCE: USGS STEWART FLAT, IDAHO, AND SAGE VALLEY, IDAHO-WYOMING, QUADRANGLE TOPOGRAPHIC MAPS (1949 AND 1980, RESPECTIVELY)

MAP 14

MONTGOMERY WATSON

Surface water samples were collected in polyethylene containers at each station for the following laboratory analyses:

Parameter	Method of Preservation
Total Selenium	Add HNO_3 to pH ≤ 2; Cool to ≤ 4°C
Filtered selenium	Add HNO_3 to pH ≤ 2; Cool to ≤ 4°C
Total dissolved solids (TDS)	Cool to ≤ 4°C

Total selenium and TDS samples were obtained at all sample stations. Those stations located on water bodies that are known to support fish, that may support fish, or that discharge directly into known or potential fish-supporting surface water bodies at some time, even if only seasonally, required a filtered water sample. Filtered samples approximate the dissolved fraction of selenium in the water column and thus represent what fish would be exposed to; total samples include particulate matter and thus represent what vertebrates ingesting the water would be exposed to. Filtering was done in-situ or immediately from water collected in 1- or 5-liter containers filled carefully so as to minimize aeration and thermal changes.

To comply with the project QAPP, quality assurance samples were required for at least 10 percent of the stations. Therefore, such samples were obtained at eight stations. Samples were taken in triplicate at these eight stations, and an additional duplicate was obtained for analysis by the project quality control laboratory at the University of California at Davis (i.e., a total of four replicate samples will be collected at quality assurance stations). Eight stations were designated as quality assurance stations. The eight stations were selected to ensure that a wide range of selenium concentrations were evaluated, and to ensure geographic representation of each of three mining districts designated by the Interagency/Phosphate Industry Selenium Working Group—west, central, and east. Equipment blanks were taken at each of the eight quality assurance stations—one unfiltered and, as appropriate, one filtered. The quality assurance samples were analyzed for selenium only.

Field measurements were made at each sampling station for the following:

- Temperature;
- pH;
- Oxidation-reduction potential;
- Dissolved oxygen;
- Specific conductance; and
- Turbidity.

Measurements were made in-situ. As required in the QAPP, field meters were used in accordance with the manufacturer's instructions and calibration records maintained. Thermisters were calibrated once following the field effort. Meters measuring conductivity, turbidity, pH, oxidation-reduction potential, and dissolved oxygen were calibrated at each station. For quality assurance stations, triplicate measurements were made, and for pH, oxidation-reduction potential, and dissolved oxygen, the meter was switched off between replicate measurement and recalibrated prior to making each replicate measurement.

Samples were collected in accordance with MW's standard operating procedure *Collection of Surface Water Samples* (SOP-NW-9.1) as appended to the QAPP. If there was no visible discharge at a stream or seep station, or if a pond has dried up, no attempt was made to sample. No visible discharge was found at Station 5; no water was present at Station 28. Further sampling instructions specific to flowing waters, standing waters, and seeps are provided below in Sections 2.2.1, 2.2.2, and 2.2.3.

2.2.1 Stream Sampling Procedures

Where multiple stations are located in a drainage, sampling proceeded in an upstream direction to prevent the potential to disturb downstream stations. Samples were taken in mid-stream above the substrate to preclude sediment from contaminating the sample. If the sampler found it necessary to wade into the stream, the sample was taken in the upstream direction to preclude disturbed sediment from contaminating the sample.

2.2.2 Pond Sampling Procedures

If a pond was used by livestock or game as a watering hole, it was sampled from the bank where the heaviest use was apparent. The sampler waded out, where feasible, to knee depth being careful to minimize disturbance of the sediment to ensure that a representative water column sample was taken. The sample was taken in the direction of the center of the pond beyond any sediment plume that resulted from the wading.

If livestock or game use was not apparent, sampling occurred from the bank that was most easily accessible.

2.2.3 Seep Sampling Procedures

Seeps were sampled from channels located immediately downstream of the seepage.

2.3 SAMPLE STORAGE AND SHIPPING PROCEDURES

At the end of each field day, samples were stored in a locked refrigerator at the operational base at Simplot's Conda Mine slurry pump station. When appropriate, the team packaged the samples obtained during previous field work for shipment to the subcontractor laboratories. This included packaging the samples in coolers with adequate coolant for the trip, sealing the coolers to ensure maintenance of the chain of custody, filling out shipping forms, and arranging for a Simplot employee to direct the shipping company to accept delivery of the coolers.

2.4 STATISTICAL ANALYSES

Preliminary data from the interim sampling was used in initial hypothesis testing. For example, the following null hypotheses were tested statistically as part of the interim survey:

- The Blackfoot River is not affected, at one point in time, by selenium releases in the Dry Valley Creek watershed.
- Certain potential fish-bearing waters do not exceed, at one point in time, a selenium dissolved concentration of 0.005 mg/L.
- A certain background stream does not experience, at one point in time, an increase in selenium concentration due to crossing the Phosphoria Formation.

In addition, statistical analyses were conducted to support the data validation process.

There are two general uses of statistics: describing data and performing tests of significance (Green, 1979). In order to do the latter, one must, before the fact, formulate a null hypothesis. A null hypothesis is one that can never scientifically be proven, but can only be rejected with a known risk of being wrong, typically 5 percent. A null hypothesis must be falsifiable, and should be the simplest possible explanation of the situation that is consistent with the available evidence. If a null hypothesis is rejected, one then adopts the alternative hypothesis as a working premise. The alternative hypothesis should be the hierarchically next more complicated explanation. Therefore, as

an example, the alternative hypothesis corresponding to the last null hypothesis presented above—no increase in selenium concentration due to flow across the Phosphoria Formation—is that the selenium concentration does increase.

The statistical methods and formulas that were used in preparing this report are presented in Appendix A.

3.0 Survey Results

3.1 SELENIUM CONCENTRATIONS

Selenium concentrations in each sample are presented in Table 3-1. Those samples analyzed by the primary laboratory, the University of Idaho's Analytical Sciences Laboratory, have laboratory identification numbers starting with W. Those samples analyzed by the quality assurance (QA) laboratory, the University of California at Davis's Veterinary Diagnostic Laboratory, have laboratory identification numbers starting with D.

3.1.1 Data Quality Considerations

The data have not been censored. That is, results below the laboratory reporting limit for selenium, 0.00074 mg/L, are not reported as less than 0.00074 mg/L in this report. At Montgomery Watson's request, both laboratories provided the actual estimates for those results that are lower than the typical reporting limit. Because of this, there are some negative values in the data set. From a laboratory analytical perspective, this is normal, expected, and, in fact, desirable. For example, samples that are known to have no selenium, such as method blanks, or samples that are expected to have no selenium, such as equipment blanks, would, under ideal conditions, yield negative values about half the time.

A statistical evaluation of the blanks shows a slight, but discernible, positive bias. The University of Idaho blanks yielded an average selenium concentration of 0.00019 mg/L. It would be appropriate to subtract this amount from each result from the primary laboratory presented in Table 3-1, but this has not been done given that the correction would be insignificant for all practical purposes. Rather, an upper 95 percent confidence bound on the 95th percentile of the distribution of blank values has been calculated to be 0.00074 mg/L for the primary laboratory. Results less than this value, which are italicized in Table 3-1, should be regarded as estimated concentrations that are not discernibly different from 0 mg/L. The corresponding value for the QA laboratory blanks is 0.00651 mg/L, a much higher value primarily because the QA laboratory appropriately, given that they were assigned far fewer samples for analysis, analyzed far fewer blanks than did the primary laboratory. Statistical analysis of the laboratory and equipment blanks, as discussed in Appendix A, shows that each laboratory's blank results validate the other's.

The benefit in not censoring the data, that is, in retaining laboratory-estimated values below the laboratory reporting limit, is realized when the data are statistically analyzed. With censored data sets, results less than the reporting limit have to be estimated prior to conducting a statistical

Table 3-1
Analytical Results - Selenium by ICP using Hydride Digestion
Fall 1997 Interim Surface Water Survey
Southeast Idaho Phosphate Resource Area

Station[1]	Mine	Water Body	Location	Map	Field Sample ID[2]	Laboratory ID[3]	Analytical Result (mg/l)
1	North Maybe Mine	Mill Creek	Below East Mill Dump Seep at FS station C-B&M-1	7	091697SW1-0-U	W9701843	**0.0336**
1					091697SW1-0-F	W9701842	**0.0346**
2		Spring Creek	Above confluence with Mill Creek at FS station C-B-2	7	091797SW02-0-U	W9701852D	*0.000303*
2					091797SW02-0-F	W9701853	*0.00039*
2					091797SW02-0-U	W9701852	*0.000447*
3			Below confluence with Mill Creek at FS station C-B-1	7	091797SW03-0-F	W9701850	0.00254
3					091797SW03-0-U	W9701851	0.00281
4		North Dry Ridge Creek	Headwaters spring at FS station C-B&M-2	7	091797SW04-0-U	W9701855	0.000883
4					091797SW04-0-F	W9701854	0.000962
5		Big Draw	Below upper Big Draw Dump Seep	8	No sample - dry		
6	Mountain Fuel Mine	New Spring #1		12	091697SW06-0-U	W9701844D	**0.0431**
6					091697SW06-0-U	W9701844	**0.0431**
7		New Spring #2		12	091697SW07-0-U	W9701845	**0.0299**
8		New Spring #3		12	091697SW08-0-U	W9701846	0.0034
9		Stock Pond		12	091697SW09-0-U	W9701847	**0.00538**
10	Champ Mine	Goodheart Creek	Headwaters spring below Champ Mine dumps	11	091797SW10-0-F	W9701857	**0.0149**
10					091797SW10-0-U	W9701856	**0.015**
11			Upper reach at FS station C-B&M-3	11	091697SW11-0-F	W9701849	**0.00568**
11					091697SW11-0-U	W9701848	**0.007**
12		Slug Creek	Above confluence with Goodheart Creek	11	092097SW12-0-U	W9701980	*0.000506*
12					092097SW12-0-F	W9701978	*0.000634*
13			Below confluence with Goodheart Creek	11	091997SW13-0-U	W9701974	0.00112
13					091997SW13-0-F	W9701973	0.00132
14	Dry Valley Mine	Maybe Creek	Above confluence with Dry Valley Creek at FMC station MB2	10	091797SW14-0-F	W9701869	***0.466***
14					091797SW14-0-U	W9701870	***0.474***
15		Dry Valley Creek	Above Dry Valley Mine at FMC station DV7	10	091797SW15-0-F	W9701858	*0.000362*
15					091797SW15-0-U	W9701859	*0.000667*
16			Above confluence with Maybe Creek at FMC station DV6	10	091797SW16-0-U	W9701860	*0.00017*
16					091797SW16-0-F	W9701861	*0.000259*
17			Below confluence with Maybe Creek at FMC station DV3	8	091797SW17-0-U	W9701871	***0.139***
17					091797SW17-0-F	W9701872	***0.148***
18			Below Dry Valley Mine at FMC station DV2	8	091797SW18-0-F	W9701864	0.00107
18					091797SW18-0-U	W9701863	0.00128
19		Blackfoot River	Above confluence with Dry Valley Creek at FMC station BF2	8	091797SW19-4-U	D9708174-9	0.0017
19					091797SW19-4-F	D9708174-10	0.0018
19					091797SW19-3-F	W9701879	0.00198
19					091797SW19-3-U	W9701878	0.00210
19					091797SW19-1-F	W9701875	0.00226
19					091797SW19-2-U	W9701877D	0.00226
19					091797SW19-2-U	W9701877	0.00232
19					091797SW19-1-U	W9701874	0.00281
19					091797SW19-2-F	W9701876D	0.00302
19					091797SW19-2-F	W9701876	0.00360
20			Below confluence with Dry Valley Creek at FMC station BF1	8	091897SW20-4-U	D9708174-5	0.0017
20					091897SW20-4-F	D9708174-6	0.0018
20					091897SW20-2-U	W9701936D	0.00190
20					091897SW20-2-F	W9701937	0.00193
20					091897SW20-2-U	W9701936	0.00207
20					091897SW20-3-F	W9701939	0.00209

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Fall 1997 Interim Surface Water Survey
Southeast Idaho Phosphate Resource Area

