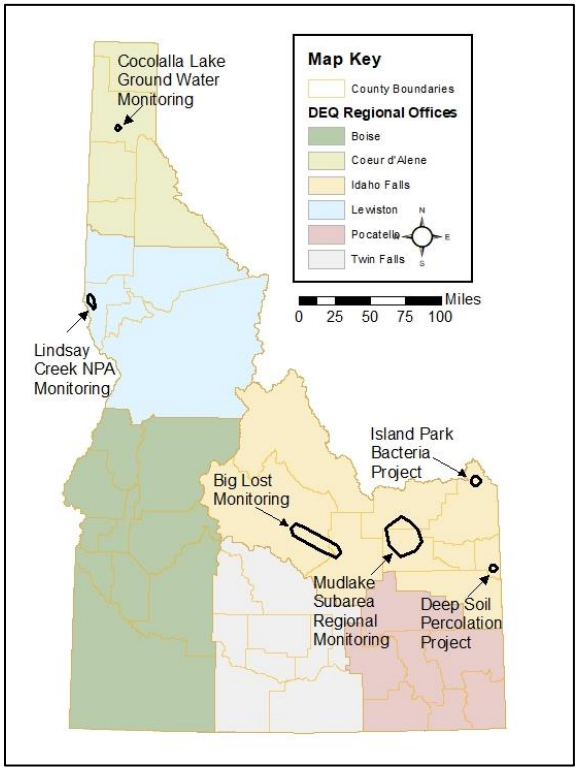
Summary Report for the Idaho Department of Environmental Quality Groundwater Quality Monitoring Projects—2020

Groundwater Quality Technical Report No. 54



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Acronyms, Abbreviations, and Symbols

°C	degrees Celsius
µg	micrograms
µS	microsiemens
bgs	below ground surface
BMP	best management practice
BTEX	benzene, toluene, ethylbenzene, and xylene
$CaCO_3$	calcium carbonate
cfu	colony forming unit
cm	centimeter
DEQ	Idaho Department of Environmental Quality
DO	dissolved oxygen
DW	domestic well
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
ESRP	Eastern Snake River Plain
FSP	field sampling plan
GWQM	groundwater quality management
IBL	Idaho Bureau of Laboratories
IDAPA	refers to citations of Idaho's administrative rules
IDWR	Idaho Department of Water Resources
ISDA	Idaho State Department of Agriculture
L	liter
m+p-Xylene	meta-Xylene plus para-Xylene
MCL	maximum contaminant level
mg	milligram
mL	milliliter
MPN	most probable number
NA	not applicable
ND	Non-detect
NPA	nitrate priority area
NPDWR	National Primary Drinking Water Regulation
NSDWR	National Secondary Drinking Water Regulation

o-Xylene	orthoxylene
per mil (‰)	parts per thousand
pCi	picocuries
PWS	public water system
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
TC	total coliform
TDS	total dissolved solids
$\delta^{15}N$	ratio of the two stable nitrogen isotopes ^{15}N and ^{14}N
$\delta^{15}N_{nitrate}$	ratio of the two stable nitrogen isotopes ^{15}N and ^{14}N of the nitrate molecule
$\delta^{18}O$	ratio of the two stable oxygen isotopes ^{18}O and ^{16}O
$\delta^{18}O_{nitrate}$	ratio of the two stable oxygen isotopes ^{18}O and ^{16}O of the nitrate molecule

1 Introduction

Groundwater is a key resource in Idaho — providing drinking water to 95% of Idahoans — and a critical component of the state's economy. The economic and social vitality of almost every Idaho community depends on access to a safe and clean groundwater supply.

Idaho Code §39-120 "Department of Environmental Quality Primary Administrative Agency – Agency responsibilities" designates the Idaho Department of Environmental Quality (DEQ) as the primary agency to coordinate and administer groundwater quality protection programs for the state. DEQ is also responsible for collecting and analyzing data for groundwater quality management purposes. Idaho Code §39-120 further directs DEQ, the Idaho Department of Water Resources (IDWR), and the Idaho State Department of Agriculture (ISDA) to conduct groundwater quality monitoring and promote public awareness of groundwater issues by making results of groundwater quality investigations available to the public.

Public water systems (PWSs) are regulated by DEQ under the federal Safe Drinking Water Act and the "Idaho Rules for Public Drinking Water Systems" (IDAPA 58.01.08). These regulations require chemical analysis of drinking water for various contaminants. DEQ ensures that follow-up monitoring is conducted when contaminants of concern are detected in PWSs. The US Environmental Protection Agency (EPA) sets National Primary Drinking Water Regulations (NPDWRs) as legally-enforceable standards, expressed as maximum contaminant levels (MCLs), which apply to PWSs. The established levels protect public health by limiting the amount of contaminants in drinking water. EPA also sets National Secondary Drinking Water Regulations (NSDWRs) as nonmandatory standards established as guidelines to assist PWSs in managing their drinking water for aesthetic considerations (e.g., taste, color, and odor).

Although these limits only apply to PWSs, they can be used to evaluate water quality in private wells, as is done throughout this report. Total coliform (TC) and *Escherichia coli* (*E. coli*) bacteria sampling results were compared to the groundwater quality standards in Idaho's Groundwater Quality Rule (IDAPA 58.01.11) rather than national regulations. The single samples collected during these projects were not appropriate for comparison to the national standards, which are based on exceedances during a month-long sampling period.

DEQ also responds to detections of contaminants of concern identified by monitoring programs implemented by other entities, such as the Statewide Ambient Groundwater Quality Monitoring Program, administered by IDWR. Follow-up investigations may develop into a DEQ local or regional monitoring project to assess conditions and identify areas where public health may be threatened. The investigation results can facilitate management decisions that protect the resource and promote public awareness for groundwater protection.

Field measurements taken during follow-up investigations and monitoring projects should be considered estimates and not used for determining exceedances of Idaho's groundwater quality standards. Field measurements are used to monitor well water during purging, ensure water in

the wellbore is removed from the well before sampling, and to qualitatively evaluate water quality variability between wells.

The groundwater quality monitoring results can also be used to define and prioritize degraded groundwater quality areas, such as nitrate priority areas (NPAs). In 2020, DEQ identified 35 areas in the state with elevated concentrations of nitrate (as N)[1] in groundwater. These NPAs are ranked based on population, water quality, and water quality trends. The criterion for an NPA designation is met when 25% or more of the wells sampled within the area meet or exceed 5 mg/L concentration, or half of the MCL (10 mg/L). EPA established an MCL for nitrate at 10 mg/L and Idaho adopted this MCL as the groundwater quality standard. The NPAs are reevaluated and re-ranked approximately every five years following the NPA delineation and ranking process (DEQ 2021).

Prioritization effectively allocates resources for water quality improvement strategies. DEQ works with state and federal agencies and stakeholders to develop groundwater quality improvement plans (i.e., groundwater quality management plans) to address groundwater degradation in NPAs. Groundwater quality data are used to evaluate the effectiveness of plan implementation.

DEQ's Groundwater Program implemented regional groundwater monitoring using a statistically-based approach to determine the monitoring network design. Most of these regional projects focused on areas designated as NPAs. This report provides an overview of DEQ's groundwater monitoring projects and investigation activities accomplished with public funds in 2020. It does not include results from privately-funded activities, including monitoring required by permits, monitoring associated with ongoing environmental remediation projects, Kootenai County Aquifer Protection District funding, or PWS requirements.

Well owners allowing DEQ access to sample are notified of the results and informed if concentrations exceed an MCL. Well owners with concentrations above health-based standards are also provided with information on health risks and possible treatment options.

[1] Unless otherwise noted, *nitrate* refers to nitrate (as N) throughout the document.

2 Summary of Groundwater Quality Projects by Region

This section presents data from groundwater quality monitoring and investigation projects conducted by DEQ in 2020. Projects are presented by DEQ regional offices and identified in Figure 1.

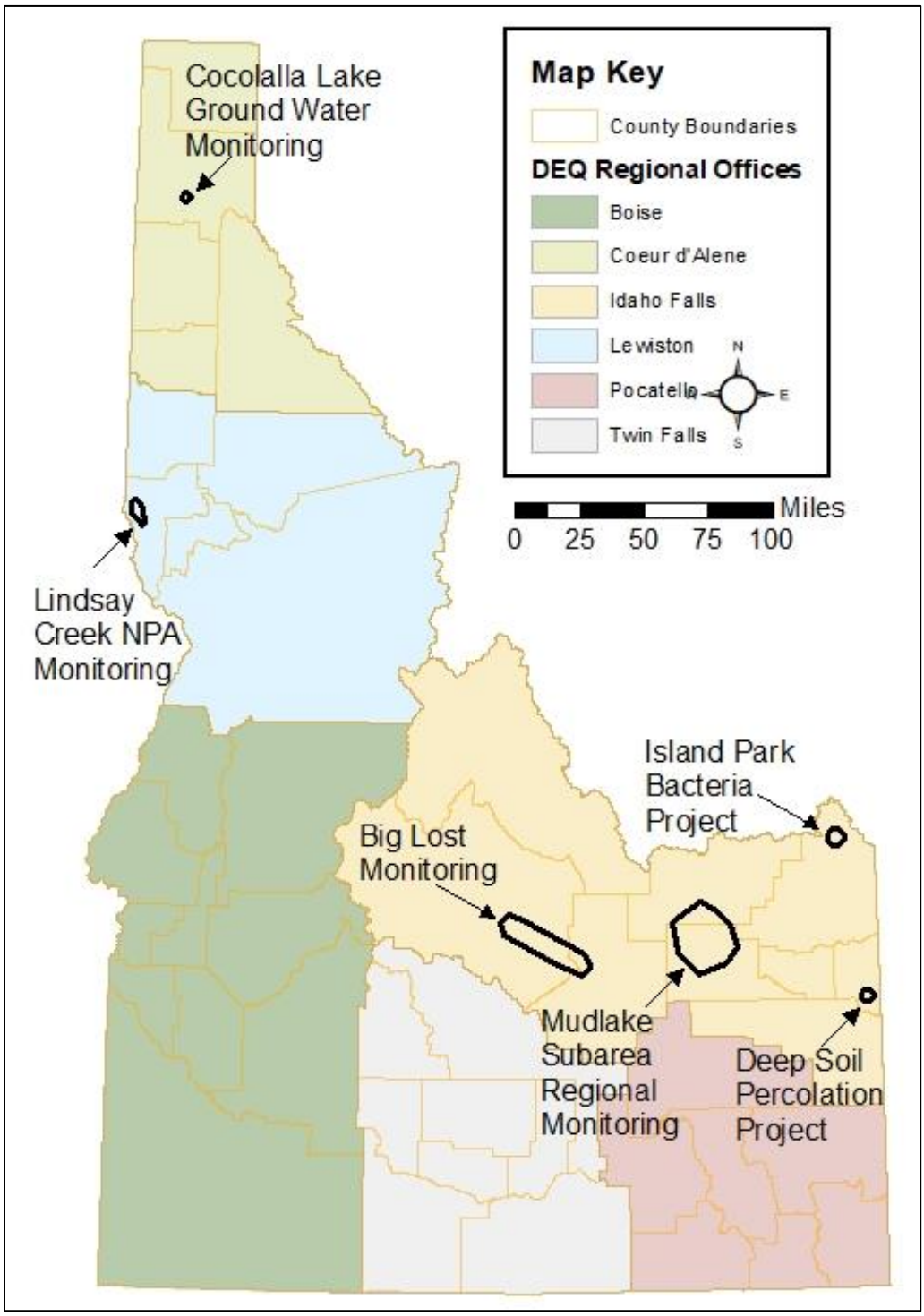


Figure 1. DEQ's 2020 groundwater quality project locations by region.

All groundwater quality data in this section are provided through an *interactive mapping application* available on DEQ's website. The application contains groundwater quality data that DEQ or its contractors collected from 1987 to the present. The application can be used to view and download data for over 350 contaminants, ranging from nitrate—a widespread groundwater contaminant—to emerging contaminants (e.g., personal care products, pharmaceuticals). The application was developed to help citizens, local officials, researchers, water quality professionals, consultants, and other stakeholders make informed decisions about land use activities. The application also provides private well owners with an indication of groundwater quality conditions in an area when considering treatment options for protecting their family's health.

2.1 Idaho Falls Region

Three groundwater quality monitoring projects were conducted in the Idaho Falls region in 2020 using public funds.

2.1.1 Mud Lake Subarea Groundwater Monitoring Project

2.1.1.1 Purpose and Background

The DEQ Idaho Falls region includes three regional monitoring subareas (Teton Basin/Ashton, Eastern Snake River Plain, and Mud Lake) based on land use and hydrogeologic boundaries to help identify impacts or changes to ambient groundwater quality (Figure 1). The process for identifying the regional subareas is described in Regional Groundwater Monitoring Network Design, Idaho Falls Regional Office (DEQ 2013a). Definitions for the specific subareas are summarized in Idaho Falls Regional Office Ambient Groundwater Monitoring Plan Development: Defining Subareas (DEQ 2013b). Sampling for the Mud Lake regional subarea was first completed in calendar year 2015 and is summarized in the 2015 annual summary report (DEQ 2017). Sampling for the Teton Basin/Ashton subarea was completed in calendar years 2013 and 2017 (DEQ 2015 and DEQ 2019c); the Eastern Snake River Plain subarea was completed in calendar years 2014 and 2018, respectively (DEQ 2016 and DEQ 2021).

Sampling for this second round of the Mud Lake subarea project began in 2019 and was completed in the first half of calendar year 2020. A complete report of this round of sampling, with results from 2019 is included with the 2020 data in this annual summary report.

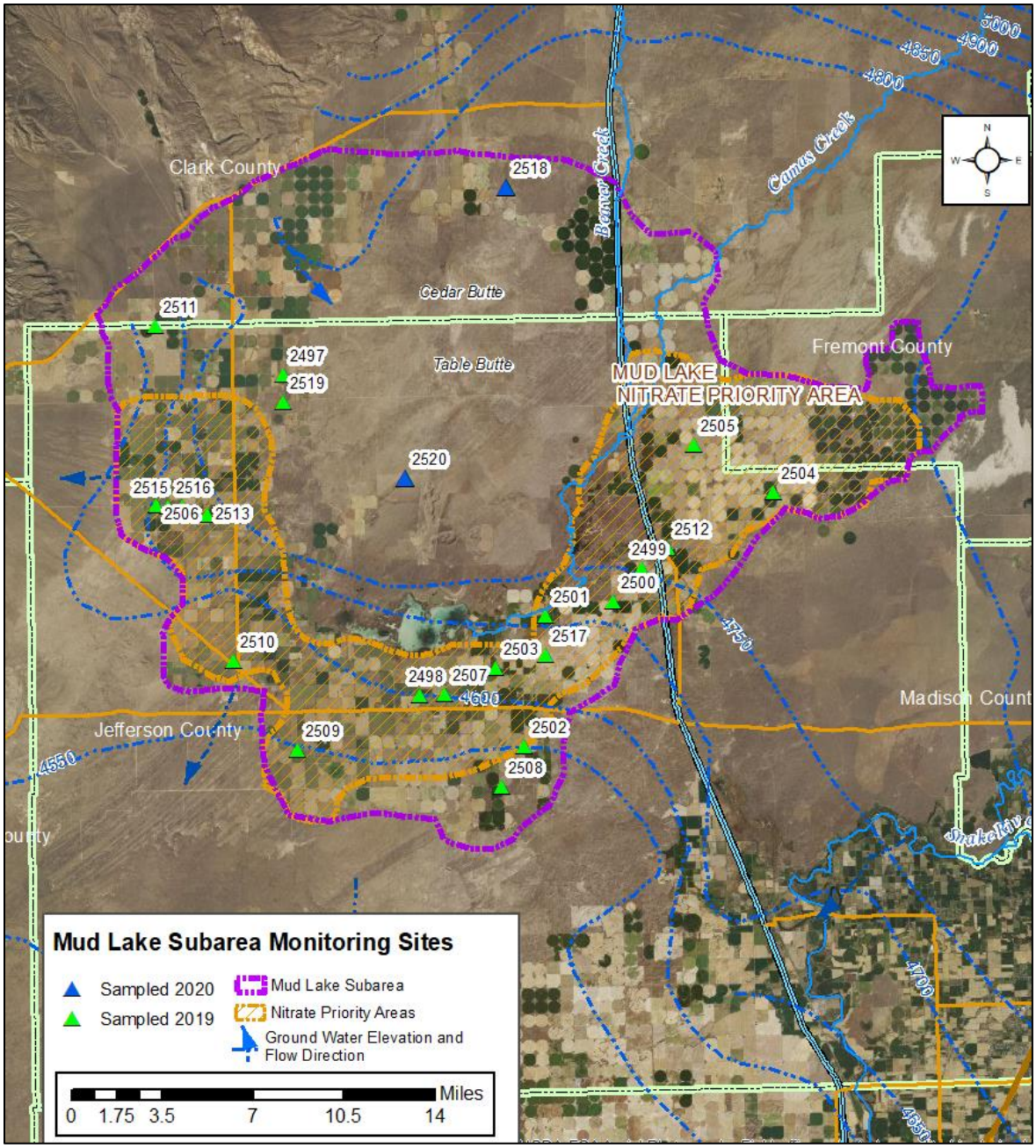


Figure 2. Site location map — Mud Lake Subarea Groundwater Monitoring Project.

The Mud Lake subarea covers 525 square miles of eastern Idaho, including the Mud Lake Terreton Basin and the lowlands surrounding the Table Butte/Cedar Butte complex of Jefferson and Clark Counties (Figure 2). The Mud Lake subarea is within the Eastern Snake River Plain (ESRP) aquifer. The regional geology for the ESRP aquifer is dominated by basalts, interbedded sediments, and rhyolites. The shallower subsurface is dominated by lake deposits and sandy, wind-blown sediments, intercalated with basalt and other volcanic deposits. The lake sediments are sufficiently continuous and of lower permeability to support a local aquifer perched above

the regional ESRP aquifer. Lake sediments and basalts are intercalated with sediments from the Beaver, Camas, and Birch Creek and other smaller drainages. Apart from shallower, perched conditions near Mud Lake, transmissivity and aquifer thickness are again greatest toward the center of the ESRP and tend to decrease toward the margins. The ESRP aquifer tends to respond as unconfined toward the center and as confined toward the margins, reflecting the larger proportion of sediments (Stearns et al. 1939; Spinizola 1994). Major sources of recharge are downward percolation of precipitation and snowmelt, runoff from the surrounding uplands, streamflow losses from drainages to the north of the region, and direct infiltration of surface water diverted for irrigation (Graham and Campbell 1981).

The objectives of this regional monitoring study are to identify areas of vulnerable or degraded water quality, collect data to aid in determining potential sources of degradation to direct and prioritize groundwater protection efforts based on potential sources, and evaluate the effectiveness of management practices used to reduce nitrate impacts.

2.1.1.2 Methods and Results

Sample locations were selected from the wells sampled in the original sampling of the project in 2015 and 2016. Original wells were selected from domestic and livestock wells with available well logs. Selection favored more recent wells with complete information concerning well construction, well-bore seals, and lithologic descriptions suggesting that groundwater sampled would represent the shallowest aquifer zone. The number of sample sites needed to adequately represent the area of interest was based on a statistical process (Steinhorst 2011), with the specific data used to determine the number of sample sites needed detailed in Idaho Falls Regional Office Ambient Groundwater Monitoring Plan Development: Defining Subareas (DEQ 2013c). A goal of 20 to 25 sample sites was established. Potential sample sites (wells) were selected from randomly identified and ordered 1-mile sections completely within the 525 square-mile study area. Sections that included IDWR or ISDA monitoring wells were excluded. A total of 23 wells were sampled in 2015 and 2016.

A total of 24 wells were sampled in October and December 2019 (22 wells) and June 2020 (2 wells (Wells 2518 and 2520) (Figure 2). Wells sampled in 2020 (Wells 2518, 2520) are stock wells and were not in use during the fall 2019 sampling period. One well sampled during the 2015/2016 sampling (2507) was not available for 2019/2020 sampling and a new well was added to the project (Well 2689). Results from these randomly selected wells can statistically represent the subarea and can be combined with results from other sampling networks to make inferences concerning the subarea.

Samples were also collected at five surface water locations in November 2019 to characterize the potential recharge to the groundwater in eastern Idaho, including the ESRP and tributary valley aquifers in the vicinity of the Teton Basin-Ashton, Mud Lake, and Eastern Snake River Plain subareas, and the South Fremont County NPA (Figure 3). The surface water sites were sampled at existing or historic US Geological Survey (USGS) stream gages on Henrys Fork, Teton River, Snake River, Beaver Creek, and Camas Creek.

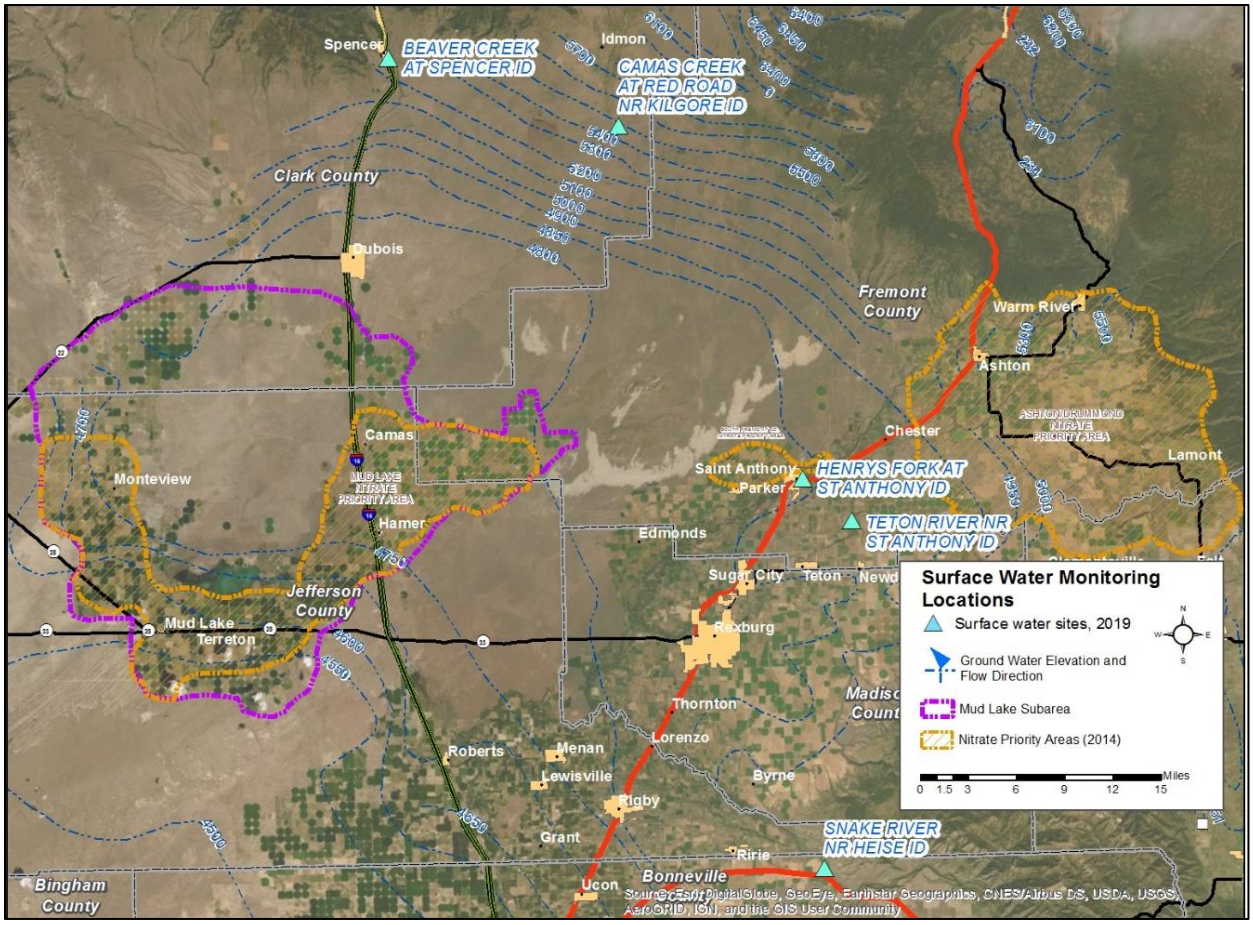


Figure 3. Surface water monitoring location map — Mud Lake Subarea Groundwater Monitoring Project.

The 24 project wells and 5 surface water locations were sampled following the appropriate QAPP (DEQ 2011) and FSP (DEQ 2019c). Water quality field parameters (pH, temperature, specific conductance, and DO) were measured at each site prior to sample collection (Table 1).

Field parameter measurements for pH ranged from 7.25 to 7.96 (Well 2499), with a mean and median of 7.70 and 7.71. Measurements for water temperature ranged from 9.1 °C to 14 °C (Well 2510), with a mean and median of 11.5 and 11.63 °C. Measurements for Specific Conductance ranged from 250 µS/cm to 976 µS/cm (Well 2513), with a mean and median of 475.5 µS/cm and 383 µS/cm. Measurements for dissolved oxygen ranged from 9.58 mg/L to 0.12 mg/L, with a mean and median of 6.8 mg/L and 7.68 mg/L. Wells 2499 and 2510 returned measurements of 0.68 mg/L and 0.12 mg/L, indicating an anoxic environment (<1.0 mg/L). Groundwater with low dissolved oxygen favor reducing conditions for nitrogen.

Field parameter measurements for the five surface water sites (Table 1) for pH ranged from 7.25 to 7.96 (Well 2499), with a mean and median of 7.70 and 7.71. Measurements for water temperature ranged from 0 °C to 4.18 °C, with a mean and median of 2.3 °C and 3.31 °C. Locations Beaver Creek at Spencer and Camas Creek both had significant surface ice at the time of sampling. Measurements for Specific Conductance ranged from 150 µS/cm to 520 µS/cm,

with a mean and median of 333 µS/cm and 360 µS/cm. Measurements for dissolved oxygen ranged from 13.2 mg/L to 10.64 mg/L, with a mean and median of 11.9 mg/L and 11.81 mg/L.

Table 1. Water quality field parameters—Mud Lake Subarea Regional Monitoring Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Water Temperature (°C)	Specific Conductance (µS/cm)	pH[A]	Dissolved Oxygen (mg/L)
Water Quality Standard:			No Standard	No Standard	**6.5-8.5**	No Standard
2405	Unk	10/23/2019	11.61	362	7.70	7.66
2497	75	11/17/2015	9.40	517	7.47	6.75
		10/28/2019	9.58	618	7.49	7.65
2498	280	11/17/2015	10.64	419	7.93	6.21
		10/21/2019	11.88	481	7.93	7.70
2499	223	11/24/2015	9.33	257	7.78	4.98
		10/23/2019	11.40	264	7.96	0.68
2500	75	11/24/2015	11.83	300	7.60	5.60
		10/23/2019	11.86	322	7.70	6.69
2501	205	11/24/2015	11.20	297	7.73	5.74
		10/21/2019	11.65	331	7.85	6.04
2502	365	11/24/2015	10.46	338	7.38	8.42
		10/21/2019	11.51	360	7.55	9.58
2503	300	11/24/2015	10.97	418	7.54	6.90
		10/21/2019	11.66	412	7.79	7.99
2504	292	12/02/2015	12.08	365	7.78	9.21
		10/23/2019	14.00	395	7.76	7.86
2505	185	12/02/2015	14.27	298	7.90	7.99
		10/23/2019	13.52	347	7.84	7.83
2506	400	12/02/2015	9.06	785	7.27	8.35
		10/29/2019	9.91	877	7.29	7.08
2508	360	12/09/2015	11.52	314	7.44	10.82
		10/21/2019	12.78	342	7.60	8.56
2509	335	12/09/2015	9.96	626	7.57	8.13
		12/10/2019	9.10	677	7.53	7.38
2510	260	12/09/2015	11.29	405	7.79	0.62
		10/22/2019	12.02	496	7.81	0.12
2511	405	12/09/2015	11.19	414	7.55	12.38
		10/28/2019	12.96	455	7.72	8.80
2512	92	03/30/2016	9.43	328	7.49	6.68
		10/23/2019	11.78	338	7.86	7.05
2513	Unk	03/30/2016	8.29	1001	7.16	3.81
		10/29/2019	9.99	976	7.38	4.01
2515	253	03/30/2016	9.74	829	7.05	7.54

		10/29/2019	9.77	836	7.26	8.24
2516	300	03/30/2016	9.47	791	7.03	7.54
		10/29/2019	10.19	857	7.25	8.35
2517	220	03/30/2016	8.41	322	7.62	4.33
		10/21/2019	11.18	377	7.88	5.18
2518	220	06/01/2016	12.31	328	7.75	7.75
		06/01/2020	12.31	343	7.68	8.51
2519	180	06/01/2016	11.25	340	7.51	2.95
		10/28/2019	11.01	349	7.78	3.63
2520	195	06/01/2016	13.60	237	7.77	8.68
		06/01/2020	13.54	250	7.75	8.67
2689	Unk	12/10/2019	10.12	389	7.42	8.44
BC @ Spencer	SW	11/12/2019	0	466	8.38	13.2
CC @ Red Road	SW	11/12/2019	0.1	151	7.83	11.27
HF @ SA	SW	11/12/2019	3.31	168	8.26	12.53
SR @ Heise	SW	11/12/2019	14.18	520	8.00	10.64
TR @ SA	SW	11/12/2019	3.76	360	8.35	11.81

Notes: ft bgs = feet below ground surface; °C = degrees Celsius; µS/cm = microsiemens/centimeter; pH = standard pH units; mg/L = milligrams per liter; Unk = Unknown. Well log not found. SW = surface water site.

[A] Contaminant with a National Secondary Drinking Water Regulation standard (NSDWR). The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Samples were analyzed by Idaho Bureau of Laboratories (IBL) in Boise for common ions (calcium, sodium, magnesium, potassium, chloride, fluoride, and sulfate), arsenic, total alkalinity, nitrite plus nitrate (nitrate), and ammonia. Samples for bacteria (TC and E. coli) were analyzed by Teton Microbiology Laboratory in Idaho Falls. After receiving the common ion chemistry and nutrient results, samples for stable isotope analysis were submitted to UC Davis for stable isotopes of nitrogen and oxygen in nitrate (δ15Nnitrate, δ18Onitrate) and University for Arizona for stable isotopes of oxygen and hydrogen in water (δ18Owater and δ2Hwater). A split sample of δ18Owater and δ2Hwater was also sent to Boise State University's (BSU's) Isotope Geology Laboratory in Boise, ID for a laboratory comparison. Samples were submitted to the University of Idaho Analytical Services Laboratory in Moscow, Idaho for total bromide at trace concentrations and trace elements (boron, lithium, strontium).

Nitrate Results

Nitrate concentrations for the Mud Lake subarea ranged from less than 0.32 mg/L to 6.7 mg/L (Well 2504), with a mean and median of 2.8 and 2.4 mg/L, respectively (Table 2). The result 0.32 mg/L (Well 2499) was qualified as an estimated value (J), due to a low nitrate concentration detected in an accompanying field blank. The spatial distribution of nitrate concentrations is presented in Figure 4.

Table 2. Nutrient and nutrient-related isotope results—Mud Lake Subarea Regional Monitoring Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Nutrient Concentration			Isotopes	
			Phosphorus	Nitrate + Nitrite[A]	Ammonia	$\delta^{18}O_{Nitrate}$	$\delta^{15}N_{Nitrate}$
			(mg/L)			(‰)	
Water Quality Standard:			No Standard	**10**	No Standard	No Standard	No Standard
2405	Unk	10/23/2019	0.020	5.6	<0.050	-6.75	2.32
2497	75	11/17/2015	—	2.8	<0.010	-4.90	3.41
		10/28/2019	0.024	2.9	<0.050	-6.98	3.33
2498	280	11/17/2015	—	3.1	0.021	-2.22	9.19
		10/21/2019	0.022	3.5	<0.050	-4.24	8.95
2499	223	11/24/2015	—	1.2	0.018	-7.37	4.40
		10/23/2019	0.021	0.32J	<0.050	-0.67	10.62
2500	75	11/24/2015	—	2.4	0.012	-4.26	4.51
		10/23/2019	0.026	2.5	<0.050	-5.72	4.46
2501	205	11/24/2015	—	1.4	0.036	-5.29	3.88
		10/21/2019	0.027	1.4	<0.050	-5.08	4.52
2502	365	11/24/2015	—	2.4	<0.010	-6.42	3.99
		10/21/2019	0.025	2.5	<0.050	-5.72	4.28
2503	300	11/24/2015	—	2.4	<0.010	-4.78	4.58
		10/21/2019	0.018	2.3	<0.050	-6.08	5.06
2504	292	12/02/2015	—	6.1	<0.010	-3.61	2.87
		10/23/2019	0.016	6.7	<0.050	-5.40	2.95
2505	185	12/02/2015	—	3.4	<0.010	-4.99	2.45
		10/23/2019	0.021	4.3	<0.050	-6.64	2.54
2506	400	12/02/2015	—	4.8	<0.010	-8.52	5.76
		10/29/2019	0.026	5.3	<0.050	-7.43	5.19
2508	360	12/09/2015	—	3.3	<0.010	-4.33	3.79
		10/21/2019	0.017	3.7	<0.050	-6.29	3.07
2509	335	12/09/2015	—	5.2	<0.010	-3.55	5.99
		12/10/2019	0.018	5.9	<0.050	-6.99	5.16

2510	260	12/09/2015	—	0.72	0.21	2.72	23.16
		10/22/2019	0.022	1.1	0.13	0.94	22.79
2511	405	12/09/2015	—	1.5	0.017	-6.47	5.73
		10/28/2019	0.016	1.6	<0.050	-5.29	5.15
2512	92	03/30/2016	—	5.0	0.013	-4.25	2.68
		10/23/2019	0.022	5.2	<0.050	-5.87	3.24
2513	Unk	03/30/2016	—	4.8	0.011	-4.34	5.22
		10/29/2019	0.042	4.9	<0.050	-6.94	4.98
2515	253	03/30/2016	—	3.8	<0.010	-5.63	5.55
		10/29/2019	0.028	4.9	<0.050	-8.96	4.90
2516	300	03/30/2016	—	4.5	<0.010	-5.87	5.18
		10/29/2019	0.025	5.6	<0.050	-8.05	5.28
2517	220	03/30/2016	—	1.2	<0.010	-4.29	4.90
		10/21/2019	0.022	1.3	<0.050	-5.70	4.83
2518	220	06/01/2016	—	0.74	<0.010	-4.80	5.57
		06/01/2020	0.021	0.76	<0.050	—	—
2519	180	06/01/2016	—	0.25	<0.010	-6.03	6.24
		10/28/2019	0.026	0.34	<0.050	-6.63	6.02
2520	195	06/01/2016	—	1.5	<0.010	-5.12	3.59
		06/01/2020	0.018	1.6	<0.050	—	—
2689	Unk	12/10/2019	0.031	3.2	<0.050	-5.74	4.06
BC @ Spencer	SW	11/12/2019	—	<0.010	<0.050	22.74	2.82
CC @ Red Road	SW	11/12/2019	—	<0.010	<0.050	16.27	6.88
HF @ SA	SW	11/12/2019	—	0.15	<0.050	1.92	4.79
SR @ Heise	SW	11/12/2019	—	0.054	<0.050	-4.7	4.65
TR @ SA	SW	11/12/2019	—	0.99	<0.050	-4.84	5.67

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; ‰ = permil; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established; Unk = Unknown. Well log not found; J = Analyte was detected, but the value of the result is an estimate; (-) = Not Analyzed. SW = surface water site.

[A] Contaminant with a National Primary Drinking Water Regulation standard.