Station[1]	Mine	Water Body	Location	Map	Field Sample ID[2]	Laboratory ID[3]	Analytical Result (mg/l)
20					091897SW20-3-U	W9701938	0.00210
20					091897SW20-1-F	W9701935	0.00212
20					091897SW20-2-F	W9701937D	0.00213
20					091897SW20-1-U	W9701934	0.00214
20					091897SW20-3-U	W9701938D	0.00259
21		Pit Dewatering Pond	FMC station PD1	8	091797SW21-0-U	W9701862	***0.113***
22	Ballrd Mine	Dredge Pond		6	091897SW22-0-U	W9701929	***0.150***
23	Henry Mine	Little Blackfoot River	Above Henry Mine	5	091997SW23-0-F	W9701943	*0.000738*
23					091997SW23-0-U	W9701942	0.000808
24			Below Henry Mine	5	091997SW24-0-F	W9701945	0.000791
24					091997SW24-0-U	W9701944	0.00106
25		Henry Pond		5	091997SW25-0-U	W9701952	**0.00669**
26		Smith Pond		5	091997SW26-4-U	D9708174-1	**0.0335**
26					091997SW26-2-U	W9701949	**0.0411**
26					091997SW26-2-U	W9701949D	**0.0413**
26					091997SW26-3-U	W9701950	**0.0414**
26					091997SW26-1-U	W9701948	**0.0435**
27		Center Henry Pond		5	091997SW27-0-U	W9701946	**0.0248**
28		Pasture #3 Seep	Below South Pit Overburden Dump	6	No sample - dry		
29		Coarse Rock Fill Seep	Below South Pit Overburden Dump	6	091997SW29-0-U	W9701947	0.00106
30	Enoch Valley Mine	Shop Pond		5	091897SW30-0-U	W9701921	**0.00512**
31		Stock Pond		5	091897SW31-4-U	D9708174-2	**0.0218**
31					091897SW31-2-U	W9701916D	**0.0246**
31					091897SW31-2-U	W9701916	**0.0247**
31					091897SW31-3-U	W9701917	**0.0249**
31					091897SW31-1-U	W9701919	**0.0277**
32		Bat Cave Pond		5	091897SW32-0-U	W9701920	**0.0161**
33		West Pond		5	091897SW33-0-U	W9701924	**0.0214**
34		South Pond		6	091897SW34-0-U	W9701926	**0.00914**
35		Tipple Pond		5	091897SW35-0-U	W9701925	***0.0708***
36		Haul Road Pond		5	091897SW36-0-U	W9701923	***0.0650***
37		North Pond		5	091897SW37-0-U	W9701922	***0.185***
38		Center Fork Angus Creek	At FS station M-B&M-1	6	091897SW38-0-U	W9701927	0.00127
38					091897SW38-0-F	W9701928	0.00148
39	Wooley Valley Mine	Large Haul Road Pond		6	091997SW39-0-U	W9701963	***0.0750***
40		Unit III Panel E Pond		6	091997SW40-0-U	W9701953	***0.0746***
41		Unit III Panel F Pond		6	091997SW41-0-U	W9701965	***0.0980***
42		Unit III Overburden Dump Seep		6	091997SW42-0-U	W9701964	***0.0650***
43		Upper Angus Creek Reservoir	FS station R-B&M-12	6	091897SW43-4-U	D9708174-3	0.0008
43					091897SW43-4-F	D9708174-4	0.0009
43					091997SW43-3-F	W9701956	0.00133
43					091997SW43-2-F	W9701961	0.00149
43					091997SW43-2-U	W9701962	0.00151
43					091997SW43-3-U	W9701958	0.00153
43					091997SW43-2-U	W9701962D	0.00157
43					091997SW43-2-F	W9701961D	0.00162
43					091997SW43-1-F	W9701954	0.00192
43					091997SW43-1-U	W9701957	0.00193

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Analytical Results - Selenium by ICP using Hydride Digestion
Fall 1997 Interim Surface Water Survey
Southeast Idaho Phosphate Resource Area

Station[1]	Mine	Water Body	Location	Map	Field Sample ID[2]	Laboratory ID[3]	Analytical Result (mg/l)
44	Conda Mine	SL3 French Drain		9	092097SW44-0-U	W9701966	***0.0647***
44					092097SW44-0-U	W9701966D	***0.0653***
45		Hoorah Hollow	Flow from underground mine pond	9	092297SW45-0-U	W9702008	0.00222
45					092297SW45-0-F	W9702012	0.00270
46		SW3 Perennial Seep		9	092297SW46-0-U	W9702011	***1.55***
47		Camp G Creek	Above Camp G Waste Dump	9	092097SW47-0-F	W9701970	*0.000285*
47					092097SW47-0-U	W9701972D	*0.000397*
47					092097SW47-0-U	W9701972	*0.000493*
48			Below Camp G Waste Dump	9	092097SW48-0-F	W9701971	0.000984
48					092097SW48-0-U	W9701968	0.000999
49	Gay Mine	Ross Fork	Above South 40	3	092297SW49-0-F	W9702018	*0.000509*
49					092297SW49-0-U	W9702017	*0.000509*
50			Below South 40	2	092197SW50-0-F	W9702014D	*0.000360*
50					092197SW50-0-F	W9702014	*0.000517*
50					092197SW50-0-U	W9702013	*0.000655*
51		Lincoln Creek	Above North Limb	1	092297SW51-0-U	W9702020D	*0.000634*
51					092297SW51-0-U	W9702020	0.000744
51					092297SW51-0-F	W9702021	0.000781
52			Below North Limb	1	092297SW52-0-U	W9702016	0.000871
52					092297SW52-0-F	W9702023	0.000915
53		Pond #1	above A-12 Pit	3	092397SW53-0-U	W9702010	0.000951
54		Pond #2	above A-12 Pit	3	092397SW54-0-U	W9702009	0.00139
55		JF Lake	in JF Pit	2	092297SW55-0-U	W9702015	**0.0468**
56		A-12 Lake	in A-12 Pit	3	092397SW56-0-U	W9702006	***0.100***
57		W Lake	in W Pit	3	092397SW57-0-U	W9702022	*0.000441*
58		Z Lake	in Z Pit	3	092297SW58-0-U	W9702019	***0.0583***
59	Eastern District	South Fork Sage Creek	above Phosphoria Formation	14	091597SW59-0-U	W9701828	*0.000471*
59					091597SW59-0-F	W9701827	*0.000521*
60			below Phosphoria Formation	14	091597SW60-0-U	W9701826	*(0.000112)*
60					091597SW60-0-F	W9701825	0.000753
61	Central District	Caldwell Creek	above Phosphoria Formation	10	091897SW61-0-F	W9701933	*0.000376*
61					091897SW61-0-U	W9701932	*0.000541*
62			below Phosphoria Formation	10	091897SW62-0-U	W9701930D	*0.000385*
62					091897SW62-0-F	W9701931	*0.000424*
62					091897SW62-0-U	W9701930	*0.000704*
63	Western District	Grizzly Creek	above Phosphoria Formation	4	092097SW63-4-F	D9708174-8	*0.0001*
63					092097SW63-4-U	D9708174-7	*0.0001*
63					092097SW63-1-U	W9701982	*0.000151*
63					092097SW63-1-F	W9701983	*0.000206*
63					092097SW63-3-F	W9701985	*0.000283*
63					092097SW63-2-F	W9701984D	*0.000334*
63					092097SW63-2-F	W9701984	*0.000340*
63					092097SW63-2-U	W9701992	*0.000449*
63					092097SW63-3-U	W9701986	*0.000520*
63					092097SW63-2-U	W9701992D	*0.000624*
64			below Phosphoria Formation	4	091797SW64-4-F	D9708174-12	*0.0002*
64					092097SW64-4-U	D9708174-11	*0.0002*
64					092097SW64-1-F	W9701988	*0.000380*
64					092097SW64-1-U	W9701975	*0.000525*

Table 3-1
Analytical Results - Selenium by ICP using Hydride Digestion
Fall 1997 Interim Surface Water Survey
Southeast Idaho Phosphate Resource Area

Station[1]	Mine	Water Body	Location	Map	Field Sample ID[2]	Laboratory ID[3]	Analytical Result (mg/l)
64					092097SW64-3-U	W9701987	*0.000587*
64					092097SW64-2-F	W9701976D	*0.000716*
64					092097SW64-3-F	W9701981	*0.000720*
64					092097SW64-2-F	W9701976	0.000762
64					092097SW64-2-U	W9701977D	0.000876
64					092097SW64-2-U	W9701977	0.000914
65	Smoky Canyon Mine	Pole Creek	Above Pole Canyon Waste Dump at FS station S-B&M-8	13	091597SW65-0-F	W9701822	*(0.0000797)*
65					091597SW65-0-U	W9701821	*0.000432*
66			Below Pole Canyon Waste Dump at FS station S-B&M-9	13	091597SW66-2-F	W9701834D	***0.557***
66					091597SW66-2-F	W9701834	***0.558***
66					091597SW66-2-U	W9701833	***0.566***
66					091597SW66-3-F	W9701836	***0.571***
66					091597SW66-3-U	W9701837	***0.580***
66					091597SW66-2-U	W9701833D	***0.592***
66					091597SW66-1-U	W9701831	***0.612***
66					091597SW66-1-F	W9701832	***0.63***
67		North Fork Sage Creek	Above confluence with Pole Creek	14	091697SW67-0-U	W9701839	0.00337
67					091697SW67-0-F	W9701838	**0.00546**
68			Below confluence with Pole Creek	14	091697SW68-0-U	W9701840	0.00323
68					091697SW68-0-F	W9701841	0.00371
69	Conda Mine	Hoorah Hollow	Pond	9	092097SW69-0-F	W9701969	*0.000332*
69					092097SW69-0-U	W9701967	*0.000372*
70	Smoky Canyon Mine	Tailings Pond #1	Upper tailings pond on Roberts Creek	13	091597SW70-0-F	W9701824	**0.0101**
70					091597SW70-0-U	W9701823	**0.0101**
70					091597SW70-0-F	W9701824D	**0.0105**
71	Conda Mine	NL4 Pond		9	092297SW71-0-U	W9702007	***0.151***
72	Dry Valley Mine	Chicken Creek	Above confluence with Dry Valley Creek at FMC station CC1	8	091797SW72-0-F	W9701868	**0.00513**
72					091797SW72-0-U	W9701867	**0.00549**

1 Stations 5 and 28 were found to be dry.

2 First five digits indicates the date in order of month-day-year; next two letters indicate the media sampled (in this case, surface water); the following three digits indicate the station number and the replicate number, respectively; the final letter indicates if the sample is unfiltered (U) or filtered (F).

3 Lab samples starting with the letter W have been analyzed by the University of Idaho Holm Research Center; samples starting with D are duplicate samples analyzed by the University of California at Davis Veterinary Diagnostic Laboratory.

0.00023: Estimated values that are below 0.000741 mg/l, which is the 95 percent upper confidence bound of the 95th percentile of the distribution of blank values.

0.00789: Values exceeding 0.005 mg/l, the chronic ambient water-quality criterion for aquatic life.

0.05098: Values exceeding 0.050 mg/l, the drinking-water maximum contaminant level (MCL).

Table 3-2
Mean Analytical Results - Selenium by ICP using Hydride Digestion
Fall 1997 Interim Surface Water Survey
Southeast Idaho Phosphate Resource Area

Station	Mine	Water Body	Location	Map	Mean Analytical Result (mg/L)
46	Conda Mine	SW3 Perennial Seep		9	1.55
66	Smoky Canyon Mine	Pole Creek	Below Pole Canyon Waste Dump at FS station S-B&M-9	13	0.58
14	Dry Valley Mine	Maybe Creek	Above confluence with Dry Valley Creek at FMC station MB2	10	0.470
37	Enoch Valley Mine	North Pond		5	0.185
71	Conda Mine	NL4 Pond		9	0.151
22	Ballrd Mine	Dredge Pond		6	0.150
17	Dry Valley Mine	Dry Valley Creek	Below confluence with Maybe Creek at FMC station DV3	8	0.144
21	Dry Valley Mine	Pit Dewatering Pond	FMC station PD1	8	0.113
56	Gay Mine	A-12 Lake	in A-12 Pit	3	0.100
41	Wolley Valley Mine	Unit III Panel F Pond		6	0.0980
39	Wooley Valley Mine	Large Haul Road Pond		6	0.0750
40	Wooley Valley Mine	Unit III Panel E Pond		6	0.0746
35	Enoch Valley Mine	Tipple Pond		5	0.0708
36	Enoch Valley Mine	Haul Road Pond		5	0.0650
42	Wolley Valley Mine	Unit III Overburden Dump Seep		6	0.0650
44	Conda Mine	SL3 French Drain		9	0.0650
58	Gay Mine	Z Lake	in Z Pit	3	0.0583
55	Gay Mine	JF Lake	in JF Pit	2	0.0468
6	Mountain Fuel Mine	New Spring #1		12	0.0431
26	Henry Mine	Smith Pond		5	0.0402
1	North Maybe Mine	Mill Creek	Below East Mill Dump Seep at FS station C-B&M-1	7	0.0341
7	Mountain Fuel Mine	New Spring #2		12	0.0299
27	Henry Mine	Center Henry Pond		5	0.0248
31	Enoch Valley Mine	Stock Pond		5	0.0247
33	Enoch Valley Mine	West Pond		5	0.0214
32	Enoch Valley Mine	Bat Cave Pond		5	0.0161
10	Champ Mine	Goodheart Creek	Headwaters spring below Champ Mine dumps	11	0.015
70	Smoky Canyon Mine	Tailings Pond #1	Upper tailings pond on Roberts Creek	13	0.0102
34	Enoch Valley Mine	South Pond		6	0.00914
25	Henry Mine	Henry Pond		5	0.00669
11	Champ Mine		Upper reach at FS station C-B&M-3	11	0.006
9	Mountain Fuel Mine	Stock Pond		12	0.00538
72	Dry Valley Mine	Chicken Creek	Above confluence with Dry Valley Creek at FMC station CC1	8	0.00531
30	Enoch Valley Mine	Shop Pond		5	0.00512
67	Smoky Canyon Mine	North Fork Sage Creek	Above confluence with Pole Creek	14	0.00442
68	Smoky Canyon Mine		Below confluence with Pole Creek	14	0.00347
8	Mountain Fuel Mine	New Spring #3		12	0.0034
3	North Maybe Mine		Below confluence with Mill Creek at FS station C-B-1	7	0.00268
45	Conda Mine	Hoorah Hollow	Flow from underground mine pond	9	0.00246
19	Dry Valley Mine	Blackfoot River	Above confluence with Dry Valley Creek at FMC station BF2	8	0.0024
20	Dry Valley Mine		Below confluence with Dry Valley Creek at FMC station BF1	8	0.0021
43	Wooley Valley Mine	Upper Angus Creek Reservoir	FS station R-B&M-12	6	0.0015
54	Gay Mine	Pond #2	above A-12 Pit	3	0.00139