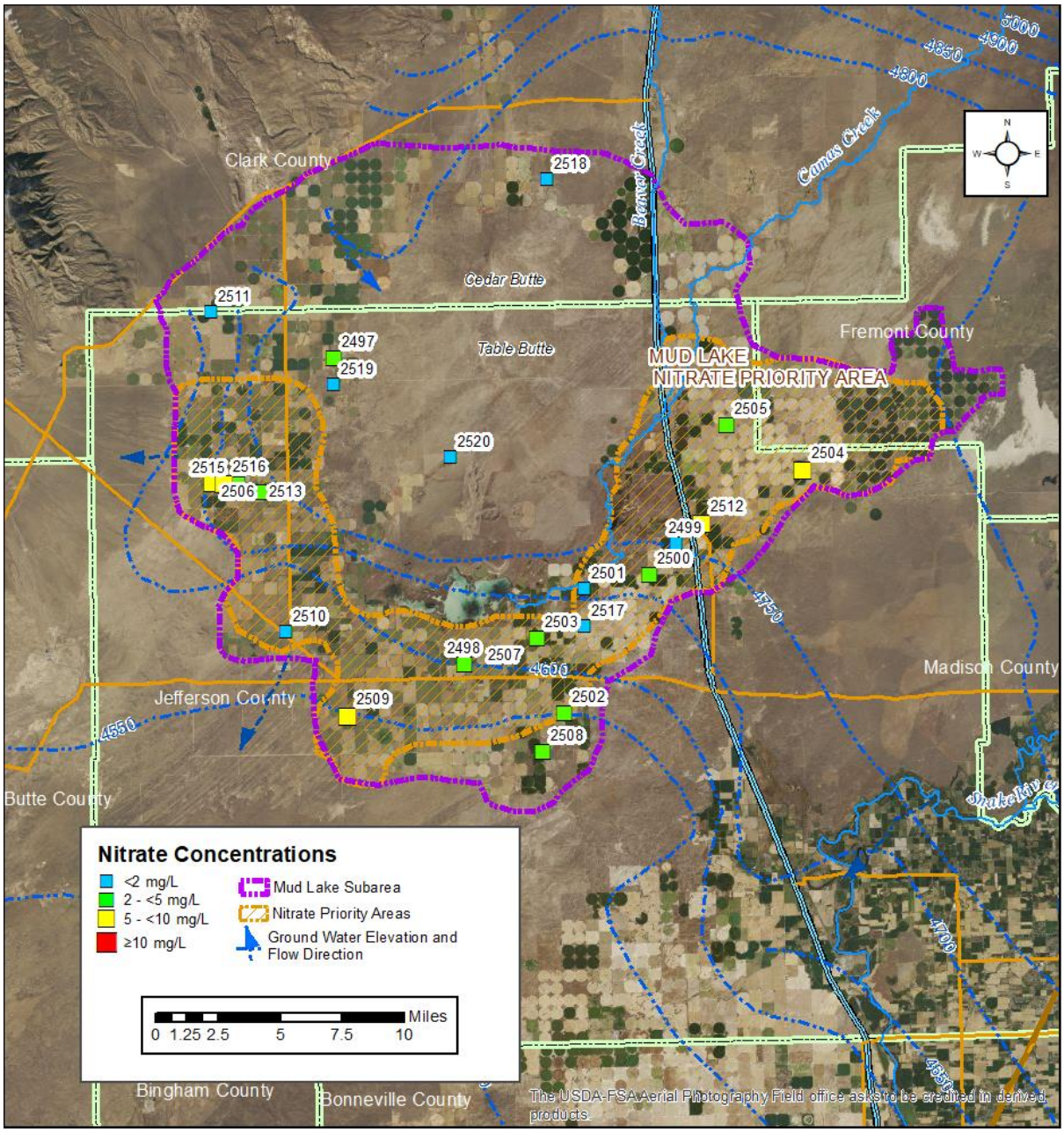


Figure 4. 2019 and 2020 Nitrate Concentrations—Mud Lake Subarea Groundwater Monitoring Project.

Ammonia Results

Ammonia was reported below the reporting limit of 0.050 mg/L for all samples from all sites except one (Well 2510) which had a concentration of 0.13 mg/L (Table 2). A nitrate concentration of 1.1 mg/L was also reported for this site. Well 2510 is characterized by relatively low sulfate compared to chloride (a ratio of less than 1) and enriched $\delta^{15}N_{nitrate}$ (22.79‰) and $\delta^{18}O_{nitrate}$ (0.94‰) values. The relatively low sulfate/chloride ratio and enriched $\delta^{15}N_{nitrate}$ are typically associated with waste-signatures. The corresponding enriched $\delta^{18}O_{nitrate}$, in combination with $\delta^{15}N_{nitrate}$ suggest isotopic fractionation, possibly due to denitrification.

Bacteria Results

TC bacteria are a group of bacteria common in the environment (such as soil) and are generally not harmful. *E. coli* bacteria (a type of coliform bacteria) are found in animal fecal matter. The presence of *E. coli* in groundwater provides strong evidence that human or animal fecal waste is present and a greater potential for pathogenic organisms exists. Bacterial analyses aid in identifying potential impacts or influences at the wellhead or sample point. 2019 and 2020 results are presented in Table 3 along with 2015 and 2016 data for comparison. TC was detected in three wells; Wells 2405 and 2508 had TC concentrations of 1 MPN/100 mL and Well 2518 and 7.5 MPN/100 mL (Table 3). All 24 wells were negative for *E. coli*. All 5 surface water site samples contained TC, with 4 of the 5 samples also containing *E. coli*. The surface water TC concentrations ranged from 35 MPN/100 mL to 387.3 MPN/100 mL. The positive *E. coli* concentrations in surface water ranged from 2 MPN/100 mL to 86 MPN/100 mL (Table 3). It is common for surface water to contain TC and *E.coli* bacteria.

Table 3. Bacteria results—Mud Lake Subarea Regional Monitoring Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Bacteria Concentrations[A]	
			E. coli	Total Coliform
			(MPN/100 mL)	
Primary or Secondary Standard:			**<1.0**	**1.0**
2405	Unk	10/23/2019	<1.0	2.0
2497	75	11/17/2015	<1.0	<1.0
		10/28/2019	<1.0	<1.0
2498	280	11/17/2015	<1.0	<1.0
		10/21/2019	<1.0	<1.0
2499	223	11/24/2015	<1.0	<1.0
		10/23/2019	<1.0	<1.0
2500	75	11/24/2015	<1.0	<1.0
		10/23/2019	<1.0	<1.0
2501	205	11/24/2015	<1.0	<1.0
		10/21/2019	<1.0	<1.0
2502	365	11/24/2015	<1.0	1.0
		10/21/2019	<1.0	<1.0
2503	300	11/24/2015	<1.0	<1.0
		10/21/2019	<1.0	<1.0
2504	292	12/02/2015	<1.0	<1.0
		10/23/2019	<1.0	<1.0
2505	185	12/02/2015	<1.0	<1.0
		10/23/2019	<1.0	<1.0
2506	400	12/02/2015	<1.0	8.6
		10/29/2019	<1.0	<1.0
2508	360	12/09/2015	<1.0	<1.0
		10/21/2019	<1.0	1.0

2509	335	12/09/2015	<1.0	<1.0
		12/10/2019	<1.0	<1.0
2510	260	12/09/2015	<1.0	<1.0
		10/22/2019	<1.0	<1.0
2511	405	12/09/2015	<1.0	<1.0
		10/28/2019	<1.0	<1.0
2512	92	03/30/2016	<1.0	<1.0
		10/23/2019	<1.0	<1.0
2513	Unk	03/30/2016	<1.0	<1.0
		10/29/2019	<1.0	<1.0
2515	253	03/30/2016	<1.0	<1.0
		10/29/2019	<1.0	<1.0
2516	300	03/30/2016	<1.0	<1.0
		10/29/2019	<1.0	<1.0
2517	220	03/30/2016	<1.0	<1.0
		10/21/2019	<1.0	<1.0
2518	220	-	-	-
		06/01/2020	<1.0	<1.0
2519	180	-	-	-
		10/28/2019	<1.0	7.5
2520	195	-	-	-
		06/01/2020	<1.0	<1.0
2689	Unk	12/10/2019	<1.0	<1.0
BC @ Spencer	SW	11/12/2019	86	387.3
CC @ Red Road	SW	11/12/2019	14.6	307.6
HF @ SA	SW	11/12/2019	2.0	72.8
SR @ Heise	SW	11/12/2019	<1.0	35.0
TR @ SA	SW	11/12/2019	2.0	68.9

Notes: ft bgs = feet below ground surface; MPN/100 mL = most probable number per 100 milliliters; Unk = Unknown. Well log not found. SW = Surface water site.

[A] Total coliform and E. coli standards are from the Idaho Groundwater Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary groundwater quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

General Groundwater Chemistry

Common ion chemistry provides a picture of the overall relative character of groundwater, including mixing from different sources and changes in groundwater chemistry from processes such as dissolution of the aquifer matrix, infiltration, and impacts from contamination sources. Common ion chemistry along with field parameters can also provide clues to ongoing chemical processes and indications of the favored chemical forms for nitrogen in groundwater (Table 4).

Table 4. Common ion and total dissolved solids results—Mud Lake Subarea Regional Monitoring Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Alkalinity as (CaCO3)	Calcium	Chloride[A]	Fluoride[AB]	Magnesium	Potassium	Sodium	Sulfate[A]
			(mg/L)				(mg/L)			
Water Quality Standard:			No Standard	No Standard	**250**	**2.0/4**	No Standard	No Standard	No Standard	**250**
2405	Unk	10/23/2019	123	37	10.6	0.820	12	2.8	16	24.2
2497	75	11/17/2015	292	77	10.2	0.275	19	3.7	29	12.8
		10/28/2019	301	78	10.5	<0.20	19	3.5	24	13.9
2498	280	11/17/2015	131	47	51.5	0.403	17	3.6	19	16.7
		10/21/2019	132	50	56.7	-	18	3.7	19	17.8
2499	223	11/24/2015	125	32	7.05	0.828	9.4	2.7	13	8.87
		10/23/2019	118	28	7.29	0.787	8.9	2.7	13	8.28
2500	75	11/24/2015	139	38	9.36	0.684	10	2.7	15	12.3
		10/23/2019	133	37	8.68	0.636	10	2.6	14	11.7
2501	205	11/24/2015	144	40	8.51	0.406	11	2.6	12	11.0
		10/21/2019	146	41	8.19	0.325	11	2.6	12	11.4
2502	365	11/24/2015	146	42	16.1	0.611	12	2.8	18	17.4
		10/21/2019	141	38	14.0	0.566	11	2.7	17	16.0
2503	300	11/24/2015	184	52	24.6	0.374	15	3.5	22	16.5
		10/21/2019	164	44	18.7	0.358	13	3.3	17	13.5
2504	292	12/02/2015	125	39	12.8	0.905	13	3.1	21	31.6
		10/23/2019	125	40	12.0	0.851	13	3.1	2.1	31.9
2505	185	12/02/2015	124	35	7.81	0.849	11	2.7	14	17.8
		10/23/2019	122	38	9.09	0.816	12	2.8	15	24.4
2506	400	12/02/2015	328	86	50.6	0.244	25	6.1	60	46.3
		10/29/2019	321	86	57.8	<0.20	25	5.7	57	49.4
2507	300	12/02/2015	132	39	21.3	0.409	12	3.0	14	12.9
2508	360	12/09/2015	128	36	11.4	0.928	11	2.9	17	16.2
		10/21/2019	126	36	10.8	0.924	11	2.9	16	16.8
2509	335	12/09/2015	243	58	42.8	0.222	15	8.0	59	30.5
		12/10/2019	245	55	43.3	<0.20	15	7.6	57	28.8
2510	260	12/09/2015	172	28	27.6	0.574	11	7.3	44	20.6
		10/22/2019	172	33	35.3	0.469	13	7.8	46	25.2

2511	405	12/09/2015	160	55	28.1	0.403	15	3.2	12	26.8
		10/28/2019	157	56	30.1	0.349	15	3.0	12	27.0
2512	92	03/30/2016	122	35	8.71	0.820	11	2.9	16	18.0
		10/23/2019	118	36	9.55	0.814	11	2.9	15	18.9
2513	Unk	03/30/2016	334	88	65.9	<0.20	27	6.0	94	101
		10/29/2019	319	78	63.5	0.210	25	5.7	87	98.6
2515	253	03/30/2016	372	84	30.9	<0.20	24	5.7	6.8	36.6
		10/29/2019	340	81	41.0	<0.20	23	5.2	56	35.2
2516	300	03/30/2016	348	84	31.2	<0.20	24	5.4	57	37.7
		10/29/2019	343	84	40.1	<0.20	24	5.1	58	49.3
2517	220	03/30/2016	150	39	8.96	0.314	11	2.7	13	10.7
		10/21/2019	141	38	8.79	0.274	10	2.6	13	10.9
2518	220	06/01/2016	161	41	10.0	0.260	12	2.5	11	10.3
		06/01/2020	160	41	8.58	0.178J	12	2.4	10	8.71
2519	180	06/01/2016	155	42	9.01	0.378	11	3.7	14	24.3
		10/28/2019	147	42	8.62	0.319	11	3.5	13	22.2
2520	195	06/01/2016	107	26	7.24	0.479	8.9	2.3	11	8.16
		06/01/2020	106	27	6.02	0.36	8.5	2.1	9.9	8.18
2689	Unk	12/10/2019	151	42	15.7	0.562	12	2.7	18	18.0
BC @ Spencer	SW	11/12/2019	219	67	17.7	<0.20	15	1.3	10	7.27
CC @ Red Road	SW	11/12/2019	73.4	19	1.28	<0.20	4.7	2.1	4	2.35
HF @ SA	SW	11/12/2019	63.2	12	5.9	2.34	3.3	2.4	17	3.36
SR @ Heise	SW	11/12/2019	166	63	23.7	0.372	16	2.6	18	62
TR @ SA	SW	11/12/2019	170	49	4.34	0.244	14	1.3	4	11.1

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; µg/L = micrograms per liter; Unk = Unknown. Well log not found; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established; (-) = Not Analyzed; J = Analyte was detected, but the value of the result is an estimate. SW = Surface water site.

[A] Contaminant with a National Secondary Drinking Water Regulation standard.

[B] Contaminant with a National Primary Drinking Water Regulation standard.

Based on the common ion results, the groundwater in the Mud Lake subarea is primarily a calcium-bicarbonate water with generally low, but increasing, relative proportions of chloride and sulfate primarily with the direction of groundwater flow (Table 4, Figure 5). The Piper trilinear water chemistry plot (Piper diagram) can help to identify major trends in groundwater chemistry. While there is a small distinction between proportions of calcium (Ca), magnesium (Mg), and sodium plus potassium (Na+K) for the Mud Lake subarea, the variation can likely be explained due to mixing of surface water recharging the groundwater. The data generally show higher chloride and sulfate concentrations in the western and south-central portions of the Mud Lake subarea, which are regionally hydraulically downgradient from multiple potential surface water recharge sources. Surface water sites sampled in 2019 are included. Groundwater chemistry also may be influenced by playa deposits within the Mud Lake basin and inputs from anthropogenic sources.

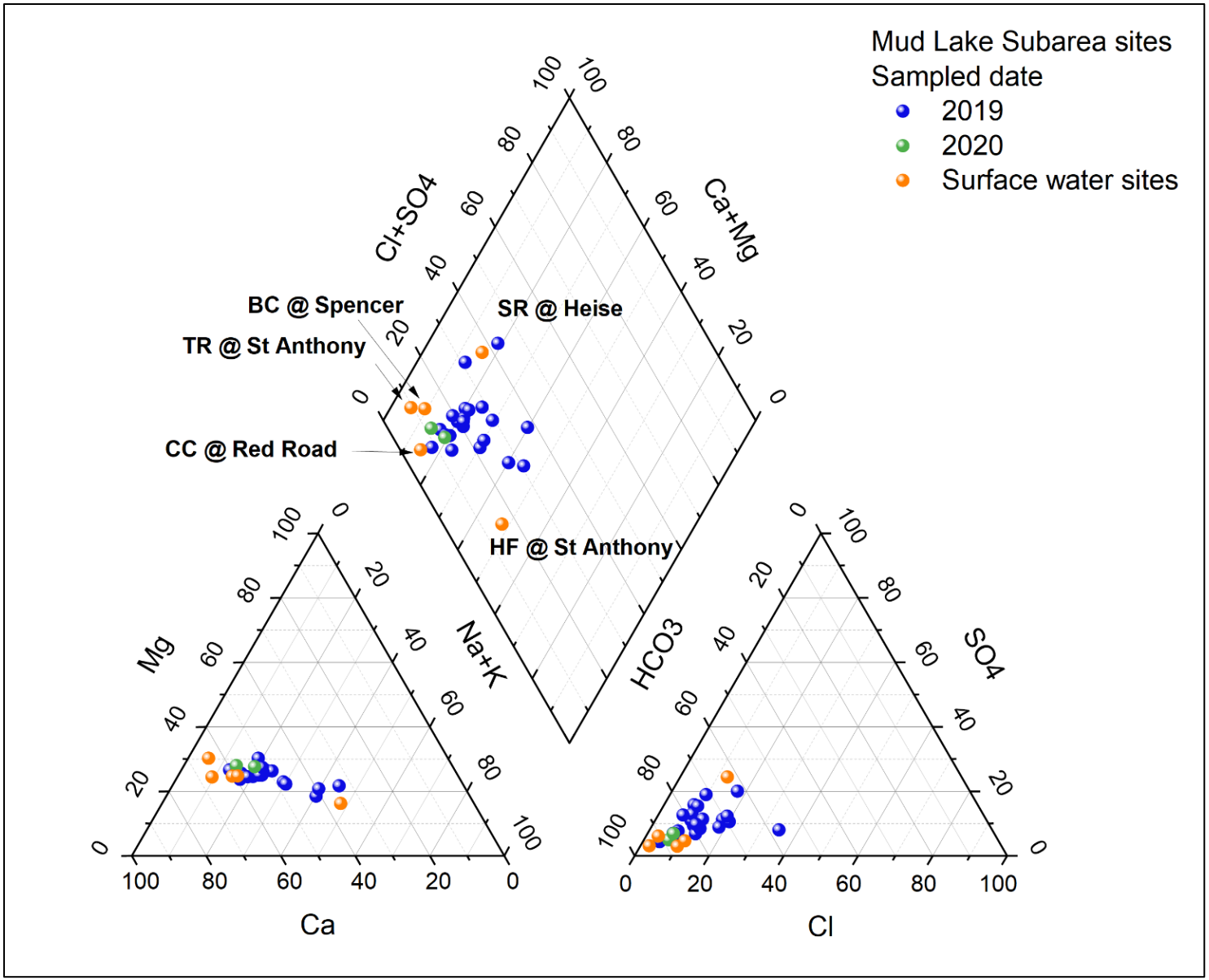


Figure 5. Piper diagram for 2019 and 2020 common ion data—Mud Lake Subarea Regional Monitoring Groundwater Monitoring Project.

Trace Metals and Elements Results

All 24 wells were sampled for arsenic, boron, lithium, and strontium. Results are presented in Table 5. None of the wells had concentrations of arsenic exceeding the MCL of 10 mg/L. The arsenic concentration ranged from non-detect (<2.0 mg/L) to 8.2 mg/L. There are no drinking water standards or health advisories for boron, lithium, and strontium. Boron concentrations ranged from 6.4 mg/L to 106.5 mg/L. Lithium concentrations ranged from 1.2 mg/L to 54 mg/L. Strontium concentrations ranged from 81 mg/L to 350 mg/L. The metals results from 2019 and 2020 sampling efforts were relatively consistent with results from previous monitoring in 2015 with the exception of three sites (2503, 2509, and 2511) which had close to 50% decreases in boron concentrations.

Table 5. Trace metals and elements results—Mud Lake Subarea Regional Monitoring Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Arsenic[A]	Boron	Bromide	Lithium	Strontium
			(µg/L)				
Water Quality Standard:			**10**	No Standard	No Standard	No Standard	No Standard
2405	Unk	10/23/2019	2.6	69.6	38	26	130
2497	75	11/17/2015	<2.0	27.0	32.6	<10	321
		10/28/2019	<2.0	30.3	34	8.4	320
2498	280	11/17/2015	4.4	21.7	88.5	13.7	235
		10/21/2019	4.7	14.2	100	13	240
2499	223	11/24/2015	<2.0	37.5	19.1	25.1	92.7
		10/23/2019	<2.0	25.9	21	23	81
2500	75	11/24/2015	<2.0	19.0	22.1	11.6	111
		10/23/2019	<2.0	24.7	24	19	110
2501	205	11/24/2015	2.4	10.8	22.3	<10	123
		10/21/2019	2.6	8.0	24	12	130
2502	365	11/24/2015	<2.0	24.7	34.5	10.9	135
		10/21/2019	<2.0	28.3	33	15	120
2503	300	11/24/2015	2.6	24.5	54.8	17.4	200
		10/21/2019	2.7	12.0	44	15	170
2504	292	12/02/2015	<2.0	45.0	35.6	16.5	116
		10/23/2019	2.1	63.6	36	22	120
2505	185	12/02/2015	<2.0	30.6	24.3	13.0	94.6
		10/23/2019	2.0	39.6	26	19	110
2506	400	12/02/2015	5.5	94.7	116	50.8	378
		10/29/2019	5.4	76.4	120	38	350
2507	300	12/02/2015	3.6	19.4	50.0	13.0	159
2508	360	12/09/2015	<2.0	56.5	34.1	29.0	96.9
		10/21/2019	<2.0	42.4	34	27	92
2509	335	12/09/2015	<2.0	57.39	99.2	22.9	262

		12/10/2019	<2.0	38.6	100	19	240
2510	260	12/09/2015	5.5	32.0	69.8	33.7	116
		10/22/2019	4.3	40.5	89	54	140
2511	405	12/09/2015	<2.0	27.2	68.2	12.3	249
		10/28/2019	<2.0	11.4	72	10	220
2512	92	03/30/2016	2.0	44.8	26.2	24.2	97.0
		10/23/2019	2.0	34.4	28	25	97
2513	Unk	03/30/2016	5.7	112	163	27.7	349
		10/29/2019	5.8	106.5	160	33	310
2515	253	03/30/2016	4.4	92.0	82.8	20.0	351
		10/29/2019	3.7	99.8	86	18	330
2516	300	03/30/2016	4.5	88.2	98.5	26.5	338
		10/29/2019	4.5	78.6	110	29	340
2517	220	03/30/2016	2.8	20.8	24.8	13.5	137
		10/21/2019	2.7	6.4	24	12	130
2518	220	06/01/2016	<2.0	27.9	33.4	6.02	172
		06/01/2020	1.4J	26.7	40	1.2	179
2519	180	06/01/2016	8.5	28.9	31.5	20.5	158
		10/28/2019	8.2	8.4	26	18	140
2520	195	06/01/2016	2.3	14.6	22.5	10.6	111
		06/01/2020	2.2	12.1	21.5	1.2	107.4
2689	Unk	12/10/2019	<2.0	49.0	36	16	150
BC @ Spencer	SW	11/12/2019	—	16	20	—	—
CC @ Red Road	SW	11/12/2019	—	9.6	9	—	—
HF @ SA	SW	11/12/2019	—	114.4	21	—	—
SR @ Heise	SW	11/12/2019	—	74.5	22	—	—
TR @ SA	SW	11/12/2019	—	15.4	18	—	—

Notes: ft bgs = feet below ground surface; µg/L = micrograms per liter; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established; Unk = Unknown. Well log not found. SW = Surface water site.

[A] Contaminant with a National Primary Drinking Water Regulation standard.

Stable Isotope Results

Stable isotope results can also aid in understanding the possible ongoing thermodynamic or biochemical processes within the system. Results for stable isotope analyses are similar to results from 2015 sampling and are presented in Table 2 and Table 6. Stable isotopes of nitrogen and oxygen for nitrate are analyzed from the same sample and provide the context for understanding isotopic fractionation due to largely microbial-facilitated nitrogen cycling processes. While characteristic ranges for $\delta^{15}N_{nitrate}$ values have been correlated to likely sources, these ranges overlap to some degree; supporting information can aid in interpreting the most likely source as well as secondary processes that might result in isotopic fractionation, modifying the observed signature. The $\delta^{15}N_{nitrate}$ values for the wells sampled ranged from 2.32‰ to 22.79‰ (Table 6). A total of seven wells had isotope $\delta^{15}N_{nitrate}$ values <~4‰, suggesting an inorganic source such as commercial fertilizer. An additional seven sites returned values ranging from 4‰ - 5‰; these sites are likely either reflective of inorganic sources or organic sources including mineralized soil N. An additional seven sites ranged from ~6‰ - <8‰; these sites more likely reflect a soil/organic source. Three sites (Wells 2498, 2499, 2510) reported $\delta^{15}N_{nitrate}$ values between 8‰ and 9‰, suggesting a possible waste source. Wells 2499 and 2510 also had $\delta^{15}N_{nitrate}$ and $\delta^{18}O_{nitrate}$ values reflecting isotopic fractionation possibly due to denitrification. The additional information of relatively higher chloride concentrations and corresponding low ratios of sulfate/chloride for wells 2499 and 2510 support the conclusion of a likely waste-related nitrogen source. Well 2498, with low nitrate (0.35 mg/L) supports more of a soil organic and possible denitrification influence. The surface water site Beaver Creek at Spencer reflects nitrification of an atmospheric nitrogen source. The samples from Henry's Fork and the Snake River reflect a soil-organic nitrogen source that's an atmospheric dominated mixture with groundwater. Teton River at St. Anthony reflects a soil organic nitrogen source.

Stable isotopes of oxygen ($\delta^{18}O$) and hydrogen ($\delta^{2}H$ [deuterium]) in groundwater can help identify the likely source and timing of recharge. Results for $\delta^{18}O$ and $\delta^{2}H$ for the Mud Lake subarea sites and surface water sites are presented in Table 6 and Figure 7. Also presented in Figure 7 are the Global Meteoric Water Line, and a Local Meteoric Water Line based on sampling specific to the upper Snake River Basin, and a line characteristic for Eastern Snake River Plain groundwater sites (Cecil and others, 2004). Sites in general follow either the line characteristic of precipitation within the Upper Snake River Basin or approximate the line characteristic of ESRP groundwater. Samples from wells 2509 and 2504 stand out: Well 2509 reflects a strong evaporation signature characteristic of evaporated groundwater. The sample from Well 2504 reflects summer precipitation. Surface water sites align with the Local Meteoric water line, with Beaver Creek reflecting a summer precipitation signature, Teton River more of a winter snowmelt, and the balance of surface waters as a mixture of both.

Split samples for $\delta^{18}O_{water}$ and $\delta^{2}H_{water}$ sent to both University of Arizona (UAz) Environmental Isotope Laboratory and the BSU Isotope Geology Laboratory as an intra-laboratory comparison returned results within the analysis-specific 1s error for both for $\delta^{18}O_{water}$ and $\delta^{2}H_{water}$ (Figure 8). Data from the 2019 and 2020 sampling is similar to results from 2015. The 2019 and 2020

results can be compared with the discussions and conclusions presented in the 2015 annual summary report (DEQ 2017).

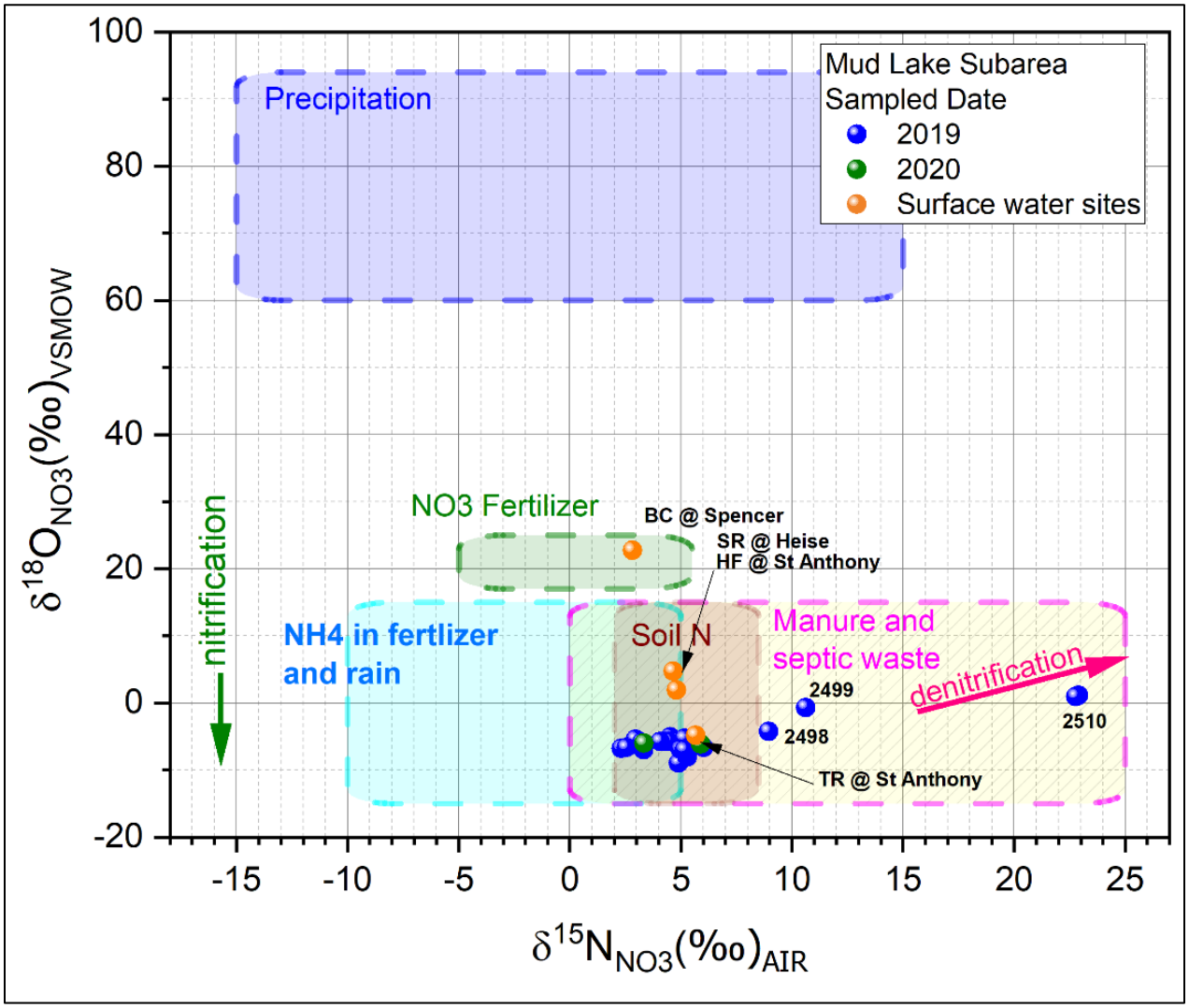


Figure 6. Plot of 2019 and 2020 $\delta^{15}N_{nitrate}$ and $\delta^{18}O_{nitrate}$ stable isotope values with ranges of isotopic values and associated sources (Kendall et al., 2007)—Mud Lake Subarea Regional Monitoring Groundwater Monitoring Project.

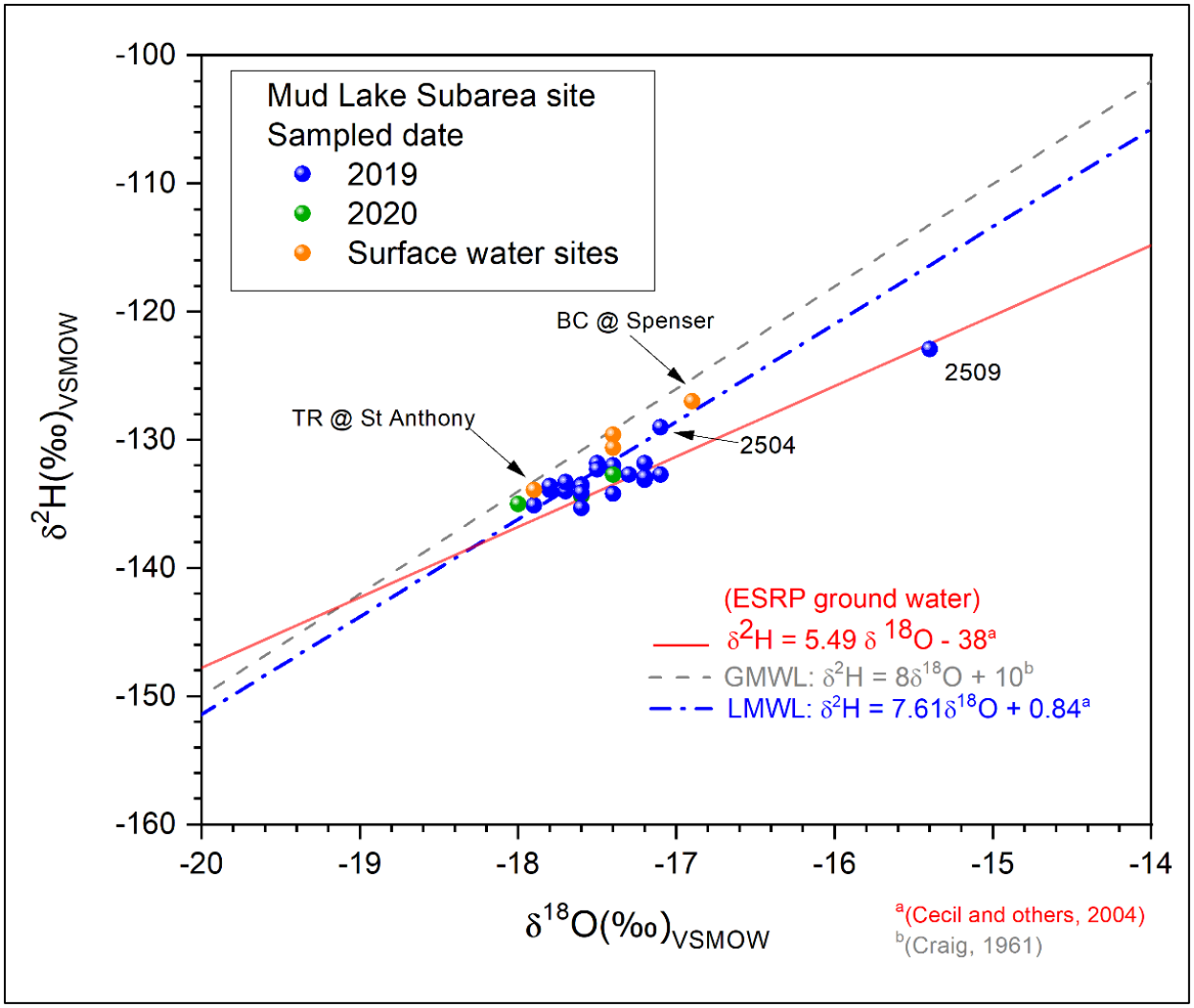


Figure 7. Plot of 2019 and 2020 and surface water sites $\delta^{18}O_{water}$ and $\delta^{2}H_{water}$ stable isotope values—Mud Lake Subarea Regional Monitoring Groundwater.

Table 6. Stable isotope results—Mud Lake Subarea Regional Monitoring Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	UAz	BSU	UAz	BSU
			δ^2H_{water}	δ^2H_{water}	$\delta^{18}O_{water}$	$\delta^{18}O_{water}$
			(‰)			
Water Quality Standard:			No Standard			
2405	Unk	10/23/2019	-132.3	—	-17.5	—
2497	75	11/17/2015	-130.1	—	-17.5	—
		10/28/2019	-132.5	—	-17.4	—
2498	280	11/17/2015	-131.7	—	-17.7	—
		10/21/2019	-132.7	—	-17.3	—
2499	223	11/24/2015	-133.4	—	-18.1	—
		10/23/2019	-135.1	—	-17.9	—
2500	75	11/24/2015	-132.3	—	-18.1	—
		10/23/2019	-133.9	—	-17.8	—
2501	205	11/24/2015	-131.4	—	-17.7	—
		10/21/2019	-131.8	—	-17.5	—
2502	365	11/24/2015	-132.8	—	-17.8	—
		10/21/2019	-133.6	—	-17.8	—
2503	300	11/24/2015	-131.0	—	-17.5	—
		10/21/2019	-133.5	—	-17.6	—
2504	292	12/02/2015	-128.9	—	-17.2	—
		10/23/2019	-129.0	—	-17.1	—
2505	185	12/02/2015	-130.9	—	-17.7	—
		10/23/2019	-132.0	—	-17.4	—
2506	400	12/02/2015	-130.2	—	-17.3	—
		10/29/2019	-131.8	—	-17.2	—
2507	300	12/02/2015	-131.7	—	-17.8	—
2508	360	12/09/2015	-130.2	—	-17.5	—
		10/21/2019	-131.8	—	-17.5	—
2509	335	12/09/2015	-121.1	—	-15.5	—
		12/10/2019	-122.9	—	-15.4	—
2510	260	12/09/2015	-131.8	—	-17.5	—
		10/22/2019	-134.2	—	-17.4	—
2511	405	12/09/2015	-131.0	—	-17.7	—
		10/28/2019	-135.3	—	-17.6	—
2512	92	03/30/2016	-129.3	—	-17.6	—
		10/23/2019	-133.6	—	-17.6	—
2513	Unk	03/30/2016	-126.0	—	-17.1	—
		10/29/2019	-133.1	—	-133.1	—

2515	253	03/30/2016	-128.8	—	-17.2	—
		10/29/2019	-132.9	—	-17.2	—
2516	300	03/30/2016	-127.6	—	-17.3	—
		10/29/2019	-132.7	—	-17.1	—
2517	220	03/30/2016	-128.8	—	-17.6	—
		10/21/2019	-134.0	—	-17.7	—
2518*	220	06/01/2016	-126.5	—	-17.4	—
		6/1/2020	-132.7	-133.1	-17.4	-17.6
2519	180	06/01/2016	-129.0	—	-17.6	—
		10/28/2019	-133.3	—	-17.7	—
2520*	195	06/01/2016	-130.3	—	-17.9	—
		6/1/2020	-135.8	-135.9	-18.0	-18.1
2689	Unk	12/10/2019	-134.1	—	-17.6	—
BC @ Spencer	SW	11/12/2019	-127.0	—	-16.9	—
CC @ Red Road	SW	11/12/2019	-129.6	—	-17.4	—
HF @ SA	SW	11/12/2019	-130.6	—	-17.4	—
SR @ Heise	SW	11/12/2019	-130.6	—	-17.4	—
TR @ SA	SW	11/12/2019	-133.9	—	-17.9	—

Notes: ft bgs = feet below ground surface; ‰ = permil; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established; Unk = Unknown. Well log not found; (—) = Not Analyzed. SW = Surface water site.

*Split samples sent to both UAz and BSU for intra-laboratory comparison.

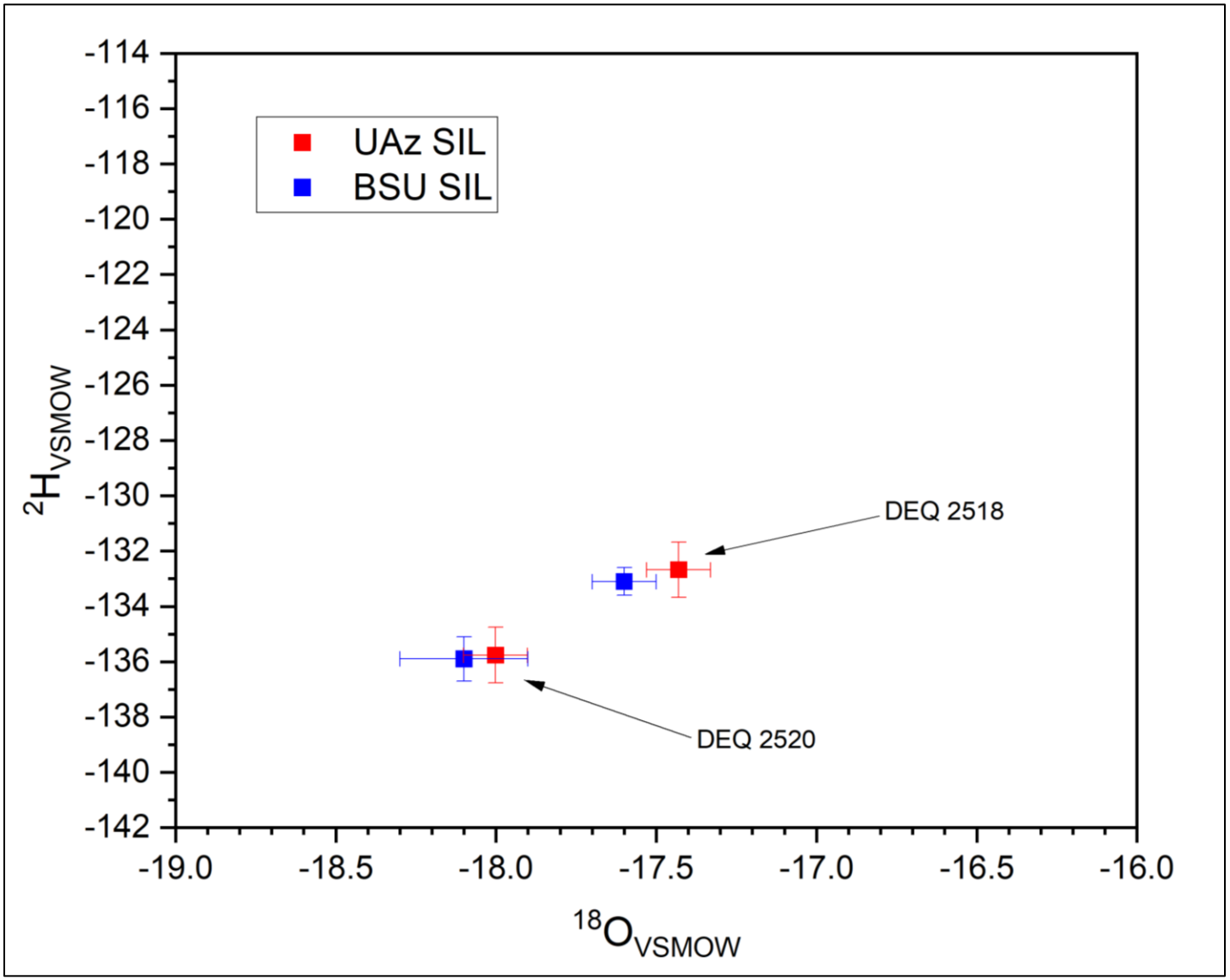


Figure 8. Stable isotope plot with intra-laboratory comparison for Wells 2518 and 2520—Mud Lake Subarea Regional Monitoring Groundwater Monitoring Project.

2.1.1.3 Conclusions

The objectives of this regional monitoring study are to: identify areas of vulnerable or degraded water quality; collect data to aid in determining potential sources of degradation to direct and prioritize groundwater protection efforts based on potential sources; and evaluate the effectiveness of management practices used to reduce nitrate impacts. The goal of this summary was to present preliminary results for the third of three regional monitoring subareas for the DEQ Idaho Falls region.

Nitrate concentrations exceeded 2 mg/L for 16 of 24 wells within the Mud Lake subarea. Nitrate concentrations of 5 mg/L or greater were detected in 6 wells, all within the Mud Lake NPA. Ammonia was detected in one well (Well 2510).

Common ion chemistry, presented with a Piper diagram, suggests that the variation in common ions may be explained as primarily a mixture of recharge from source areas (Beaver Creek, Camas Creek, and the Henrys Fork of the Snake River) and the addition of sulfate and chloride from other sources including playa deposits within the Mud Lake basin, as well as inputs from anthropogenic sources (septic wastes/fertilizer). A relatively small but general increase of both chloride and sulfate along the regional groundwater flow paths was observed.

Two wells plotted with $\delta^{15}N_{nitrate}$ values indicative of a waste source (>9‰) and returned relatively low sulfate concentrations compared to chloride typically associated with waste sources. Two wells (2499 and 2510) also had $\delta^{15}N_{nitrate}$ and $\delta^{18}O_{nitrate}$ values reflecting isotopic fractionation possibly due to processes including denitrification.

2.1.1.4 Recommendations

Common ion chemistry, chloride, sulfate, and stable isotopes should be considered for sampling to identify potential nitrate sources. Further support for nitrate source evaluation may come from trace elements. A combination of analytes may be beneficial by providing multiple lines of evidence for identifying potential nitrate sources. The results from these analyses may inform future investigations evaluating potential nitrate impacts to groundwater across Idaho.

2.1.2 Teton Valley Deep Soil Percolation and Groundwater Sampling for BMP Evaluation Project

2.1.2.1 Purpose and Background

The DEQ Idaho Falls Regional Office (IFRO) sampled four groundwater sites in support of multi-year soil health cover crop demonstration project in cooperation with a Teton Valley-based non-profit organization Friends of the Teton River. Sites were selected from the nearest domestic wells (DWs) to the cover crop demonstration site, approximately up gradient, and down gradient of the cover crop demonstration site (Figure 9). Sites were sampled in fall and spring through the three-year duration of the project, spring 2018 through spring 2021. Sites were sampled for analytes consistent with regional nitrate monitoring and with the Deep Soil Percolation (DSP) monitoring project.

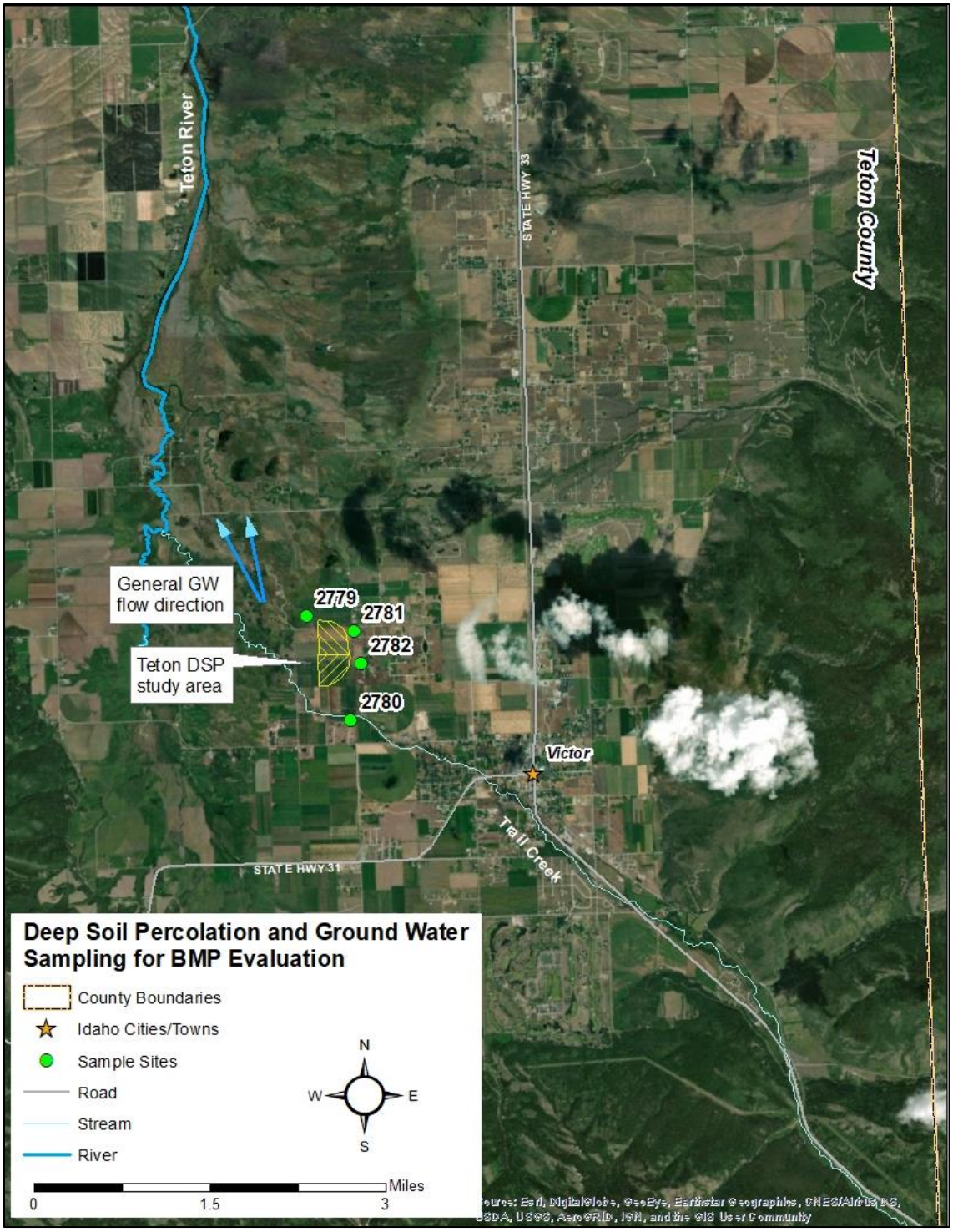


Figure 9. Sample site locations— Deep Soil Percolation and Groundwater Sampling for BMP Evaluation, Teton County SWCD, 2020 Groundwater Monitoring Project.

2.1.2.2 Methods and Results

DEQ collected groundwater samples in May and October 2020, from four private DWs located within the Teton Valley near Victor, ID (Figure 9). Sample locations were selected from DWs

with available well logs. Selection favored more recent wells with complete information on well construction, well-bore seals, and lithologic descriptions, suggesting that sampled groundwater would represent the shallowest aquifer zone. One of the four selected DWs identified as having a drilling permit on file and an issued well tag number was determined to not have a well driller's log (Well 2782). Wells nearest to this location ranged in depth from 79–112 feet with open bottom-casing completions. Depth to water for these nearest wells ranges from 35–40 feet bgs. Contact for continued sample permission could not be made for well 2781; this well was not sampled, May 2020. Updated contact information was obtained and permission to continue sampling was obtained for this well for in October 2020.

Sites selected were the closest to the DSP study area. Well 2782 was maintained in the list of sample sites despite lack of confirmation of well depth due to proximity to the study area, similar age of construction to surrounding wells, and permission to sample. It was determined that a well permit and a tag number were issued, but a construction log was not submitted by the driller.

Samples were analyzed by IBL for common ions (i.e., calcium, sodium, magnesium, potassium, chloride, fluoride, sulfate), arsenic (May only), total alkalinity, nitrite-nitrate nitrogen (nitrate), and ammonia. Samples for bacteria (TC and *E. coli*) were analyzed by Teton Microbiology Lab, Idaho Falls.

After receiving the common ion chemistry and nutrient results, samples for stable isotope analysis were submitted to both Boise State University Isotope Geology Laboratory and the University of Arizona for stable isotopes of oxygen and hydrogen in water (δ18Owater and δ2Hwater) and to University of California, Davis Stable Isotope Facility for stable isotopes of nitrogen and oxygen in nitrate. Stable isotope samples for δ18Owater and δ2Hwater were submitted to both the Boise State University and University of Arizona labs as an interlaboratory comparison. All sampling was conducted according to the regional QAPP (DEQ 2011) and FSP (DEQ 2015b).

The University of Idaho Analytical Sciences Laboratory, Moscow performed metal analysis on samples for boron, bromide, lithium, and strontium (lithium and strontium were not analyzed for in the October samples). Analysis for lithium and strontium were dropped following the Spring, 2020 sampling as it was determined that no additional information was being gained, and these parameters had been sufficiently characterized.

Water quality field parameters (i.e., pH, temperature, specific conductance, DO) were measured before sample collection to ensure adequate purging of the well for a representative sample of the local aquifer (Table 7).

Table 7. Water quality field parameters—Deep Soil Percolation and Groundwater Sampling for BMP Evaluation, Teton County SWCD, 2020 Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Water Temperature (°C)	Specific Conductance (µS/cm)	pH[A]	Dissolved Oxygen (mg/L)
Water Quality Standard:			No Standard	No Standard	**6.5-8.5**	No Standard
2779	62	05/13/2020	6.63	334	7.44	9.52
		10/28/2020	6.82	359	7.33	9.74
2780	118	05/13/2020	6.52	388	7.39	7.27
		10/28/2020	6.34	383	7.23	9.88
2781	80	10/28/2020	7.06	342	7.39	10.16
2782	Unk	05/13/2020	6.38	332	7.47	7.98
		10/28/2020	7.29	332	7.36	10.98

Notes: ft bgs = feet below ground surface; °C = degrees Celsius; µS/cm = microsiemens/centimeter; pH = standard pH units; mg/L = milligrams per liter; Unk = Unknown. Well log not found.

[A] Contaminant with a National Secondary Drinking Water Regulation standard (NSDWR). The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Nutrient and Stable Isotope Results

The nitrate (nitrate plus nitrite) results were all below the water quality standard of 10 mg/L, ranging from 0.40 mg/L to 1.2 mg/L, which were similar results to 2019 results for nitrate. Ammonia results were all below the reporting limit (< 0.050 mg/L) (Table 8). Results for $\delta^{18}O_{nitrate}$ ranged from -7.20‰ to -6.09‰ and results $\delta^{15}N_{nitrate}$ ranged from 4.03‰ to 7.3‰, with all $\delta 15N_{nitrate}$ (Table 8). The nutrient isotope results were consistent with the 2019 results, which had similar ranges and suggested a mixed or organic soil source of nitrogen (Seiler, 1996; Table 9). Results for stable isotopes $\delta^{2}H_{water}$ and $\delta^{18}O_{water}$ ranged from -136.4‰ to -133.6‰ and -18.2‰ to -18.0‰, respectively (Table 10). These results were also consistent with 2019 results.

Table 8. Nutrient and nutrient-related isotope results—Deep Soil Percolation and Groundwater Sampling for BMP Evaluation, Teton County SWCD, 2020 Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Nutrient Concentration				Isotopes	
			Phosphorus	Nitrite[A]	Nitrate + Nitrite[A]	Ammonia	$\delta^{18}O_{Nitrate}$	$\delta^{15}N_{Nitrate}$
			(mg/L)				(‰)	
Water Quality Standard:			No Standard	**1.0**	**10**	No Standard	No Standard	No Standard
2779	62	05/13/2020	0.0084	<0.30	0.46	<0.050	-5.41	5.71
		10/28/2020	0.011	-	0.75	<0.050	-6.21	6.56
2780	118	05/13/2020	0.010	<0.30	1.2	<0.050	-6.95	4.77
		10/28/2020	0.0094	-	1.0	<0.050	-7.20	4.94
2781	80	10/28/2020	0.0084	-	0.47	<0.050	-7.14	4.03
2782	Unk	05/13/2020	0.0086	<0.30	0.40	<0.050	-4.57	7.3
		10/28/2020	0.011	-	0.48	<0.050	-6.09	6.07

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; ‰ = permil; Unk = Unknown. Well log not found; (-) = Not Analyzed; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established.
[A] Contaminant with a National Primary Drinking Water Regulation standard.

Table 9. Typical δ15N values from various nitrogen sources.

Potential Nitrate Source	$\delta^{15}N$ (‰)
Precipitation	−4
Commercial fertilizer	−4 to +4
Organic nitrogen in soil or mixed nitrogen source	+4 to +9
Animal or human waste	Greater than +9

Source: *Seiler* 1996

Table 10. Stable isotope results (from two laboratories for lab comparison)—Deep Soil Percolation and Groundwater Sampling for BMP Evaluation, Teton County SWCD, 2020 Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	UAz	BSU	UAz	BSU
			$\delta^{2}H_{Water}$	$\delta^{2}H_{Water}$	$\delta^{18}O_{Water}$	$\delta^{18}O_{Water}$
			(‰)			
Water Quality Standard:			No Standard			
2779	62	05/13/2020	-137.2	-135.9	-18.3	-18.4
		10/28/2020	-134.2	-134.0	-18.1	-18.3
2780	118	05/13/2020	-134.0	-135.0	-17.9	-18.0
		10/28/2020	-134.7	-133.1	-18.0	-18.0
2781	80	10/28/2020	-133.6	-133.6	-18.2	-18.2
2782	Unk	05/13/2020	-136.3	-136.4	-18.3	-18.3
		10/28/2020	-134.5	-134.6	-18.2	-18.3

Notes: ft bgs = feet below ground surface; ‰ = permil; Unk = Unknown. Well log not found; (-) = data is unavailable or was not analyzed; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established.

Bacteria Results

None of the four sites sampled had positive detections of *E. coli* or TC in either the May or October sampling round. Results are presented in Table 11.

Table 11. Bacteria Results—Deep Soil Percolation and Groundwater Sampling for BMP Evaluation, Teton County SWCD, 2020 Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Bacteria Concentrations[A]	
			E. coli	Total Coliform
			(MPN/100 mL)	
Water Quality Standard:			**<1**	**1.0**
2779	62	05/13/2020	<1	<1.0
		10/28/2020	<1	<1.0
2780	118	05/13/2020	<1	<1.0
		10/28/2020	<1	<1.0
2781	80	10/28/2020	<1	<1.0
2782	Unk	05/13/2020	<1	<1.0
		10/28/2020	<1	<1.0

Notes: ft bgs = feet below ground surface; MPN/100 mL = most probable number per 100 milliliters; Unk = Unknown. Well log not found.

[A] Total coliform and *E. coli* standards are from the Idaho Groundwater Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary groundwater quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

General Groundwater Chemistry Results

The four project wells were sampled for the following common ions to evaluate the general groundwater chemistry: bromide, calcium, chloride, fluoride, magnesium, potassium, sodium, and sulfate. Samples were also analyzed for alkalinity (as CaCO3). Results were consistent between May and October and are presented in Table 12.

Table 12. Common ion and total dissolved solids results—Deep Soil Percolation and Groundwater Sampling for BMP Evaluation, Teton County SWCD, 2020 Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Alkalinity as (CaCO3)	Calcium	Chloride[A]	Fluoride[AB]	Magnesium	Potassium	Sodium	Sulfate[A]
			(mg/L)							
Water Quality Standard:			No Standard	No Standard	**250**	**2.0/4**	No Standard	No Standard	No Standard	**250**
2779	62	05/13/2020	176	47	1.52	<0.200	13	0.63	1.1	7.22
		10/28/2020	180	51	1.78	0.0794J	15	0.64	1.2	7.17
2780	118	05/13/2020	204	55	2.69	<0.200	14	0.56	1.2	6.96
		10/28/2020	190	56	2.55	0.0781J	15	0.56	1.2	6.94
2781	80	10/28/2020	171	48	1.97	0.0825J	14	0.56	1.1	6.75
2782	Unk	05/13/2020	175	46	1.61	<0.200	13	0.52	1.1	6.73
		10/28/2020	166	47	1.99	0.0740J	14	0.52	1.1	7.25

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; µg/L = micrograms per liter; Unk = Unknown. Well log not found; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established. J = value is considered an estimate.

[A] Contaminant with a National Secondary Drinking Water Regulation standard.

[B] Contaminant with a National Primary Drinking Water Regulation standard.

Trace Metals and Elements Results

Sites were sampled for trace constituents including arsenic, boron, bromide, lithium, and strontium in May 2020. Following a review of sample results, the list of trace constituents was reduced to Boron and Bromide in October 2020. Results between May and October sampling were consistent for boron and bromide. The three arsenic samples from May were all below the detection limit, consistent with trends for these sites for previous sampling rounds. Results are provided in Table 13. The 2020 results for trace constituents were consistent with the 2019 results, with the exception of lithium; spring 2020 results for Wells 2779 and 2782 were greater than for previous sampling events. Lithium occurs naturally in groundwater and tends to be present at low levels in sedimentary aquifers.

Table 13. Trace metals and elements results—Deep Soil Percolation and Groundwater Sampling for BMP Evaluation, Teton County SWCD, 2020 Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Arsenic[A]	Boron	Bromide	Lithium	Strontium
			(µg/L)				
Water Quality Standard:			**10**	No Standard	No Standard	No Standard	No Standard
2779	62	05/13/2020	<2.0	<5	6.0	6.8	72
		10/28/2020	-	<100	4.8	-	-
2780	118	05/13/2020	<2.0	<5	8.3	1.5	80
		10/28/2020	-	<100	5.7	-	-
2781	80	10/28/2020	-	<100	4.4	-	-
2782	Unk	05/13/2020	<2.0	<5	5.3	12	71
		10/28/2020	-	<100	4.6	-	-

Notes: ft bgs = feet below ground surface; µg/L = micrograms per liter; Unk = Unknown. Well log not found; (-) = data is unavailable or was not analyzed; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established.

[A] Contaminant with a National Primary Drinking Water Regulation standard.

2.1.2.3 Conclusions

No conclusions have been made at this time as this is a multi-year project to evaluate nutrient flow in groundwater and not all rounds of data have been collected. Future data collected will be presented in corresponding annual reports. Conclusions will be made when the project is complete and will be summarized in a future technical report.

2.1.2.4 Recommendations

DEQ plans to continue this multi-year project to evaluate nutrient flow in groundwater. Data will be summarized in a future annual report with additional details. Data may also be presented in a future technical report.

2.1.3 Big Lost River Groundwater Monitoring Project

2.1.3.1 Purpose and Background

The Big Lost River Basin, within the larger Big Lost River hydrologic subbasin, covers 1,400 square miles of east-central Idaho spanning Custer and Butte Counties. Geology for the Big Lost River basin is dominated by consolidated sedimentary strata including Precambrian and Paleozoic limestones, dolomite, quartzite, sandstone, shale and argillites. The western portion of the basin is also noted by Eocene Challis volcanics consisting of intermediate to felsic rock types. Groundwater is present in unconsolidated alluvial aquifers within the valleys. The Big Lost River valley aquifer is tributary to the Eastern Snake River Plain aquifer at Arco.

The Big Lost River Basin is the focus of an ongoing cooperative hydrologic investigation. Idaho Department of Water Resources (IDWR), Idaho Geological Survey (IGS), and US Geological Survey (USGS) are assessing surface water-groundwater interactions to update a hydrologic framework and groundwater budget for the basin, as well as collecting water quality information to assess current conditions. This study included a network of 45 wells monitored for water level and sampled for water quality in 2020. DEQ partnered with IDWR, IGS, and USGS, augmenting their water quality network, with a planned 6-8 additional sites, randomly selected from mile sections within the study area where a cooperative site was not located and drawing from the shallow-most portion of the aquifer. The focus of this study is the Big Lost River Basin from the Thousand Springs Valley down gradient to Arco. Contact was made and permission was received from five of the planned locations. Cooperative sampling with IDWR, IGS, and USGS allows DEQ to augment cooperative partners' sampling efforts. DEQ sample sites were DWs with known construction drawing from the upper-most portion of the aquifer with sites chosen in a manner consistent with that for IFRO regional water quality monitoring sites.

The focus of this monitoring project was to identify areas of highly vulnerable or degraded water quality, identify potential sources causing degradation, and collect information that will aid in directing and prioritizing protection efforts, evaluating the effectiveness of protection measures, and informing any needed regulatory decisions.

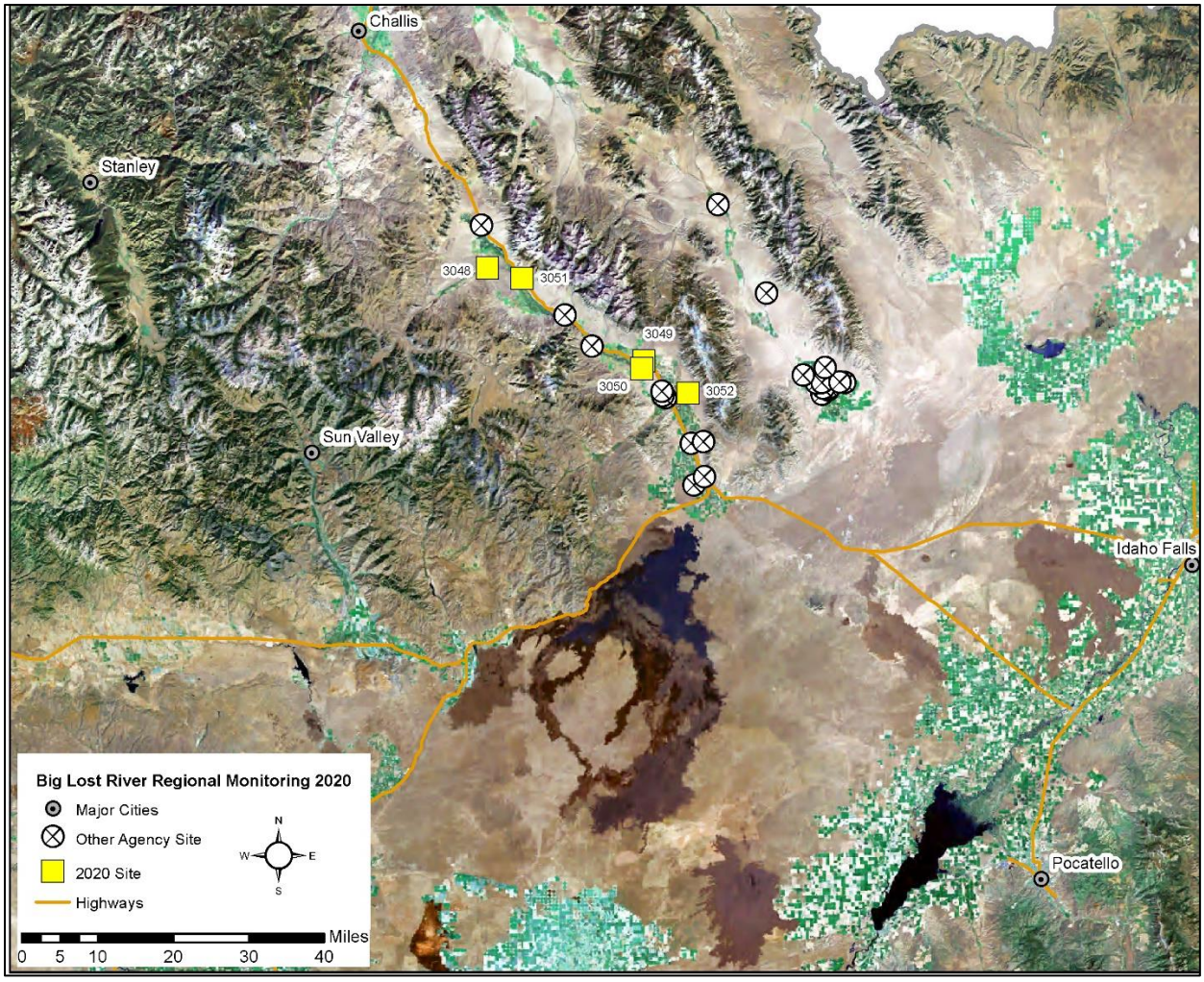


Figure 10. Big Lost River Site Locations – Big Lost River Groundwater Monitoring Project

2.1.3.2 Methods and Results

Sample locations were selected from domestic and livestock wells with available well logs. A total of five wells were sampled in September 2020. Results from these randomly selected wells can statistically represent the subarea and can be combined with results from other sampling networks to make inferences concerning the subarea.

The five project wells were sampled following the appropriate QAPP (DEQ 2011) and FSP (DEQ 2019c). Water quality field parameters (i.e., pH, temperature, specific conductance, DO) were measured before sample collection to ensure adequate purging of the well for a representative sample of the local aquifer (Table 14).

Table 14. Water quality field parameters—Big Lost River Regional Monitoring Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Water Temperature (°C)	Specific Conductance (µS/cm)	pH[A]	Dissolved Oxygen (mg/L)
Water Quality Standard:			No Standard	No Standard	**6.5-8.5**	No Standard
3048	120	09/16/2020	8.62	172	7.34	8.45
3049	79	09/16/2020	9.68	462	7.14	6.51
3050	80	09/16/2020	10.12	493	7.11	4.34
3051	60	09/16/2020	13.14	415	7.76	3.27
3052	180	09/16/2020	10.87	492	7.23	10.11

Notes: ft bgs = feet below ground surface; °C = degrees Celsius; µS/cm = microsiemens/centimeter; pH = standard pH units; mg/L = milligrams per liter; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established.
[A] Contaminant with a National Secondary Drinking Water Regulation standard (NSDWR). The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Nutrient and Stable Isotope Results

Samples were analyzed by the UC Davis Stable Isotope Facility for stable isotopes of oxygen and nitrogen in nitrate ($\delta^{18}O_{nitrate}$, $\delta^{15}O_{nitrate}$). Deuterium/protium stable isotope ratio (H^1/H^2) and δ^2H_{water} and $\delta^{18}O_{water}$ samples were sent to Boise State University Isotope Geology Laboratory. Boron and bromide samples were analyzed by University of Idaho Analytical Services Laboratory. Total coliform and *E. coli* samples were sent to Teton Microbiology and all other samples were analyzed by Idaho Bureau of Laboratories.

Nitrate results were all below the EPA standard of 10 mg/L, ranging from 0.038 mg/L to 2.6 mg/L. Ammonia results were all below the reporting limit. Results for $\delta^{18}O_{nitrate}$ ranged from -7.02‰ to -3.19‰ and $\delta^{15}N_{nitrate}$ results ranged from 3.34‰ to 6.41‰. Corresponding $\delta^{18}O_{nitrate}$ values ranged from -3.19‰ to -6.86‰ (Table 15; Table 9). The combination of $\delta^{15}N_{nitrate}$ and $\delta^{18}O_{nitrate}$ values for Well 3048 reflects an expected natural concentration nitrate and isotopic signature expected from a primarily ambient, atmopheric nitrogen source. Well 3052, with a nitrate concentration within the range typically cited as an anthropogenic impact, has an isotopic signature reflecting a primarily organic nitrogen signature. The remaining sites show a possible mixture of ambient, inorgainc sources with an increasing contribution from soil/organic sources, but all at low levels (Figure 11).

Results for δ^2H_{water} and $\delta^{18}O_{water}$ ranged from -134.6‰ to -130.2‰ and -17.8‰ to -17.3‰, respectively (Table 16). Results for Wells 3048 and 3052 are also identified. Well 3048 reflects a largely winter precipitation/snow melt run-off signature characteristic of precipitation from higher elevations. Well 3052 plots consistent with the local meteoric water line, possibly reflecting groundwater characterizing more by average annual precipitation as opposed to an influence from evaporated irrigation water as is likely with the other Big Lost River sites (Figure 12).

Table 15. Nutrient and nutrient-related isotope results—Big Lost River Regional Monitoring Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Nutrient Concentration			Isotopes	
			Phosphorus	Nitrate + Nitrite[A]	Ammonia	$\delta^{18}O_{Nitrate}$	$\delta^{15}N_{Nitrate}$
			(mg/L)			(‰)	
Water Quality Standard:			No Standard	**10**	No Standard	No Standard	No Standard
3048	120	09/16/2020	0.0065	0.038	<0.050	-3.19	3.34
3049	79	09/16/2020	0.013	1.1	<0.050	-6.45	4.76
3050	80	09/16/2020	0.016	1.8	<0.050	-6.86	3.89
3051	60	09/16/2020	0.012	0.19	<0.05	-7.02	6.41
3052	180	09/16/2020	0.031	2.6	<0.050	-6.55	6.12

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; ‰ = permil; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established.
[A] Contaminant with a National Primary Drinking Water Regulation standard.

Table 16. Stable isotope results—Big Lost River Regional Monitoring Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	$\delta^{2}H_{Water}$	$\delta^{18}O_{Water}$
			(‰)	
Water Quality Standard:			No Standard	No Standard
3048	120	09/16/2020	-134.6	-17.8
3049	79	09/16/2020	-131.5	-17.4
3050	80	09/16/2020	-130.9	-17.3
3051	60	09/16/2020	-130.2	-17.4
3052	180	09/16/2020	-131.1	-17.3

Notes: ft bgs = feet below ground surface; ‰ = permil; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established.

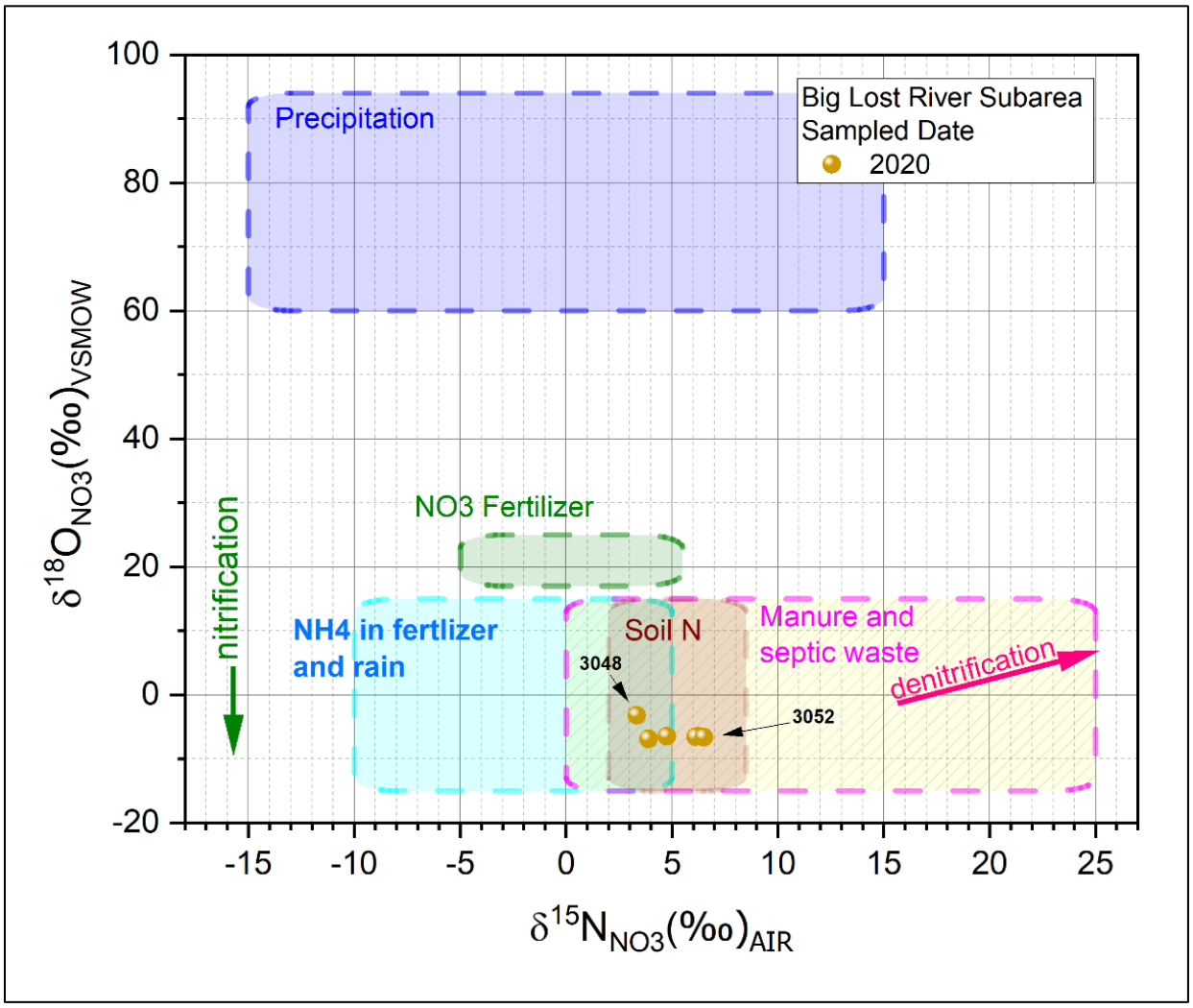


Figure 11. Plot of $\delta^{15}N_{nitrate}$ and $\delta^{18}O_{nitrate}$ stable isotope values—Big Lost River Subarea Regional Monitoring Groundwater Monitoring Project. Ranges of isotopic values and sources are from Kendall et al., 2007

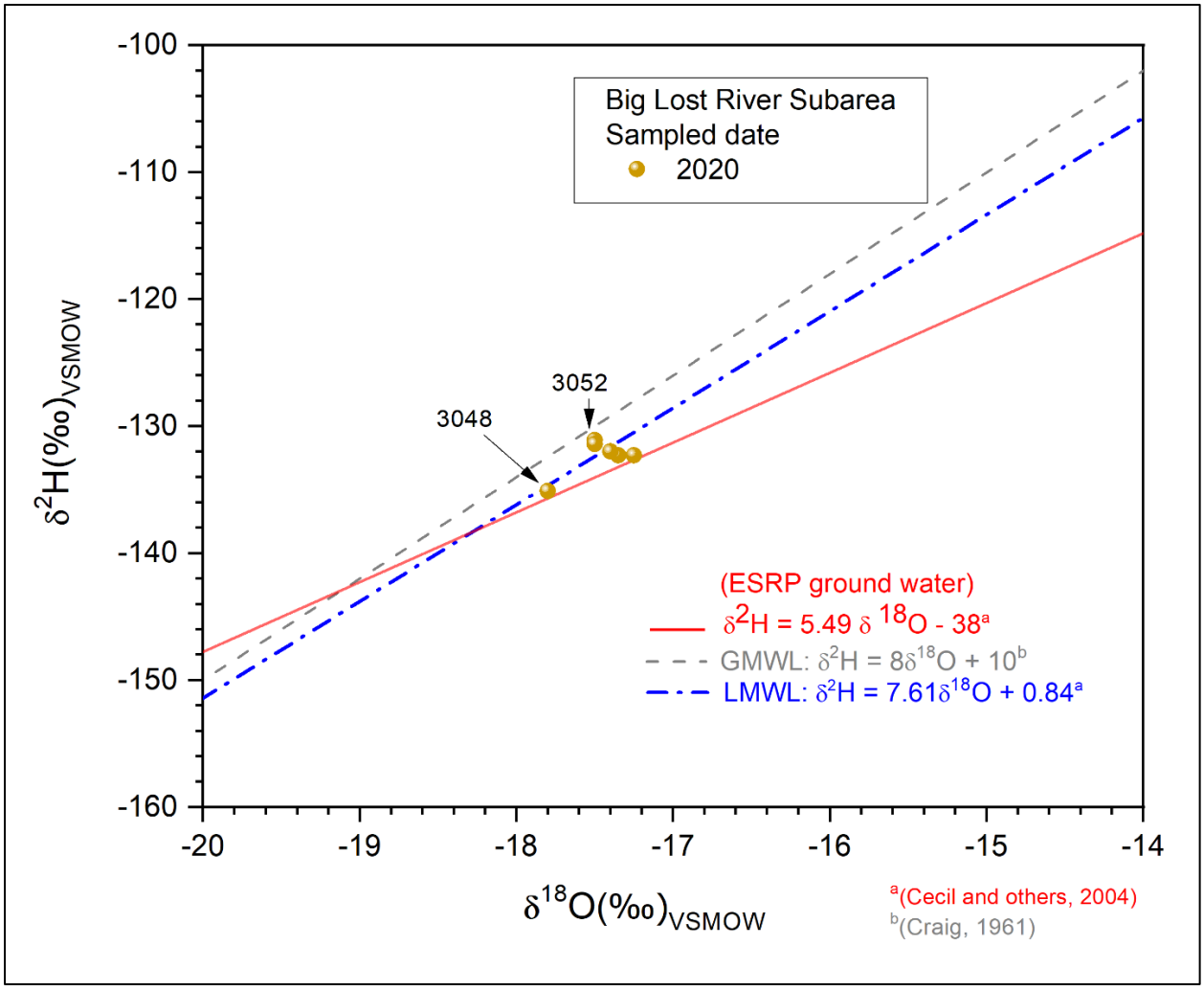


Figure 12. Plot of $\delta^{18}O_{water}$ and $\delta^{2}H_{water}$ stable isotope values—Big Lost River Subarea Regional Monitoring Groundwater Monitoring sites.