Table 3-2
Mean Analytical Results - Selenium by ICP using Hydride Digestion
Fall 1997 Interim Surface Water Survey
Southeast Idaho Phosphate Resource Area

Station	Mine	Water Body	Location	Map	Mean Analytical Result (mg/L)
38	Enoch Valley Mine	Center Fork Angus Creek	At FS station M-B&M-1	6	0.00138
13	Champ Mine		Below confluence with Goodheart Creek	11	0.00122
18	Dry Valley Mine		Below Dry Valley Mine at FMC station DV2	8	0.00118
29	Henry Mine	Coarse Rock Fill Seep	Below South Pit Overburden Dump	6	0.00106
48	Conda Mine		Below Camp G Waste Dump	9	0.000992
53	Gay Mine	Pond #1	above A-12 Pit	3	0.000951
24	Henry Mine		Below Henry Mine	5	0.00093
4	North Maybe Mine	North Dry Ridge Creek	Headwaters spring at FS station C-B&M-2	7	0.000923
52	Gay Mine		Below North Limb	1	0.000893
23	Henry Mine	Little Blackfoot River	Above Henry Mine	5	0.000773
51	Lincoln Creek	Lincoln Creek	Above North Limb	1	0.000720
64	Western District		below Phosphoria Formation	4	0.000588
12	Champ Mine	Slug Creek	Above confluence with Goodheart Creek	11	0.000570
15	Dry Valley Mine	Dry Valley Creek	Above Dry Valley Mine at FMC station DV7	10	0.000515
50	Gay Mine		Below South 40	2	0.000511
49	Gay Mine	Ross Fork	Above South 40	3	0.000509
62	Central District		below Phosphoria Formation	10	0.000504
59	Eastern District	South Fork Sage Creek	above Phosphoria Formation	14	0.000496
61	Central District	Caldwell Creek	above Phosphoria Formation	10	0.000459
57	Gay Mine	W Lake	in W Pit	3	0.000441
47	Conda Mine	Camp G Creek	Above Camp G Waste Dump	9	0.000392
2	North Maybe Mine	Spring Creek	Above confluence with Mill Creek at FS station C-B-2	7	0.00038
69	Conda Mine	Hoorah Hollow	Pond	9	0.000352
60	Eastern District		below Phosphoria Formation	14	0.000321
63	Western District	Grizzly Creek	above Phosphoria Formation	4	0.0003
16	Dry Valley Mine		Above confluence with Maybe Creek at FMC station DV6	10	0.00021
65	Smoky Canyon Mine	Pole Creek	Above Pole Canyon Waste Dump at FS station S-B&M-8	13	0.000176
5	North Maybe Mine	Big Draw	Below upper Big Draw Dump Seep	8	*
28	Henry Mine	Pasture #3 Seep	Below South Pit Overburden Dump	6	*

* Stations 5 and 28 were found to be dry.

analysis. Retaining values estimated by the laboratory thus avoids having to estimate estimated values below the reporting limit and introducing potential bias.

Statistical hypothesis tests were conducted to compare the QA laboratory results to the primary laboratory results on a station-specific basis. Triplicate samples were analyzed by the primary laboratory at each of the QA stations. Eight QA stations were defined for the interim survey; at seven of these, the QA laboratory received a fourth replicate sample for independent analysis. A prediction interval to contain one additional observation (that of the QA laboratory), defined with 95 percent confidence, was calculated for each of these stations with the primary laboratory results. The prediction interval calculations are presented in Appendix A, Table A-3. In each case, the value reported by the QA laboratory fell within the prediction interval, thus validating the primary laboratory's results.

Hypothesis testing was also used to compare concentrations in filtered samples to those in unfiltered samples. Unfiltered and filtered samples were collected at seven QA stations. At each of the QA stations, the variances and means of the unfiltered and filtered results were compared by F-test and t-test, respectively. The F-test and t-test calculations are presented in Appendix A, Table A-1. Selenium concentration values between unfiltered and filtered samples were found to be statistically insignificant at a 95 percent confidence level. In other words, no differences between unfiltered and filtered samples can be discerned. This is also the case for the unfiltered and filtered equipment blanks. On the basis of this finding, unfiltered and filtered results were pooled at each station for subsequent statistical analyses.

A more detailed and more traditional evaluation of data quality is presented in the data validation report (Appendix B).

3.1.2 Preliminary Impact Assessment for Selenium

Several QA stations provided replicated results for use in a preliminary statistical impact assessment. These include the two Blackfoot River stations, Stations 19 and 20, located above and below the river's confluence with Dry Valley Creek; two Grizzly Creek stations, Stations 63 and 64, located above and below a section of the undeveloped Phosphoria Formation; and one Pole Creek station, Station 66, located below the Pole Canyon overburden disposal area. The survey was not designed to be an impact assessment; therefore, the following evaluations must be regarded as entirely preliminary. The evaluations will be of use in planning further studies and may prove useful in refining the Working Group's conceptual understanding of the selenium situation in the Southeast Idaho Phosphate Resource Area.

Whether Dry Valley Creek affects the selenium content of the Blackfoot River, and whether the Phosphoria Formation affects the selenium content of Grizzly Creek is evaluated with a t-test.

Whether Pole Creek is affected by the waste-rock dump can be evaluated with an upper bound prediction limit; but, the average concentration downstream of the dump, 0.584 mg/L, is so much greater than that above the dump, 0.00018 mg/L, or essentially 0 mg/L, that statistical analysis of this question is not necessary. The results of the analyses of the Blackfoot River and Grizzly Creek, however, are presented below.

As shown in Appendix A, Table A-2, after averaging intra-laboratory duplicate results, pooling filtered and unfiltered results, and pooling the primary and QA results, the ten observations available at each of the upstream and downstream stations on the Blackfoot River and Grizzly Creek yield three degrees of freedom, or unconstrained values, for each station. No differences in the variances upstream as compared to those downstream, as measured by an F-test at a 95 percent level of confidence, can be discerned for either streams.

On the Blackfoot River, no differences in upstream and downstream means, as measured by a t-test at a 95 percent level of confidence, can be discerned. Thus, selenium fluxes from Dry Valley Creek and the groundwater associated with the Dry Valley Creek drainage appear to have no affect on the selenium concentration of the Blackfoot River water column, at least at the time of the survey. Therefore, the upstream and downstream concentrations in the Blackfoot River can be pooled to provide an estimated selenium concentration of 0.00212 mg/L in the vicinity of the Dry Valley Creek confluence. With a standard deviation of 0.00041 mg/L and a total of six degrees of freedom, this average concentration is well below the State of Idaho's water quality standard for the protection of cold-water biota, which is 0.005 mg/L.

On Grizzly Creek, the mean of the downstream station is higher than that of the upstream station, as determined by a t-test at a 95 percent level of confidence. Thus, the undeveloped Phosphoria Formation appears to be adding a discernible amount of selenium to the water column of Grizzly Creek. The downstream average concentration of 0.00053 mg/L may be discernibly greater than the upstream average of 0.00030 mg/L, but both of these values lie well within the range of blank values. The ability to discern this small difference serves as a further testament to the high quality of the data.

3.1.3 Comparisons to Initial Risk-Based Benchmarks for Selenium

Selenium concentrations in Table 3-1 that exceed the water quality standard for the protection of cold-water biota, 0.005 mg/L, are bolded. This standard is used as a benchmark in this report because it may be applicable to some of the water bodies included in the survey. On the other hand, there may be valid regulatory arguments for not applying this standard to certain of the water bodies. Therefore, the State's cold-water biota standard in this report should be regarded as an initial screening benchmark only.

Those concentrations that exceed the State of Idaho's MCL for drinking water, which is 0.05 mg/L, are bolded and italicized in Table 3-1. This standard, which was established to protect human health, is applicable, at the tap, in community water supplies. None of the water bodies sampled in the survey are used for human consumption..

A review of Table 3-1 shows that selenium concentrations range from essentially 0 mg/L up to 1.55 mg/L. Thirty-five of the stations, 50 percent of the 70 sampled, have selenium concentrations in excess of the 0.005 mg/L cold-water biota standard. Seventeen of the stations, approximately 25 percent, have selenium concentrations in excess of the 0.05 mg/L upper range of the veterinary advisory levels for livestock drinking water. Two of the stations, approximately 3 percent, have selenium concentrations within the range known to have caused chronic selenosis in mammals.

The fraction of stations exceeding certain benchmarks should be considered within the appropriate context. The stations for the interim surface water survey were not selected at random; therefore, the overall distribution of results cannot be regarded as representative. Rather, the Interagency/Phosphate Industry Selenium Working Group selected stations in locations where government agencies have shown interest and where elevated levels of selenium were suspected. Thus, the results of the survey present a biased perspective on surface water quality.

3.1.4 Selenium Background Concentrations

Grizzly Creek, Caldwell Creek, and South Fork Sage Creek have been designated by the Interagency/Phosphate Industry Selenium Working Group as background stations for the western, central, and eastern districts of the Southeast Idaho Phosphate Resource Area. Each of these streams crosses an undeveloped portion of the Phosphoria Formation and sampling stations were established on each just above and below the formation. After averaging intra-laboratory duplicate results and pooling filtered and unfiltered results and QA laboratory results, Grizzly Creek was the only background location with degrees of freedom allowing for a statistical test of whether the formation affects downstream water quality. However, the averaged results for the downstream stations on Caldwell Creek and South Fork Sage Creek, as shown in Appendix A, Table A-4, are seen to be slightly lower than those upstream of the formation. Therefore, we conclude that the Phosphoria Formation is not affecting the water quality of either stream, and we have pooled the upstream and downstream values on each stream to derive average selenium concentrations for further background characterization.

An F-test was used to discern differences in variances in selenium concentrations at the different background stations. This statistical test is presented in Appendix A, Table A-4. The F-tests indicate that there are variance differences. Therefore, results from the three streams are

regarded as coming from three distinct locations. Thus, the pooled results for Caldwell Creek and South Fork Sage Creek are used with the results for the downstream station on Grizzly Creek to define an upper bound of the regional distribution of background values. Assuming that the background selenium concentration is lognormally distributed in space, an upper 95 percent confidence bound of the 95th percentile of the regional background distribution of selenium is calculated to be 0.00094 mg/L.

3.1.5 Value-of-Information Analysis for Sample Replication

One objective of the interim survey was to evaluate the need for replicate sampling. Standard methods of selenium analysis are known to generate data that are quite imprecise at low concentrations. Table A-5, in Appendix A, presents the 95 percent confidence bounds of the mean selenium concentration for each QA station. Confidence bounds are calculated by t-statistic.

If no replication is done (i.e., the sample size is 1), then the lower and upper confidence bounds increase to negative infinity and positive infinity, respectively. In the absence of replicate sampling, statistical analyses cannot be performed; one can only discuss the data qualitatively. Table A-5, in Appendix A shows what the 95 percent confidence bounds for each of the QA stations would be with minimum replication, a sample size of 2. Such predicted confidence bounds assume a higher confidence factor due to the lower sample size and also take the relevant inherent low bias in the estimate of sample standard deviation attributable to small sample sizes into account.

3.2 FILTERABLE RESIDUE CONCENTRATIONS

Table 3-3 presents the results of the filterable residue analyses. Filterable residue is commonly referred to as total dissolved solids (TDS). The TDS data are also not censored. The upper 95 percent confidence bound of the 95th percentile of the TDS blanks is 9.7 mg/L; thus, values less than this are not statistically discernible from 0 mg/L.

There are no applicable, primary TDS standards; however, the State of Idaho does have a secondary MCL for TDS of 500 mg/L. Secondary MCLs are advisory standards established for aesthetic considerations, such as taste, in community water supplies which would not apply in this case. Twenty-seven of the stations, about 39 percent of them, have TDS concentrations exceeding the secondary MCL.