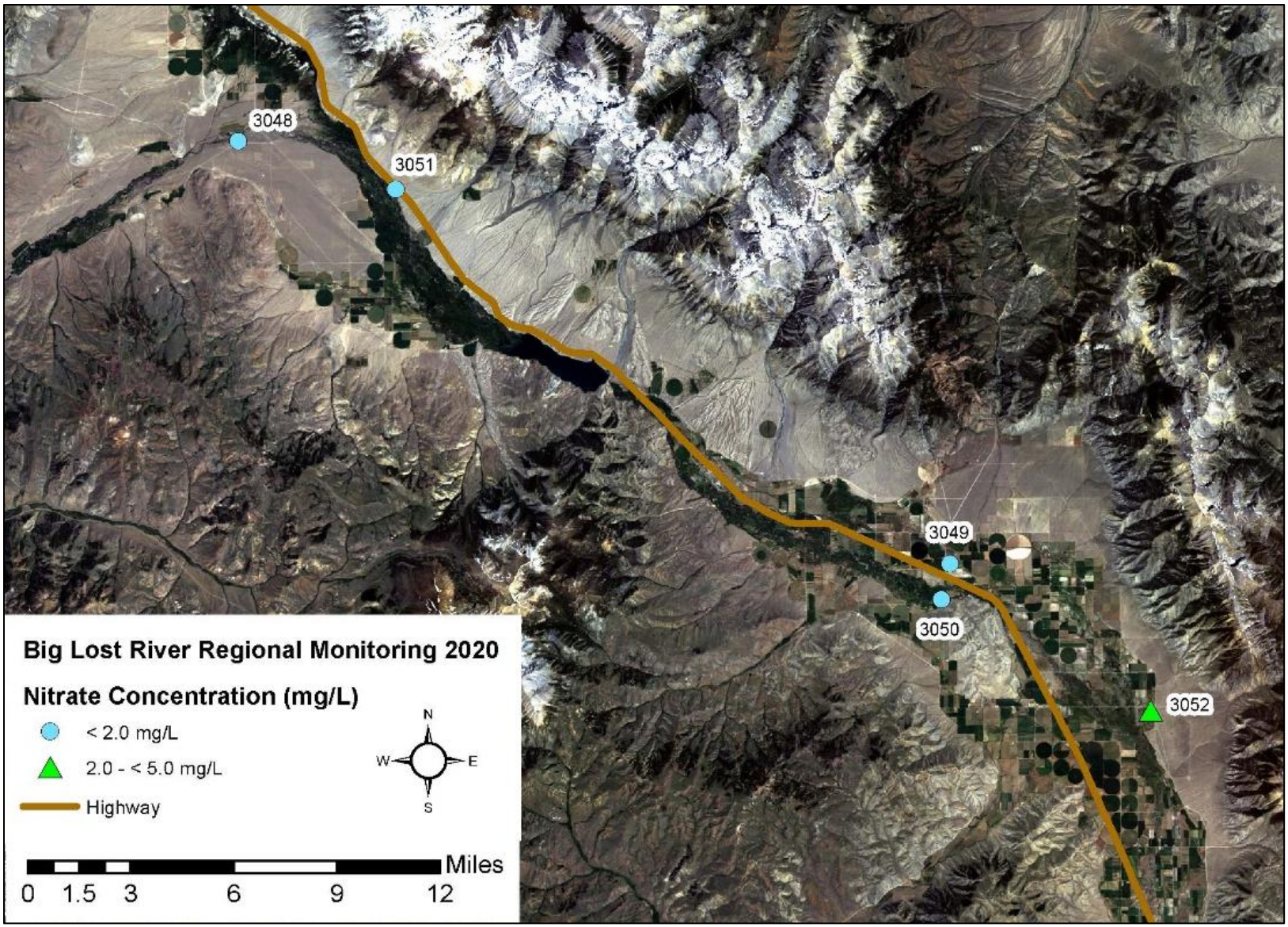


Figure 13. Big Lost River Nitrate Concentrations—Big Lost River Regional Monitoring Groundwater Monitoring Project.

Bacteria Results

None of the five sites sampled had positive detections of *E. coli* or total coliform. Results are presented in Table 17.

Table 17. Bacteria Results—Big Lost River Regional Monitoring Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Bacteria Concentrations[A]	
			E. coli	Total Coliform
			(MPN/100 mL)	
Water Quality Standard:			**<1**	**1.0**
3048	120	09/16/2020	<1	<1
3049	79	09/16/2020	<1	<1
3050	80	09/16/2020	<1	<1
3051	60	09/16/2020	<1	<1
3052	180	09/16/2020	<1	<1

Notes: ft bgs = feet below ground surface; MPN/100 mL = most probable number per 100 milliliters.

[A] Total coliform and *E. coli* standards are from the Idaho Groundwater Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary groundwater quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

General Groundwater Chemistry Results

The five project wells were sampled for the following common ions to evaluate the general groundwater chemistry: bromide, calcium, chloride, fluoride, magnesium, potassium, sodium, and sulfate. Samples were also analyzed for alkalinity (as CaCO3). Results are presented in Table 18. Sampled sites share a very similar chemical signature – a dominant calcium-bicarbonate water (Figure 14). The sites identified (Wells 3048, 3052) are spatially arranged upgradient (3048) to downgradient (3052). Suggesting the primary impact to water quality is likely dissolution of the aquifer matrix as opposed to increasing chloride and sulfate due to significant anthropogenic impacts.

Table 18. Common ion and total dissolved solids results—Big Lost River Regional Monitoring Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Alkalinity as (CaCO3)	Calcium	Chloride[A]	Fluoride[AB]	Magnesium	Potassium	Sodium	Sulfate[A]
			(mg/L)							
Water Quality Standard:			No Standard	No Standard	**250**	**2.0/4**	No Standard	No Standard	No Standard	**250**
3048	120	09/16/2020	71.7	24	1.34	0.136	5.2	0.66	3.0	12.4
3049	79	09/16/2020	210	67	5.58	0.159	16	1.1	6.4	23.9
3050	80	09/16/2020	224	71	5.24	0.152	17	1.3	6.9	24.7
3051	60	09/16/2020	187	57	8.17	0.165	16	1.7	6.0	18.6
3052	180	09/16/2020	211	57	11.0	0.169	23	0.95	12	25.0

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; µg/L = micrograms per liter; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established.

[A] Contaminant with a National Secondary Drinking Water Regulation standard.

[B] Contaminant with a National Primary Drinking Water Regulation standard.

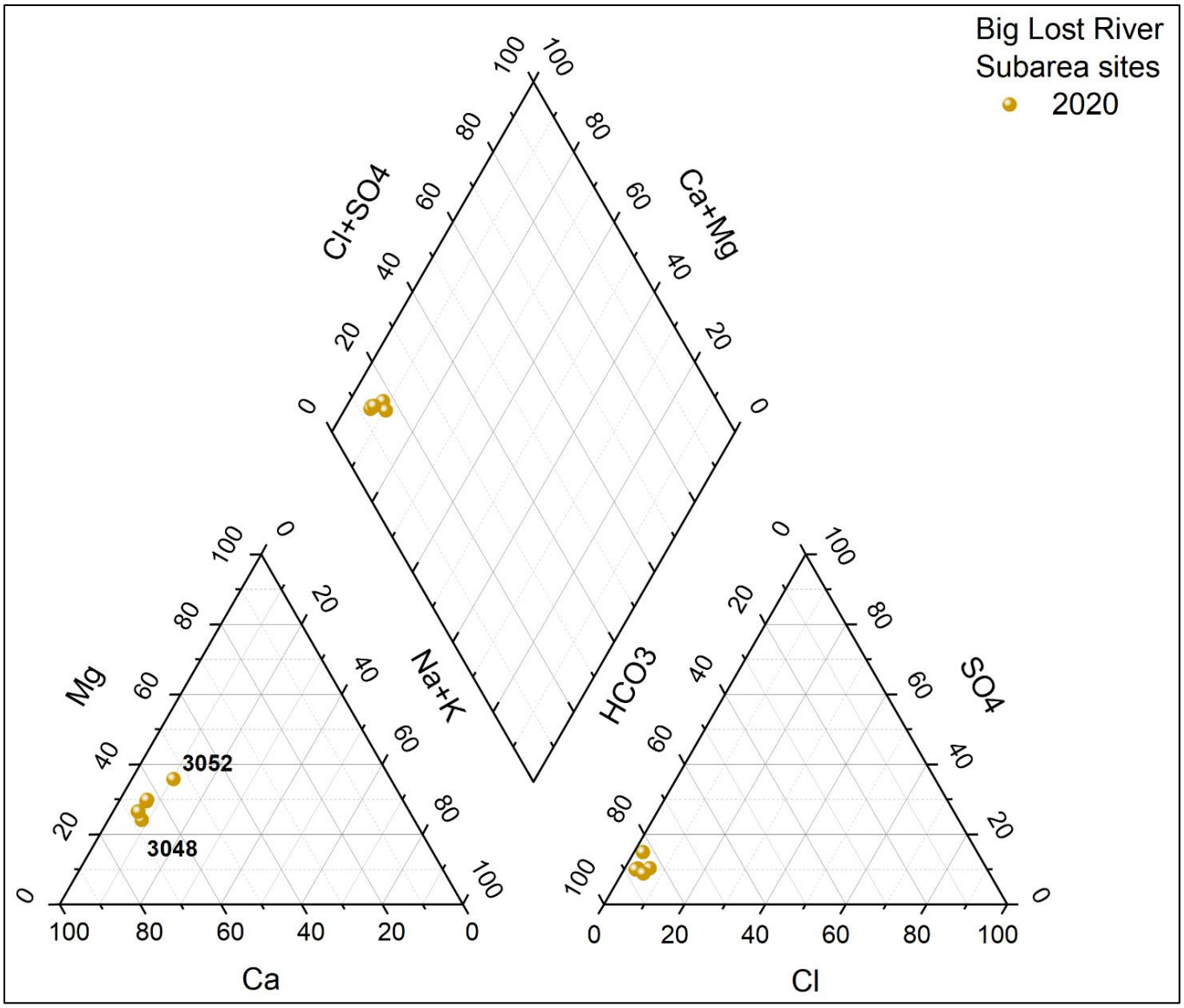


Figure 14, Piper diagram of common ion data—Big Lost River Subarea Regional Monitoring Groundwater Monitoring Project.

Trace Metals and Elements Results

All sites were sampled for trace constituents including arsenic and boron. The MCL for arsenic was not exceeded in any sample. There is no designated standard for boron, but results ranged from 4.0 µg/L to 15 µg/L with one non-detect result.

Table 19. Trace metals and elements results—Big Lost River Regional Monitoring Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Arsenic[A]	Bromide	Boron
				(µg/L)	
Water Quality Standard:			**10**	No Standard	No Standard
3048	120	09/16/2020	0.28	11	<0.1
3049	79	09/16/2020	0.79	19	5.8
3050	80	09/16/2020	0.89	22	6.7
3051	60	09/16/2020	0.5	34	4.0
3052	180	09/16/2020	1.4	42	15

Notes: ft bgs = feet below ground surface; µg/L = micrograms per liter; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established.

[A] Contaminant with a National Primary Drinking Water Regulation standard.

2.1.4 Island Park Groundwater Bacteria Investigation

2.1.4.1 Purpose and Background

In the spring of 2020, routine sampling by public water system (PWS) wells in the Mack's Inn and Island Park Village area showed an increase in total coliform (TC) and Escherichia coli (*E. coli*) bacteria detections. In response, the DEQ Idaho Falls Regional Office and the Eastern Idaho Public Health District (EIPHD) partnered with Fremont County, the City of Island Park, and PWS operators to understand the possible causes for the bacteria detections.

The project was designed to address the following questions:

- What are the primary sources of bacterial contamination? - Is impact from surface water a significant source, or are there other sources?
- What role does snowmelt play in the timing of bacteria detections in drinking water wells?
- What physical factors control why some sites are impacted and others are not?

Two rounds of sampling were planned - an initial round in late summer/fall 2020, with a follow-up round in spring 2021. Sampling design also allowed for modification to sites and analytes based on results from the initial sampling round. This report will focus on the initial sampling round in 2020, and interim conclusions. Results and conclusions from the 2021 sampling including a discussion of multivariate statistical analysis will be included in a later report.

Selected groundwater and surface water sites were sampled in fall 2020 and analyzed for bacteria, common ion chemistry and stable isotopes. Additionally, field parameter

measurements (water temperature, pH, dissolved oxygen, and specific conductance) were measured at the time of collection.

Sites sampled included PWS wells and private domestic wells (DWs) in the Mack's Inn and Island Park Village areas. Samples were also collected from surface water sites to characterize possible sources of bacteria and recharge. Samples were analyzed for bacteria and other characteristics to aid in identifying possible sources of bacteria. A combination of data review and analysis methods were used to determine similar sites and characteristics and thus similar sources or factors impacting them. The results were reviewed to relate sampling outcomes to typical interpretations of geochemical characteristics and general water infiltration sources. Multivariate analysis methods were used to identify related groupings of geochemical characteristics, spatially-related groups, or statistically significant clusters, and the appropriate interpretive context. This report will focus on the bacterial, common-ion chemistry, and stable isotope results. This combination of relational factors helps identify bacteria source signatures and specific characteristics driving the seasonal and location variability. The outcome of these steps provides the basis for a path forward for those responsible for and impacted by bacteria contamination in the Mack's Inn/Island Park Village area.

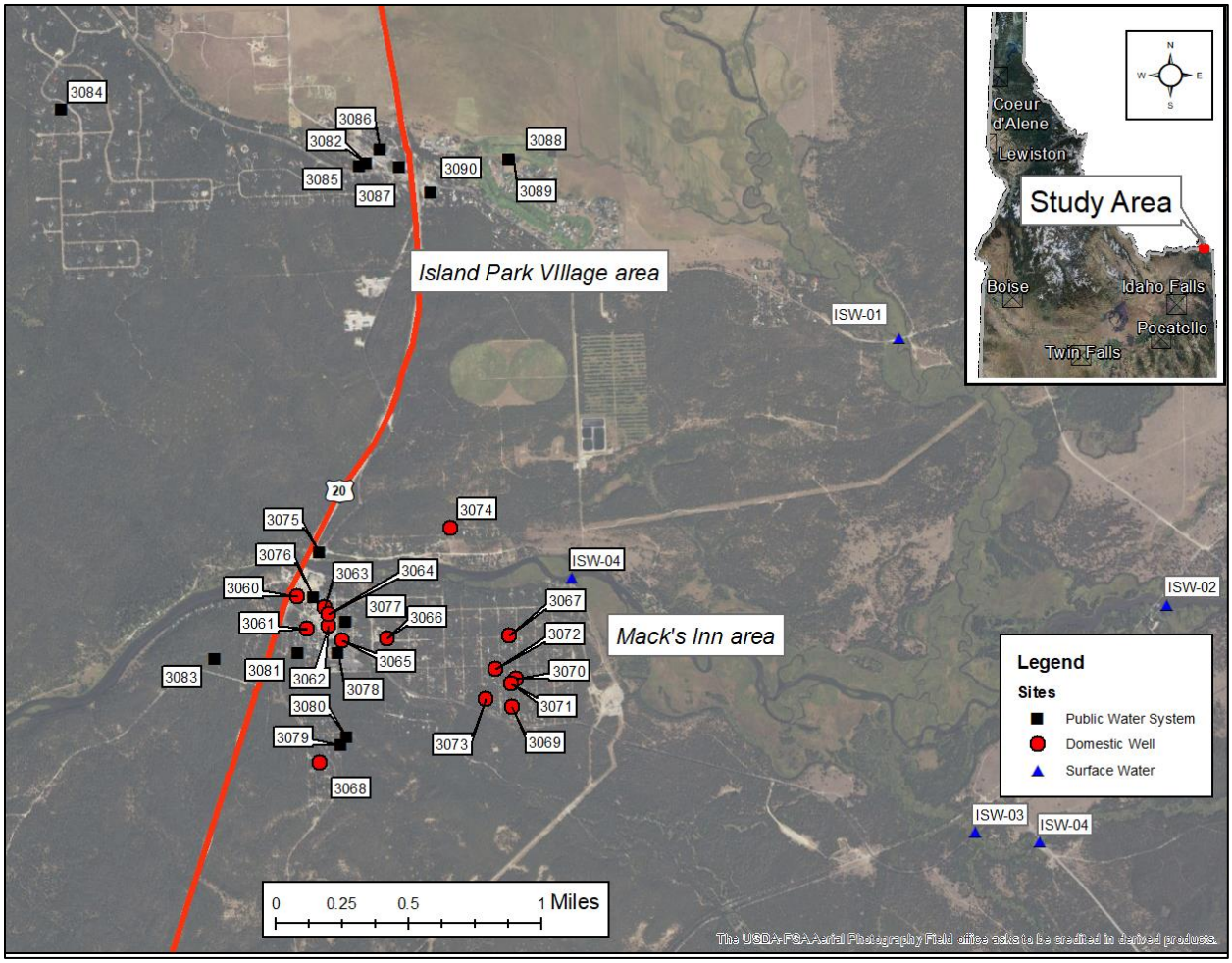


Figure 15. 2020 monitoring locations—Island Park Bacteria Investigation Groundwater Monitoring Project.

2.1.4.2 Methods and Results

A total of 36 sites were sampled in August 2020, including 15 private DWs from the Mack's Inn area, 16 PWS wells from both the Mack's Inn and Island Park Village areas, and 5 surface water sites to characterize possible sources of recharge or impact. The PWS wells accounted for nearly all the available PWS sources. The DW sites were chosen from a list of well owners volunteering to participate. The sites sampled were those that were successfully contacted. The compilation of sites represents less than 10 percent of known wells in the study area. Well construction information could be confirmed for 11 of the 16 PWS wells and only 4 of the 15 DW sites. The surface water sites represented the nearest five tributaries to the Henrys Fork of the Snake River.

Samples collected during 2020 were analyzed for bacteria (TC, *E. coli*), common ion chemistry (calcium, magnesium, sodium, potassium, total alkalinity, chloride, sulfate (SO_4)), nutrients (nitrate + nitrite (NO_2+NO_3), and ammonium (NH_4) for selected sites), and stable isotopes of oxygen and hydrogen in water ($\delta^{18}O$, $\delta^{2}H$). All samples were collected in accordance with the project QAPP (DEQ 2020) and FSP (DEQ 2020). Water quality field parameters (pH,

temperature, specific conductance, and DO) were measured at each groundwater and surface water site prior to sample collection (Table 20).

Table 20. Water quality field parameters—Island Park Bacteria Investigation Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Water Temperature (°C)	Specific Conductance (µS/cm)	pH[A]	Dissolved Oxygen (mg/L)
Water Quality Standard:			No Standard	No Standard	**6.5-8.5**	No Standard
3060	Unk	08/06/2020	8.67	90	6.88	8.05
3061	Unk	08/13/2020	8.26	149	*6.49*	4.56
3062	Unk	08/13/2020	7.26	157	*6.47*	3.63
3063	Unk	08/13/2020	8.60	118	*6.33*	7.53
3064	Unk	08/13/2020	7.75	214	7.53	0.30
3065	83	08/13/2020	7.44	200	6.87	1.00
3066	Unk	08/13/2020	6.88	133	*6.37*	5.11
3067	Unk	08/13/2020	8.06	99	*6.32*	7.00
3068	160	08/13/2020	7.74	99	6.84	4.43
3069	Unk	08/13/2020	7.53	132	6.93	7.05
3070	Unk	08/13/2020	7.94	105	6.81	7.38
3071	Unk	08/13/2020	11.05	110	6.92	6.50
3072	80	08/13/2020	7.16	96	6.76	7.85
3073	70	08/13/2020	9.54	143	7.01	4.76
3074	Unk	08/13/2020	6.08	121	6.61	8.43
3075	Unk	08/06/2020	6.54	78	*6.47*	9.59
3076	285	08/06/2020	7.20	86	7.99	7.62
3077	122	08/06/2020	6.56	111	*6.41*	7.89
3078	Unk	08/06/2020	9.16	125	*6.49*	6.37
3079	Unk	08/06/2020	6.69	116	6.54	8.72
3080	Unk	08/06/2020	6.86	107	*6.41*	7.03
3081	125	08/06/2020	7.67	138	6.52	5.90
3082	65	08/06/2020	7.08	78	*6.34*	9.98
3083	119	08/13/2020	7.41	101	*6.22*	4.89
3084	290	08/06/2020	6.07	70	7.48	6.45
3085	140	08/06/2020	6.71	77	6.91	8.29
3086	150	08/06/2020	7.39	76	6.80	8.05
3087	143	08/06/2020	6.59	86	6.66	7.75
3088	145	08/06/2020	6.44	85	6.74	7.24
3089	207	08/06/2020	6.95	85	6.74	7.41
3090	106	08/06/2020	6.79	142	6.56	6.35
ISW-01	—	08/06/2020	20.45	197	*8.78*	8.77
ISW-02	—	08/06/2020	12.96	97	7.08	9.33
ISW-03	—	08/06/2020	17.85	95	7.72	8.14
ISW-04	—	08/06/2020	18.18	130	8.42	9.02

ISW-05	—	08/13/2020	18.01	119	7.73	8.33

Notes: ft bgs = feet below ground surface; °C = degrees Celsius; µS/cm = microsiemens/centimeter; pH = standard pH units; mg/L = milligrams per liter; Unk = Unknown. Well log not found; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established; (-) = Not analyzed or not applicable. Shaded and italicized numbers indicate a violation of a National Secondary Drinking Water Regulation (NSDWR) standard.
[A] Contaminant with a National Secondary Drinking Water Regulation standard (NSDWR). The NSDWR standard for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Samples were analyzed by IBL in Boise for common ions (calcium, sodium, magnesium, potassium, chloride, fluoride, and sulfate), nitrite plus nitrate (nitrate), and ammonia. Samples for bacteria (TC and *E. coli*) were analyzed by Teton Microbiology Laboratory in Idaho Falls and Boise State University Stable Isotope Laboratory for stable isotopes of oxygen and hydrogen in water ($\delta^{18}O_{water}$ and $\delta^{2}H_{water}$).

Nitrate Results

The 2020 nitrate (total NO_2 +NO_3 as N) results are presented in Table 21. While bacteria in groundwater is the primary concern for the Mack's Inn and Island Park Village area, nitrate concentrations are considered with this study to aid in distinguishing between natural and anthropogenic sources of water quality impact. Waste sources of nitrogen, septic or sewage/sanitary wastes, which are also sources of TC and *E. coli*, will tend to have elevated nitrate concentrations. Nitrogen (N) may also be present as ammonium (NH_4) (the ionic form of ammonia [NH_3]). Ammonium and nitrate are also present at low levels in precipitation. Where dissolved oxygen in groundwater is very low, nitrogen will commonly be present as both nitrate and ammonium, but with a greater proportion as ammonium.

Primary natural sources of nitrate in groundwater for Island Park include precipitation (as snowmelt and rain), and organic matter from soils. Other likely sources include wastes from individual septic systems and possible leaks from sewer systems. There are very few areas where nitrate fertilizer might be applied within the study area. While there are cattle grazing on the Henry's Lake flats to the north, and abundant wildlife, concentrations of animals are distant from sites sampled in this study.

The 2020 nitrate concentrations ranged from non-detect (less than 0.010 mg/L) to 0.90 mg/L (Well 3090), with a mean and median of 0.27 and 0.28 mg/L, respectively (Table 21). Samples from four sites were analyzed for ammonium (NH_4^+), with two sample results less than the reporting level (<0.050 mg/L) and two results with reportable results, 0.12 and 0.10 mg/L. Sites were selected for ammonium analysis based on low dissolved oxygen reported in the field. Sites with detectable ammonium reported dissolved oxygen measurements of 0.30 and 1.00 mg/L; two sites with ammonium at less than reportable levels reported dissolved oxygen at 3.63 and 4.56 mg/L. Site 3064, with 0.12 mg/L ammonium was the only groundwater with a less-than-reportable nitrate concentration. The nitrate concentration observed for site 3090, being significantly greater than the observed interquartile range, can be characterized as an outlier.

Table 21. Nutrient and nutrient-related isotope results—Island Park Bacteria Investigation Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Nutrient Concentration	
			Nitrate + Nitrite[A]	Ammonia
			(mg/L)	
Water Quality Standard:			**10**	No Standard
3060	Unk	08/06/2020	0.14	—
3061	Unk	08/13/2020	0.33	<0.050
3062	Unk	08/13/2020	0.39	<0.050
3063	Unk	08/13/2020	0.41	—
3064	Unk	08/13/2020	<0.010	0.12
3065	83	08/13/2020	0.18	0.10
3066	Unk	08/13/2020	0.26	—
3067	Unk	08/13/2020	0.31	—
3068	160	08/13/2020	0.17	—
3069	Unk	08/13/2020	0.29	—
3070	Unk	08/13/2020	0.31	—
3071	Unk	08/13/2020	0.30	—
3072	80	08/13/2020	0.32	—
3073	70	08/13/2020	0.28	—
3074	Unk	08/13/2020	0.21	—
3075	Unk	08/06/2020	0.18	—
3076	285	08/06/2020	0.11	—
3077	122	08/06/2020	0.33	—
3078	Unk	08/06/2020	0.31	—
3079	Unk	08/06/2020	0.30	—
3080	Unk	08/06/2020	0.23	—
3081	125	08/06/2020	0.38	—
3082	65	08/06/2020	0.18	—
3083	119	08/13/2020	0.20	—
3084	290	08/06/2020	0.13	—
3085	140	08/06/2020	0.15	—
3086	150	08/06/2020	0.18	—
3087	143	08/06/2020	0.24	—
3088	145	08/06/2020	0.35	—
3089	207	08/06/2020	0.34	—
3090	106	08/06/2020	0.90	—
ISW-01	—	08/06/2020	<0.010	—
ISW-02	—	08/06/2020	0.10	—
ISW-03	—	08/06/2020	0.053	—
ISW-04	—	08/06/2020	0.027	—
ISW-05	—	08/13/2020	0.033	—

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; Unk = Unknown. Well log not found; (-) = Not analyzed or not applicable; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established.

[A] Contaminant with a National Primary Drinking Water Regulation standard.

Bacteria Results

TC bacteria are commonly present in soils but do not travel very far in groundwater. TC bacteria can also be present within the plumbing fixtures and not from bacteria in the groundwater. TC and *E. coli* are nearly always detected in surface water. Both families of bacteria can be present intermittently at the same location. TC bacteria are a group of bacteria common in the environment (such as soil) and are generally not harmful. *E. coli* bacteria (a type of coliform bacteria) are found in human and animal fecal matter. The presence of *E. coli* in groundwater provides strong evidence that human or animal fecal waste is present and a greater potential for pathogenic organisms exists. Bacterial analyses aid in identifying potential impacts or influences at the wellhead or sample point.

A total of 17 groundwater sites were positive for bacteria; 12 of the 17 were positive for TC and 5 sites were positive for both TC and *E. coli*. TC concentrations ranged from 1.0 to 727.0 MPN/100mL. All 5 surface water site samples contained TC and *E. coli*. The surface water TC concentrations ranged from 517.2 MPN/100 mL to 2419.6 MPN/100 mL. *E. coli* concentrations in surface water ranged from 4.1 MPN/100 mL to 68.9 MPN/100 mL (Table 22). PWS and DW sites with bacteria detections are identified in Figure 16.

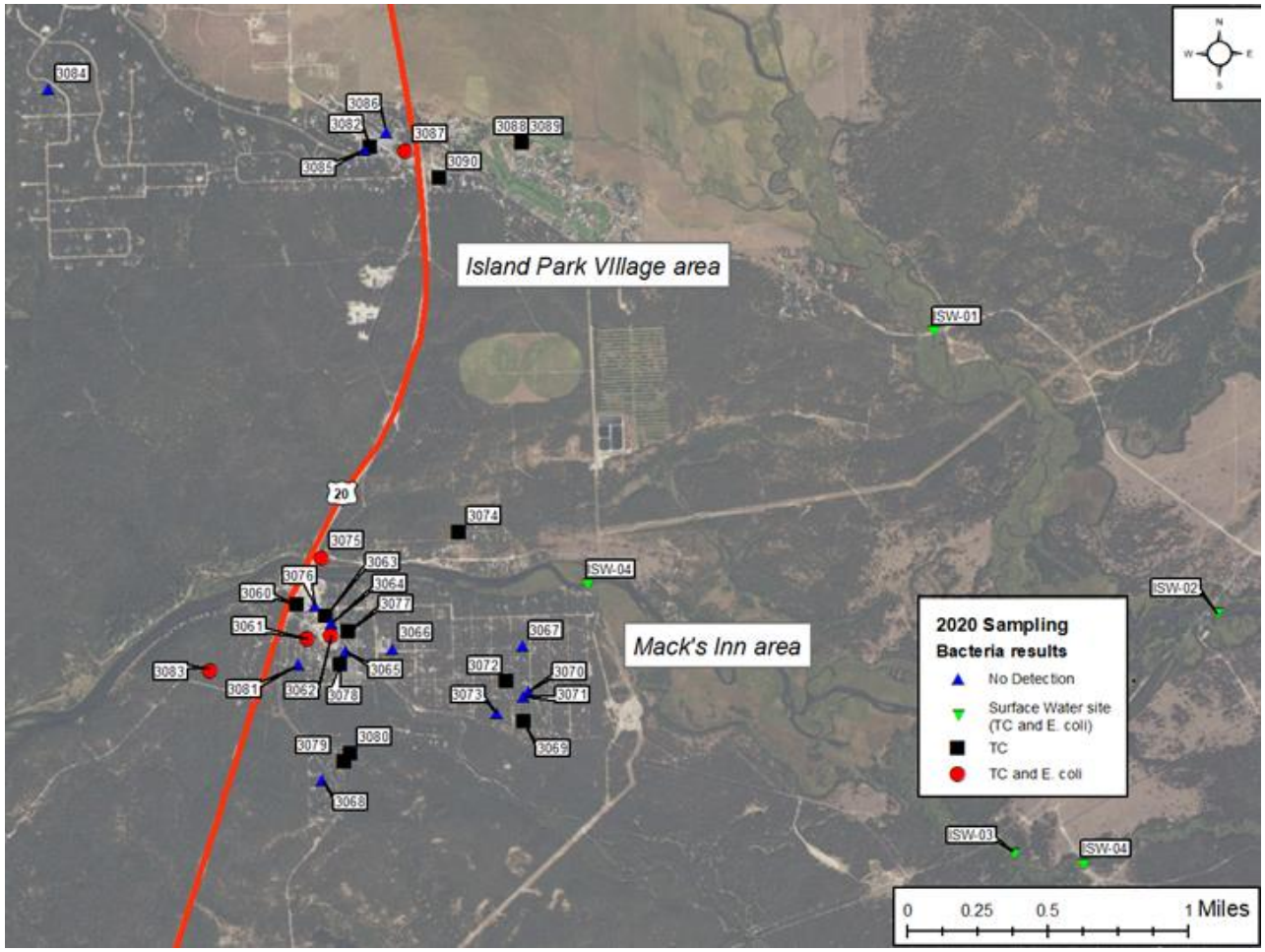


Figure 16. 2020 bacteria detections—Island Park Bacteria Investigation Groundwater Monitoring Project.

Table 22. Bacteria Results—Island Park Bacteria Investigation Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Bacteria Concentrations[A]	
			E. coli	Total Coliform
			(MPN/100 mL)	
Water Quality Standard:			**<1**	**1.0**
3060	Unk	08/06/2020	<1	2.0
3061	Unk	08/13/2020	**1.0**	3.1
3062	Unk	08/13/2020	**1.0**	1.0
3063	Unk	08/13/2020	<1.0	2.0
3064	Unk	08/13/2020	<1.0	<1.0
3065	83	08/13/2020	<1.0	<1.0
3066	Unk	08/13/2020	<1.0	<1.0
3067	Unk	08/13/2020	<1.0	<1.0
3068	160	08/13/2020	<1.0	<1.0
3069	Unk	08/13/2020	<1.0	4.1
3070	Unk	08/13/2020	<1.0	<1.0
3071	Unk	08/13/2020	<1.0	<1.0
3072	80	08/13/2020	<1.0	28.2
3073	70	08/13/2020	<1.0	<1.0
3074	Unk	08/13/2020	<1.0	2.0
3075	Unk	08/06/2020	**40.8**	727.0
3076	285	08/06/2020	<1.0	<1.0
3077	122	08/06/2020	<1.0	2.0
3078	Unk	08/06/2020	<1.0	2.0
3079	Unk	08/06/2020	<1.0	1.0
3080	Unk	08/06/2020	<1.0	1.0
3081	125	08/06/2020	<1.0	<1.0
3082	65	08/06/2020	<1.0	58.3
3083	119	08/13/2020	**1.0**	248.1
3084	290	08/06/2020	<1.0	<1.0
3085	140	08/06/2020	<1.0	<1.0
3086	150	08/06/2020	<1.0	<1.0
3087	143	08/06/2020	**6.3**	77.1
3088	145	08/06/2020	<1.0	<1.0
3089	207	08/06/2020	<1.0	1.0
3090	106	08/06/2020	<1.0	18.5
ISW-01	—	08/06/2020	**68.9**	2419.6
ISW-02	—	08/06/2020	**4.1**	613.1
ISW-03	—	08/06/2020	**48.0**	517.2
ISW-04	—	08/06/2020	**35.9**	517.2
ISW-05	—	08/13/2020	**28.7**	1119.9

Notes: ft bgs = feet below ground surface; MPN/100 mL = most probable number per 100 milliliters; Unk = Unknown. Well log not found; (-) = Not analyzed or not applicable.