The TDS and selenium data were evaluated by linear regression to see if TDS is useful in predicting selenium concentrations. While the regression is significant at a 95 percent confidence level (i.e., the slope of the line fitting the natural logarithm, ln, of selenium

Table 3-3
Analytical Results - Total Dissolved Solids by EPA Method 160.1
Fall 1997 Interim Surface Water Survey
Southeast Idaho Phosphate Resource Area

Station[1]	Field Sample ID[2,3]	Analytical Result (mg/l)
1	091697SW1-0-U	219
2	091797SW02-0-U	215
3	091797SW03-0-U	206
4	091797SW04-0-U	218
6 *	091697SW06-0-U	602
7	091697SW07-0-U	276
8	091697SW08-0-U	246
9	091697SW09-0-U	887
10	091797SW10-0-U	1,847
11	091697SW11-0-U	446
12	092097SW12-0-U	287
13	091997SW13-0-U	252
14 *	091797SW14-0-U	440
15 *	091797SW15-0-U	280
16	091797SW16-0-U	259
17	091797SW17-0-U	359
18 *	091797SW18-0-U	262
19	091797SW19-0-U	212
20	091897SW20-1-U	243
21	091797SW21-0-U	1,008
22	091897SW22-0-U	829
23	091997SW23-0-U	477
24	091997SW24-0-U	463
25 *	091997SW25-0-U	877
26	091997SW26-1-U	619
27	091997SW27-0-U	439
29	091997SW29-0-U	725
30	091897SW30-0-U	727
31	091897SW31-1-U	911
32	091897SW32-0-U	490
33	091897SW33-0-U	550
34	091897SW34-0-U	1,302
35	091897SW35-0-U	2,958
36	091897SW36-0-U	2,434
37 *	091897SW37-0-U	4,379
38	091897SW38-0-U	226
39	091997SW39-0-U	1,693
40	091997SW40-0-U	253
41	091997SW41-0-U	144
42	091997SW42-0-U	1,924
43	091997SW43-0-U	659
44	092097SW44-0-U	918

Table 3-3
Analytical Results - Total Dissolved Solids by EPA Method 160.1

Fall 1997 Interim Surface Water Survey
Southeast Idaho Phosphate Resource Area

Station[1]	Field Sample ID[2,3]	Analytical Result (mg/l)
45	092297SW45-0-U	331
46 *	092297SW46-0-U	2,981
47 *	092097SW47-0-U	252
48	092097SW48-0-U	260
49 *	092297SW49-0-U	594
50	092197SW50-0-U	164
51	092297SW51-0-U	350
52	092297SW52-0-U	616
53	092397SW53-0-U	797
54	092397SW54-0-U	790
55	092297SW55-0-U	650
56	092397SW56-0-U	1,006
57	092397SW57-0-U	346
58	092297SW58-0-U	485
59	091597SW59-0-U	217
60 *	091597SW60-0-U	206
61 *	091897SW61-0-U	261
62	091897SW62-0-U	293
63 *	092097SW63-1-U	270
64 *	092097SW64-1-U	407
65	091597SW65-0-U	238
66	091597SW66-00-U	681
67	091697SW67-0-U	310
68	091697SW68-0-U	404
69	092097SW69-0-U	302
70	091597SW70-0-U	322
71	092297SW71-0-U	429
72	091797SW72-0-U	315

* Analytical results are averaged using two laboratory duplicates

1 Stations 5 and 28 were found to be dry.

2 First five digits indicates the date in order of month-day-year; next two letters indicate the media sampled (in this case, surface water); the following three digits indicate the station number and the replicate number, respectively; the final letter indicates if the sample is unfiltered (U) or filtered (F).

3 All lab samples for TDS have been analyzed by the University of Idaho Holm Research Center.

Table 3-4
Field Data
Fall 1997 Interim Surface Water Survey
Southeast Idaho Phosphate Resource Area

Station	Water Temperature (Celsius)	pH	Specific Conductivity (umhos/cm @ 25 C)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Oxidation-Reduction Potential Relative to Normal Hydrogen Electrode (mV)	Notes
1	5.8	7.87	351	0-1	7.44	396.0	Turbidity reading varied
2	9.5	8.12	297	16	9.65	361.1	
3	13.4	8.65	295	29	11.00	330.2	
4	7.2	7.8	320	2	10.04	-	
5	-	-	-	-	-	-	Dry - no sample taken
6	17.8	7.6	689	202	12.10	337.9	Redox value is last reading taken; dissolved oxygen is estimated due to fluctuating field readings
7	12.3	7.1	309	94	3.00		Redox value is last reading taken
8	12.2	9.4	364	35	5.48	428.4	Redox value is last reading taken.
9	13.9	9.78	1,144		11.80	330.8	Redox value is last reading taken
10	19.6	7.87	2,031	4	9.98	236.8	pH value varied; value listed is last reading taken
11	15.7	8.27	549	5	7.30	390.1	Redox value is last reading taken
12	7.0	7.85	419	5	3.43	362.6	Turbidity is estimated; fluctuating readings
13	8.8	7.33	421	1	5.80	337.5	
14	9.6	8.52	620	4	7.43	354.4	
15	10.7	8.09	444	115		306.7	
16	12.6	7.8	423	2	8.83	370.6	
17	15.6	8.53	525	0	13.75	340.2	
18	14.6	8.36	445	4	11.27	309.8	
19	12.2	8.52	353	0	12.19	308.5	
19	12.1	8.49	354	0	12.38	305.7	
19	12.0	8.49	355	0	12.24	334.3	
20	9.9	8.54	304	-	14.35	395.4	Turbidity is estimated; fluctuating readings
20	9.9	8.6	307	1	14.91	366.2	
20	10.0	8.53	309	0	14.61	354.3	
21	14.2	9.84	1,246	10	12.17	255.7	
22	11.5	10.5	688	720	19.99	223.5	
23	12.7	8.45	775	0	12.11	302.1	
24	11.3	8.41	774	1	9.30	317.8	
25	12.9	7.94	1,198		6.58	305.4	Turbidity is estimated; fluctuating readings
26	10.9	9.87	806	8	11.93	200.1	Turbidity is estimated; fluctuating readings
26	11.0	9.75	873	9	12.36	262.5	Turbidity is estimated; fluctuating readings
26	10.8	9.72	883	13	10.86	227.3	Turbidity is estimated; fluctuating readings
27	11.1	9.86	622	-	10.71	232.5	
28	-	-	-	-	-	-	Dry - no sample taken
29	7.5	6.91	1,169	21	7.27	143.5	
30	11.7	8.24	1,283	20	10.45	242.2	
31	14.4	8.51	1,235	2	10.29	290.9	
31	14.4	8.36	1,255	2	10.74	279.6	

Table 3-4
Field Data
Fall 1997 Interim Surface Water Survey
Southeast Idaho Phosphate Resource Area

Station	Water Temperature (Celsius)	pH	Specific Conductivity (umhos/cm @ 25 C)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Oxidation-Reduction Potential Relative to Normal Hydrogen Electrode (mV)	Notes
31	14.3	8.53	1,256		10.81	272.4	
32	12.5	9.23	630	1	5.82	294.1	Turbidity and dissolved oxygen readings are estimated; fluctuating readings
33	12.1	9.38	722	2	8.31	293.7	Dissolved oxygen reading is estimated; fluctuating readings
34	11.4	8.36	1,540	0	8.72	309.5	Turbidity and dissolved oxygen readings are estimated; fluctuating readings
35	12.0	9.16	3,999	14	9.47	288.2	
36	12.0	9.26	3,425		10.09	265.8	
37	13.1	9.09	12,279	45	7.26	-	Turbidity is estimated; fluctuating readings
38	6.5	7.75	381	-	4.06	361.5	Turbidity reading not taken
39	10.0	8.6	2,574	<10	9.90	316.9	
40	10.0	8.4	319	30	9.90	310.6	
41	11.1	8.6	247	<10	9.30	374.4	
42	9.0	7.5	2,269	10-20	7.70	362.4	Redox value is last reading taken.
43	12.1	8.1	759	10-20	10.90	304.1	
43	12.1	8.1	779	<10	10.80	271.7	
43	12.1	8	789	<10	9.00	133.1	Redox may have dropped due to distrubance of sediments
44	7.9	7.75	1,333	10	7.21	-15.0	Turbidity is estimated; fluctuating readings
45	7.3	8.29	524	19	6.57	367.8	
46	9.7	8.29	3,132	12	5.59	347.0	Redox value is last reading taken.
47	6.6	8.21	384	10	10.70	363.0	Turbidity is estimated; fluctuating readings
48	5.9	8.79	374	10	10.92	338.6	Turbidity is estimated; fluctuating readings
49	11.5	8.66	760	4	10.80	299.0	
50	8.9	8.44	241	9	12.46	333.5	
51	7.0	8.42	497	52	11.46	325.2	Redox value is last reading taken.
52	9.0	7.82	877	10	8.35	351.0	Turbidity reading is questionable; stream was very clear
53	11.5	8.27	1,314	0	6.99	286.7	Redox value is last reading taken; turbidity is estimated
54	11.7	8.21	1,313	0	7.44	363.2	Turbidity is estimated; fluctuating readings
55	14.4	8.65	1,051	1	13.36	283.7	
56	13.7	8.06	1,533	0	6.03	360.6	Turbidity is estimated; fluctuating readings
57	12.9	8.09	471	10	6.36	410.3	
58	14.5	8.8	622	2	10.05	310.8	
59	6.6	8.32	317	8	12.22	427.4	
60	7.0	8.56	294	15	11.48	429.0	
61	6.9	8.17	373	96	10.65	362.1	
62	7.4	8.39	370	43	10.49	411.0	
63	12.0	7.43	399	181	6.14	347.5	

Table 3-4
Field Data
Fall 1997 Interim Surface Water Survey
Southeast Idaho Phosphate Resource Area

Station	Water Temperature (Celsius)	pH	Specific Conductivity (umhos/cm @ 25 C)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Oxidation-Reduction Potential Relative to Normal Hydrogen Electrode (mV)	Notes
63	12.0	7.42	351	214	6.07	350.0	
63	12.0	7.43	395	207	5.84	355.2	
64	12.0	6.94	626	92	6.95	382.0	
64	12.1	6.92	633	90	7.14	367.9	
64	12.2	6.86	628	81	7.21	353.4	
65	6.6	8.58	360	0	6.50	349.4	
66	8.4	8.21	991	62	4.50	351.6	
66	8.3	8.3	981	51	4.80	349.7	
66	8.3	8.07	1,023	60	4.43	380.7	
67	11.8	7.89	43	13	6.75	259.1	
68	8.8	8.13	575	17	9.64	380.3	
69	10.9	8.46	432	10	19.99	218.2	Turbidity and dissolved oxygen readings are estimated; fluctuating readings
70	15.7	8.27	408	10	9.83	435.3	
71	14.0	7.82	563	<10	5.66	343.7	Reported incorrectly in field log book as Site 74
72	12.0	8.31	467	14	7.49	339.2	Turbidity is estimated; fluctuating readings

Table 3-5a
Correlation Coefficient Factors Using Untransformed Values
Fall 1997 Interim Surface Water Survey
Southeast Idaho Phosphate Resource Area

Parameters	Water Temperature; sample size: 70	pH; sample size: 70	Specific Conductivity; sample size: 70	Turbidity; sample size: 61	Dissolved Oxygen; sample size: 69	Oxidation-Reduction Potential*; sample size: 67	TDS; sample size: 70	Selenium; sample size: 70
Water Temperature	1.000	0.161	0.215	-0.088	-0.051	-0.080	0.224	-0.020
pH	0.154	1.000	0.223	-0.386	0.614	-0.078	0.210	0.008
Specific Conductivity	0.162	0.179	1.000	-0.019	-0.050	-0.280	0.904	0.249
Turbidity	0.067	0.261	-0.019	1.000	-0.028	-0.127	0.010	0.040
Dissolved Oxygen	-0.085	-0.166	-0.050	-0.028	1.000	0.017	-0.074	-0.046
Oxidation-Reduction Potential*	-0.119	-0.129	-0.280	-0.127	0.017	1.000	-0.265	0.035
TDS	0.214	0.197	0.904	0.010	-0.074	-0.265	1.000	0.428
Selenium	-0.037	0.052	0.249	0.040	-0.046	0.035	0.428	1.000

Table 3-5b
Correlation Coefficient Using Natural Log Transformed Values

Parameters	Water Temperature; sample size: 70	pH; sample size: 70	Specific Conductivity; sample size: 70	Turbidity; sample size: 61	Dissolved Oxygen; sample size: 69	Oxidation-Reduction Potential*; sample size: 67	TDS; sample size: 70	Selenium; sample size: 70
Water Temperature	1.000	0.178	0.270	0.001	0.012	-0.225	0.347	0.343
pH	0.178	1.000	0.184	-0.054	0.094	-0.188	0.197	0.296
Specific Conductivity	0.270	0.184	1.000	0.025	-0.070	-0.304	0.922	0.478
Turbidity	0.001	-0.054	0.025	1.000	-0.216	-0.054	0.074	0.019
Dissolved Oxygen	0.012	0.094	-0.070	-0.216	1.000	-0.131	-0.106	-0.125
Oxidation-Reduction Potential*	-0.225	-0.188	-0.304	-0.054	-0.131	1.000	-0.395	-0.157
TDS	0.347	0.197	0.922	0.074	-0.106	-0.395	1.000	0.562
Selenium	0.343	0.296	0.478	0.019	-0.125	-0.157	0.562	1.000

concentration to the natural logarithm of the TDS concentration is discernibly different from zero), the coefficient of determination, 0.316, is low. The coefficient of determination is interpreted as follows: the variability in the ln-transformed TDS concentration data explains only 31.6 percent of the variability in the ln-transformed selenium concentration data.

3.2.1 Field Measurements

Field measurements conducted during the survey are presented in Table 3-4. Correlation matrixes of these field variables, and the laboratory variables of selenium and TDS, are presented in Tables 3-5a and 3-5b. The matrixes present correlation coefficients for untransformed and ln-transformed data: the exception being pH, which, as the negative base-10 logarithm of hydronium ion activity, is already log-transformed.

Several variables are significantly correlated at a 95 percent confidence level. Ln-transformed water temperatures are positively correlated with ln-transformed values for specific conductivity, TDS, and selenium. There is a positive correlation between pH and ln-transformed values for selenium and turbidity. The ln-transformed values for specific conductivity are further correlated positively with ln-transformed values for oxidation-reduction potential, TDS, and selenium. The positive correlation between ln-transformed TDS and selenium concentrations has already been discussed above. Of the correlations displayed in Table 3-5b, only one appears to be of predictive value: with a coefficient of determination of 0.850, 85 percent of the variability in the ln-transformed TDS data can be explained by the variability in the ln-transformed specific conductivity data. Dissolved oxygen is not correlated with any other variable.

4.0 Discussion

The laboratory selenium data are of extremely high quality. Despite considerable effort to detect one, no difference between unfiltered and filtered results can be discerned. Therefore, one can conclude that virtually all of the selenium in the water column is in a dissolved form. Whether this situation, under conditions of low flow and low turbidity during the fall, will also occur under high-flow, high-turbidity conditions, is a subject under discussion by the Interagency/Phosphate Industry Selenium Working Group.