[A] Total coliform and *E. coli* standards are from the Idaho Groundwater Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary groundwater quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total

coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

General Groundwater Chemistry

Common ion chemistry provides a picture of the overall relative character of groundwater, including mixing from different sources and changes in groundwater chemistry from processes such as dissolution of the aquifer matrix, infiltration, and impacts from contamination sources. Common ion chemistry along with field parameters can also provide clues to ongoing chemical processes and indications of the favored chemical forms for nitrogen in groundwater (Table 23).

Differences in general groundwater chemistry between sites can be summarized by a type of ternary diagram referred to as a Piper diagram. Water quality results are represented by the proportional composition of the common ions (calcium, magnesium, sodium, potassium, total alkalinity (as CaCO3), chloride, and sulfate)), in terms of their electrochemical equivalent concentration (milliequilivents per liter). Results are presented as their proportional cation and anion concentrations and as proportions calcium + magnesium and chloride + sulfate. The significance of this presentation is that the proportional differences in composition are not masked by mass-concentrations. Presenting results as a Piper diagram aids in understanding mixing between chemical endmembers (sources). Overall, the regional groundwater can be described as a calcium-magnesium or magnesium-bicarbonate water type. The additional surface water sites ISW-02, -03, -05 (Big Springs, Lucky Dog, and Moose Creek) are more of a sodium-bicarbonate water type. Distinct sample sites identified (wells 3075, 3090, 3074, and 3083) differ with a chemistry reflecting a proportional increase in chloride compared to the surface water sites and other groundwater sites. These specific sites are among those that had positive bacteria detections.

Table 23. Common ion and total dissolved solids results—Island Park Bacteria Investigation Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Alkalinity as (CaCO3)	Calcium	Chloride[A]	Magnesium	Potassium	Sodium	Sulfate[A]
			(mg/L)						
Water Quality Standard:			No Standard	No Standard	**250**	No Standard	No Standard	No Standard	**250**
3060	Unk	08/06/2020	41.3	9.0	0.725	2.5	2.1	4.0	1.53
3061	Unk	08/13/2020	68.9	16	2.84	4.8	2.4	7.2	1.46
3062	Unk	08/13/2020	74.2	16	3.23	5.1	2.4	7.3	1.47
3063	Unk	08/13/2020	49.8	12	4.02	3.4	2.1	5.4	1.90
3064	Unk	08/13/2020	107	21	1.23	7.2	2.7	9.8	0.246
3065	83	08/13/2020	102	20	1.57	6.8	2.8	9.1	0.634
3066	Unk	08/13/2020	60.4	14	2.35	3.9	2.2	6.5	1.86
3067	Unk	08/13/2020	43.5	9.4	2	2.5	2.2	5.7	1.88
3068	160	08/13/2020	45.6	9.5	1.47	2.9	1.9	5.0	1.69
3069	Unk	08/13/2020	61.5	13	2.20	3.4	2.6	8.0	2.06
3070	Unk	08/13/2020	46.6	9.8	2.01	2.5	2.4	6.7	1.93
3071	Unk	08/13/2020	45.6	9.2	2.18	2.4	2.4	6.5	1.90
3072	80	08/13/2020	41.3	9.0	2.14	2.3	2.3	5.9	1.89
3073	70	08/13/2020	73.1	14	1.94	4.3	2.5	7.4	1.67
3074	Unk	08/13/2020	28.6	9.0	18.1	2.5	1.7	8.9	1.56
3075	Unk	08/06/2020	29.7	7.6	4.32	1.9	1.2	4.1	1.46
3076	285	08/06/2020	41.3	8.4	0.724	2.9	1.5	3.8	1.57
3077	122	08/06/2020	47.7	11	3.29	3.0	1.9	5.0	2.13
3078	Unk	08/06/2020	55.1	13	2.86	3.5	2.2	5.9	1.68
3079	Unk	08/06/2020	49.8	11	3.25	3.0	2.1	6.2	1.70
3080	Unk	08/06/2020	47.7	10	2.21	2.6	2.2	6.4	1.73
3081	125	08/06/2020	64.7	14	3.11	4.2	2.2	6.4	1.47
3082	65	08/06/2020	37.1	8.2	0.945	2.4	1.2	3.0	1.27
3083	119	08/13/2020	39.2	8.9	6.57	2.4	1.6	6.8	1.62
3084	290	08/06/2020	31.8	7.9	1.11	1.8	1.1	3.3	1.37

3085	140	08/06/2020	37.1	8.6	0.834	2.4	1.2	3.1	1.28
3086	150	08/06/2020	37.1	8.3	1.43	2.4	1.1	3.0	1.20
3087	143	08/06/2020	38.2	9.0	3.40	2.7	1.3	3.5	1.19
3088	145	08/06/2020	41.3	9.8	1.26	3.0	1.5	2.5	1.20
3089	207	08/06/2020	41.3	9.7	1.24	3.0	1.5	2.6	1.17
3090	106	08/06/2020	39.2	13	17.3	3.8	1.8	7.3	2.41
ISW-01	—	08/06/2020	109	24	1.31	9.7	1.4	2.9	3.31
ISW-02	—	08/06/2020	37.1	5.2	2.73	0.78	2.8	13	2.29
ISW-03	—	08/06/2020	31.8	4.4	2.07	0.66	2.8	11	2.02
ISW-04	—	08/06/2020	63.6	12	2.10	4.0	2.3	8.8	2.59
ISW-05	—	08/13/2020	46.6	4.8	3.45	0.74	3.4	18	2.82

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established; Unk = Unknown. Well log not found; (-) = Not analyzed or not applicable.

[A] Contaminant with a National Secondary Drinking Water Regulation standard.

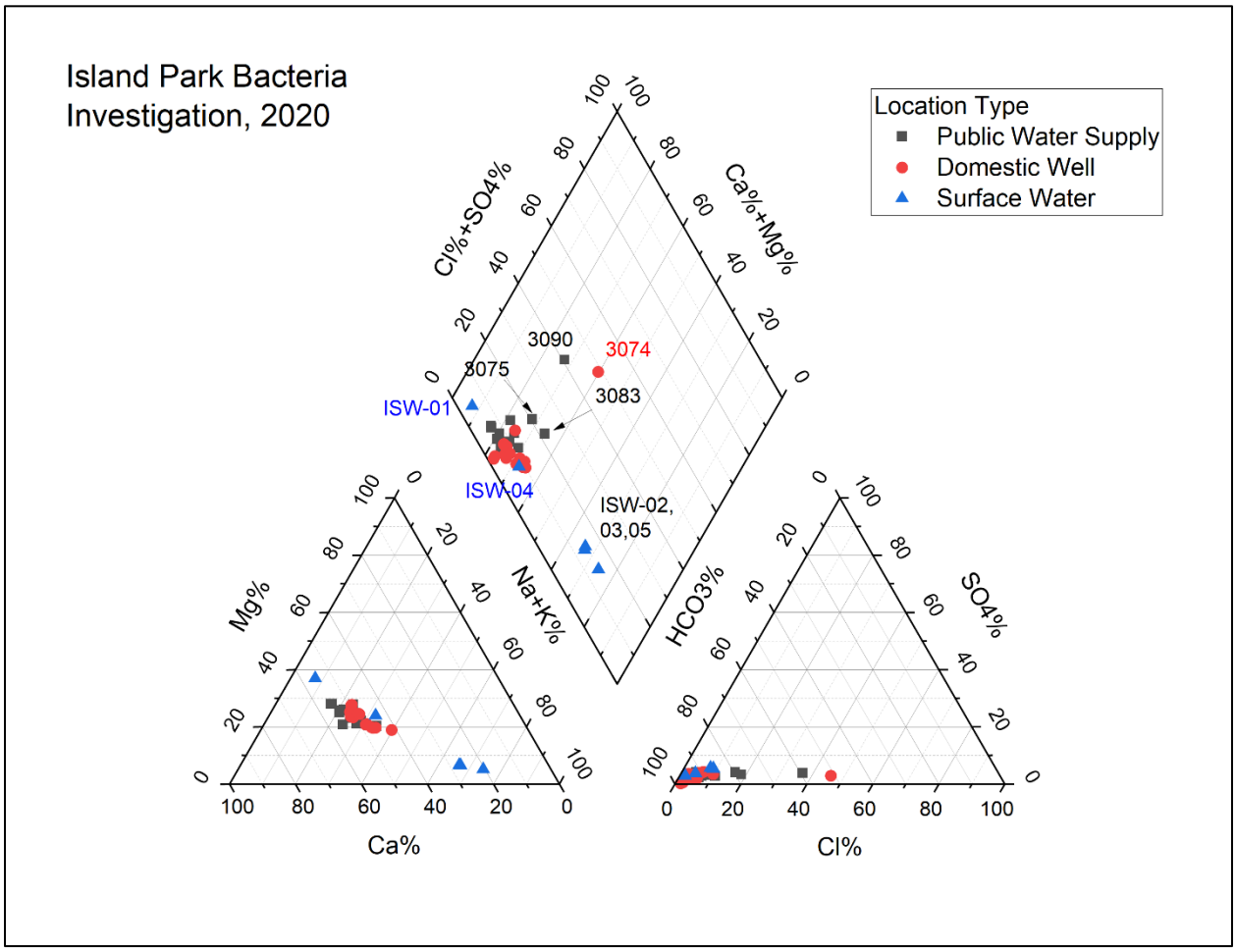


Figure 17. Piper diagram with 2020 common ion data—Island Park Bacteria Investigation Groundwater Monitoring Project

Stable Isotope Results

Stable isotope results can aid in understanding the possible ongoing thermodynamic or biochemical processes within the system. Results for stable isotope analyses are presented in Table 24. Isotopes of oxygen and hydrogen in water ($\delta^{18}O_{water}$, $\delta^{2}H_{water}$) aid in understanding the timing of precipitation and factors impacting the "history" of the water. Results are compared to the Global Meteoric Water Line (GMWL) and to a Local Meteoric Water Line (LMWL) based on precipitation and snow samples from the Upper Snake River basin (Cecil and other, 2005) (Figure 18). Isotopic ratios vary due to factors including the temperature during precipitation and the potential for evaporation. Summer precipitation tends to plot less negatively on the graphic (to the upper right), winter precipitation tends to plot more negatively, and the average annual precipitation tends to plot as an average of the two. Meteoric Water Lines tend to have a slope of about 8. Water that is partially evaporated when applied as irrigation water will plot less-negative and have a lower slope than a meteoric water line. Most sampled sites reflect an $\delta^{18}O_{water}$, $\delta^{2}H_{water}$ result characteristic of average annual precipitation. Specific sites 3064, 3065 plot more depleted for both $\delta^{18}O_{water}$ and $\delta^{2}H_{water}$, reflecting recharge dominated by winter-precipitation/snowmelt,

two sites – 3074, 3090 reflect less depleted, summer precipitation, and two sites, 3066, 3089, fall more closely to the characteristic trend reflecting evaporation. Surface water site ISW-01 is located on Henry's Lake Outlet, up-stream from the Mack's Inn-area and likely up-gradient from the study area. ISW-04 also reflects more of a summer-precipitation signature.

Table 24. Stable isotope results—Island Park Bacteria Investigation Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	δ^2H_{Water}	$\delta^{18}O_{Water}$
			(‰)	
Water Quality Standard:			No Standard	No Standard
3060	Unk	08/06/2020	-137.5	-18.1
3061	Unk	08/13/2020	-136.6	-18.2
3062	Unk	08/13/2020	-137.2	-18.3
3063	Unk	08/13/2020	-133.4	-17.7
3064	Unk	08/13/2020	-141.9	-18.5
3065	83	08/13/2020	-140.4	18.3
3066	Unk	08/13/2020	135.2	-17.0
3067	Unk	08/13/2020	-133.7	-17.8
3068	160	08/13/2020	-136.5	-17.9
3069	Unk	08/13/2020	-135.3	-18.3
3070	Unk	08/13/2020	-134.7	-18.1
3071	Unk	08/13/2020	-133.4	-18.1
3072	80	08/13/2020	-133.5	-17.8
3073	70	08/13/2020	-136.7	-18.3
3074	Unk	08/13/2020	-131.4	-17.3
3075	Unk	08/06/2020	-134.7	-17.8
3076	285	08/06/2020	-137.6	-18.4
3077	122	08/06/2020	-134.9	-17.9
3078	Unk	08/06/2020	-135.1	-18.0
3079	Unk	08/06/2020	-133.4	-18.0
3080	Unk	08/06/2020	-133.9	-17.9
3081	125	08/06/2020	-135.8	-18.1
3082	65	08/06/2020	-133.4	-18.1
3083	119	08/13/2020	-135.7	-17.7
3084	290	08/06/2020	-133.4	-18.4
3085	140	08/06/2020	-133.6	-18.3
3086	150	08/06/2020	-132.2	-18.3
3087	143	08/06/2020	-131.3	-17.9
3088	145	08/06/2020	-133.0	-17.8
3089	207	08/06/2020	-134.8	-17.8
3090	106	08/06/2020	-129.7	-17.5
ISW-01	—	08/06/2020	-120.6	-15.6
ISW-02	—	08/06/2020	-134.6	-18.5
ISW-03	—	08/06/2020	-133.5	-18.5

ISW-04	—	08/06/2020	-130.1	-17.4
ISW-05	—	08/13/2020	-135.3	-17.8

Notes: ft bgs = feet below ground surface; ‰ = permil; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established; Unk = Unknown. Well log not found; (-) = Not analyzed or not applicable.

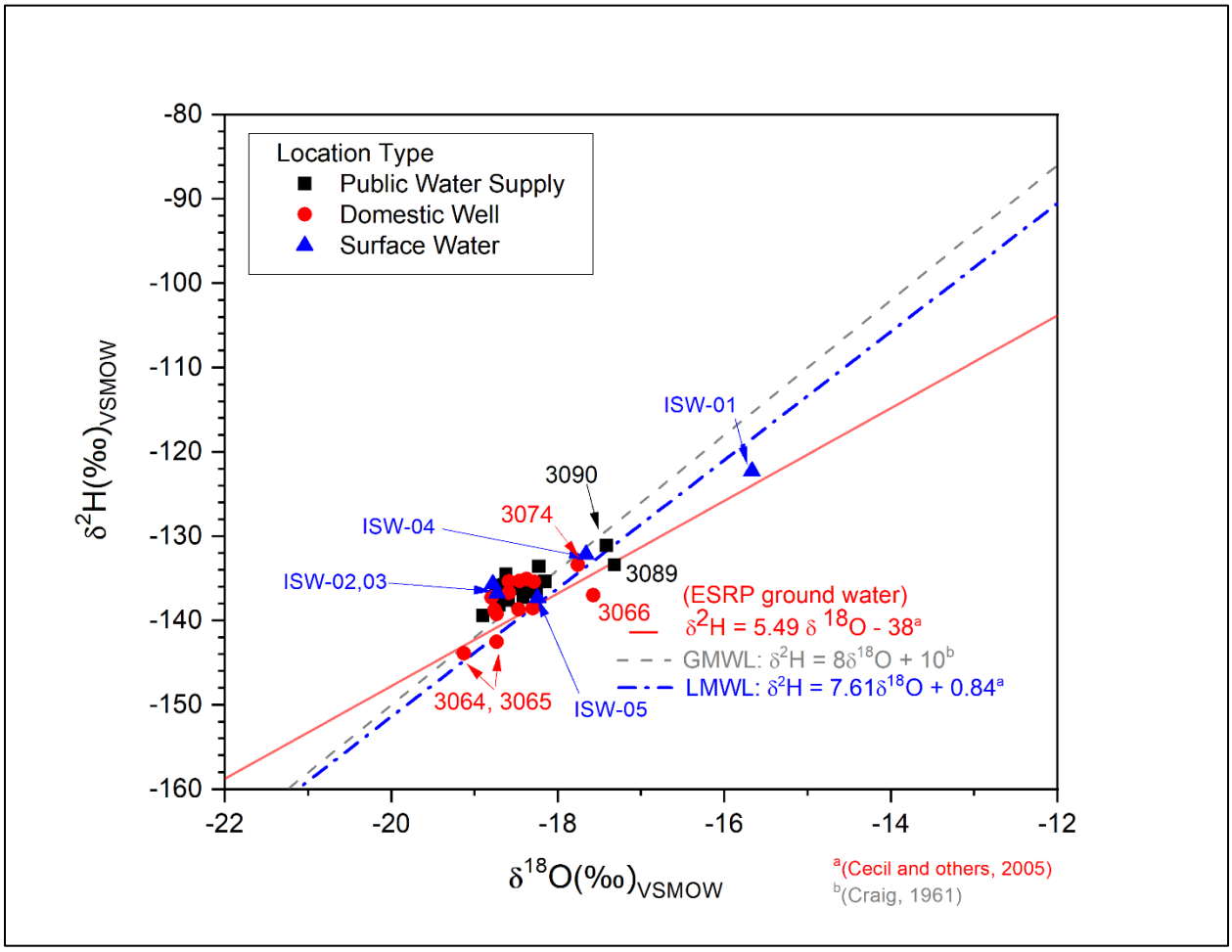


Figure 18. Stable isotope plot of δ^2H_{water} versus $\delta^{18}O_{water}$—Island Park Bacteria Investigation Groundwater Monitoring Project.

2.1.4.3 Conclusions

The objectives of this regional monitoring study were to investigate the increase in bacteria detections near Mack's Inn and Island Park Village area in PWS wells to determine potential sources of contamination and the extent of the impact. The goal of this summary was to present the activities and results from the 2020 round of sampling. Additional data was collected in 2021 and a full summary was provided to the community in the form of an *ArcGIS Story Map*. (https://storymaps.arcgis.com/stories/6897a2392cea45f49e9272a44da7f51)

Total coliform (TC) bacteria detections for both PWS wells and DWs were relatively widespread for the 2020 sampling period, with 17 of 31 groundwater sites (10 PWS and 7 DW) with a positive detection of TC; 5 of these sites (3 PWS and 2 DW) also had *E. coli* detections. As expected, surface water sites were positive for both TC and *E. coli* and had higher concentrations than groundwater sites. Seasonality for bacteria detections will be assessed when the 2021 (spring) sampling data are presented in the 2021 annual report. A complete summary of 2020 and 2021 sampling results is available on the Island Park Story Map (referenced above).

An interim conclusion from nitrate and ammonium sampling is that evaluating nitrogen input from atmospheric sources and from the Mack's Inn/Island Park treated wastewater land application site may aid in discerning possible waste-related nitrate impacts to groundwater.

Review of common ion chemistry presented as a Piper diagram illustrates that most groundwater sites plot between surface water sites ISW-01 and ISW-04, suggesting a combination of the representative chemistry from ISW-01 and most groundwater sites reflects the common ion chemistry represented by ISW-04. Also apparent is the chemistry represented by the remaining surface water sites (ISW-02,03,05) is distinct. Sites 3090. 3074, 3083 and 3075, reflect a water source with a proportionally greater chloride composition, and a general mixing of that ISW-01-type water and this proportionally greater chloride-type water can largely explain the variation in groundwater chemistry. Additionally, these distinct sites also returned bacteria detections, and one of these sites also returned a nitrate result distinct from other sites.

Review of results for stable isotopes of oxygen and hydrogen in water ($\delta^{18}O_{water}$, $\delta^{2}H_{water}$) identified sites 3090 and 3074 with a less-depleted, more summer precipitation-like signature distinct from most groundwater sites. Surface water sites ISW-01 and 04 also plot distinct, with that summer-like signature. This combination by itself, considering the spatial relationship of the sites, does not support a conclusion that surface water from these sites have a strong influence on groundwater. Two sites, 3064 and 3065 plot in a region that would support a conclusion that groundwater for those sites is significantly influenced by winter snow melt, and thus melting winter snows are likely a factor in driving existing bacteria sources through the soil profile to groundwater for some areas. Surface water from Henry's Lake outlet and the Henry's Fork in the Mack's Inn area is less likely to be a significant influence on bacteria occurrence.

Impacted sites more frequently included older wells completed to older and less-stringent construction standards.

2.1.4.4 Recommendations

Based on the outcome of this investigation, DEQ recommends PWS operators contact DEQ Idaho Falls Region Source Water Protection staff to discuss source water protection for their systems. They are also encouraged to reach out to their regional Drinking Water Compliance staff if they have reoccurring bacteria detections. Options may include drilling a new well that seals out shallow (surface) sources of contamination or modifying an existing seal; consolidating with another PWS with the added benefit of sharing the infrastructure costs; or installing necessary treatment to provide safe and reliable drinking water to its consumers.

Private DW owners impacted by the bacteria contamination (as well as others with concerns) are encouraged to contact DEQ, EIPHD, or Idaho Department of Water Resources staff to learn more about options to provide safe drinking water to their homes. Options include onsite treatment, new well construction or well modification, or connection to a public water system. Private well owners are encouraged to test their well water regularly—DEQ and EIPHD have recommendations for the list of constituents and frequency of sampling as well as a list of certified laboratories for sample analysis. Monitoring tutorial videos have been created by Idaho Department of Health and Welfare staff and are available on their website along with health information for select contaminants commonly detected in groundwater. Well owners with a septic system are also strongly encouraged to have their system professionally serviced every 3-5 years (or more frequently, depending on level of use).

City and county officials are encouraged to investigate potential contamination sources (leaks in sewer collection lines), identify active septic systems, and work with the property owners to connect to the central wastewater system. Additionally, development and enforcement of ordinances to protect groundwater quality is encouraged. Such ordinances could require new construction and development to connect to the nearest public water system and central wastewater system and increase the required bacteria sampling frequency from private wells serving known rentals.

2.2 Coeur d'Alene Region

One groundwater quality project was conducted using public funds in the Coeur d'Alene region in 2020.

2.2.1 Cocolalla Lake Groundwater Monitoring Project

2.2.1.1 Purpose and Background

DEQ Coeur d'Alene Regional Office (CRO) groundwater staff led an investigative effort to determine the extent of naturally occurring high levels of uranium and/or radionuclides in the vicinity of the Arrowhead Ranch Water Association, Inc. (Arrowhead Ranch) PWS (Figure 19). This was a result of consistent sampling of radionuclides at the Arrowhead Ranch that indicated levels of uranium in drinking water above the EPA MCL of 30 µg/L. This is a brief overview of the project. Further detailed information on this project will be available in a "Cocolalla Area Uranium Groundwater Investigation technical report currently in preparation.

Arrowhead Ranch water system is located in an unincorporated community in Northern Idaho known as Cocolalla, approximately 12 miles north of Athol along the southwest shore of Cocolalla Lake in the southern end of Bonner County (Figure 19). Arrowhead Ranch became a regulated PWS in April 2019 and began initial compliance sampling in the summer of 2019. All the sampled constituents were below regulatory standards with the exception of uranium. The initial sampling event conducted by the water system operator in July 2019 resulted in a total uranium concentration of 165 µg/L, which is 5.5 times above the EPA designated MCL of 30 µg/l. A subsequent sampling event in August 2019 confirmed the result.

Uranium detected in the area wells can be from naturally-occurring geochemical conditions of the subsurface coupled with the mineralogy of the granitic bedrock aquifer on the west side of Cocolalla Lake. In addition, there have been several historic uranium mining claims (not formally investigated) in the area which may have resulted in the granitic bedrock containing levels of uranium above what occurs naturally in the area. DEQ investigated whether pumping of Arrowhead Ranch's well was creating specific chemical conditions (e.g. introduction of oxygen) necessary for the dissolution of uranium in groundwater. As such, private bedrock wells determined to likely be screened in the same fractures as the PWS well were sampled for uranium and secondary constituents that can be correlated with uranium dissolution (i.e., alkalinity, pH, dissolved oxygen (DO), specific conductance, and oxidation reduction).

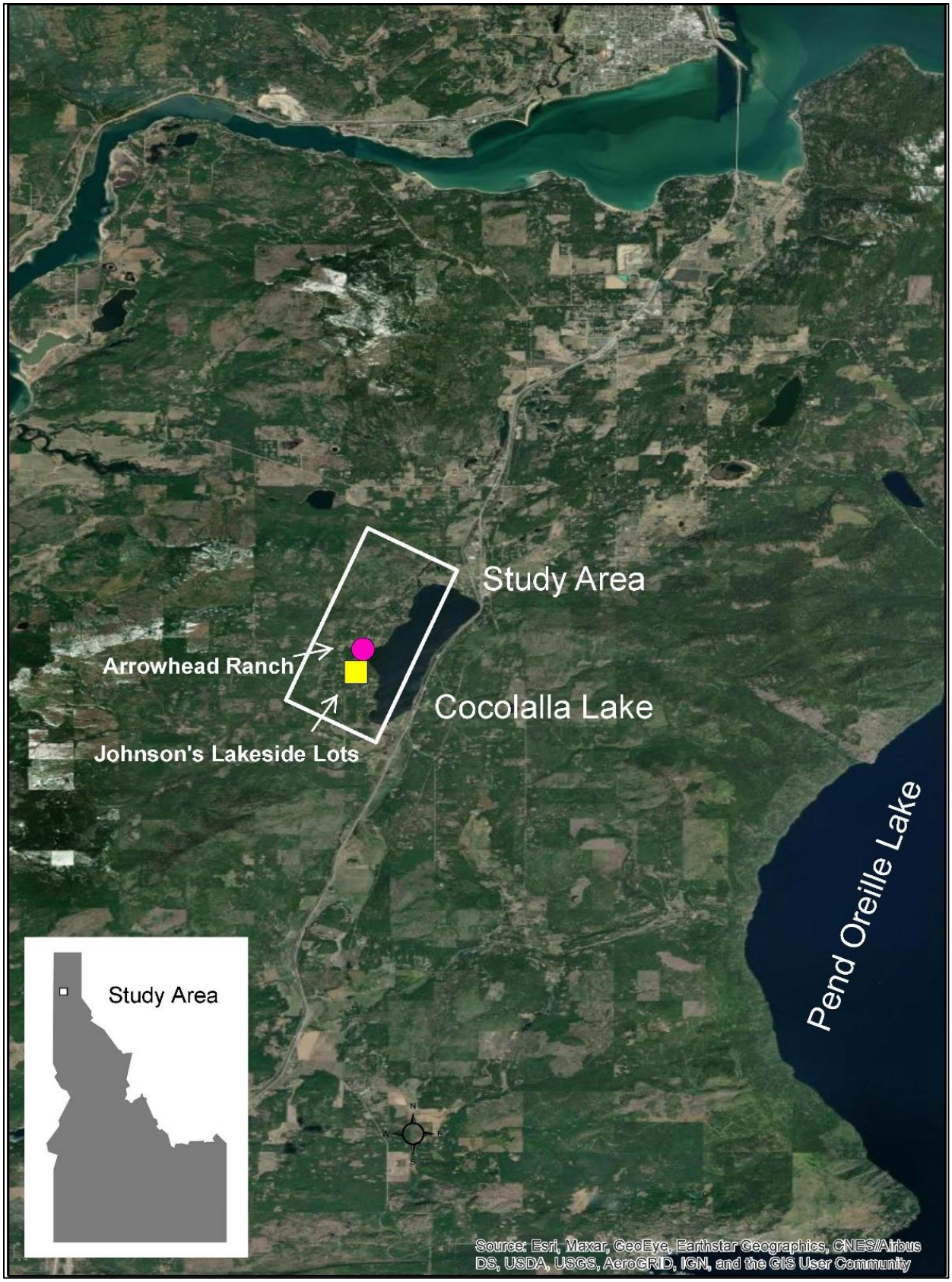


Figure 19. Project Study Area—Cocolalla Uranium Groundwater Monitoring Project.

2.2.1.2 Methods and Results

CRO staff collected samples from five private wells on two separate days in March 2020. Samples were intended to be representative of groundwater and collected prior to any storage or filtration. If a water sample could not be obtained prior to treatment, the type of treatment was documented, the system was flushed, and a water sample was obtained after the physical parameters had stabilized. The locations were chosen in an effort to best delineate the extent of the high uranium content in area groundwater while ultimately being determined by permissions acquired to sample private wells.

In addition to the five locations that were sampled by DEQ some well owners opted to do their own sample collection. In these instances, inquiry into their data sample collection methods were examined and verified.

Field duplicates and equipment/field blanks were taken and submitted to the lab blind to satisfy QA/QC standards. All samples were submitted to SVL Analytical in Kellogg, ID.

Temperature, pH, dissolved oxygen, specific conductance, and oxidation reduction potential were taken using a YSI Pro plus water quality meter using a flow cell prior to sample collection.

Table 25. Water quality field parameters—Cocolalla Uranium Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Water Temperature (°C)	Specific Conductance (µS/cm)	pH[A]	Dissolved Oxygen (mg/L)
Water Quality Standard:			No Standard	No Standard	**6.5-8.5**	No Standard
3156	445	03/13/2020	4.8	200.4	7.81	12.2
3158	Unk	03/04/2020	8.4	152.9	*6.46*	10.6
3161	300	03/04/2020	8.7	123.7	6.69	6.0
3162	Unk	03/04/2020	10.1	103.6	5.64	9.7
3168	460	03/13/2020	9.2	168.2	6.89	6.2

Notes: ft bgs = feet below ground surface; °C = degrees Celsius; µS/cm = microsiemens/centimeter; pH = standard pH units; mg/L = milligrams per liter; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established; Unk = Unknown. Well log not found. Shaded and italicized numbers indicate a violation of a National Secondary Drinking Water Regulation (NSDWR) standard.
[A] Contaminant with a National Secondary Drinking Water Regulation standard (NSDWR). The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

General Groundwater Chemistry Results

Groundwater samples were submitted to SVL Analytical and analyzed for alkalinity, bicarbonate, ORP, and uranium to assess the water quality in the project area.

Of the five wells sampled by DEQ that included secondary constituents, the alkalinity results ranged from 26 mg/L to 122 mg/L; the pH results ranged from 6.2-8.1; and the dissolved oxygen results ranged from 4.7-10.2 mg/L (Table 25, Table 26).

Table 26. Common ion and total dissolved solids results—Cocolalla Uranium Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Alkalinity as (CaCO3)	Bicarbonate	Oxidation reduction potential (ORP)
			(mg/L)		(mV)
Water Quality Standard:			No Standard	No Standard	No Standard
3156	445	03/13/2020	111	111	264.2
3158	Unk	03/04/2020	51.9	51.9	210.9
3161	300	03/04/2020	60.7	60.7	180.8
3162	Unk	03/04/2020	26.2	26.2	284.1
3168	460	03/13/2020	84.4	84.4	265.1

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; mV = millivolts; Unk = Unknown. Well log not found; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established.

Radionuclide Results

A total of 17 uranium results were reported. Of those, five locations had their sampling carried out by DEQ (Table 27). For those volunteers who sampled their wells themselves, they were contacted by CRO staff to validate their method of sample collection to assure that they adhered to the laboratory protocol for sample collection. This report is designed to document data collected by DEQ so only DEQ results are stored in the DEQ groundwater quality database and provided in tabular format. Additional field parameter and common ion data were collected during sampling conducted by DEQ. Results of samples collected by well owners are provided in the figures when available.

Of the 17 wells sampled, 7 wells had uranium concentrations above the MCL of 30 ug/L. An additional four locations were also above 5 ug/L. The remaining 6 wells reported concentrations of uranium below 5 ug/L or non-detect (Figure 20).

Table 27. Radionuclide results—Cocolalla Uranium Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Uranium[A] (µg/L)
Water Quality Standard:			**30**
3156	445	03/13/2020	4.27
3158	Unk	03/04/2020	<1.00
3161	300	03/04/2020	6.25
3162	Unk	03/04/2020	4.14
3168	460	03/13/2020	7.87

Notes: ft bgs = feet below ground surface. µg/L = micrograms per liter; Unk = Unknown. Well log not found.

[A] Contaminant with a National Primary Drinking Water Regulation standard.

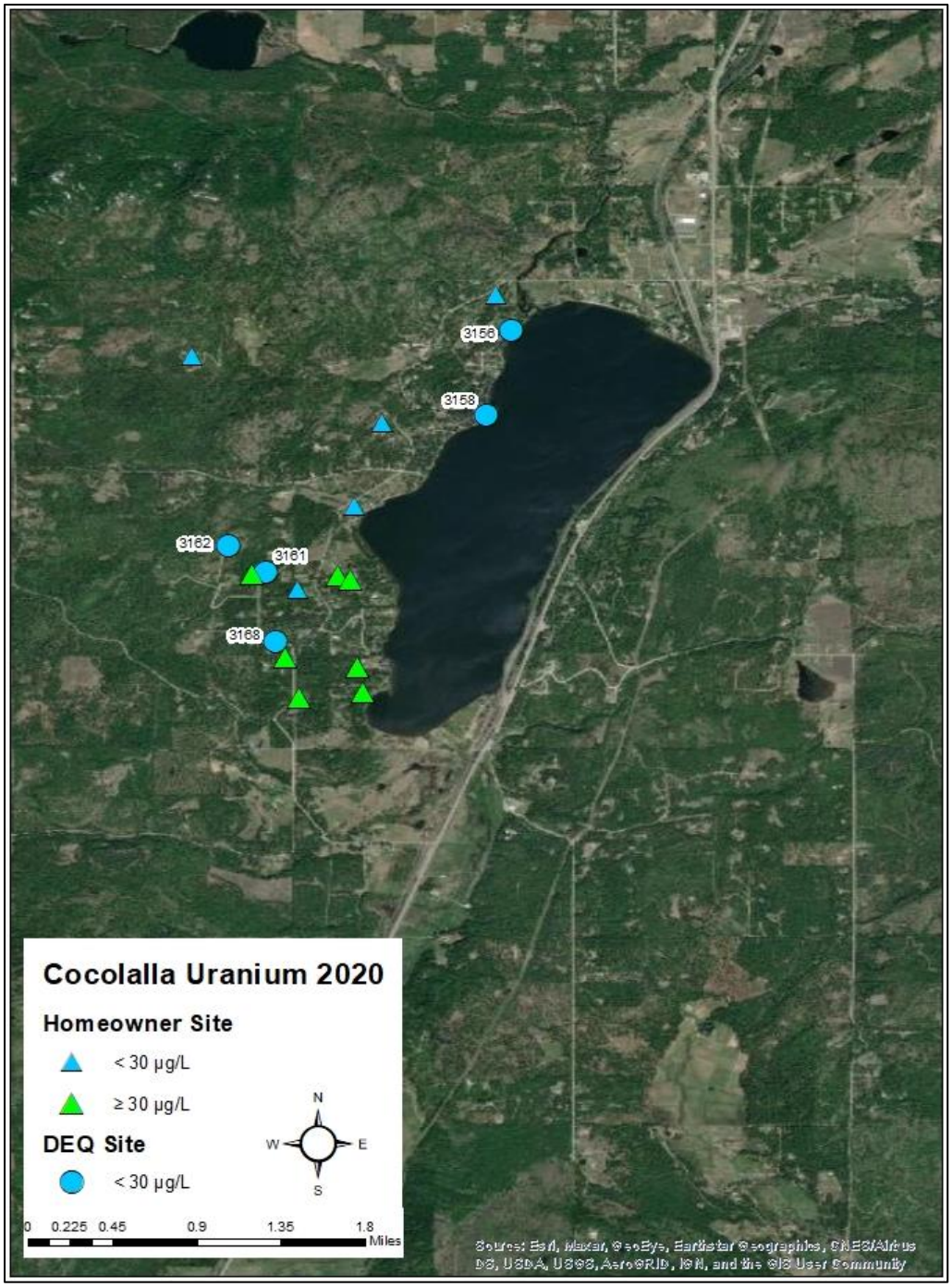


Figure 20. Sample locations and uranium results—Cocolalla Uranium Groundwater Monitoring Project.

2.2.1.3 Conclusions

Those wells that are screened deeper than and elevation of 1,950 ft above sea level (asl) consistently had low uranium concentrations and, where available, accompanying secondary-constituent chemistry that did not coincide with uranium dissolution.