Elevated levels of selenium were detected in several surface waters located on or adjacent to past and present phosphate mining operations in southeastern Idaho. The selenium results include a broad range of values from essentially 0 mg/L to 1.55 mg/L as compared to background concentrations ranging to 0.00094 mg/L. These levels were sometimes in excess of the upper range of veterinary advisory levels for livestock, 0.05mg/L.

These results correspond well to existing data reported by or to FS. There is considerable spatial variability in the data, and the results do not appear to correlate with the type of water body or the location, type, or age of the mine associated with the water body. An apparent exception to this lack of predictability is that streams supporting fisheries—this includes Spring Creek, Slug Creek, Angus Creek, Blackfoot River, Little Blackfoot River, and North Fork Sage Creek in Caribou County, as well as Ross Fork and Lincoln Creek in Bingham County—do not appear to be adversely impacted by past or present mining activities. The selenium concentrations observed in such waters were well within the State of Idaho cold-water biota standard of 0.005 mg/L at the time they were sampled for this survey. The sole anomaly in this apparent pattern is Mill Creek, a tributary of Spring Creek that is known to be cutthroat trout spawning habitat. Mill Creek had a selenium concentration of 0.0341 mg/L (see Table 3-2).

With regard to the other analytes included in the survey, specific conductivity is a good predictor of TDS. Given that reliable measurements of specific conductivity can be made in the field and that TDS has a short holding time that can complicate the schedule of sample shipment and laboratory analysis, substituting specific conductivity for TDS in future sampling events would be appropriate. Consideration can also be given to dropping some field analytes. For example, dissolved oxygen and turbidity provided little if any useful information.

In summary, few conclusions can be made from the results of the interim surface water survey, and further investigation is recommended. Consideration should be given by the Interagency/Phosphate Industry Selenium Working Group to use the results of the interim survey to optimize the sampling design for the 1998 investigation.

5.0 References

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Appendices

Appendix A
Statistical Analyses

Replicate sampling results allows for statistical analysis. At a given surface water location at a given time there is a true, but unknown concentration of selenium. The variability in the replicated results arises from laboratory analytical and sampling uncertainties. Such uncertainties are known to be normally distributed. The mean or average values of these results, when the number of replicates is small, are known to be distributed according to Students's t-distribution. Therefore, t-tests are used for hypothesis testing to compare means and t-statistics are used to calculate confidence limits about the means. Prior to conducting t-tests to compare means, variances are compared with an F-test. The ratio of two variances is known to be distributed according to a F-distribution. If no difference in variances of results at two stations being compared are found, a single pooled variance is calculated. Laboratory method blanks and equipment blanks are also evaluated with t- and F-tests.

Procedures for conducting t-tests and F-tests can be found in any introductory statistics text book. The equation for calculating confidence limits about a mean is:

$$\hat{\mu} = \overline{x} \pm \frac{t_{(1-\alpha/2;\nu)} s}{\sqrt{n}} \qquad \text{(Equation 2-1)}$$

where:

- $\hat{\mu}$ is the estimate of the population mean, μ (in this case, the true concentration);
- $\overline{x}$ is the sample mean (the arithmetic average of the observations);
- $t_{(1-\alpha/2;\nu)}$ is the Students's t-statistic, with a $[100\times(1-\alpha)]$ percent degree of confidence (where α is the type-I, or false-positive, error rate, i.e., the likelihood of discerning a difference when in reality no difference exists), for ν degrees of freedom;
- s is the sample standard deviation; and,
- n is the sample size.

The sample mean is calculated as follows:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad \text{(Equation 2-2)}$$

where x_i is the ith observation of x. The value of $t_{(\nu;1-\alpha)}$ is obtained from a table. Degrees of freedom for one set of samples is calculated as:

$$\nu = n - 1 \qquad \text{(Equation 2-3)}$$

The sample standard deviation is calculated as follows:

$$s = \sqrt{\frac{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2}{n-1}} \qquad \text{(Equation 2-4)}$$

The F-statistic is calculated as:

$$F = \frac{\text{larger of } s_1^2 \text{ and } s_2^2}{\text{smaller of } s_1^2 \text{ and } s_2^2} \qquad \text{(Equation 2-5)}$$

where s_2 is the standard deviation of the second sample set and s_1 is the standard deviation of the first sample set. The square of s is called the sample variance. The calculated F is compared to a table of $F_{(1-\alpha/2;\text{the larger of } \nu_1 \text{ and } \nu_2,\text{the smaller of } \nu_1 \text{ and } \nu_2)}$ where ν_1 and ν_2 are the respective degrees of freedom for the first and second sample sets. If the calculated F does not exceed the tabulated F, one cannot assume that the two sample variances are different, and therefore one can combine them to calculate a pooled variance as follows:

$$s_{1,2} = \sqrt{\frac{\nu_1 s_1^2 + \nu_2 s_2^2}{\nu_1 + \nu_2}} \qquad \text{(Equation 2-6)}$$

A t-statistic to compare two sample means, $\bar{x}_1$ and $\bar{x}_2$, to see if $\bar{x}_2$ is greater than $\bar{x}_1$ when the two variances are pooled is calculated as:

$$t = \frac{\bar{x}_2 - \bar{x}_1}{s_{1,2}\sqrt{\frac{1}{n_2} + \frac{1}{n_1}}} \qquad \text{(Equation 2-7)}$$

The calculated t is compared to a table of $t_{(1-\alpha;\nu_{1,2})}$. If the calculated t does not exceed the tabulated t, one cannot assume that the two sample means are different, and therefore one can combine them to calculate a pooled mean as follows:

$$\bar{x}_{1,2} = \frac{n_1\bar{x}_1 + n_2\bar{x}_2}{n_1 + n_2} \qquad \text{(Equation 2-8)}$$

If the two sample variances are different, a t'-statistic is calculated (Kvanli, 1988):

$$t' = \frac{\bar{x}_2 - \bar{x}_1}{\sqrt{\frac{s_2^2}{n_2} + \frac{s_1^2}{n_1}}} \qquad \text{(Equation 2-9)}$$

The t' is compared to a table of $t_{(1-\alpha;\nu_{1,2})}$ as in the case of equal variances, but $\nu_{1,2}$ is calculated as:

$$\nu_{1,2} = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{\left(\frac{s_1^2}{n_1}\right)^2}{\nu_1} + \frac{\left(\frac{s_2^2}{n_2}\right)^2}{\nu_2}} \qquad \text{(Equation 2-10)}$$

For any subsequent hypothesis testing, the degrees of freedom for the pooled statistics are calculated as:

$$\nu_{1,2} = (n_1 - 1) + (n_2 - 1) = \nu_1 + \nu_2 \qquad \text{(Equation 2-10)}$$

The t-test can also be used to compare a sample mean to a benchmark value, B, such as a regulatory standard. For such a test to see if a sample mean is greater than B, the numerator of Equation 2-7 is replaced with $\bar{x}$ - B, and the denominator is replaced with $s/\sqrt{n}$. The t-statistic thus calculated is compared with the tabulated value of $t_{(1-\alpha;\nu)}$.

The F-test and t-test calculations are presented in Table A-1. Selenium concentration values between unfiltered and filtered samples were found to be statistically insignificant at a 95 percent confidence level. In other words, no differences between unfiltered and filtered samples can be discerned. This is also the case for the unfiltered and filtered equipment blanks. On the basis of this finding, unfiltered and filtered results were pooled at each station for subsequent statistical analyses.

As shown in Table A-2, after averaging intra-laboratory duplicate results, pooling filtered and unfiltered results, and pooling the primary and QA results, the ten observations available at each of the upstream and downstream stations on the Blackfoot River and Grizzly Creek yield three degrees of freedom, or unconstrained values, for each station. No differences in the variances upstream as compared to those downstream, as measured by an F-test at a 95 percent level of confidence, can be discerned for either streams.

Table A-1
Statistical Comparison of Unfiltered and Filtered Water Samples
Fall 1997 Interim Surface Water Survey

					Comparison of Unfiltered and Filtered Sample Variances Using a Two-Tail F-Test					Comparison of Unfiltered and Filtered Result Means Using an One-Sided t-Test										
Station	**Field Sample ID**	**Analytical Result** (mg/L)	**Pooled Averages** (mg/L)	**Pooled Standard Deviations** (mg/L)	df for Unfiltered Array (ν)	df for Filtered Array (ν)	F-Test	Two-Tail F-Statistic at 0.05	Reject H_0? (No difference between unfiltered and filtered variances)	Unfiltered s	Unfiltered s^2	Filtered s	Filtered s^2	Unfiltered sample no. (n)	Filtered sample no. (n)	ν for t-distribution (adjusted if variances are different)	Weighted Variance Average (pooled variances)	One-tail t-test	One-tail t-statistic at 0.05	Reject H_0? (Difference between unfiltered and filtered means is less than or equal to 0)
Blackfoot River																				
Above confluence with Dry Valley Creek																				
19	091797SW19-1-U	0.00281	0.00223	0.00046	2	2	2.1460	39.0000	No	4.610E-04	2.126E-07	6.754E-04	4.562E-07	4	4	4	3.3436E-07	0.2751	2.1320	No
19	091797SW19-2-U	0.00232																		
19	091797SW19-2-U*	0.00226																		
19	091797SW19-3-U	0.00210																		
19	091797SW19-4-U	0.0017																		
19	091797SW19-1-F	0.00226	0.00234	0.00068																
19	091797SW19-2-F	0.00360																		
19	091797SW19-2-F*	0.00302																		
19	091797SW19-3-F	0.00198																		
19	091797SW19-4-F	0.0018																		
Below confluence with Dry Valley Creek																				
20	091897SW20-1-U	0.00214	0.00204	0.00027	2	2	3.2655	39.0000	No	2.718E-04	7.387E-08	1.504E-04	2.262E-08	4	4	4	4.8249E-08	-0.3622	2.1320	No
20	091897SW20-2-U	0.00207																		
20	091897SW20-2-U*	0.00190																		
20	091897SW20-3-U	0.00210																		
20	091897SW20-3-U*	0.00259																		
20	091897SW20-4-U	0.0017																		
20	091897SW20-1-F	0.00212	0.00199	0.00015																
20	091897SW20-2-F*	0.00213																		
20	091897SW20-2-F	0.00193																		
20	091897SW20-3-F	0.00209																		
20	091897SW20-4-F	0.0018																		
Grizzly Creek																				
Above Phosphoria Formation																				
63	092097SW63-1-U	0.000151	0.00036	0.00018	2	2	3.2091	39.0000	No	1.842E-04	3.394E-08	1.028E-04	1.058E-08	4	4	4	2.22557E-08	-1.2572	2.1320	No
63	092097SW63-2-U*	0.000624																		
63	092097SW63-2-U	0.000449																		
63	092097SW63-3-U	0.000520																		
63	092097SW63-4-U	0.0001																		
63	092097SW63-1-F	0.000206	0.00023	0.00010																
63	092097SW63-2-F	0.000340																		
63	092097SW63-2-F*	0.000334																		
63	092097SW63-3-F	0.000283																		
63	092097SW63-4-F	0.0001																		

Table A-1
Statistical Comparison of Unfiltered and Filtered Water Samples
Fall 1997 Interim Surface Water Survey

					Comparison of Unfiltered and Filtered Sample Variances Using a Two-Tail F-Test					Comparison of Unfiltered and Filtered Result Means Using an One-Sided t-Test										
Station	**Field Sample ID**	**Analytical Result** (mg/L)	**Pooled Averages** (mg/L)	**Pooled Standard Deviations** (mg/L)	df for Unfiltered Array (ν)	df for Filtered Array (ν)	F-Test	Two-Tail F-Statistic at 0.05	Reject H_0? (No difference between unfiltered and filtered variances)	Unfiltered s	Unfiltered s^2	Filtered s	Filtered s^2	Unfiltered sample no. (n)	Filtered sample no. (n)	ν for t-distribution (adjusted if variances are different)	Weighted Variance Average (pooled variances)	One-tail t-test	One-tail t-statistic at 0.05	Reject H_0? (Difference between unfiltered and filtered means is less than or equal to 0)
Below Phosphoria Formation																				
64	092097SW64-1-U	0.000525	0.00055	0.00028	2	2	1.1621	39.0000	No	2.849E-04	8.117E-08	2.643E-04	6.985E-08	4	4	4	7.5508E-08	-0.2162	2.1320	No
64	092097SW64-2-U	0.000914																		
64	092097SW64-2-U*	0.000876																		
64	092097SW64-3-U	0.000587																		
64	092097SW64-4-U	0.0002																		
64	091797SW64-4-F	0.0002	0.00051	0.00026																
64	092097SW64-1-F	0.000380																		
64	092097SW64-2-F	0.000762																		
64	092097SW64-2-F*	0.000716																		
64	092097SW64-3-F	0.000720																		
Pole Creek																				
Above Pole Canyon waste rock disposal area																				
65	091597SW65-0-U	0.000432	0.00043	-	0	0		Not applicable							Not applicable					
65	091597SW65-0-F	-0.0000797	-0.00008	-																
Above Pole Canyon waste rock disposal area																				
66	091597SW66-1-U	0.612	0.58267	0.01815	2	2	0.2215	39.0000	No	1.815E-02	3.293E-04	3.856E-02	1.487E-03	3	3	4	9.0796E-04	0.1423	2.1320	No
66	091597SW66-2-U*	0.592																		
66	091597SW66-2-U	0.566																		
66	091597SW66-3-U	0.580																		
66	091597SW66-1-F	0.63	0.58617	0.03856																
66	091597SW66-2-F	0.558																		
66	091597SW66-2-F*	0.557																		
66	091597SW66-3-F	0.571																		