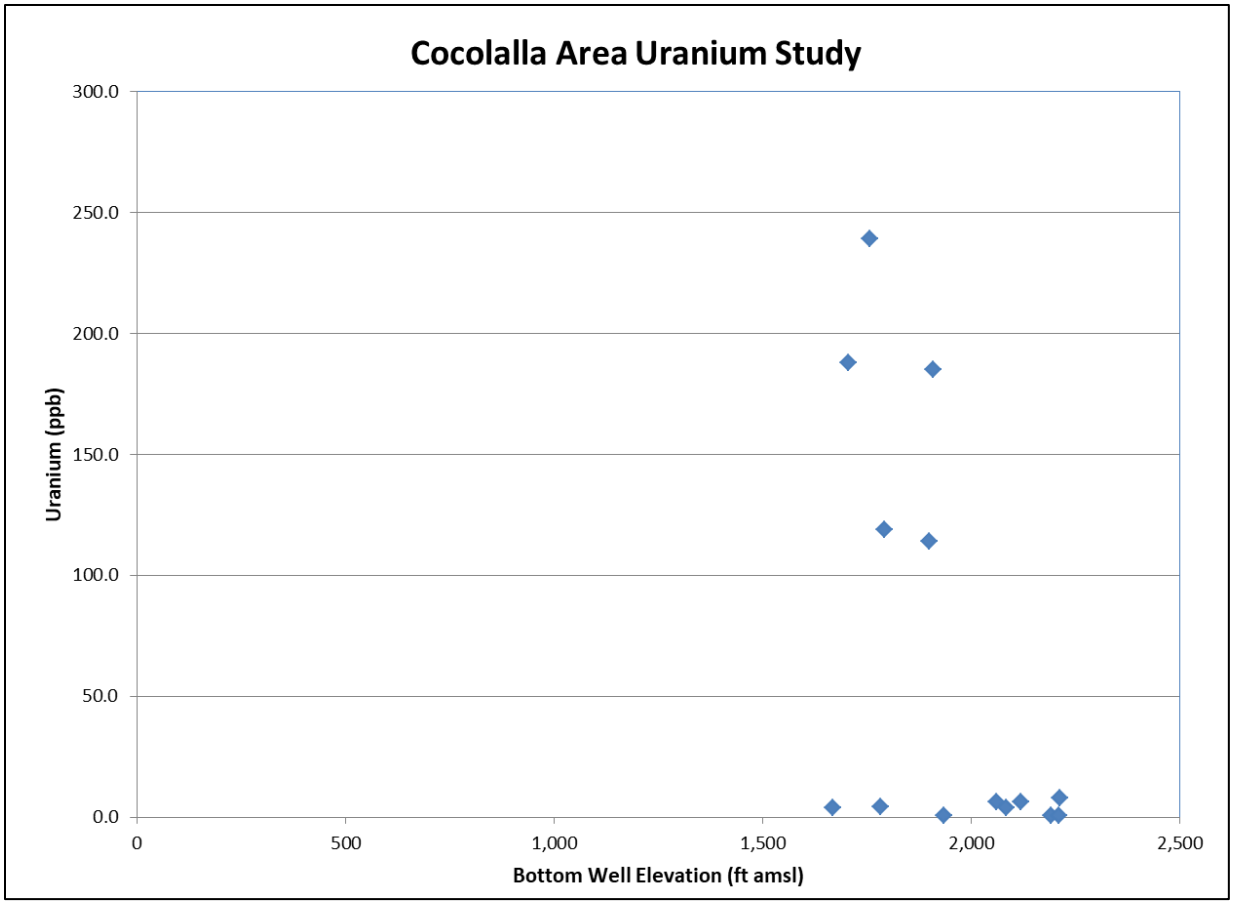


Figure 21. Well depth vs. Uranium concentration—Cocolalla Uranium Groundwater Monitoring Project.

With the current project data resolution, it is unlikely a more precise elevation range can be determined at which the fracture system promotes uranium dissolution. It can only be said that the elevation ceiling for the high uranium concentrations in groundwater is about 1,950 ft asl and the floor is currently unknown (Figure 21).

The Arrowhead Ranch pumping activities are likely not inducing or exacerbating the rate of uranium dissolution. Private well residences that were far outside the cone of influence of the Arrowhead Ranch well with much lower pumping rates and water usage recorded uranium levels, in several instances, that exceeded the Arrowhead Ranch uranium concentrations. This suggests that the local area's uranium results are naturally occurring and not anthropogenic. The areal extent of high uranium concentration was not found to extend east of the lake, or north of Johnson's Lakeside Lots. However, the westerly and southerly extent has not been clearly defined. Most importantly, the ceiling depth of the uranium fracture system is likely between 1,915 ft asl and 1,950 ft asl.

As for the positive correlation between secondary constituents of alkalinity/pH and uranium concentration, not enough data was obtained. In general, uranium dissolution occurs in environments with higher pH (>7.1), alkalinity (150 mg/L or >), and DO. As none of the wells sampled for secondary constituents had coincided with a uranium MCL exceedance, no certain correlation could be accurately determined. Further sampling of wells with uranium MCL

exceedances would need to be carried out to affirm or deny any correlation between alkalinity/pH and uranium MCL exceedances.

2.2.1.4 Recommendations

The DEQ CRO groundwater staff recommends that further messaging be distributed encouraging relevant Cocolalla residents to sample their wells where possible, particularly to those residents south of Steep Lane where the extent was not delineated in this project. The occurrence of high uranium levels in the area presents the possibility of other associated constituents like arsenic and the related radionuclides gross alpha and radium 226 and 228 being present in groundwater in the affected areas. However, compliance monitoring at the Arrowhead Ranch PWS for those inorganic and radiological chemicals do not indicate high levels, other than uranium.

2.3 Lewiston Region

Three groundwater quality monitoring projects were conducted in the Lewiston region in 2020 using public funds.

2.3.1 Lindsay Creek Nitrate Priority Area Groundwater Monitoring Project

This section summarizes the 2020 sampling results from an ongoing groundwater quality evaluation of nitrate concentrations in the Lindsay Creek NPA near Lewiston, Idaho.

2.3.1.1 Purpose and Background

The goal of the Lindsay Creek NPA Groundwater Monitoring Project (previously referred to as the Tammany and Lindsay Creeks Groundwater Monitoring Project) is to create an ambient groundwater quality monitoring network to complete a multi-year trend analysis that detects nitrate changes in groundwater in the Lindsay Creek NPA and extend groundwater quality monitoring to include the aquifer within the Tammany Creek watershed.

The project area is located east and southeast of Lewiston, Idaho (Figure 22). The land use is primarily agricultural, specifically dry-land farming. Rangeland and grazing are also common in the area. Groundwater in the area is most commonly found in the basalt and occasionally in the alluvial valley sediments and basement rocks. Well depths from groundwater sampling locations ranged from 150 feet to 1,025 feet bgs.

Tammany Creek is located on the south side of the project area and the watershed has similar spring-fed nutrient load characteristics as the Lindsay Creek watershed on the north side of Lewiston. The groundwater in this watershed may also be a potential source of excess nutrients to Tammany Creek. Tammany Creek is currently impaired by nutrients and has an approved nutrient total maximum daily load (DEQ 2010).

DEQ collected groundwater quality data from 14 wells and/or springs as part of an ambient groundwater quality monitoring network from 2010 to 2016. Nitrate concentrations from these

samples were analyzed to determine if seasonal or spatial trends exist in the monitoring network in addition to monitoring long-term regional changes. Anomalous nitrate concentrations were addressed as isolated or localized situations and dropped from the ambient network.

2.3.1.2 Methods and Results

In November of 2020, DEQ sampled 11 sites (10 wells and 1 spring) as part of the Lindsay Creek NPA project. Site selection was conducted with an emphasis on historically-sampled wells, well logs, homeowner permission, and spatial distribution across the project area to achieve a representative distribution.

Samples were collected for nitrate (nitrate-nitrite nitrogen) and bacteria (TC and *E. coli*) in accordance with the QAPP (DEQ 2019a) and the FSP (DEQ 2020). All samples were submitted for analysis to Anatek Labs, Moscow, Idaho. EPA method 300.0 was used for all nitrate sample analysis.

Water quality field parameters (e.g., pH, temperature, specific conductance, DO) were measured before sample collection to ensure adequate purging of the well for a representative sample of the local aquifer. Field parameter data for sampling efforts is presented in Table 28.

Table 28. Water quality field parameters—Lindsay Creek Nitrate Priority Area Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Water Temperature (°C)	Specific Conductance (µS/cm)	pH[A]	Dissolved Oxygen (mg/L)
Water Quality Standard:			No Standard	No Standard	6.5-8.5	No Standard
533	225	11/05/2020	13.6	1097	8.04	10.35
699	285	11/04/2020	18.8	362	8.04	2.80
1037	Unk	11/04/2020	16.2	249	8.44	5.30
1038	150	11/03/2020	12.8	1347	7.91	10.21
1217	264	11/04/2020	17.0	557	8.30	0.10
1223	20	11/03/2020	17.1	585	8.24	0.07
1225	16	11/03/2020	14.8	920	7.16	7.62
1315	589	11/05/2020	11.0	630	8.09	9.78
2022	950	11/04/2020	14.6	262	*8.99*	5.97
2650	380	11/03/2020	17.9	378	8.02	5.87
2880	Spring	11/03/2020	13.6	1112	7.18	8.96

Notes: ft bgs = feet below ground surface; °C = degrees Celsius; µS/cm = microsiemens/centimeter; pH = standard pH units; mg/L = milligrams per liter; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established; Unk = Unknown. Well log not found; Shaded and italicized = Exceeds a National Secondary Drinking Water Regulation standard.

[A] Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Nitrate Results

Nitrate results are presented in Table 29 and shown in Figure 22. Of the 11 sites (10 wells and 1 spring) sampled, three (27%) exceeded the MCL of 10 mg/L and 2 (18%) were between 5 mg/L

and 10 mg/L. All sites had been sampled at least once historically. The median nitrate results for the detected values in 2020 is 10.6 mg/L. The mean nitrate concentration 10.27 mg/L in 2020.

Table 29. Nutrient and nutrient-related isotope results—Lindsay Creek Nitrate Priority Area Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Nutrient Concentration
			Nitrate + Nitrite[A]
			mg/L
Water Quality Standard:			**10**
533	225	11/05/2020	**10.8**
699	285	11/04/2020	<0.100
1037	Unk	11/04/2020	<0.100
1038	150	11/03/2020	**10.6**
1223	20	11/03/2020	<0.1
1225	16	11/03/2020	6.36
1315	589	11/05/2020	**14.1**
2022	950	11/04/2020	<0.100
2650	380	11/03/2020	<0.100
2880	Spring	11/03/2020	9.48

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; Unk=Unknown. Well log not found; Shaded and bold = Exceeds a National Primary Drinking Water Regulation standard.

[A] Contaminant with a National Primary Drinking Water Regulation standard.

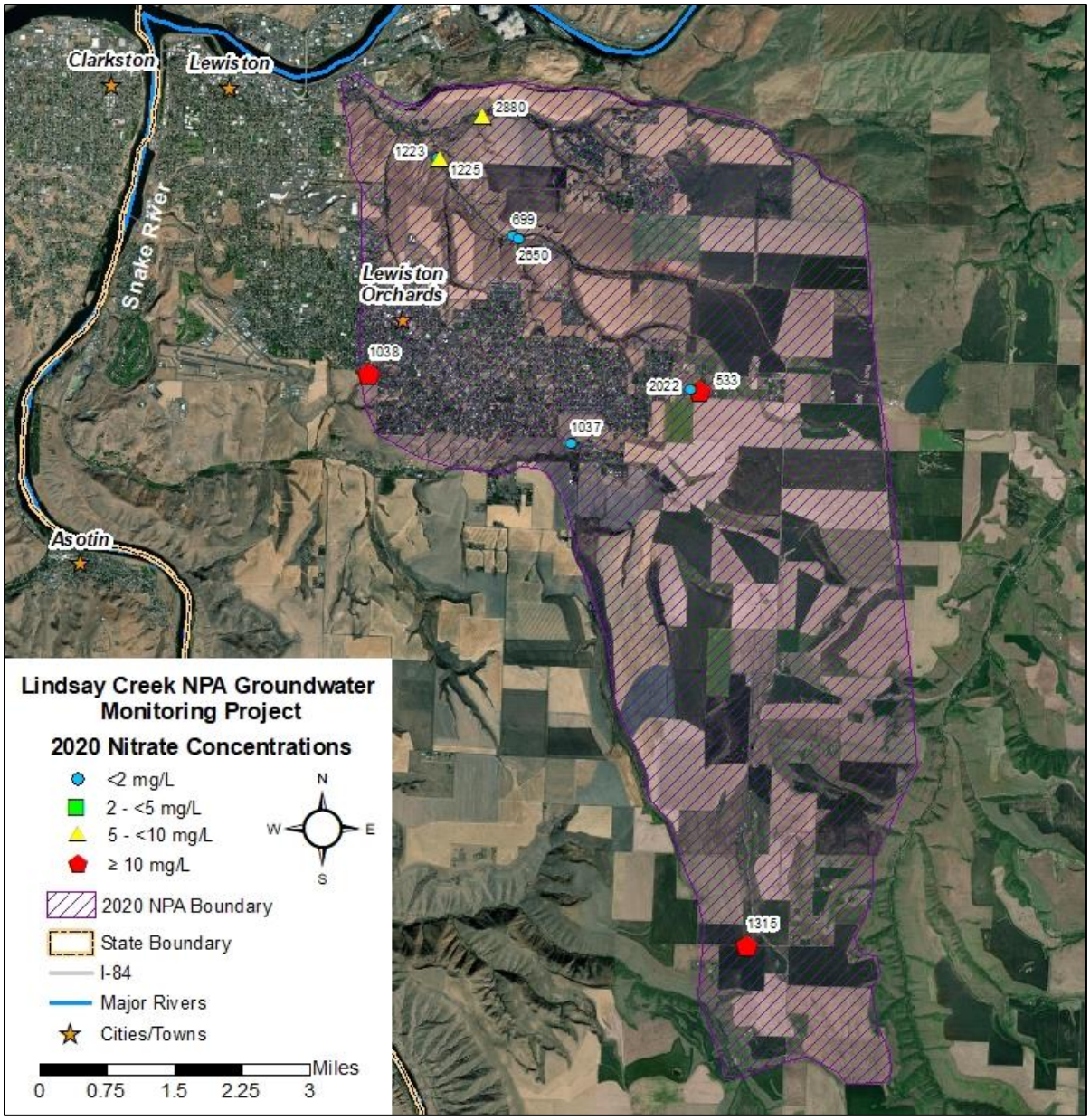


Figure 22. Nitrate results and site locations—Lindsay Creek Nitrate Priority Area Groundwater Monitoring Project.

Bacteria Results

Bacteria results from the October sampling effort are represented in Table 30. Of the 11 sites sampled, three (27%) had positive detections of TC bacteria. Due to a lab error, several sites (2880, 1225, 1223, 2650, 1038) were processed for presence/absence instead of bacteria counts. Concentrations of the remaining sites ranged from less than 1 to 12.2 MPN/100 mL. *E. coli* was not detected at any of the sites.

Table 30. Bacteria Results—Lindsay Creek Nitrate Priority Area Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Bacteria Concentrations[A]

			E. coli	Total Coliform
			MPN/100 mL	
Water Quality Standard:			**<1**	**1.0**
533	225	11/05/2020	<1	<1
699	285	11/04/2020	<1	4.1
1037	Unk	11/04/2020	<1	12.2
1038	150	11/03/2020	<1	<1
1217	264	11/04/2020	<1	<1
1223	20	11/03/2020	<1	>1
1225	16	11/03/2020	<1	>1
1315	589	11/05/2020	<1	12.2
2022	950	11/04/2020	<1	<1
2650	380	11/03/2020	<1	>1
2880	Spring	11/03/2020	<1	>1

Notes: ft bgs = feet below ground surface; MPN/100 mL = most probable number per 100 milliliters; Unk = Unknown. Well log not found.

[A] Total coliform and *E. coli* standards are from the Idaho Groundwater Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary groundwater quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

General Groundwater Chemistry Results

Based on budget and availability of historical data, select project wells were sampled for the following common ions to evaluate the general groundwater chemistry: fluoride, bicarbonate, calcium, chloride, magnesium, potassium, sodium, and sulfate. Samples were also analyzed for alkalinity (as CaCO3) and bicarbonate. All samples were submitted for analysis to Anatek Labs, Moscow, Idaho. All sample results were below any set primary or secondary drinking water standard and are presented in Table 31. A Piper diagram was prepared to identify variation in water quality and ion composition of samples (Figure 23). Water chemistry for the deepest well, Well 2022, plotted as mixed, sodium carbonate type. Well 1037 plots on the cusp of mixed and sodium bicarbonate types and 2650 is plotted as mixed, sodium bicarbonate type. Site 2880 plots as magnesium bicarbonate type. Because it's a spring, mixing of ground water and precipitation and/or surface water infiltration is likely.

Table 31. Common ion and total dissolved solids results—Lindsay Creek Nitrate Priority Area Groundwater Monitoring Project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Bicarbonate	Calcium	Chloride[A]	Fluoride[AB]	Magnesium	Potassium	Sodium	Sulfate[A]
			(mg/L)							
Water Quality Standard:			No Standard	No Standard	**250**	**2.0/4**	No Standard	No Standard	No Standard	**250**
533	225	11/05/2020	232	-	-	-	-	-	-	-
699	285	11/04/2020	112	-	-	-	-	-	-	-
1037	Unk	11/04/2020	116	15.3	<.05	0.540	3.43	10.4	31.0	11.4
1038	150	11/03/2020	500	-	-	-	-	-	-	-
1217	264	11/04/2020	160	-	-	-	-	-	-	-
2022	950	11/04/2020	88.0	5.32	<0.05	1.10	0.535	3.68	53.6	27.6
2650	380	11/03/2020	116	11.0	<0.05	0.778	8.49	10.4	51.6	57.1
2880	Spring	11/03/2020	248	71.8	<0.05	0.601	46.9	8.96	82.7	184

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; Unk = Unknown. Well log not found; (-) = Not Analyzed; No Standard = No Primary or Secondary Drinking Water Regulation or Idaho Groundwater Quality Rule standard currently established.

[A] Contaminant with a National Secondary Drinking Water Regulation standard.

[B] Contaminant with a National Primary Drinking Water Regulation standard.

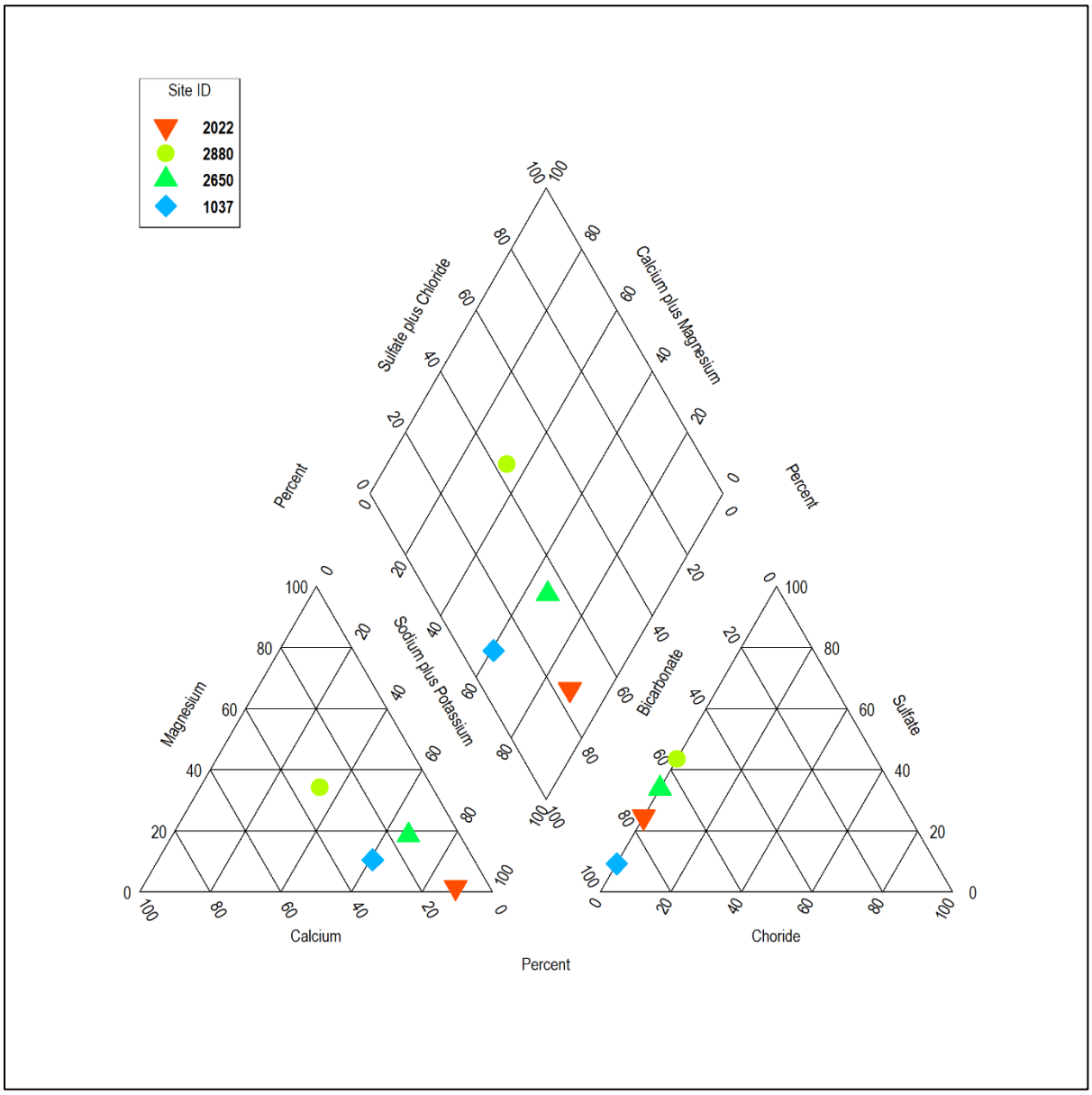


Figure 23. Piper diagram with 2020 common ion data —Lindsay Creek Nitrate Priority Area Groundwater Monitoring Project.

2.3.1.3 Conclusions

The objective of this ongoing project is to use an ambient groundwater quality monitoring network in the Lindsay Creek NPA to complete a multi-year trend analysis for nitrate.

DEQ conducted an annual sampling round in the Lindsay Creek NPA to assess nitrate concentrations and evaluate groundwater quality. The Lindsay Creek NPA is identified as an area experiencing nitrate impact to groundwater based on historic sampling. Of the 11 sites (10 wells and 1 spring) sampled, three (27%) exceeded the MCL of 10 mg/L and 2 (18%) were between 5 mg/L and 10 mg/L. There were no detections of *E. Coli* bacteria.

Continued monitoring and comparing concentrations over multiple years will allow tracking of trends in ambient nitrate groundwater concentration due to changes in land uses or source controls. This comparison will assist in determining nitrate concentration variability due to changes in cropping patterns, fertilizer application, nitrogen uptake by crops due to growing season conditions, and leaching rates related to the amount and timing of precipitation available to mobilize nitrogen below the crop root zone.

2.3.1.4 Recommendations

Yearly monitoring of wells and springs in the Lindsay Creek NPA should continue to enhance the groundwater quality data set. Continuing to develop the groundwater quality data set allows DEQ to track multi-year trends, specifically for nitrate. DEQ recommends future sampling efforts at locations with low DO concentrations include ammonia. It is also recommended that staff determine if well modifications (for example, deepening) have been made to wells sampled by DEQ over the past 30 years.

3 DEQ Cooperative Project

This section presents data from special groundwater quality monitoring projects conducted jointly by DEQ and other state agencies in calendar year 2020.

3.1 DEQ-IDWR Groundwater Monitoring Project

This section presents data from special groundwater quality monitoring and investigation projects that were conducted jointly by DEQ and IDWR in calendar year 2020.

3.1.1 Purpose and Background

The IDWR Statewide Ambient Groundwater Quality Monitoring Network assesses groundwater quality across Idaho. DEQ partnered with IDWR to collect nitrogen isotope ($\delta^{15}N$) samples to help assess groundwater quality in Idaho. The groundwater samples were collected by IDWR staff during statewide network sampling events, while DEQ paid for the analysis. The addition of $\delta^{15}N$ will assist in future nitrogen source evaluation. Results are provided in Appendix A.

3.1.2 Methods and Results

Nitrogen isotope samples were collected from 55 wells (sites with nitrate concentrations greater than 5 mg/L) in 2020. The 2020 isotope samples were submitted together to the University of Arizona in Tucson, AZ for analysis. (Appendix A).

Nitrogen Isotope Results

The 2020 $\delta^{15}N$ results are presented in Table A1; Figure A2. The $\delta^{15}N$ ratios ranged from 2.2‰ to 23.0‰. Eight of the 55 samples (14.5%) had a ratio consistent with inorganic sources (<4.0‰); 39 (71%) samples had ratios consistent with a mixed or organic source of nitrogen (4.0 – <9.0‰); 8 (14.5%) samples had ratios consistent with waste (animal or human) sources of nitrogen (≥9.0‰) (Seiler 1996; Table 9).

3.1.3 Conclusions

The cooperative project between IDWR and DEQ resulted in the cost-effective collection of additional $\delta^{15}N$ which may assist in future nitrogen source evaluation. The nitrogen isotope ratios provide one line of evidence for the potential sources of nitrogen contributing to the nitrate concentrations in groundwater. Trends in $\delta^{15}N$ ratios can be an indicator if nitrate sources are changing or remain stable with time. Information from this investigation may be combined with historical $\delta^{15}N$ results to evaluate changes in $\delta^{15}N$ sources or relationships with $\delta^{15}N$ and other constituents. The cooperative project between IDWR and DEQ for the cost-effective collection of additional dissolved methane data was postponed in 2020 due to COVID-19. Cooperative collection of dissolved methane data is expected to resume in 2021. The continuation of dissolved methane sampling will be helpful in establishing baseline concentrations of dissolved methane in drinking water in areas with potential for oil and gas development or ongoing gas exploration and development.

3.1.4 Recommendations

This project is an example of a collaborative effort between state agencies in Idaho saving time and money by using existing groundwater monitoring networks and sampling schedules. IDWR and DEQ should continue these cooperative efforts to increase program efficiency and protect groundwater quality in the state of Idaho.

3.2 DEQ-ISDA Groundwater Monitoring Project

This section presents data from special groundwater quality monitoring and investigation projects that were conducted jointly by DEQ and ISDA in calendar year 2020.

3.2.1 Purpose and Background

The ISDA Groundwater Program has developed a groundwater monitoring network across Idaho to assess the impacts of pesticide use on groundwater quality. DEQ partnered with ISDA and paid for analysis of nitrate, arsenic, uranium, and $\delta^{15}N$ to help assess groundwater quality across the state. The groundwater samples were collected by ISDA staff during pesticide sampling events, while DEQ paid for the analysis. The data will help identify areas of concern and potential health threats associated with degraded groundwater quality. Additionally, the information will be used to augment data from public water systems, the IDWR Statewide Ambient Groundwater Quality Monitoring Network, and local-scale monitoring projects to be used in the NPA ranking process.

3.2.2 Methods and Results

In cooperation with DEQ, ISDA submitted groundwater samples from a total of 153 DWs across the state following its *Ambient Groundwater Quality Monitoring* QAPP (ISDA 2017a) and corresponding regional FSPs: *Ambient Groundwater Quality Monitoring: Boise Regional Office* FSP, *Ambient Groundwater Quality Monitoring: Idaho Falls Regional Office* FSP, *Ambient Groundwater Quality Monitoring: Northern Regional Office* FSP, *Ambient Groundwater Quality Monitoring: Pocatello Regional Office* FSP, and *Ambient Groundwater Quality Monitoring: Twin Falls Regional Office* FSP (ISDA 2020b-f). The analytes of interest included nitrate (nitrate-nitrite nitrogen), ammonia, total phosphorus, arsenic, uranium, and the nitrogen ($\delta^{15}N$) isotope. All 153 wells sampled were sampled for nitrate. A subset of the 153 wells were also sampled for ammonia or total phosphorus, based on location within known areas with presence of elevated concentrations or special interest. In addition, 24 quality assurance duplicates samples were collected (no blank samples were analyzed). Samples for nitrate, ammonia, and total phosphorus analysis were submitted to IBL in Boise, Idaho. Most samples with nitrate concentrations above 5 mg/L were sent to the University of Arizona in Tucson, AZ for $\delta^{15}N$ analysis. Water quality field parameters (pH, temperature, and specific conductivity) were measured and recorded before sample collection. Field parameter, ammonia, nitrate, and $\delta^{15}N$ results are shown in Table B1 (Appendix B).

Nitrate (Nitrate-Nitrite Nitrogen) Results

Nitrate (nitrate-nitrite nitrogen) concentrations for this project ranged from non-detect (less than 0.010 mg/L) to 45 mg/L. Out of the 153 samples collected for nitrate analysis, 44 samples (28.8%) were between 5 mg/L (half the EPA MCL of 10 mg/L) and 10 mg/L; 26 samples (17%) met or exceeded the MCL. Four of the 18 ISDA projects (Projects 530 [Ada County], 710 [Washington/Payette Counties], 730 [Minidoka County] and 790 [Cassia County]) sampled in 2020 had 77% of the 10 mg/L or greater nitrate concentrations. In total, 122 samples (80%) were at or greater than 2 mg/L, indicating some type of nitrogen source associated with anthropogenic (human) activities. Naturally occurring sources of nitrate are rare so 2 mg/L is a conservatively high estimate of ambient background levels (DEQ 2014a).

Well locations and nitrate concentrations are shown in Table B1 and Figures B1–B21.

Ammonia Results

A total of six wells were sampled for ammonia in addition to nitrate. Ammonia concentrations for this project ranged from non-detect (less than 0.050 mg/L) to 9 mg/L (Table B1). Median concentration was 8.2 mg/L. There is currently no MCL or Idaho Groundwater Quality standard for ammonia.

The majority of wells sampled for ammonia were within Owyhee County, which is known to have wells drilled into a deeper, confined aquifer with low or depleted dissolved oxygen concentrations. Sampling for ammonia can provide information on potential sources of nitrogen in groundwater where nitrate is not present. In shallow groundwater near liquid animal or human waste, nitrogen may be present as ammonia. This ammonia may oxidize into nitrate as groundwater carries it downgradient. Knowledge of ammonia along with dissolved oxygen can provide information on less apparent potential sources of nitrate.

Total Phosphorus Results

In September and October 2020, a total of 33 total phosphorus samples were collected, in two separate events, from 16 sites from Project 783 – *Thousand Springs Aquifer Project*. Project 783 was initiated by ISDA in 2020 to assess groundwater impacts to surface water quality by evaluating water quality (nutrients [total phosphorus and nitrate] and pesticides) at groundwater discharge (spring) locations along the Snake River in Gooding and Jerome Counties (Figure B12). Total phosphorus concentrations for this project ranged from 0.022 mg/L to 0.072 mg/L (Table B1). Median concentration was 0.027 mg/L. Phosphorus is not often a constituent of concern for groundwater as it is typically adsorbed onto soil particles; however, it can be a concern for surface water quality. Under certain environmental conditions, it can become mobile and enter groundwater systems and in an interconnected system, this can impact surface water quality. This sampling was conducted to help augment research being conducted by the USGS as well as determine current phosphorus levels in the groundwater entering surface water at the spring discharge locations. Groundwater can be a major contributor of non-point source pollution, including Total Phosphorus (TP) to waters of the US. Having accurate data from reliable sources enables the DEQ's Surface Water Bureau to provide

up-to-date Total Maximum Daily Load (TMDL) numbers in the TMDL revision. If these sources are not monitored, over-estimation of groundwater contribution may be reported which is not helpful to those groups working to improve groundwater quality. Up-to-date monitoring also allows the TMDL process to account for other sources of pollution should it be found groundwater is not a major contributor and ensure point sources potentially contributing to the impairment of the Snake River can be regulated appropriately. Monitoring groundwater TP concentrations is an established method to obtain an estimation of potential phosphorous contribution from groundwater. There is currently no MCL or Idaho Groundwater Quality standard for phosphorus.

Nitrogen Isotope Results

DEQ submitted a total of nine ISDA-collected nitrogen isotope ($\delta^{15}N$) samples from wells with nitrate concentrations of approximately 5 mg/L or greater. The nine samples were collected from 5 projects, including 350 [Ada County], 710 [Washington/Payette Counties], 750 [Lincoln/Gooding Counties], 780 [Twin Falls County], and 830 [Jefferson County].

The measurable $\delta^{15}N$ values ranged from 1.7‰ to 6.9‰. A total of three samples had values between 1.7‰ to +3.3‰, suggesting commercial fertilizer as the likely nitrate source. The remaining six samples had $\delta^{15}N$ values between 4.4‰ and 6.9‰, suggesting organic nitrogen in soil or a mixed nitrogen source as the likely nitrate source (Seiler 1997; Tables 9 and B1).

3.2.3 Conclusions

The cooperative project between ISDA and DEQ resulted in the cost-effective collection of additional nitrate and nitrogen isotope data that helped assess groundwater quality across the state. Out of the 153 samples collected for nitrate analysis, 26 samples (17%) met or exceeded the EPA nitrate MCL of 10 mg/L and 44 samples (28.8%) were between 5 mg/L and 10 mg/L. The nitrate results indicate degraded groundwater in specific vulnerable aquifers within a few counties (Figures B1-B21). These data will be helpful in the next NPA delineation and ranking process conducted by DEQ and the Groundwater Monitoring Technical Committee. The nitrogen isotope ratios provide one line of evidence to identify potential sources of nitrogen contributing to the nitrate concentrations in groundwater.

3.2.4 Recommendations

This project is an example of a collaborative effort between state agencies in Idaho saving time and money by using existing groundwater monitoring networks and sampling schedules. ISDA and DEQ should continue these cooperative efforts to increase program efficiency and protect groundwater quality in Idaho.

Additionally, when budgets allow, arsenic and uranium samples should be collected in areas with known elevated concentrations to provide more information regarding the presence of those naturally occurring constituents of concern. This data provides valuable information to homeowners as well as for those working to better understand areas with concentrations at levels that present human health risks.

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Appendix A. Idaho Department of Water Resources Collected Data–2020

Table A1. 2020 Field parameters, nitrate, and nitrogen isotope results—DEQ-IDWR Joint Groundwater Monitoring Project.

Map ID	IDWR Site ID	County	Well Depth (ft bgs)	Sample Date	Temperature (°C)	pH[A]	Dissolved Oxygen (mg/L)	Specific Conductance (uS/cm)	Nitrate[B] (mg/L)	$\delta^{15}N$ (‰)
	Water Quality Standard:				No Standard	6.5-8.5		No Standard	**10**	No Standard
N-1	01S 01W 07CBB2	Ada	275	7/29/2020	19.3	7.24	3.43	965.1	**15**	11.6
N-2	02N 01E 33CAC2	Ada	210	7/29/2020	16.4	7.86	7.28	716.6	9.1	5.4
N-3	02N 01W 01ABD1	Ada	200	8/5/2020	14.7	7.81	8.16	615.7	7.1	4.5
N-4	03N 01E 17ABCC1	Ada	70	8/13/2020	17.1	7.24	4.44	763.7	5.1	6.3
N-5	04N 01E 31DCC1	Ada	104	8/5/2020	14.9	7.37	2.98	816.7	7.5	6.3
N-6	04N 01W 04DDA1	Ada	120	6/18/2020	15.0	6.96	-	976.6	**11**	14.7
N-7	05N 01W 34ACAC1	Ada	85	8/13/2020	15.8	7.09	4.26	859.0	**28**	7.9
N-8	15S 46E 06CCA1	Bear Lake	38	6/24/2020	8.4	7.17	0.14	1220	8.9	23.0
N-9	01N 15E 35BDD1	Camas	202	7/30/2020	13.0	7.09	8.15	186.3	6.0	5.1
N-10	02N 02W 09ACC1	Canyon	194	7/14/2020	18.3	7.75	5.02	728.1	5.3	5.0
N-11	03N 01W 05BAA1	Canyon	75	7/6/2020	13.2	7.38	3.57	1011	**14**	4.2
N-12	03N 02W 04DDAA2	Canyon	63	7/6/2020	16.0	7.33	4.40	1022	**15**	6.4
N-13	03N 03W 09BAB1	Canyon	122	8/25/2020	13.8	7.71	6.59	909.9	**13**	3.6
N-14	03N 03W 14CDA1	Canyon	80	7/1/2020	14.3	7.66	6.08	989.5	**10**	5.1
N-15	03N 03W 31ADA1	Canyon	260	7/1/2020	16.8	7.45	6.29	1382	**21**	3.9
N-16	03N 04W 05AAB1	Canyon	325	7/13/2020	18.8	7.20	2.93	1144	**11**	3.2
N-17	04N 04W 21DCD2	Canyon	100	7/13/2020	16.9	7.66	4.60	773.0	9.7	8.2
N-18	04N 05W 02CBB1	Canyon	90	6/19/2020	15.5	7.62	3.28	1179	**17**	6.1
N-19	04N 05W 21AAB2	Canyon	220	6/19/2020	17.3	7.77	7.00	543.7	6.1	4.5
N-20	05N 03W 25DCB1	Canyon	87	8/25/2020	15.1	7.48	4.45	666.4	9.0	6.9
N-21	06N 05W 29DAD1	Canyon	124	6/19/2020	17.3	7.74	8.29	688.2	8.8	9.8
N-22	09S 41E 13CCC1	Caribou	138	6/24/2020	9.2	7.39	7.27	628.0	6.1	4.4
N-23	10S 22E 27ABA1	Cassia	335	6/22/2020	15.3	7.47	6.79	1591	**11**	12.7
N-24	11S 22E 14BAB1	Cassia	206	6/22/2020	14.6	7.55	8.16	1255	**13**	6.1
N-25	13S 22E 08CBC1	Cassia	199	6/24/2020	12.7	7.33	6.80	633.8	6.2	7.4
N-26	09N 43E 23AAB1	Fremont	342	8/5/2020	9.8	7.44	7.98	606.8	9.7	4.5
N-27	09N 43E 28DAC1	Fremont	198	8/5/2020	12.9	7.88	7.56	484.7	7.9	2.3
N-28	05S 15E 35DBD3	Gooding	205	6/19/2020	15.2	7.28	7.33	894.9	**12**	9.1
N-29	07N 37E 11BAD1	Jefferson	115	7/22/2020	12.0	7.96	6.75	344.8	5.0	2.2
N-30	08S 24E 26ACD1	Minidoka	173	7/9/2020	14.3	7.54	6.85	909.7	7.4	4.0
N-31	09S 22E 17CCC1	Minidoka	302	8/4/2020	13.6	7.61	8.28	1529	**12**	5.3
N-32	09S 22E 27ADB1	Minidoka	250	6/23/2020	15.1	7.42	6.70	1003	8.0	6.4

N-33	09S 23E 13ABB1	Minidoka	137	8/4/2020	15.7	7.49	4.28	784.1	6.8	6.3
N-34	10S 22E 24BAA1	Minidoka	61	6/22/2020	10.7	7.42	0.72	1458	**11**	8.6
N-35	35N 03W 15DAD1	Nez Perce	207	7/27/2020	15.6	7.63	7.50	294.1	6.3	7.6
N-36	37N 03W 03ABB1	Nez Perce	758	7/7/2020	-	-	-	-	**10**	7.5
N-37	03N 06W 13BCA1	Owyhee	290	7/2/2020	15.8	7.12	5.14	2824	7.3	5.2
N-38	05S 03E 22BBB2	Owyhee	131	7/30/2020	-	-	-	-	6.0	4.3
N-39	08N 05W 36DCC1	Payette	50	7/1/2020	14.6	7.69	5.54	839.1	**10**	3.8
N-40	09N 05W 26CBB1	Payette	88	6/30/2020	15.6	7.47	3.02	1181	5.0	4.3
N-41	09S 13E 02DBD2	Twin Falls	580	7/7/2020	20.2	6.69	6.42*	1106	6.1	4.9
N-42	09S 13E 25ADD1	Twin Falls	400	7/8/2020	15.3	6.61	6.21*	982.9	7.1	7.0
N-43	09S 15E 13DDA1	Twin Falls	62	7/1/2020	15.1	6.80	8.91*	974.9	5.9	4.4
N-44	09S 16E 20BDD1	Twin Falls	215	7/7/2020	14.8	6.90	7.77*	100.6	6.5	5.1
N-45	09S 17E 29CCB1	Twin Falls	240	7/14/2020	15.3	7.04	7.72*	1122	7.2	5.2
N-46	09S 18E 31DCA1	Twin Falls	152	8/5/2020	19.8	*6.21*	7.37*	841.0	5.5	4.1
N-47	10S 14E 33BBA1	Twin Falls	155	7/14/2020	-	-	-	-	**12**	6.4
N-48	10S 16E 24DDD1	Twin Falls	100	7/15/2020	14.4	-	6.21*	1132	5.8	9.0
N-49	10S 17E 14BAB1	Twin Falls	180	7/13/2020	17.9	7.04	6.74*	1332	8.9	6.4
N-50	11S 20E 31CDC2	Twin Falls	300	7/27/2020	20.9	7.37	7.32	1005	9.0	5.5
N-51	12S 17E 18DDD2	Twin Falls	300	7/15/2020	-	-	-	-	5.0	4.9
N-52	10N 05W 12BAC1	Washington	40	6/30/2020	14.2	7.30	8.40	884.1	5.8	2.6
N-53	11N 05W 29CBB1	Washington	80	6/30/2020	17.1	7.41	3.89	794.7	7.6	4.4
N-54	11N 06W 14BCD1	Washington	70	6/29/2020	14.8	7.00	3.84	2070	**33**	9.1
N-55	11N 06W 25CAC1	Washington	39	6/29/2020	13.9	7.56	2.18	923.1	**11**	2.5

Notes: ft bgs = feet below ground surface; ^{o}C = degrees Celsius; µS/cm = microsiemens per centimeter; milligrams per liter; ‰ = per mil; (-) = not analyzed or data are unavailable. Italicized numbers indicate an EPA secondary drinking water standard regulation was exceeded. Bold gray shaded numbers indicate an EPA primary drinking water standard regulation was exceeded.