* University of Idaho sample duplicate; averaged with subsample resulting in an average analytical value

Table A-2
Statistical Comparison of Upstream and Downstream Water Samples
Fall 1997 Interim Surface Water Survey

Station	Field Sample ID	Analytical Result (mg/L)	Pooled Average of Unfiltered and Filtered Results (refer to Table 3-3) (mg/L)	Pooled Standard Deviations of Unfiltered and Filtered Results (refer to Table 3-3) (mg/L)	Comparison of Upstream and Downstream Sample Variances Using a Two-Tail F-test: ν for Upstream Array	ν for Downstream Array	F-Test	Two-tail F-Statistic at 0.05	Reject H_0? (No difference between unstream and downstream variances)	Comparison of Upstream and Downstream Result Means Using One-Tail t-Test (Equal Variance) or t'-Test (Unequal Variance): Upper reach s	Upper reach s^2	Lower reach s	Lower reach s^2	Upper reach pooled sample no.	Lower reach pooled sample no.	df	Weighted Variance Average for t-test (pooled variances)	t-Test	One-tail t (or t') statistic at 0.05	Reject H_0? (Difference between downstream and upstream means is less than or equal to 0)	Comparison of Means to Freshwater Chronic Criterion for Selenium: t-test statistic to determine if pooled or unpooled Se value is less than or equal to 0.005 mg/l	One-tail t statistic at 0.05	Reject H_0? (Value is less than or equal to 0.005 mg/l)
Blackfoot River																							
Above confluence with Dry Valley Creek																							
19	091797SW19-1-U	0.00281	0.00223	0.00054	4	4	6.867	9.600	No	5.3871E-04	2.9021E-07	2.0557E-04	4.2260E-08	8	8	8	1.6624E-07	-1.6342	1.8600	No	-15.1226	1.8600	No
19	091797SW19-2-U	0.00232																					
19	091797SW19-2-U*	0.00226																					
19	091797SW19-3-U	0.00210																					
19	091797SW19-4-U	0.0017																					
19	091797SW19-1-F	0.00226																					
19	091797SW19-2-F	0.00360																					
19	091797SW19-2-F*	0.00302																					
19	091797SW19-3-F	0.00198																					
19	091797SW19-4-F	0.0018																					
Below confluence with Dry Valley Creek																							
20	091897SW20-1-U	0.00214	0.00201	0.00021																			
20	091897SW20-2-U	0.00207																					
20	091897SW20-2-U*	0.00190																					
20	091897SW20-3-U	0.00210																					
20	091897SW20-3-U*	0.00259																					
20	091897SW20-4-U	0.0017																					
20	091897SW20-1-F	0.00212																					
20	091897SW20-2-F*	0.00213																					
20	091897SW20-2-F	0.00193																					
20	091897SW20-3-F	0.00209																					
20	091897SW20-4-F	0.0018																					
Grizzly Creek																							
Above Phosphoria Formation																							
63	092097SW63-1-U	0.000151	0.00030	0.00016	4	4	2.706	9.600	No	1.5525E-04	2.4102E-08	2.5539E-04	6.5225E-08	8	8	8	4.4663E-08	2.2044	1.9430	No	-49.4963	6.3140	No
63	092097SW63-2-U*	0.000624																					
63	092097SW63-2-U	0.000449																					
63	092097SW63-3-U	0.000520																					
63	092097SW63-4-U	0.0001																					
63	092097SW63-1-F	0.000206																					
63	092097SW63-2-F	0.000340																					
63	092097SW63-2-F*	0.000334																					
63	092097SW63-3-F	0.000283																					
63	092097SW63-4-F	0.0001																					

Table A-2
Statistical Comparison of Upstream and Downstream Water Samples
Fall 1997 Interim Surface Water Survey

					Comparison of Upstream and Downstream Sample Variances Using a Two-Tail F-test					Comparison of Upstream and Downstream Result Means Using One-Tail t-Test (Equal Variance) or t'-Test (Unequal Variance)											Comparison of Means to Freshwater Chronic Criterion for Selenium		
Station	Field Sample ID	Analytical Result (mg/L)	Pooled Average of Unfiltered and Filtered Results (refer to Table 3-3) (mg/L)	Pooled Standard Deviations of Unfiltered and Filtered Results (refer to Table 3-3) (mg/L)	ν for Upstream Array	ν for Downstream Array	F-Test	Two-tail F-Statistic at 0.05	Reject H_0? (No difference between unstream and downstream variances)	Upper reach s	Upper reach s^2	Lower reach s	Lower reach s^2	Upper reach pooled sample no.	Lower reach pooled sample no.	df	Weighted Variance Average for t-test (pooled variances)	t-Test	One-tail t (or t') statistic at 0.05	Reject H_0? (Difference between downstream and upstream means is less than or equal to 0)	t-test statistic to determine if pooled or unpooled Se value is less than or equal to 0.005 mg/l	One-tail t statistic at 0.05	Reject H_0? (Value is less than or equal to 0.005 mg/l)
Below Phosphoria Formation																							
64	092097SW64-1-U	0.000525	0.00053	0.00026																			
64	092097SW64-2-U	0.000914																					
64	092097SW64-2-U*	0.000876																					
64	092097SW64-3-U	0.000587																					
64	092097SW64-4-U	0.0002																					
64	091797SW64-4-F	0.0002																					
64	092097SW64-1-F	0.000380																					
64	092097SW64-2-F	0.000762																					
64	092097SW64-2-F*	0.000716																					
64	092097SW64-3-F	0.000720																					
Pole Creek																							
Above Pole Canyon waste rock disposal area																							
65	091597SW65-0-U	0.000432	0.00018	0.00036	0	4	Not applicable; assume yes			3.6183E-04	1.3092E-07	2.7019E-02	7.3004E-04	2	6	5	-	52.9513	2.0150	Yes	52.5282 (downstream only)	2.0150	Yes
65	091597SW65-0-F	-0.0000797																					
Above Pole Canyon waste rock disposal area																							
66	091597SW66-1-U	0.612	0.58442	0.02702																			
66	091597SW66-2-U*	0.592																					
66	091597SW66-2-U	0.566																					
66	091597SW66-3-U	0.580																					
66	091597SW66-1-F	0.63																					
66	091597SW66-2-F	0.558																					
66	091597SW66-2-F*	0.557																					
66	091597SW66-3-F	0.571																					

* University of Idaho sample duplicate; averaged with subsample resulting in an average analytical value

To compare an inter-laboratory duplicate at a given station to assess inter-laboratory performance, a prediction interval to encompass one additional analysis from the quality assurance (QA) laboratory was calculated on the replicated results from the primary laboratory. This test also assumes a normal distribution, and the procedure for calculating a prediction interval is presented in Hahn and Meeker (1991). The formula for the prediction interval is:

$$\overline{x}_m = \overline{x} \pm t_{(1-\alpha/2;\nu)} s \sqrt{\left(\frac{1}{m} + \frac{1}{n}\right)} \quad \text{(Equation 2-11)}$$

where m is the number of future, independently and randomly selected observations (in this case, 1).

To differentiate between blank results and results truly indicative of the presence of selenium, an upper confidence limit on the 95th percentile of the distribution of blank results is calculated. The distribution of blank results is assumed to be attributable to only analytical and, for equipment blanks, sampling uncertainties and is therefore assumed to be normally distributed. The procedure for calculating the upper bound of a percentile (also referred to as a tolerance bound), is presented in Hahn and Meeker (1991). The formula is:

$$\tilde{p} = \overline{x} + g_{(1-\alpha;p,\nu+1)} s \quad \text{(Equation 2-12)}$$

where $g_{(1-\alpha;p,\nu+1)}$ is the tabulated tolerance factor which is a function of the type-I error rate, the percentile of interest (in this case, the 95th percentile or 0.95), and the degrees of freedom.

The prediction interval calculations are presented in Table A-3. In each case, the value reported by the QA laboratory fell within the prediction interval, thus validating the primary laboratory's results.

To characterize the background concentration of selenium in regional surface waters, a tolerance bound approach is also used. However, rather than assuming a normal distribution, the spatial distribution of selenium concentration is appropriately assumed to be lognormal. A lognormal distribution is known to well describe the patchy nature of trace element occurrence in the environment (Gilbert, 1987). The procedure for calculating the upper bound of a percentile from a lognormal distribution is also presented in Hahn and Meeker (1991). The procedure is identical to that used for determining the tolerance bound for a normal distribution except that the calculations are performed on the logarithms of the observations, then the logarithmic result is transformed to a normal result using the exponential function to yield the sought-after statistic. If the data set contains zero or negative values, a constant must be added to all values that is of sufficient magnitude to produce all positive values before ln-transforming. During the back-transformation, this constant is subtracted out following the exponentiation step.

Table A-3

Comparison of University of California Duplicate Results with University of Idaho Results

Fall 1997 Interim Surface Water Survey

Station	Field Sample ID	Analytical Result (mg/L)	Averaged Analytical Result (mg/L)	Prediction Interval to Contain the U of C Davis Duplicates with U of I Results: Prediction Interval (α)	Number of U of I Results (n)	U of I Mean (mg/L)	U of I Standard Deviation (s) (mg/L)	$t_{(1-\alpha/2;\,\nu)}$ (from Table A.1, Hahn & Meeker)	Lower Prediction Bound (mg/L)	Upper Prediction Bound (mg/L)	Reject H_o? (U of C Davis results are the same as U of I results)	Pooled Averages (mg/L)	Pooled Standard Deviations (mg/L)
Blackfoot River													
Above confluence with Dry Valley Creek													
19	091797SW19-1-U	0.00281	0.00281	0.05	3	0.00240	0.00037	4.303	0.00057	0.00423	No	0.00223	0.00046
19	091797SW19-2-U	0.00232	0.00229										
19	091797SW19-2-U*	0.00226											
19	091797SW19-3-U	0.00210	0.00210										
19	091797SW19-4-U**	0.0017	0.00170										
19	091797SW19-1-F	0.00226	0.00226	0.05	3	0.00252	0.00070	4.303	-0.00097	0.00600	No	0.00234	0.00068
19	091797SW19-2-F	0.00360	0.00331										
19	091797SW19-2-F*	0.00302											
19	091797SW19-3-F	0.00198	0.00198										
19	091797SW19-4-F**	0.0018	0.00180										
Below confluence with Dry Valley Creek													
20	091897SW20-1-U	0.00214	0.00214	0.05	3	0.00216	0.00018	4.303	0.00126	0.00305	No	0.00204	0.00027
20	091897SW20-2-U	0.00207	0.00199										
20	091897SW20-2-U*	0.00190											
20	091897SW20-3-U	0.00210	0.00235										
20	091897SW20-3-U*	0.00259											
20	091897SW20-4-U**	0.0017	0.00170										
20	091897SW20-1-F	0.00212	0.00213	0.05	3	0.00205	0.00010	4.303	0.00153	0.00256	No	0.00199	0.00015
20	091897SW20-2-F*	0.00213											
20	091897SW20-2-F	0.00193	0.00193										
20	091897SW20-3-F	0.00209	0.00209										
20	091897SW20-4-F**	0.0018	0.00180										
Grizzly Creek													
Above Phosphoria Formation													
63	092097SW63-1-U	0.000151	0.00039	0.05	3	0.00045	0.00007	4.303	0.00012	0.00078	No	0.00036	0.00018
63	092097SW63-2-U*	0.000624											
63	092097SW63-2-U	0.000449	0.00045										
63	092097SW63-3-U	0.000520	0.00052										
63	092097SW63-4-U**	0.0001	0.00010										
63	092097SW63-1-F	0.000206	0.00021	0.05	3	0.00028	0.00007	4.303	-0.00005	0.00060	No	0.00023	0.00010
63	092097SW63-2-F	0.000340	0.00034										
63	092097SW63-2-F*	0.000334											
63	092097SW63-3-F	0.000283	0.00028										
63	092097SW63-4-F**	0.0001	0.00010										
Below Phosphoria Formation													
64	092097SW64-1-U	0.000525	0.00053	0.05	3	0.00067	0.00020	4.303	-0.00032	0.00165	No	0.00055	0.00028
64	092097SW64-2-U	0.000914	0.00090										
64	092097SW64-2-U*	0.000876											
64	092097SW64-3-U	0.000587	0.00059										
64	092097SW64-4-U**	0.0002	0.00020										
64	091797SW64-4-F**	0.0002	0.00020	0.05	3	0.00061	0.00020	4.303	-0.00039	0.00162	No	0.00051	0.00026
64	092097SW64-1-F	0.000380	0.00038										
64	092097SW64-2-F	0.000762	0.00074										
64	092097SW64-2-F*	0.000716											
64	092097SW64-3-F	0.000720	0.00072										

Table A-3

Comparison of University of California Duplicate Results with University of Idaho Results

Fall 1997 Interim Surface Water Survey

Station	Field Sample ID	Analytical Result (mg/L)	Averaged Analytical Result (mg/L)	Prediction Interval to Contain the U of C Davis Duplicates with U of I Results: Prediction Interval (α)	Number of U of I Results (n)	U of I Mean (mg/L)	U of I Standard Deviation (s) (mg/L)	$t_{(1-\alpha/2;\,\nu)}$ (from Table A.1, Hahn & Meeker)	Lower Prediction Bound (mg/L)	Upper Prediction Bound (mg/L)	Reject H_o? (U of C Davis results are the same as U of I results)	Pooled Averages (mg/L)	Pooled Standard Deviations (mg/L)
Pole Creek													
Above Pole Canyon waste rock disposal area													
65	091597SW65-0-U	0.000432	0.00043				Not applicable					0.00043	-
65	091597SW65-0-F	-0.0000797	-0.00008				Not applicable					-0.00008	-
Above Pole Canyon waste rock disposal area													
66	091597SW66-1-U	0.612	0.60200				Not applicable					0.58267	0.01815
66	091597SW66-2-U*	0.592											
66	091597SW66-2-U	0.566	0.56600										
66	091597SW66-3-U	0.580	0.58000										
66	091597SW66-1-F	0.63	0.63000				Not applicable					0.58617	0.03856
66	091597SW66-2-F	0.558	0.55750										
66	091597SW66-2-F*	0.557											
66	091597SW66-3-F	0.571	0.57100										

* University of Idaho sample duplicate; averaged with subsample resulting in an average analytical value

** University of California duplicate

An F-test was used to discern differences in variances in selenium concentrations at the different background stations. This statistical test is presented in Table A-4. The F-tests indicate that there are variance differences. Therefore, results from the three streams are regarded as coming from three distinct locations. Thus, the pooled results for Caldwell Creek and South Fork Sage Creek are used with the results for the downstream station on Grizzly Creek to define an upper bound of the regional distribution of background values. Assuming that the background selenium concentration is lognormally distributed in space, an upper 95 percent confidence bound of the 95th percentile of the regional background distribution of selenium is calculated to be 0.00094 mg/L.