[A] Contaminant with a National Secondary Drinking Water Regulation (NSDWR) standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

[B] Contaminant with a National Primary Drinking Water Regulation standard.

*DO values originally reported as % saturation. The % saturation values were converted to mg/L using temperature and estimated land surface elevation.

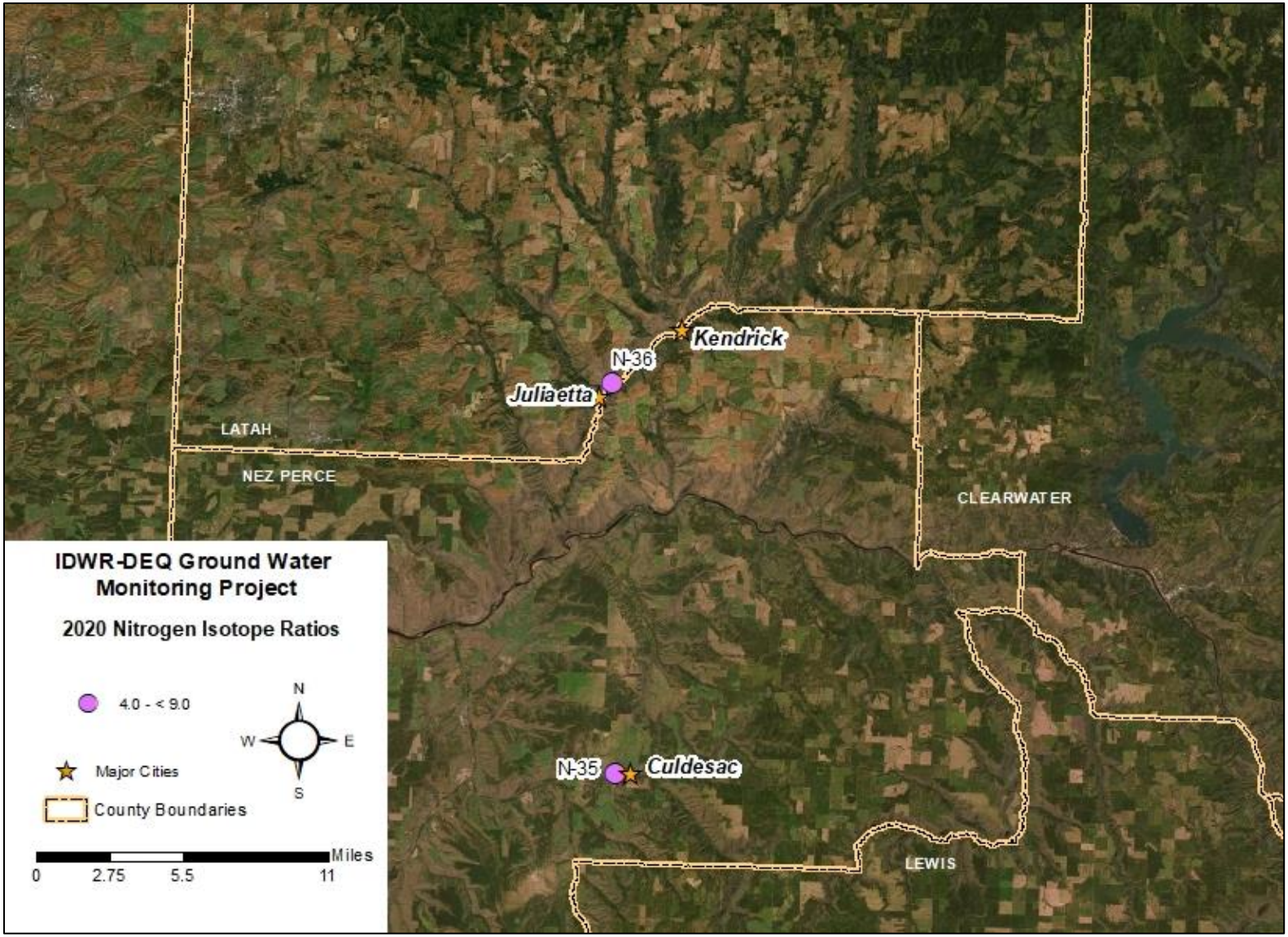


Figure A1. 2020 northern Idaho nitrogen isotope ratios—DEQ-IDWR Joint Groundwater Monitoring Project.

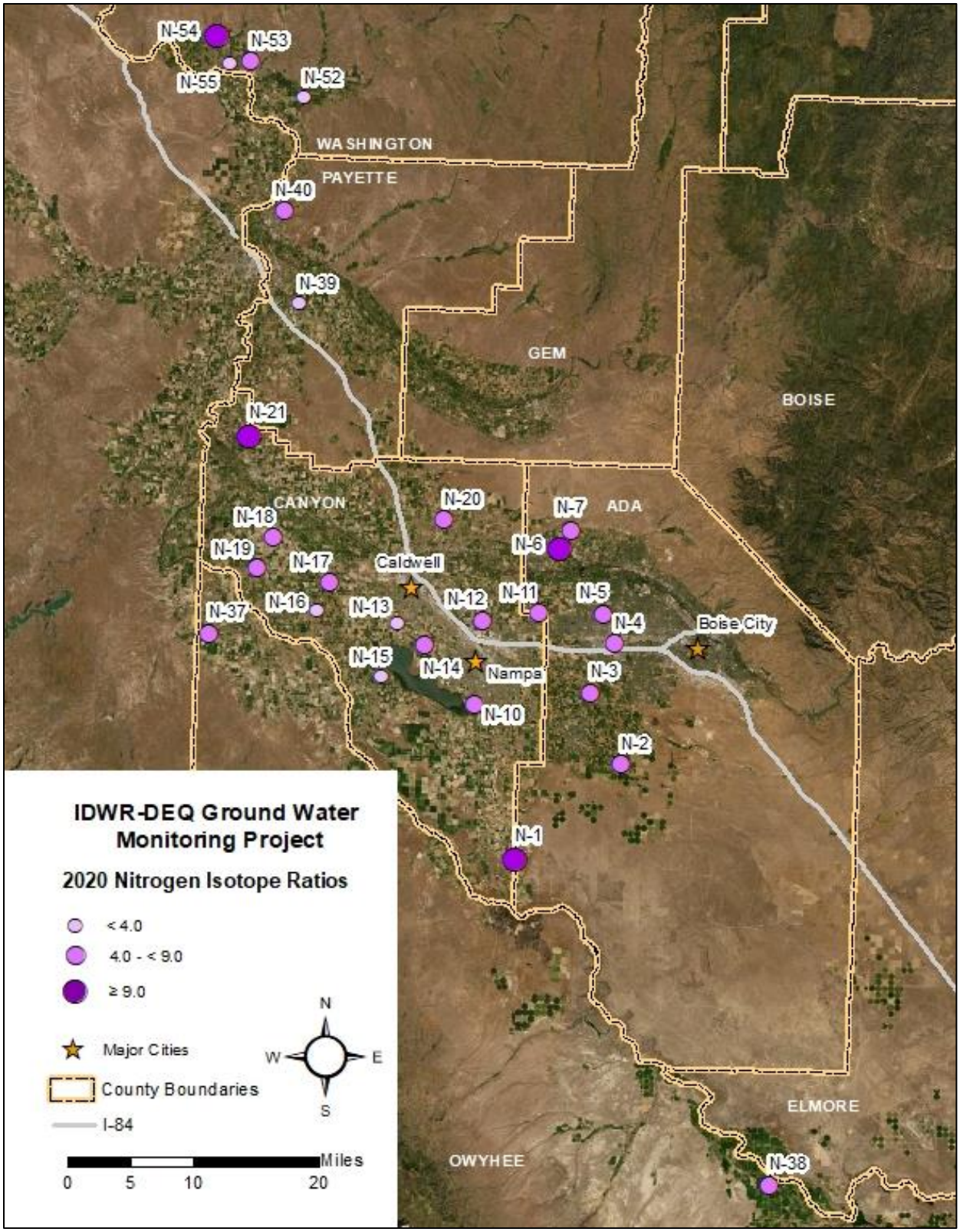


Figure A2. 2020 southwest Idaho nitrogen isotope ratios—DEQ-IDWR Joint Groundwater Monitoring Project.

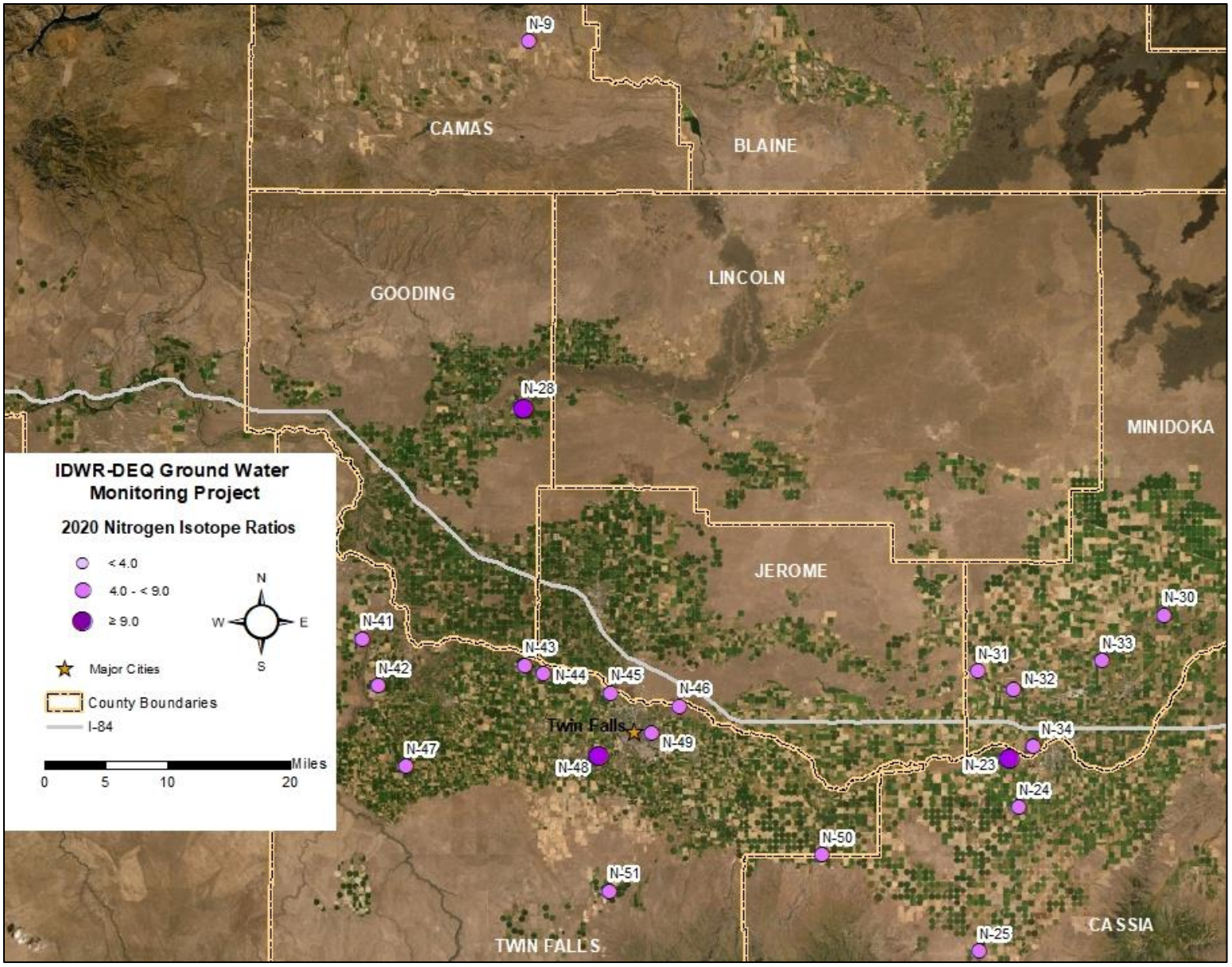


Figure A3. 2020 southcentral Idaho nitrogen isotope ratios—DEQ-IDWR Joint Groundwater Monitoring Project.

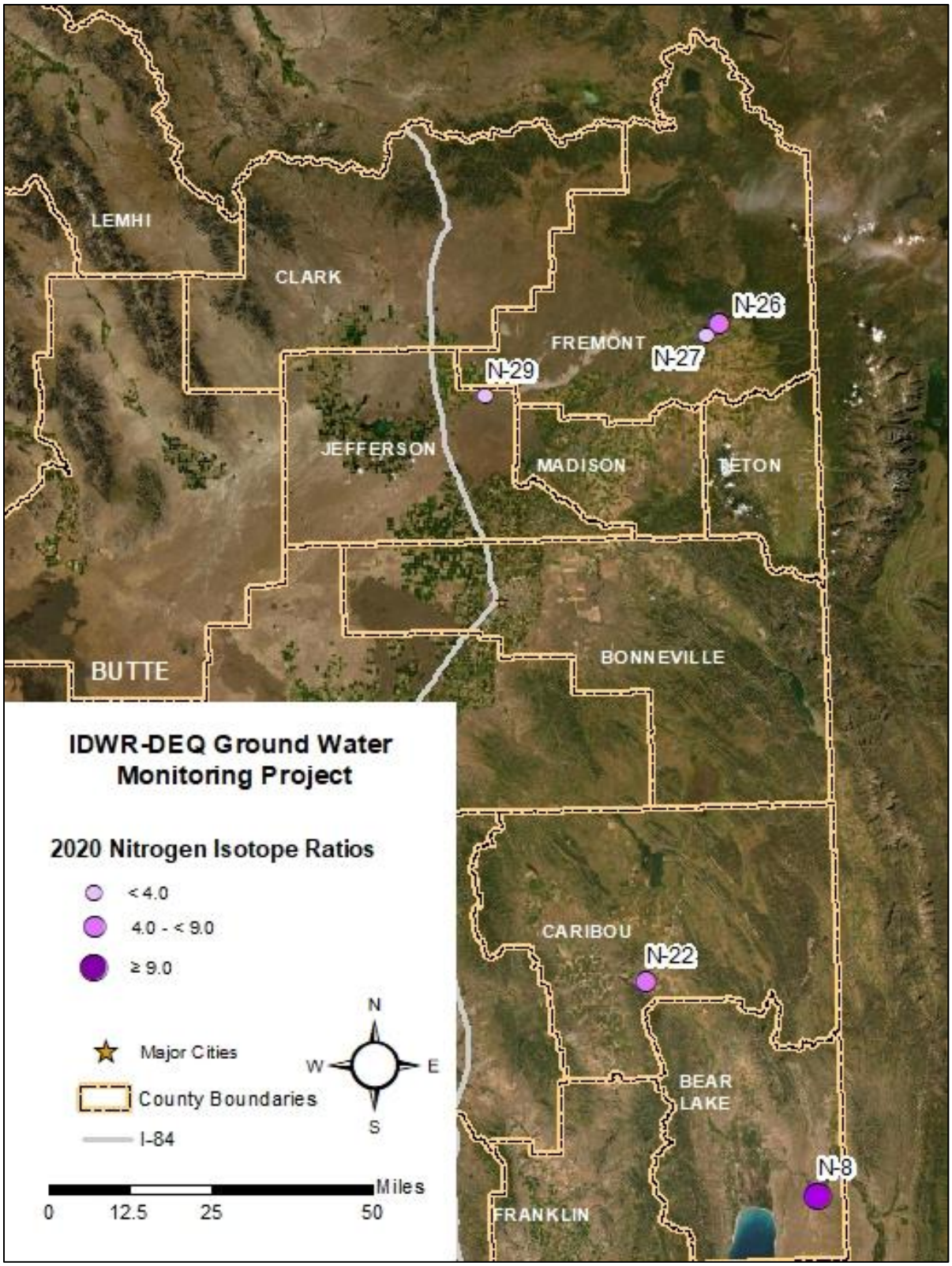


Figure A4. 2020 eastern Idaho nitrogen isotope ratios—DEQ-IDWR Joint Groundwater Monitoring Project. Idaho State Department of Agriculture Collected Data—2020

Appendix B. Idaho State Department of Agriculture Collected Data–2020

Table B1. DEQ–ISDA Groundwater Monitoring Project data.

ISDA Well ID	Project Number	Sample Date	Project County Location	Temperature (°C)	pH	Specific Conductance (µS/cm)	Nitrate-Nitrite as N	Ammonia	Total Phosphorous	N15 Isotope
							(mg/L)			
Water Quality Standard:				No Standard	**6.5-8.5**	No Standard	10	No Standard	No Standard	No Standard
2201301	220	7/28/2020	Ada/Canyon	15.2	7.97	637.9	7.1	-	-	-
2201801	220	7/28/2020	Ada/Canyon	14.7	7.56	650.1	9.6	-	-	-
2203001	220	7/28/2020	Ada/Canyon	14.1	7.14	619.3	5.7	-	-	-
2204701	220	7/28/2020	Ada/Canyon	14.7	7.46	696.3	6.1	-	-	-
2206501	220	7/28/2020	Ada/Canyon	14.8	7.47	575.6	5.0	-	-	-
2206601	220	8/24/2020	Ada/Canyon	15.3	7.35	549.9	2.0	-	-	-
2207001	220	7/28/2020	Ada/Canyon	15.1	7.59	1277	4.1	-	-	-
3100401	310	8/11/2020	Owyhee	21.6	7.80	2195	<0.010	8.4	-	-
3100601	310	8/11/2020	Owyhee	22.0	7.55	2424	2.6	6.5	-	-
3101101	310	8/11/2020	Owyhee	18.7	7.57	2695	1.4	8	-	-
3101601	310	8/11/2020	Owyhee	21.4	7.84	2257	0.56	8.4	-	-
3400101	340	8/26/2020	Payette	15.2	7.43	981.2	8.4	-	-	-
3400701	340	8/26/2020	Payette	17.2	7.60	820.1	1.2	-	-	-
3401501	340	8/26/2020	Payette	14.5	7.65	1022	**12**	-	-	-
3500101	350	7/21/2020	Ada	14.6	7.18	633.9	4.4	-	-	6.9
3500201	350	7/22/2020	Ada	13.9	6.69	454.1	4.4	-	-	6.7
3500501	350	7/21/2020	Ada	15.2	6.88	239.9	2.0	-	-	-
3500701	350	7/22/2020	Ada	14.8	6.68	548.0	7.6	-	-	6.3
3501401	350	7/22/2020	Ada	15.6	6.98	343.9	2.5	-	-	-
3503001	350	7/22/2020	Ada	15.0	7.07	343.8	1.8	-	-	-
3503101	350	7/21/2020	Ada	14.4	6.84	243.5	2.9	-	-	-
5302401	530	7/29/2020	Ada	13.9	7.69	819.1	**28**	-	-	-
5302701	530	7/29/2020	Ada	13.5	7.01	798.5	**45**	-	-	-
5303401	530	7/29/2020	Ada	14.8	7.10	879.5	**42**	-	-	-
7100101	710	8/26/2020	Washington	16.6	7.61	815.3	4.0	-	-	-
7100501	710	8/26/2020	Washington	13.8	7.56	798.5	**11**	-	-	-
7100901	710	8/26/2020	Washington	14.9	7.27	1161	**18**	-	-	-
7101701	710	8/26/2020	Washington	15.2	7.52	860.6	**12**	-	-	-
7102501	710	8/31/2020	Washington	14.9	7.03	2235	**32**	-	-	-
7102701	710	8/31/2020	Washington	13.4	7.48	707.9	**12**	-	-	-

7103401	710	8/31/2020	Washington	15.0	7.21	797.4	3.5	-	-	-
7103701	710	8/31/2020	Washington	14.2	7.35	866.1	6.8	-	-	-
7104101	710	8/31/2020	Washington	13.9	7.41	1262	**20**	-	-	-
7104701	710	8/31/2020	Washington	15.9	7.98	1057	**12**	-	-	-
7105101	710	8/31/2020	Washington	13.4	7.39	873.5	**13**	-	-	-
7105801	710	8/31/2020	Washington	15.6	7.30	987.9	**12**	-	-	2.7
7107101	710	8/31/2020	Washington	14.4	7.43	673.2	1.3	-	-	-
7300501	730	7/7/2020	Minidoka (Shallow)	16.4	7.69	1275	1.2	-	-	-
7300801	730	7/7/2020	Minidoka (Shallow)	11.7	7.42	1665	**25**	-	-	-
7301301	730	7/7/2020	Minidoka (Shallow)	16.7	7.54	608.0	2.8	-	-	-
7301601	730	7/7/2020	Minidoka (Shallow)	12.4	7.44	1897	**11**	-	-	-
7302701	730	7/7/2020	Minidoka (Shallow)	13.2	7.44	892.4	7.9	-	-	-
7303001	730	7/8/2020	Minidoka (Shallow)	17.7	7.57	663.0	5.8	-	-	-
7303201	730	7/8/2020	Minidoka (Shallow)	13.2	7.23	3254	**42**	-	-	-
7303901	730	7/8/2020	Minidoka (Shallow)	14.9	7.56	645.5	8.4	-	-	-
7304101	730	7/7/2020	Minidoka (Shallow)	14.1	7.57	732.8	8.8	-	-	-
7304301	730	7/8/2020	Minidoka (Shallow)	14.9	7.51	665.8	5.3	-	-	-
7304501	730	7/7/2020	Minidoka (Shallow)	12.2	7.42	987.0	9.8	-	-	-
7305401	730	7/8/2020	Minidoka (Shallow)	13.2	7.91	508.5	0.012	-	-	-
7305501	730	8/11/2020	Minidoka (Shallow)	14.0	7.95	507.0	<0.010	-	-	-
7401501	740	7/7/2020	Minidoka (Deep)	15.0	7.46	871.9	8.4	-	-	-
7404801	740	8/18/2020	Minidoka (Deep)	13.7	7.50	922.6	7.5	-	-	-
7500601	750	8/19/2020	Jerome/Gooding/Lincoln	16.1	7.50	673.2	**11**	-	-	4.6
7505601	750	8/12/2020	Jerome/Gooding/Lincoln	14.9	7.37	625.2	3.3	-	-	-
7505801	750	8/12/2020	Jerome/Gooding/Lincoln	14.9	7.32	656.2	2.5	-	-	-
7506601	750	8/12/2020	Jerome/Gooding/Lincoln	15.2	7.87	690.6	7.5	-	-	-
7506701	750	8/12/2020	Jerome/Gooding/Lincoln	16.5	7.23	619.3	3.2	-	-	-
7507001	750	8/19/2020	Jerome/Gooding/Lincoln	14.2	7.35	1099	3.0	-	-	-
7800201	780	8/12/2020	Twin Falls	14.1	7.54	865.8	5.4	-	-	4.4
7800301	780	8/5/2020	Twin Falls	14.4	7.58	791.5	4.2	-	-	-
7801701	780	8/5/2020	Twin Falls	14.5	7.84	985.8	8.5	-	-	-
7803601	780	8/5/2020	Twin Falls	13.1	7.74	1317	**12**	-	-	-
7803701	780	8/11/2020	Twin Falls	13.3	7.64	823.4	5.4	-	-	-
7804201	780	8/11/2020	Twin Falls	13.3	7.57	892.2	7.4	-	-	-
7804301	780	8/11/2020	Twin Falls	13.5	7.55	963.2	9.3	-	-	-
7804401	780	8/11/2020	Twin Falls	14.5	7.49	957.7	4.0	-	-	-
7805501	780	8/11/2020	Twin Falls	13.8	7.60	857.7	7.8	-	-	-
7805601	780	8/11/2020	Twin Falls	14.4	7.62	858.8	5.6	-	-	-
7805701	780	8/5/2020	Twin Falls	14.1	7.52	881.4	7.9	-	-	-

7806401	780	8/5/2020	Twin Falls	14.6	7.50	727.7	3.3	-	-	-
7806601	780	8/11/2020	Twin Falls	12.4	7.51	905.5	4.1	-	-	-
7807701	780	8/12/2020	Twin Falls	13.7	7.53	1269	5.1	-	-	4.6
7807801	780	8/5/2020	Twin Falls	12.9	7.61	2527	**12**	-	-	3.3
7810101	780	8/5/2020	Twin Falls	13.5	7.70	1169	6.4	-	-	-
7810201	780	8/5/2020	Twin Falls	15.7	7.74	772.3	3.6	-	-	-
7830203	783	9/24/2020	Gooding	14.5	7.81	386.3	2.5	-	0.034	-
		10/6/2020		-	-	-	2.8	-	0.035	-
7830503	783	9/24/2020	Gooding	15.2	7.82	452.4	2.9	-	0.027	-
		10/6/2020		-	-	-	3.1	-	0.025	-
7831603	783	9/24/2020	Gooding	15.2	8.34	522.3	3.2	-	0.032	-
		10/6/2020		-	-	-	3.3	-	0.031	-
7832103	783	8/25/2020	Gooding	16.5	7.80	776.5	6.8	-	0.029	-
		9/24/2020		15.1	7.98	629.1	6.9	-	0.037	-
		10/6/2020		-	-	-	6.8	-	0.029	-
7832403	783	9/23/2020	Gooding	15.8	8.13	310.6	2.2	-	0.023	-
		10/7/2020		15.5	8.20	311.1	2.2	-	0.029	-
7833303	783	9/23/2020	Gooding	15.6	7.97	287.3	1.1	-	0.024	-
		10/7/2020		15.5	8.00	269.5	1.1	-	0.025	-
7833403	783	9/24/2020	Gooding	16.6	8.05	505.4	2.3	-	0.027	-
		10/6/2020		-	-	-	2.2	-	0.026	-
7833703	783	9/23/2020	Gooding	15.1	8.19	283.1	1.3	-	0.024	-
		10/7/2020		15.3	8.19	298.3	1.2	-	0.030	-
7834103	783	9/24/2020	Gooding	15.0	8.24	494.5	3.1	-	0.025	-
		10/6/2020		-	-	-	3.2	-	0.027	-
7834303	783	9/23/2020	Gooding	15.2	7.03	303.0	1.0	-	0.022	-
		10/7/2020		15.2	8.17	282.1	1.1	-	0.027	-
7834603	783	9/23/2020	Gooding	16.5	8.25	365.3	2.4	-	0.072	-
		10/7/2020		15.2	*8.50*	334.8	2.2	-	0.023	-
7834803	783	9/23/2020	Gooding	15.4	8.49	337.0	2.3	-	0.027	-
		10/7/2020		15.5	8.25	342.9	2.3	-	0.067	-
7835403	783	9/24/2020	Gooding	16.8	8.01	517.3	2.4	-	0.028	-
		10/6/2020		-	-	-	2.3	-	0.025	-
7835603	783	9/23/2020	Gooding	15.5	7.89	348.3	2.4	-	0.024	-
		10/7/2020		15.1	7.84	341.2	2.2	-	0.026	-
7836303	783	9/24/2020	Gooding	17.2	8.05	504.4	2.2	-	0.027	-
		10/6/2020		-	-	-	2.3	-	0.025	-
7837203	783	9/23/2020	Gooding	15.1	8.08	283.6	1.1	-	0.037	-
		10/7/2020		15.0	8.19	295.2	1.1	-	0.036	-

7900101	790	7/14/2020	Cassia	17.7	7.78	929.6	5.6	-	-	-
7900601	790	7/14/2020	Cassia	12.6	7.70	979.3	**10**	-	-	-
7901401	790	7/14/2020	Cassia	12.8	7.48	934.5	**14**	-	-	-
7901501	790	7/14/2020	Cassia	14.4	7.54	906.3	8.5	-	-	-
7901701	790	7/14/2020	Cassia	12.7	7.60	815.8	8.0	-	-	-
7901901	790	7/15/2020	Cassia	12.3	7.51	1083	**16**	-	-	-
7903601	790	7/14/2020	Cassia	13.4	7.57	842.6	**11**	-	-	-
7904001	790	7/15/2020	Cassia	13.9	7.41	768.7	5.3	-	-	-
7907301	790	7/14/2020	Cassia	12.9	7.67	803.0	**11**	-	-	-
8051301	805	10/5/2020	Madison/Fremont/Teton	9.8	7.49	567.7	5.3	-	-	-
8051401	805	10/5/2020	Madison/Fremont/Teton	11.6	7.43	495.8	7.9	-	-	-
8052801	805	10/5/2020	Madison/Fremont/Teton	8.4	7.45	597.9	9.4	-	-	-
8053401	805	10/5/2020	Madison/Fremont/Teton	10.1	7.68	368.8	1.5	-	-	-
8053501	805	10/5/2020	Madison/Fremont/Teton	8.2	7.30	622.3	**11**	-	-	-
8101701	810	9/1/2020	Owyhee	14.7	7.11	479.8	5.0	-	-	-
8302001	830	10/5/2020	Jefferson	12.4	8.32	322.8	0.15	-	-	-
8303201	830	10/5/2020	Jefferson	11.7	7.94	381.8	5.6	-	-	1.7
8401601	840	10/6/2020	Bonneville/Jefferson/Madison	11.1	7.60	504.4	1.6	-	-	-
8404201	840	10/6/2020	Bonneville/Jefferson/Madison	11.9	7.67	503.7	1.5	-	-	-
8404401	840	10/6/2020	Bonneville/Jefferson/Madison	12.6	7.65	518.3	2.4	-	-	-
8404801	840	10/6/2020	Bonneville/Jefferson/Madison	12.4	7.56	496.0	1.2	-	-	-
8404901	840	10/6/2020	Bonneville/Jefferson/Madison	11.7	7.65	497.4	1.8	-	-	-
8406101	840	10/6/2020	Bonneville/Jefferson/Madison	12.5	7.59	531.0	1.2	-	-	-
8406601	840	10/6/2020	Bonneville/Jefferson/Madison	11.7	7.75	517.7	1.7	-	-	-
8407501	840	10/6/2020	Bonneville/Jefferson/Madison	11.8	7.48	514.6	2.5	-	-	-
8420101	842	10/13/2020	Bingham/Bonneville	12.9	7.37	639.3	0.96	-	-	-
8420201	842	10/13/2020	Bingham/Bonneville	13.5	7.42	568.3	1.7	-	-	-
8420401	842	10/13/2020	Bingham/Bonneville	15.5	7.34	754.8	2.3	-	-	-
8420801	842	10/14/2020	Bingham/Bonneville	13.8	7.55	472.8	1.0	-	-	-
8420901	842	10/14/2020	Bingham/Bonneville	13.3	7.53	559.6	2.0	-	-	-
8421001	842	10/14/2020	Bingham/Bonneville	12.8	7.49	580.8	3.1	-	-	-
8421501	842	10/13/2020	Bingham/Bonneville	12.9	7.36	587.3	3.4	-	-	-
8421601	842	10/14/2020	Bingham/Bonneville	13.2	7.67	640.8	3.4	-	-	-
8421701	842	10/13/2020	Bingham/Bonneville	12.7	7.48	562.3	2.1	-	-	-
8422001	842	10/13/2020	Bingham/Bonneville	13.2	7.29	464.5	1.6	-	-	-
8601101	860	8/11/2020	Owyhee	14.7	7.32	2345	6.3	<0.050	-	-
8603001	860	8/11/2020	Owyhee	21.2	7.27	1461	<0.010	9	-	-
8700501	870	8/18/2020	Gooding	12.5	7.74	662.2	7.1	-	-	-
8700601	870	8/18/2020	Gooding	15.9	7.64	570.7	5.0	-	-	-

8701201	870	8/18/2020	Gooding	15.2	7.76	850.9	7.5	-	-	-
8701801	870	8/18/2020	Gooding	16	7.46	810.2	3.2	-	-	-
8706201	870	8/18/2020	Gooding	17.4	7.36	1038	10	-	-	-
8706501	870	8/18/2020	Gooding	19	7.92	316	<0.010	-	-	-
8900501	890	9/1/2020	Elmore	17.5	7.53	874.1	3.9	-	-	-
8901801	890	9/1/2020	Elmore	17.1	7.54	1119	6.4	-	-	-

Notes: **ºC** = degrees Celsius; µS/cm = microsiemens per centimeter; mg/L = milligrams per liter; (-) = Not Analyzed. Italicized numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was exceeded. Bolded gray shaded numbers indicate EPA's National Primary Drinking Water Regulation NPDWR standard (NPDWR), expressed as a maximum contaminant level (MCL), was reached or exceeded.

a. Contaminant with a NSDWR standard.

b. Contaminant with a NPDWR standard.