The correlation coefficient, r, between variables, x and y, are calculated as follows:

$$r = \frac{\sum_{i=1}^{n} x_i y_i - \frac{\sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{n}}{\sqrt{\frac{\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2}{n}} \sqrt{\frac{\sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y_i\right)^2}{n}}}. \quad \text{(Equation 2-13)}$$

The coefficient of determination, r^2, explains the degree of correlation between two variables and is simply the square of the correlation coefficient. Procedures for calculating correlations are found in any introductory statistics text. To determine whether a correlation is statistically significant, r is compared to a tabulated value of $r_{(\nu;1-\alpha/2)}$. If the calculated r exceeds the tabulated r, one cannot conclude that there is no correlation between variables x and y. Values of $r_{(\nu;1-\alpha/2)}$ were obtained from Diem (1962).

To assess the value of information gained from minimal sample replication—two replicate samples per station—the confidence factors for the replicated QA stations are adjusted to predict the confidence factors if only two replicates would have been obtained. If Equation 2-1 is rewritten as follows:

$$\hat{\mu} = \bar{x} \pm \frac{t_{(1-\alpha/2;\nu)} s}{\sqrt{n}} = \bar{x} \pm c_e s \qquad \text{(Equation 2-14)}$$

where c_e can be regarded as the empirical confidence factor, which is a function of the degrees of freedom, the confidence level, the sample standard deviation, and the sample size. The confidence factor for a sample size of 2, c_2, can be estimated as follows:

$$c_2 = c_e \left(\frac{t_{(1-\alpha/2;1)}}{t_{(1-\alpha/2;\nu)}}\right)\left(\frac{\sqrt{n}}{\sqrt{2}}\right)\left(\frac{k_{s(\nu)}}{1.2533}\right) \qquad \text{(Equation 2-15)}$$

Table A-4
Upper Tolerance Limit for Background Selenium Concentrations
Fall 1997 Interim Surface Water Survey

Station	Analytical Result (mg/l)	Transformed Pooled Background Average (excluding upper Grizzly Creek) Ln(mg/L + 2)	Transformed Pooled Background Standard Dev. (excluding upper Grizzly Creek) Ln(mg/L + 2)	One-tail 95% Upper Tolerance Limit using Transformed Values: Probability (1-α)	Proportion (p)	Sample No. (ν+1)	Tolerance Factor (g; Table A.12d, Hahn & Meeker)	Transformed Upper Tolerance Limit Ln(mg/L+2)	Upper Tolerance Limit (excluding upper Grizzly Creek) (mg/L)
South Fork Sage Creek									
Above Phosphoria Formation									
59	0.000471	0.69338	0.00003	0.95	0.95	9	3.031	0.6935	0.0007
59	0.000521								
Below Phosphoria Formation									
60	(0.000112)								
60	0.000753								
Caldwell Canyon									
Above Phosphoria Formation									
61	0.000541								
61	0.000376								
Below Phosphoria Formation									
62	0.000704								
62	0.000385								
62	0.000424								
Grizzly Creek									
Above Phosphoria Formation									
63	0.000151								
63	0.000624								
63	0.000449								
63	0.000520								
63	0.0001								
63	0.000206								
63	0.000340								
63	0.000334								
63	0.000283								
63	0.0001								
Below Phosphoria Formation									
64	0.000525								
64	0.000914								
64	0.000876								
64	0.000587								
64	0.0002								
64	0.0002								
64	0.000380								
64	0.000762								
64	0.000716								
64	0.000720								

where $t_{(1-\alpha/2;\nu)}$ is the tabulated t-statistic associated with the c_e, n is the sample size associated with c_e, and $k_{s(\nu)}$ is the sample standard deviation correction factor associated with the empirical value of s. For a sample size of 2, $k_{s(1)}$ is 1.2533. The sample standard deviation correction factor is needed because s underestimates σ, the true, population standard deviation, and the smaller the sample size, the greater the degree of bias. Mathematically:

$$\hat{\sigma} = k_{s(\nu)} s \qquad \text{(Equation 2-16)}$$

where $\hat{\sigma}$ is the estimate of σ. The t-statistic takes this underestimation into account, but double counting of this phenomenon would occur without the $k_{s(\nu)}$ ratio in the equation. The values of $k_{s(\nu)}$ are obtained from Diem (1962).

Table A-5 presents the 95 percent confidence bounds of the mean selenium concentration for each QA station. Confidence bounds are calculated by t-statistic. If no replication is done (i.e., the sample size is 1), then the lower and upper confidence bounds increase to negative infinity and positive infinity, respectively. In the absence of replicate sampling, statistical analyses cannot be performed; one can only discuss the data qualitatively. Table A-5 shows what the 95 percent confidence bounds for each of the QA stations would be with minimum replication, a sample size of 2. Such predicted confidence bounds assume a higher confidence factor due to the lower sample size and also take the relevant inherent low bias in the estimate of sample standard deviation attributable to small sample sizes into account.

Table A-5
Confidence Intervals of Mean Selenium Concentrations at Quality Assurance Stations
Fall 1997 Interim Surface Water Survey

Station	Field Sample ID	Analytical Result (mg/L)	One-tail 95% Confidence Interval: Mean Selenium Concentration (mg/l)	Standard Deviation (s) (mg/l)	Degree of Freedom (ν)	t-statistics $t_{(1-\alpha,\ 1)}$	t-statistics $t_{(1-\alpha,\ \nu)}$	Standard Deviation Correction Factor (Diem, 1962) $k_{s(\nu)}$	Standard Deviation Correction Factor (Diem, 1962) $k_{s(1)}$	Empirical Confidence Factor[1] for n = 2 (c_2)	c_2*s	Lower Confidence Bound (mg/L)	Upper Confidence Bound (mg/L)
Blackfoot River													
Above confluence with Dry Valley Creek													
19	091797SW19-1-U	0.00281	0.00215	0.00042	8	6.3140	1.8600	1.0317	1.2533	5.9278	0.0025	-0.0003	0.0046
19	091797SW19-2-U	0.00232											
19	091797SW19-2-U*	0.00226											
19	091797SW19-3-U	0.00210											
19	091797SW19-4-U	0.0017											
19	091797SW19-1-F	0.00226											
19	091797SW19-2-F	0.00360											
19	091797SW19-2-F*	0.00302											
19	091797SW19-3-F	0.00198											
19	091797SW19-4-F	0.0018											
Below confluence with Dry Valley Creek													
20	091897SW20-1-U	0.00214											
20	091897SW20-2-U	0.00207											
20	091897SW20-2-U*	0.00190											
20	091897SW20-3-U	0.00210											
20	091897SW20-3-U*	0.00259											
20	091897SW20-4-U	0.0017											
20	091897SW20-1-F	0.00212											
20	091897SW20-2-F*	0.00213											
20	091897SW20-2-F	0.00193											
20	091897SW20-3-F	0.00209											
20	091897SW20-4-F	0.0018											
Grizzly Creek													
Above Phosphoria Formation													
63	092097SW63-1-U	0.000151	0.00041	0.00024	8	6.3140	1.8600	1.0317	1.2533	5.9278	0.0014	-0.0010	0.0018
63	092097SW63-2-U*	0.000624											
63	092097SW63-2-U	0.000449											
63	092097SW63-3-U	0.000520											
63	092097SW63-4-U	0.0001											
63	092097SW63-1-F	0.000206											
63	092097SW63-2-F	0.000340											
63	092097SW63-2-F*	0.000334											
63	092097SW63-3-F	0.000283											
63	092097SW63-4-F	0.0001											

Table A-5
Confidence Intervals of Mean Selenium Concentrations at Quality Assurance Stations
Fall 1997 Interim Surface Water Survey

Station	Field Sample ID	Analytical Result (mg/L)	One-tail 95% Confidence Interval: Mean Selenium Concentration (mg/l)	Standard Deviation (s) (mg/l)	Degree of Freedom (ν)	t-statistics $t_{(1-\alpha,\ 1)}$	t-statistics $t_{(1-\alpha,\ \nu)}$	Standard Deviation Correction Factor (Diem, 1962) $k_{s(\nu)}$	Standard Deviation Correction Factor (Diem, 1962) $k_{s(1)}$	Empirical Confidence Factor[1] for n = 2 (c_2)	c_2*s	Lower Confidence Bound (mg/L)	Upper Confidence Bound (mg/L)
Below Phosphoria Formation													
64	092097SW64-1-U	0.000525											
64	092097SW64-2-U	0.000914											
64	092097SW64-2-U*	0.000876											
64	092097SW64-3-U	0.000587											
64	092097SW64-4-U	0.0002											
64	091797SW64-4-F	0.0002											
64	092097SW64-1-F	0.000380											
64	092097SW64-2-F	0.000762											
64	092097SW64-2-F*	0.000716											
64	092097SW64-3-F	0.000720											
Pole Creek													
Above Pole Canyon waste rock disposal area													
65	091597SW65-0-U	0.000432	Detected difference in comparison to downstream station; refer to Table 3-4 for F- and t-test results										
65	091597SW65-0-F	-0.0000797											
Above Pole Canyon waste rock disposal area													
66	091597SW66-1-U	0.612	0.58442	0.02702	4	6.3140	2.1320	1.0638	1.2533	3.9746	0.1074	0.4770	0.6918
66	091597SW66-2-U*	0.592											
66	091597SW66-2-U	0.566											
66	091597SW66-3-U	0.580											
66	091597SW66-1-F	0.63											
66	091597SW66-2-F	0.558											
66	091597SW66-2-F*	0.557											
66	091597SW66-3-F	0.571											

* University of Idaho sample duplicate; averaged with subsample resulting in an average analytical value

1 Refer to Appendix A, Equation 15 for confidence factor equation

Appendix B
Data Validation and Quality Control Summary Report

INTERIM SURFACE WATER SURVEY
DATA VALIDATION AND QUALITY CONTROL SUMMARY REPORT

The following is a summary of the data validation and quality control (QC) review conducted for surface water samples collected in September, 1997, near Soda Springs, Idaho, for the Southeast Idaho Selenium Project. The University of Idaho (UI) Analytical Sciences Laboratory (ASL) located in Moscow, Idaho, was the primary analytical laboratory performing the analyses. The California Veterinary Diagnostic Laboratory located in Davis, California was the quality assurance (QA) laboratory tasked with analyzing surface water samples collected at pre-determined QA stations. Both laboratories were selected and audited prior to submitting samples, and both were proficient in the analysis of selenium using a perchloric acid digestion sample preparation procedure. A complete audit report of both analytical laboratories has been submitted to the Selenium Subcommittee of the Idaho Mining Association (Montgomery Watson, 1997).

A total of 154 surface water samples, which includes 14 equipment blanks (7 filtered and 7 unfiltered), were collected for this field sampling effort. Samples were submitted under chain-of-custody to each laboratory. The field samples and associated QC samples were analyzed for the following:

- Filterable Residue by EPA Method 160.1 (hereafter referred to as total dissolved solids, TDS)
- Selenium by UI Method SMM.55.020.05 and by Davis SOP 50.10.86

Data quality objectives (DQOs) are qualitative and quantitative statements that specify the quality of the data required to meet the goals of site investigations or to support decisions made in environmental management activities. DQOs for the interim surface water survey were expressed in terms of precision, accuracy, representativeness, completeness, and comparability (PARCC). The results of QC samples were evaluated against the DQOs and the quality of the data was assessed according to the PARCC parameters. QC sample results that fall outside these criteria serve to signal unacceptable or biased data that could result in corrective actions being implemented, or qualification of the data. The following is a summary of the data review, including data qualification that resulted from the validation effort.

The data were validated following statistical evaluation by the Project Manager. The evaluation specified a value that represented the 95% upper confidence bound of the 95th percentile of the distribution of the blank values of selenium for the UI and Davis data sets (0.000741 mg/L and 0.006507, respectively) based on the evaluation of the method and equipment blanks reported by each laboratory

(no differences in filtered and unfiltered equipment blanks were discerned nor in equipment and method blanks). For the surface water data, the entire sampling effort was considered a sample delivery group and all the laboratory blanks were pooled together to determine the blank value. The selenium results that were below the values (0.000741 mg/L for UI data, 0.006507 mg/L for Davis data) were assigned an "L" (less than the statistical limit) qualifier prior to validation, and were considered estimated values (i.e., results flagged with an L are not discernibly different from a blank). Thus, there are no "nondetects" in the surface water data set. The remaining step in the data validation process following the blank assignment was conducted in general compliance with EPA Functional Guidelines (EPA, 1990), however, all data were considered detected in the validation effort.

The data were also evaluated statistically based on the blank results for total dissolved solids (TDS). The blank value of 9.7 mg/L was determine statistically for the data evaluation as being the 95% upper confidence bound of the 95th percentile of the distribution of the blank values of the TDS; values below 9.7 mg/L were again assigned an "L" prior to validation. Surface water samples were only submitted to UI for TDS analysis and not Davis.

Precision and Accuracy

Precision and accuracy were evaluated based on the QC results generated from site specific matrix spike samples, laboratory duplicates, standard reference material (SRM) analysis and laboratory control samples. In addition, initial and continuing calibration results were used to assess accuracy. All precision and accuracy goals were met.

Standard reference materials were analyzed with the samples. The primary and QC laboratories analyzed SRMs with acceptable results, UI analyzed two aqueous SRMs identified as APG Water 7878 and APG 7879, from Analytical Products Group, Belpre, OH and Davis analyzed two solid SRMs identified as Bovine Liver NIST 1577b and DORM-2 tissue NRCC, with acceptable results.

One sample was reported as a spike (UI sample W9701938MS), however, it was later identified as having been analyzed as a normal sample. Therefore, this sample should be considered a laboratory duplicate rather than a matrix spike.

The upper calibration range for the selenium analysis is 300 ppb. Sample results above 300 ppb were not identified as being analyzed at dilutions by the laboratory, however, based on discussions with the laboratory, samples were diluted as appropriate. Reporting the dilution factor with the sample results will be requested in future sampling events. Also, there was no qualification to the data since the surface water concentrations were not significantly above 300 ppb and the ICP instrument on which the samples were analyzed demonstrates linearity above 300 ppb.

Representativeness

Representativeness was evaluated through the analysis of laboratory method blanks and equipment blank samples. As previously noted, the evaluation of the blanks was performed prior to the data validation. Selenium concentrations and TDS values below the statistical limits (Se: 0.000741 mg/L for UI and 0.006507 mg/L for Davis; TDS: 9.7 mg/L) were qualified as estimated with an "L" and considered detected for the validation effort.

There were low levels of selenium in both the UI and Davis method blanks, ranging from less than zero to 0.00079 mg/L for the UI analyses, and less than zero to 0.0012 mg/L for the Davis analyses. The TDS blanks ranged from 0 to 7 mg/L. There were also low levels of selenium in the equipment blank samples, ranging from 0.0000648 mg/L to 0.000590 mg/L. Data were not qualified based on the low levels of selenium detected in the equipment blanks.

Completeness

Field QC samples were collected and analyzed, and laboratory QC samples were analyzed as specified in the Field Sampling Plan (Montgomery Watson, August 1997). Completeness for field and laboratory QC data was 99 percent (although, three samples were collected for TDS but were broken during shipment). All sample analytical holding times were met.

Both laboratories provided data packages that contained the raw data results, QC results and documentation supporting the calibrations. The primary laboratory analyzed matrix spikes at several levels (50 ppb and 100 ppb) however, the actual spike amount and recoveries were not included on the QC summary sheets. Complete reporting of matrix spikes will be requested for future sampling events.

Comparability

Comparability was achieved by analyzing the samples according to the specified methods. Each laboratory used their specific analytical method for selenium analysis; the TDS samples were analyzed using an EPA method. The detection limits for the selenium analyses were reported by each laboratory, however, as previously stated, the values below the reporting limit were qualified with an "L" and were considered estimated for the data validation.

Summary of Data Quality

The evaluation of the PARCC criteria provided information on the quality of the data. The data were considered usable as a result of the validation.

References

EPA 1994. "National Functional Guidelines for Inorganic Data Review." USEPA Contract Laboratory Program. Publication 9240.1-05-01, PB94-963502, EPA 540/R-94/013. Office of Emergency and Remedial Response, USEPA, Washington DC. February.

Montgomery Watson 1997. "Sampling and Analysis Plan - Southeast Idaho Phosphate Resource Area Selenium Project, Fall 1997 Interim Surface Water Survey." September.

INORGANIC DATA ASSESSMENT SUMMARY

PROJECT:IMA Se Interim Surface water	SITE: Idaho
LABORATORY: UI & Davis	SDG:NA
SAMPLES/MATRIX/ANALYSES: See COC for sample collected. Surface water matrix, Selenium by ICP - Hydride and TDS	

DATA ASSESSMENT SUMMARY

REVIEW ITEM	ICP	AA	HG	CYANIDE	OTHER
1. Data completeness	O				
2. Holding Times	O				
3. Calibration	O				
4. Blanks	see qc memo				
5. ICS	NA				
6. LCS	O				
7. Duplicate RPD	O				
8. Spike Recovery	O				
9. MSA	NA				
10. Other QC - Eq. blanks	O				
11. Field Duplicates	O				
12. Result Verification	O				
13. Overall Assessment	O				

O = Data had no problems/or qualified due to minor problems.
M = Data qualified due to major problems.
NA = Data review item not applicable.
X = Problems exist, but do not affect data useability.
Z = Data unacceptable.

Comments/Qualified Results: TDS for blanks in database are reported as the detection limit instead of a value less than the detection limit.

Verified and Validated by: Christina Jensen Date: 12/19/97

Reviewed and Approved by: _____ Date: _____

INORGANIC DATA ASSESSMENT SUMMARY

1. Data package completeness (check if present)

___Case narrative
_x _Chain of custody
_x__Sample Results
_x_ICV/CCV Results
_x__Blank Results
___ICP Interference Check Results
_x__Spike Recovery Results
_x__Duplicate Results
_x__LCS Results
___Standard Addition Results
___ICP Serial Dilution
_x__Instrument Det. Limits
___ICP Correction Factors
___ICP Linear Ranges
_x__Preparation Logs
_x__Analysis Run Logs
_x__ICP Raw Data
___GFAA Raw Data
___Hg Raw Data
___Cyanide Raw Data
___Other_____

Comments/Qualified Results: COC review indicated there were three samples collected and not analyzed by UI for TDS due to breakage in transit: 091897SW20-2-U, 091897SW20-3-U and 092197SW50-0-F.

2. Holding times (check all that apply)

_x__ICP/GFAA metals completed in <6 mos from collection
___Mercury analyzed in <28 days from collection
___Cyanide completed in 14 days from collection

Qualify as estimated (J, UJ) all results analyzed past the holding times listed but within 2x times the limit. Qualify detects as estimated (J) and non-detects unusable (UR) for results analyzed greater than 2x above the limit. If soil data are qualified based on water holding time criteria, note.
Comments/Qualified Results: Davis - all sample holding times were met. UI - all holding times were met.

3. Calibrations (check all that apply)

___GFAA/Hg correlation coefficient <0.995, results estimated (J,UJ)
___ICV/CCV %R, ICP 89-111%, Hg 80-120%, Cn 85-115%, results acceptable
___ICV/CCV %R, ICP, 75-89%, Hg 65-79%, Cn 70-84%m results <IDL estimated (UJ)
___ICV/CCV %R, ICP <75%, Hg <65%, Cn <70%, results >IDL unusable (R)
___ICV/CCV %R, ICP >125%, Hg >135%, Cn >130%, results >IDL unusable (R), <IDL acceptable
___ICV/CCV %R, ICP 75%-89% or 111%-125%, Hg 65-79% or 121-135%, Cn 70-84% or 116-130%, results >IDL estimated (J)

Comments/Qualified Results: Calibration checks: +/- 15 (85-115) is UI limit. Davis correlation coeff ok, blank, 10 and 300 ppb used for ICAL.Dorm-2 result was low, telephone conversation with Davis indicated the DORM-2 was consistently reading low - perhaps due to moisture, no

qualification of data since this SRM was provided by Davis due to Montgomery's request to see all of the raw data.

4. Blanks (check all that apply)

___Detects reported in ICB/CCB, list : not applicable see QC text for explanation for samples qualified "L" less than the value provided by project manager Bill Wright. All results are considered estimated "L", or detected (above the blank value). TDS: all blank results were below attached statistical value.

___Detects in preparation blanks, list : none

___Detects in field blanks, list : none

Qualify as undetected (U) all sample concentrations ³5X any associated blank concentrations.

Comments/Qualified Results: none

5. Interference Checks (check all that apply)

___ICS A/B Recoveries Acceptable
___Al, Ca, Fe, Mg sample concentrations >ICS concentrations
___ICS %R >120%, results >IDL estimated (J)
___ICS %R 50-79%, results >IDL estimated (J), possible false negative
___ICS %R 50-79%, results <IDL estimated (UJ)
___ICS %R <50%, results >IDL and <IDL rejected (R/UR)
___ICS %R >120, results <IDL acceptable

Comments/Qualified Results: NA

6. Laboratory Control Samples (check all that apply)

_x__LCS %R 80-120 (Ag, Sb no limits) and SRM
___LCS %R 50-79% or >120%, results >IDL estimated (J)
___LCS %R 50-79% and results <IDL estimated (UJ)
___LCS %R <50% and all results rejected (R/UR)
___LCS %R >120%, results <IDL acceptable

Comments/Qualified Results: Telephone call with Davis discussed DORM-2 (tissue) %R seems to be coming in a little low. The DORM-2 was not for our samples, just in the batch. There is no SRM that Davis has to analyze for an aqueous matrix at this time. DAVIS: SRM is bovine liver, DORM-2. Davis also performed a blank spike on 18MOHM which is ultrapure deionized water. 102%R, good. UI did not run a separate LCS, they considered their check standards a

blank spike - their %R were acceptable. UI SRMs were aqueous - AGP 7878, APG 7879 - 2 SRMS @ 2 levels with acceptable results

7. Duplicate (check all that apply)

_x__Duplicate RPD ³20% for waters (³35% for soils) for results >5X CRDL
_x__Duplicate range is within ±CRDL (±2xCRDL for soils) for results ³5X CRDL
___Qualify positive results estimated (J) if the above criteria were not met

Comments/Qualified Results: Davis duplicate of 18 MOHM ok. Davis demonstrated precision. Overall triplicate precision not done in this validation, will be evaluated statistically by project manager. UI all laboratory duplicate results were acceptable. UI performed TDS duplicate analysis on 1859, 1826, 1844, 1863, 1870, 1932, 1952, 1972, 1975, 1982, 2011 and 2017. UI performed duplicate analysis on 1865, 1959, 1990, 1852, 1844, 1876, 1877, 1937, 1936, 1949, 1916, 1961, 1962, 1972, 2014, 2020, 1930, 1992, 1984, 1977, 1976, 1833, 1834, and 1824 with acceptable results.

8. Spike Recovery (check all that apply)

__x_Spike %R with 75-125%
___Spike %R 30-74%, >125%, results >IDL estimated (J)
___Spike %R 30-74% results <IDL estimated (UJ)
___Spike %R <30%, results <IDL rejected (UR)
___Field blank used for spike analysis
___Spike %R >125%, results <IDL acceptable
___Sample concentration exceeds spike concentration by a factor of >4x, acceptable

Comments/Qualified Results: Davis spike is blood 102%R ok. Also, blank spike (LCS) on water ok. All within limits. UI TDS - NA. Surface water spikes @ 100 or 50 ppb, lab did not identify the spike level and sample ID and recovery on the QC sheet - will request for next sampling round. One sample, 1938 was inadvertently reported by the lab as a spike, upon communication with the lab, the lab said that the sample was not spiked, it was just another analysis. %R up to 1ppm appears to be acceptable, two samples were spiked at this level with good recovery.

9. GFAA Performance (check all that apply)

___Duplicate injection RSD <20%
___Duplicate injection RSD >20%, results >CRDL estimated (J)
___Analytical spike %R 85-115%
___Analytical spike %R 40-85%, results >IDL estimated (J)
___Analytical spike %R 10-40%, results <IDL estimated (UJ)
___Analytical spike %R <10%, results <IDL rejected (R)
___Analytical spike %R <40%, results >IDL estimated (J)

___MSA required but not run, results estimated (J)
___MSA run at incorrect level, results estimated (J)
___MSA correlation coefficient <0.995, results estimated (J)
Comments/Qualified Results: NA

10. Serial Dilution (check all that apply)

___Serial Dilution %D within 10% for sample results >50x the IDL
___Serial Dilution %D greater than 10%, results >50x the IDL estimated (J)
Comments/Qualified Results: NA

11. Field Duplicates (check all that apply)

___Field duplicate RPD ³20% waters (³35% for soils) if >5x CRDL
___Field duplicate range is within ±CRDL (±2x CRDL for soils) for results <5xCRDL

Note: There are no qualification requirements for field QC samples exceeding limits.
Comments/Qualified Results: Field duplicates reviewed at statistical level once validation is performed. Samples were collected in triplicate and also at QA stations, one sample at each station was also sent to Davis for confirmation.

12. Result Verification (check all that apply)

_x__All results supported in raw data

Comments/Qualified Results: Davis results - lab run samples twice and the average is reported. Data base - not checked 100% but no transcription errors noted on items that were checked. All samples were reported with no dilution information - assumed no dilution however based on a telephone conversation with UI chief chemist, some samples were analyzed at dilutions, it was done in-house. Since accuracy has been demonstrated at levels of 1ppm due to spikes, data were not qualified. For next sampling event, the dilution will be requested to be reported on the result form.

13. Overall Assessment
"L" was the only qualification of the data for the surface water set.