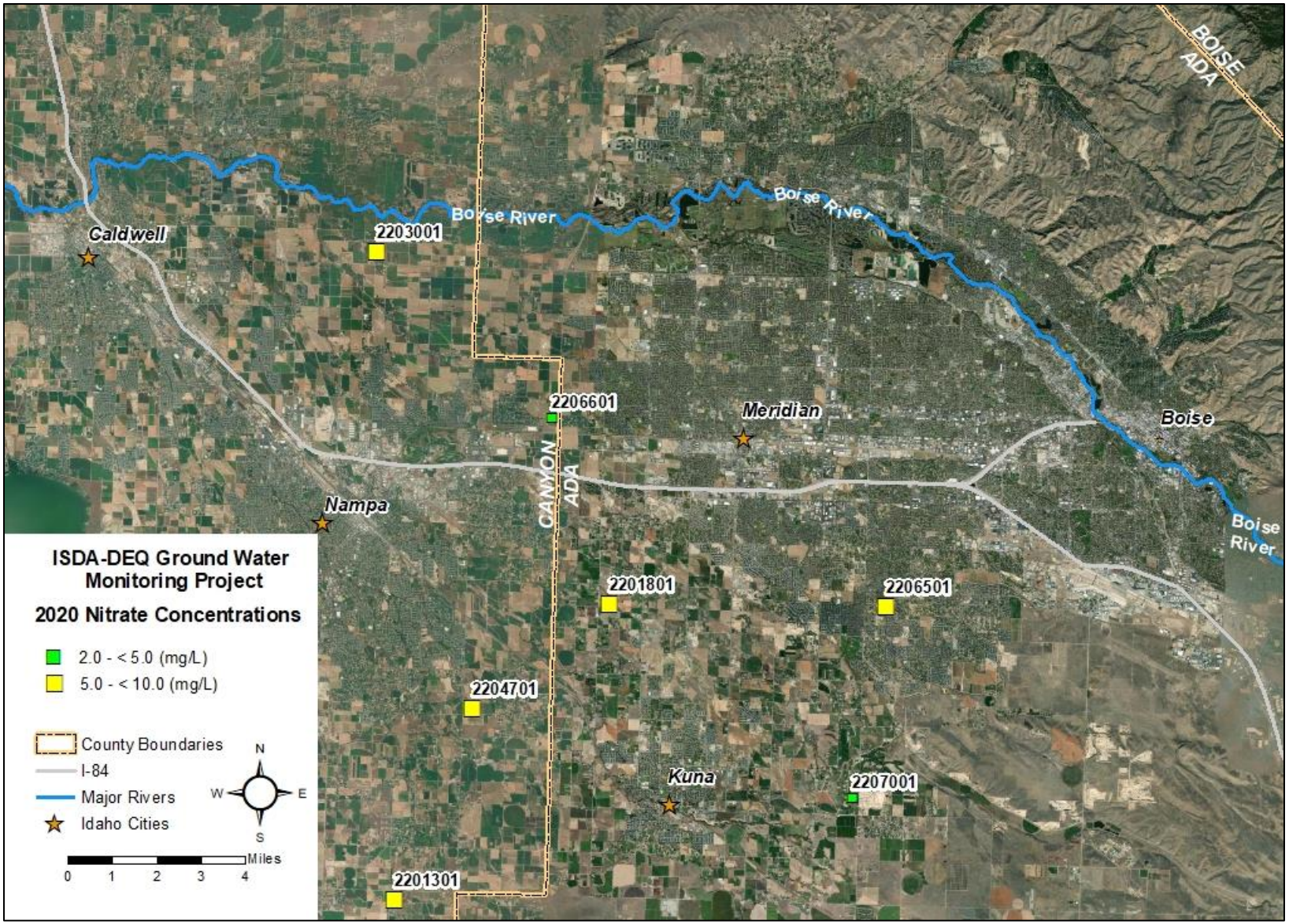


Figure B1. Project 220 (Ada and Canyon Counties) nitrate concentrations, 2020 ISDA data.

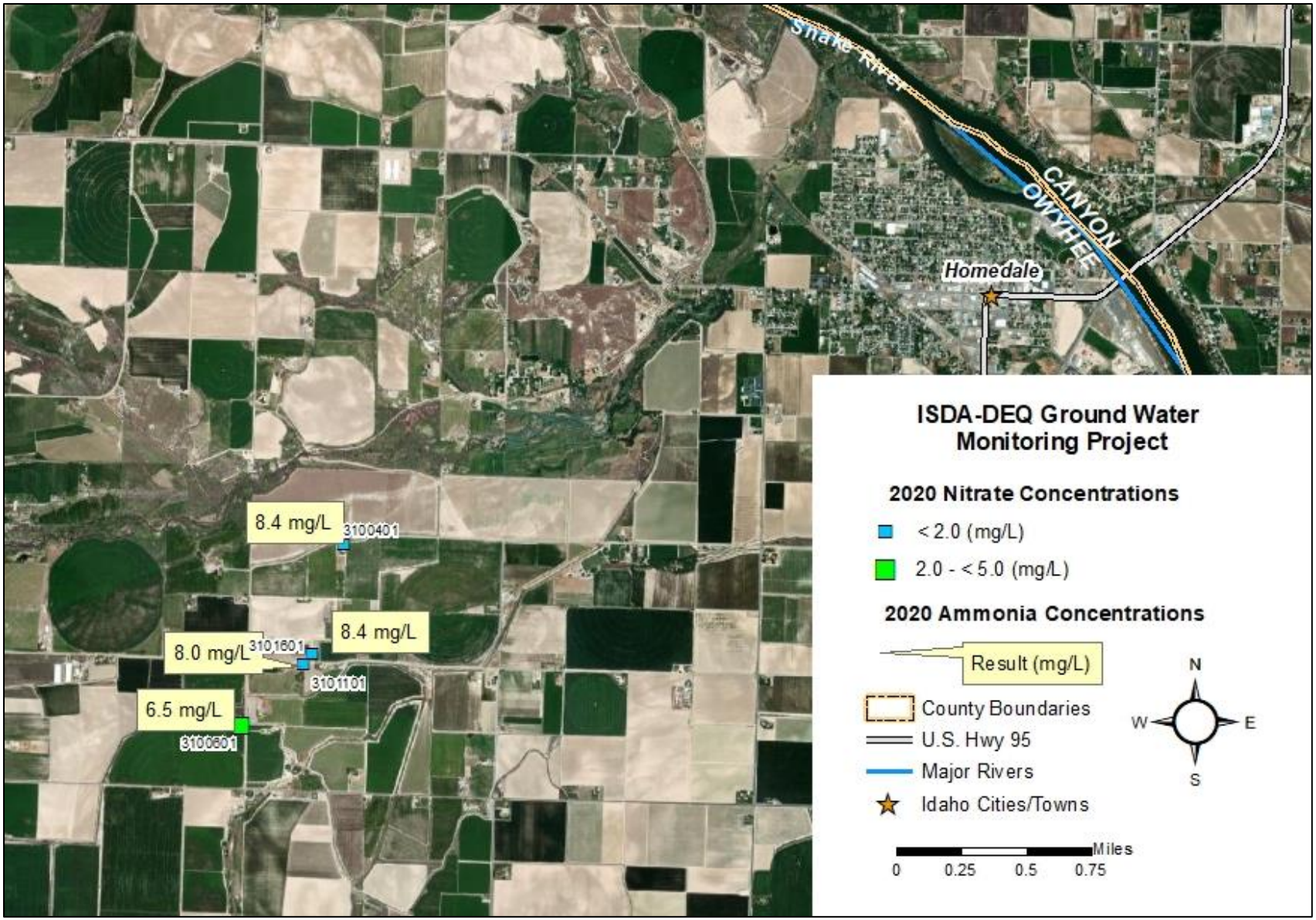


Figure B2. Project 310 (Owyhee County) nitrate concentrations, 2020 ISDA data.

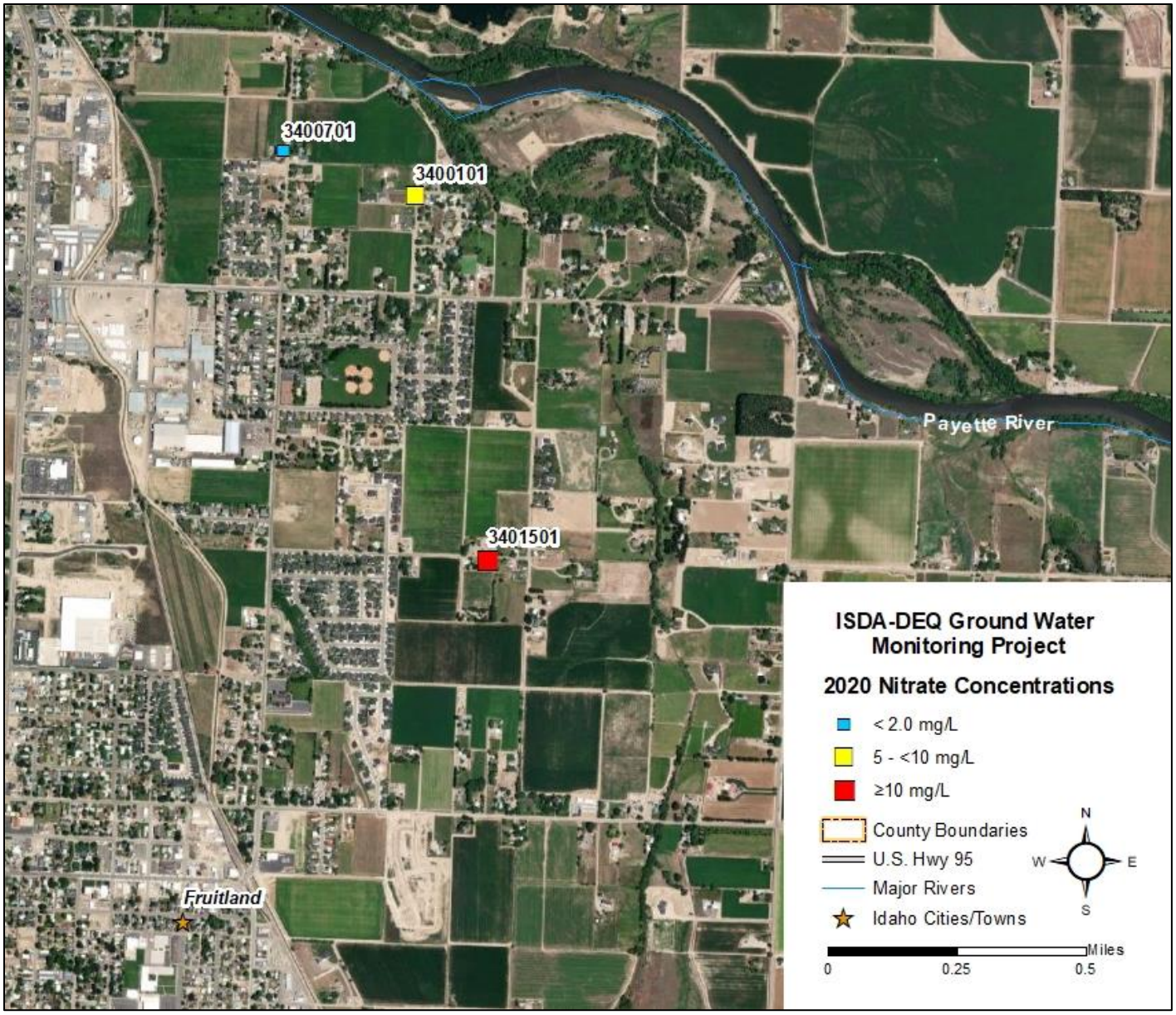


Figure B3. Project 340 (Payette County) nitrate concentrations, 2020 ISDA data.

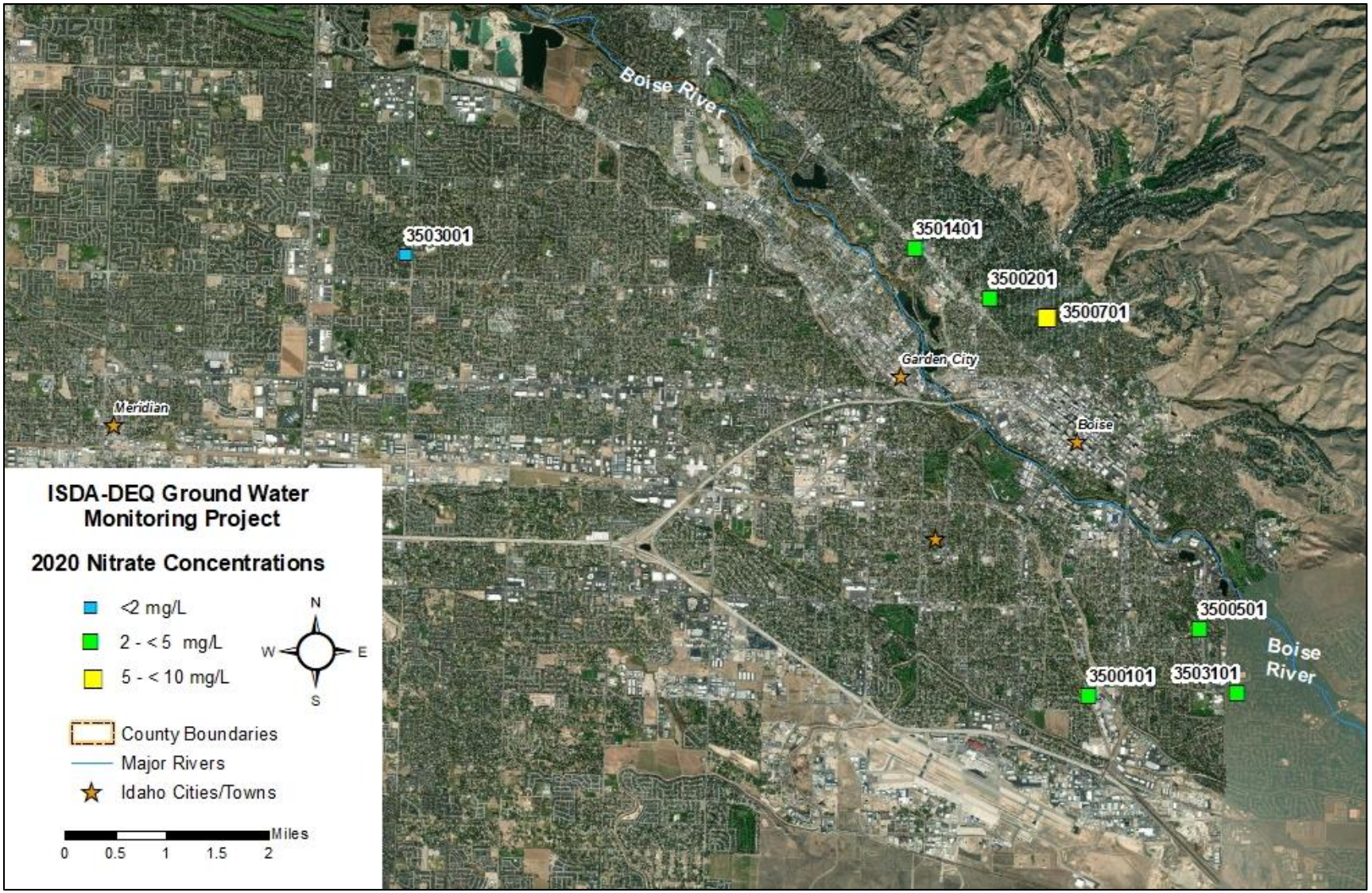


Figure B4. Project 350 (Ada County) nitrate concentrations, 2020 ISDA data.

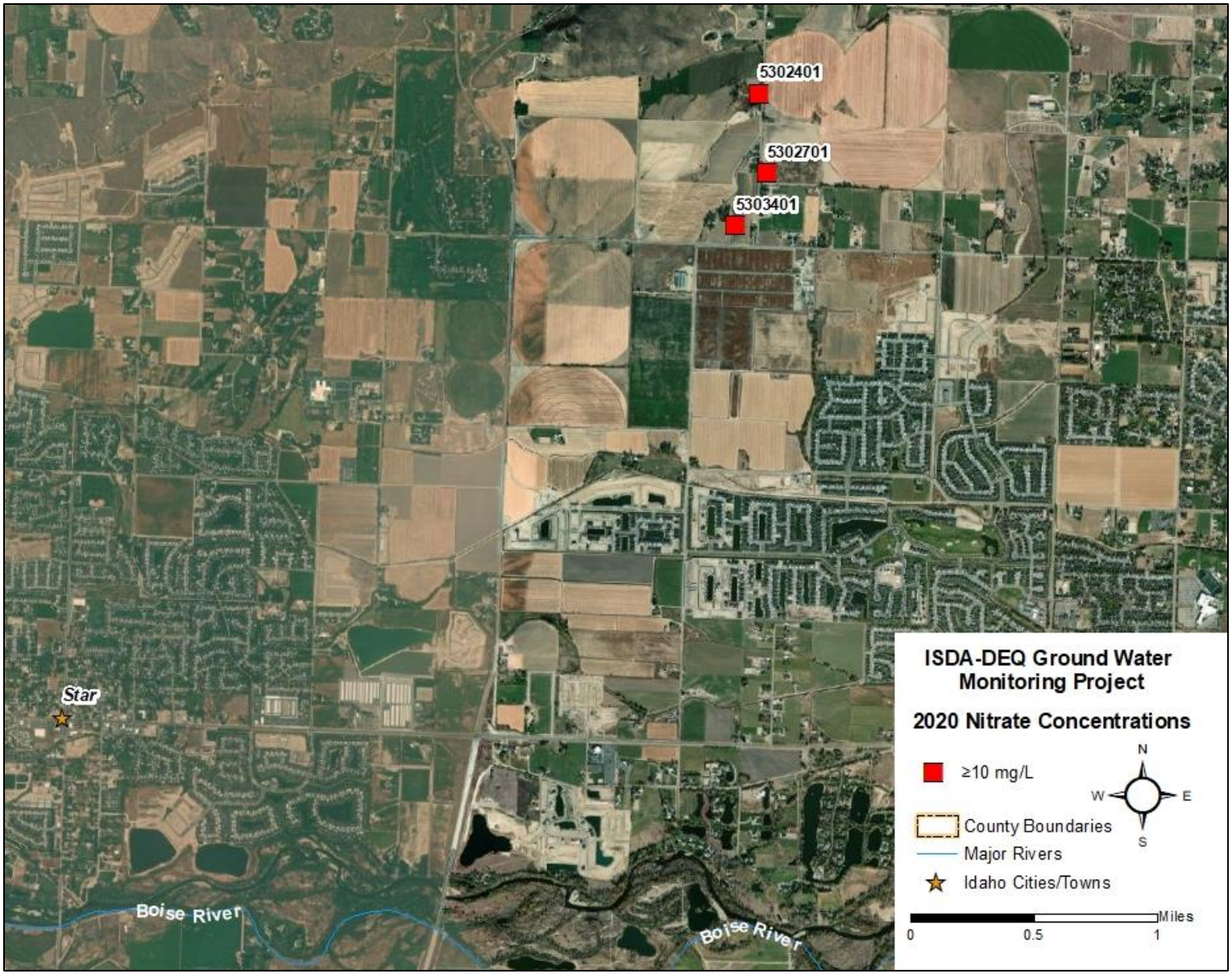


Figure B5. Project 530 (Ada County) nitrate concentrations, 2020 ISDA data.

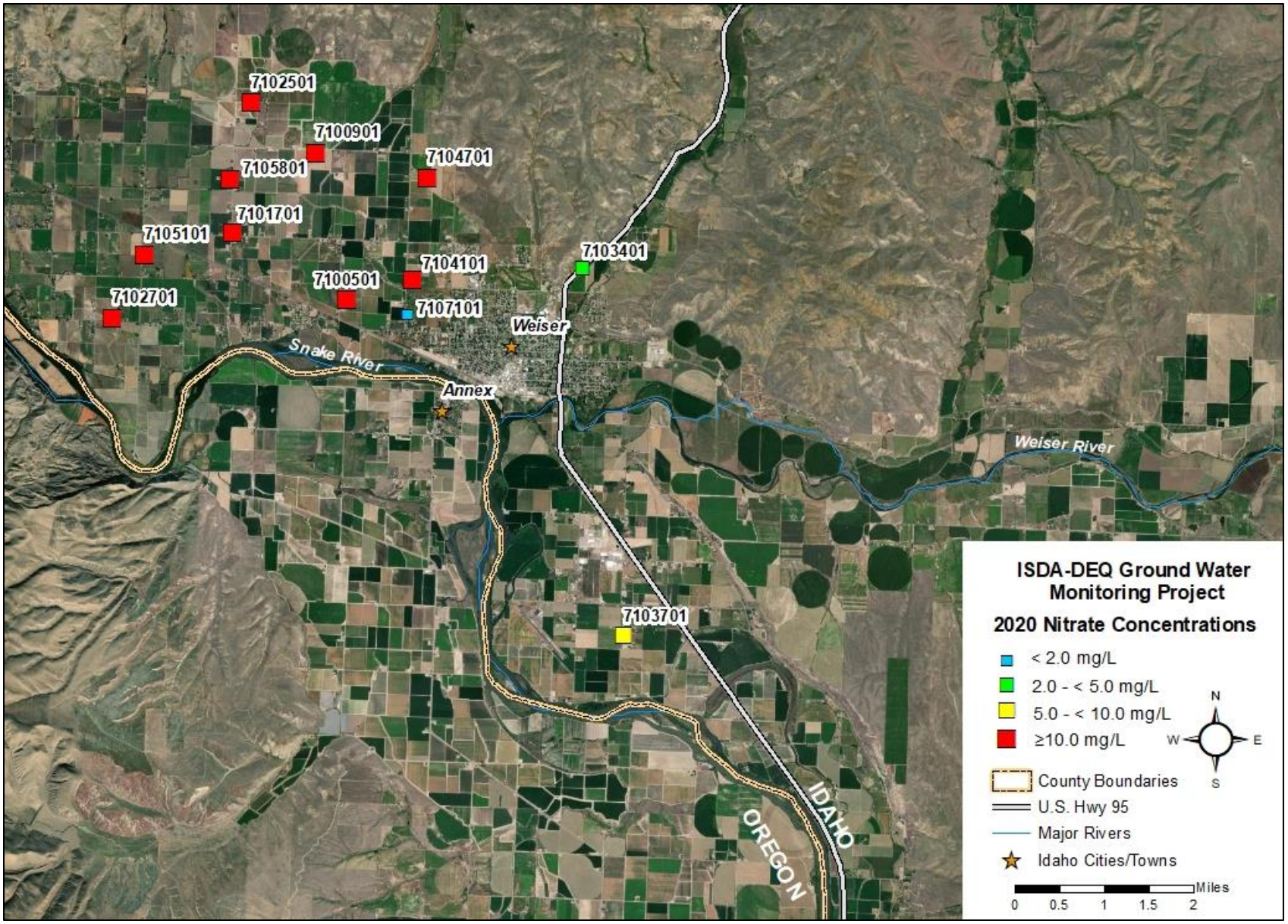


Figure B6. Project 710 (Washington County) nitrate concentrations, 2020 ISDA data.

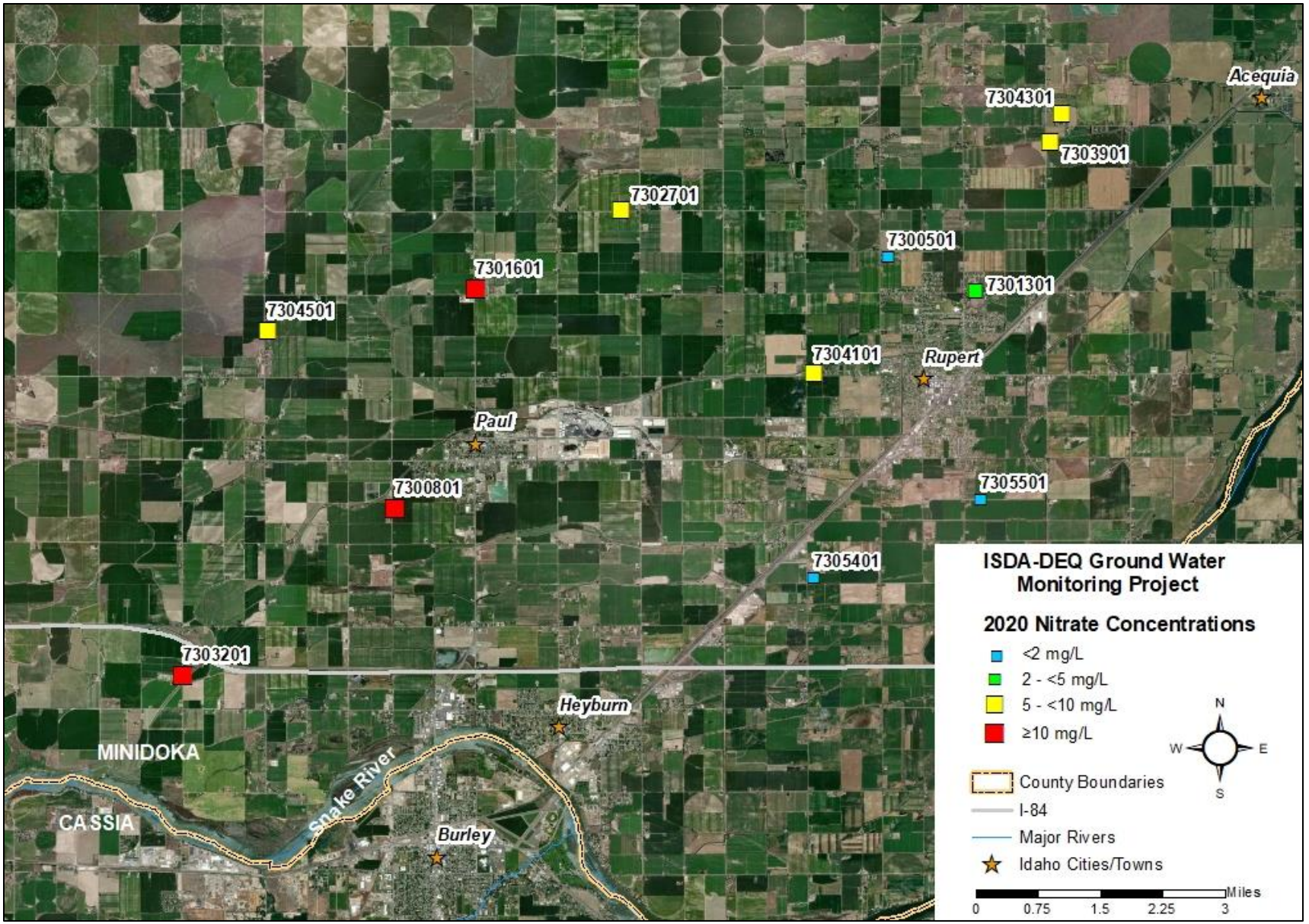


Figure B7. Project 730 (Minidoka County (shallow)) nitrate concentrations, 2020 ISDA data.

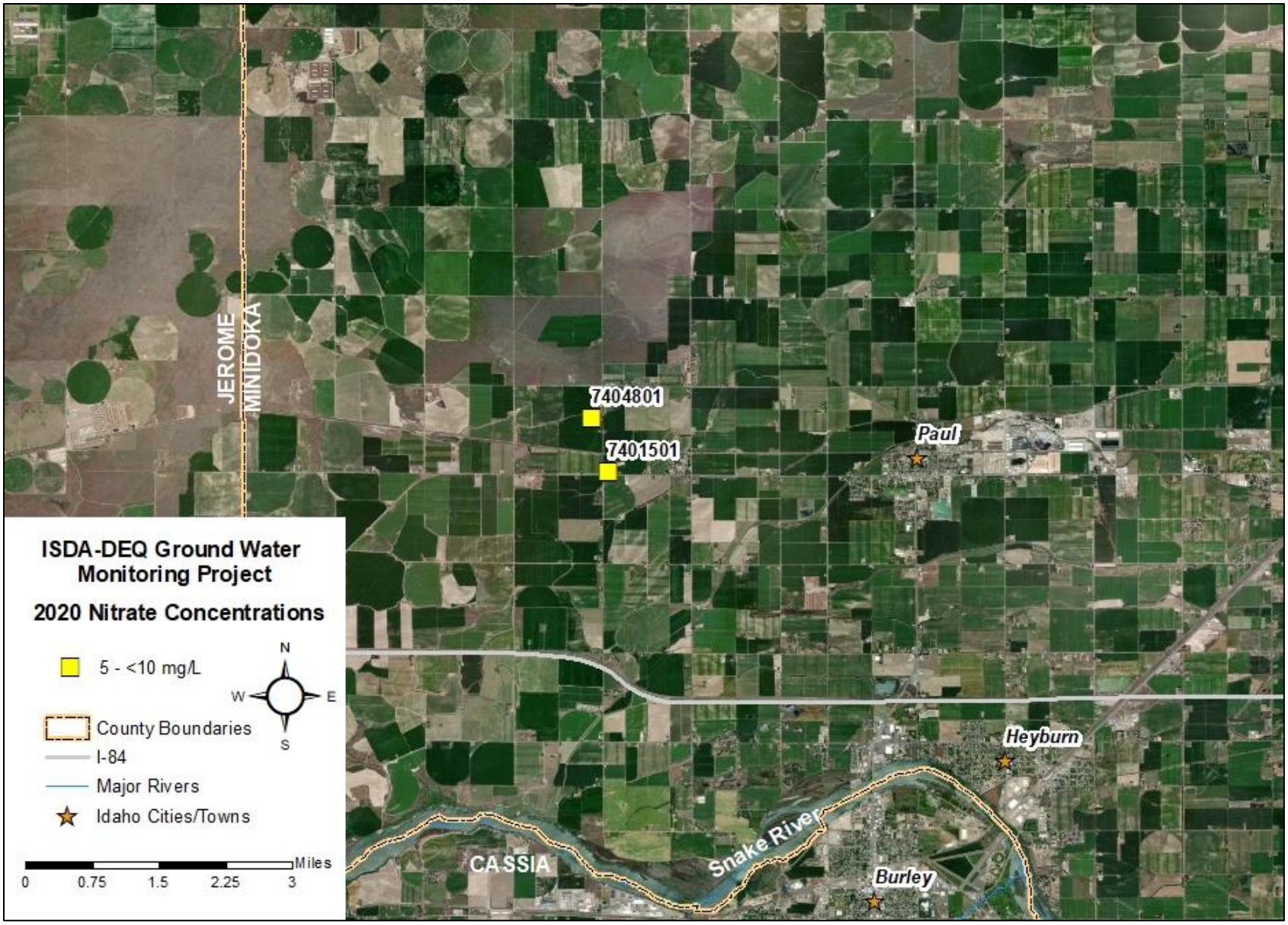


Figure B8. Project 740 (Minidoka County (deep)) nitrate concentrations, 2020 ISDA data.

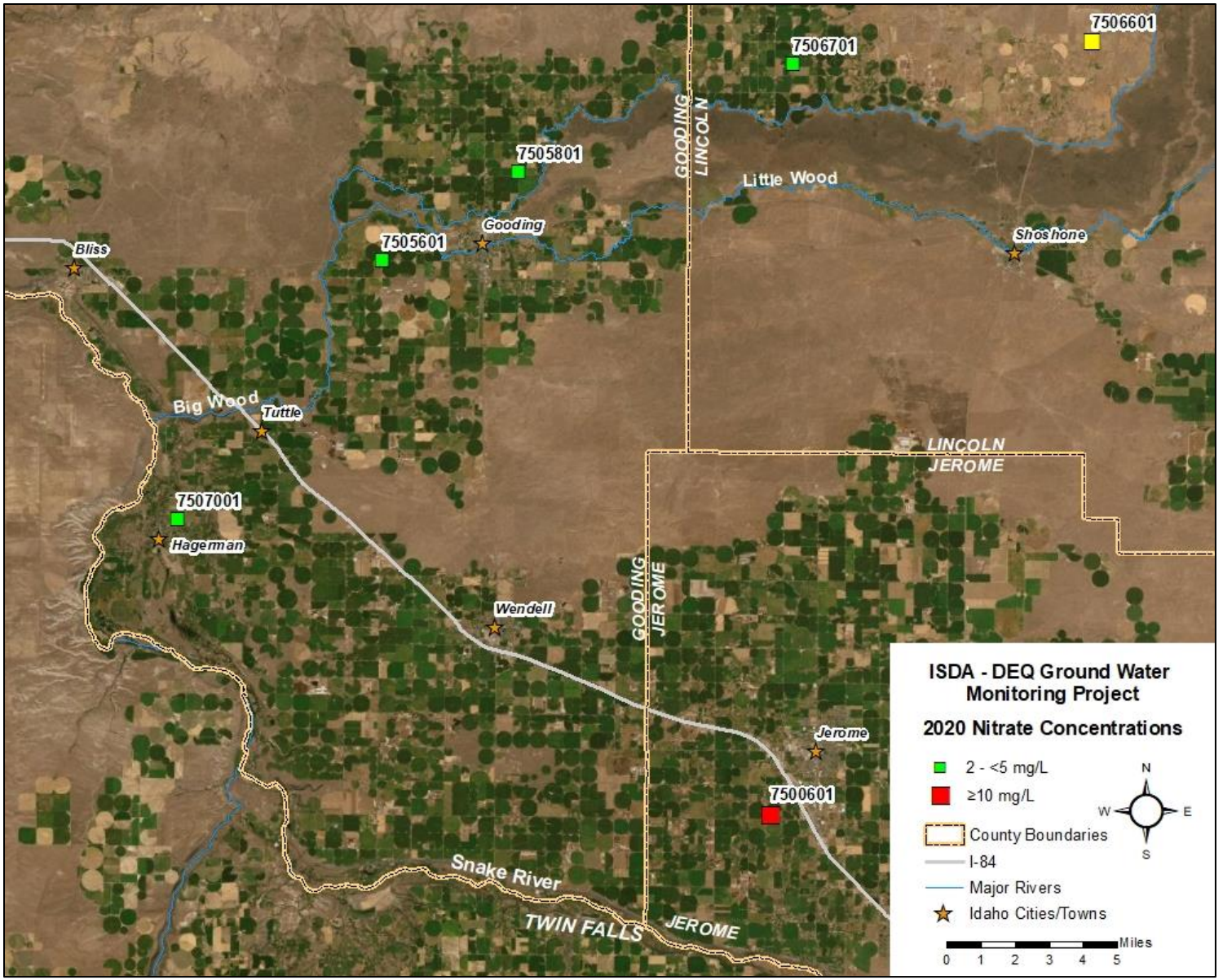


Figure B9. Project 750 (Gooding and Jerome Counties) nitrate concentrations, 2020 ISDA data.

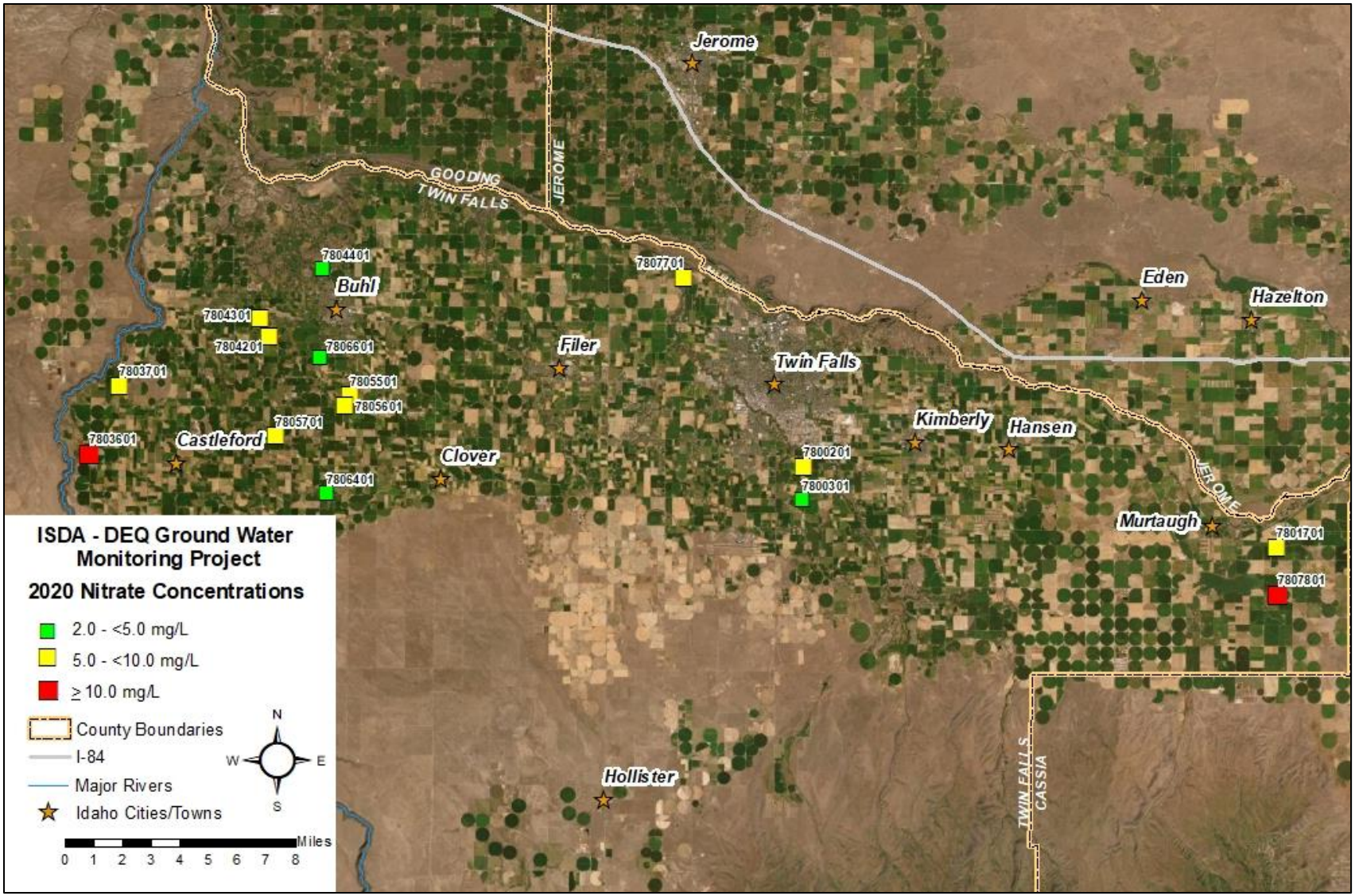


Figure B10. Project 780 (Twin Falls County) nitrate concentrations, 2020 ISDA data.

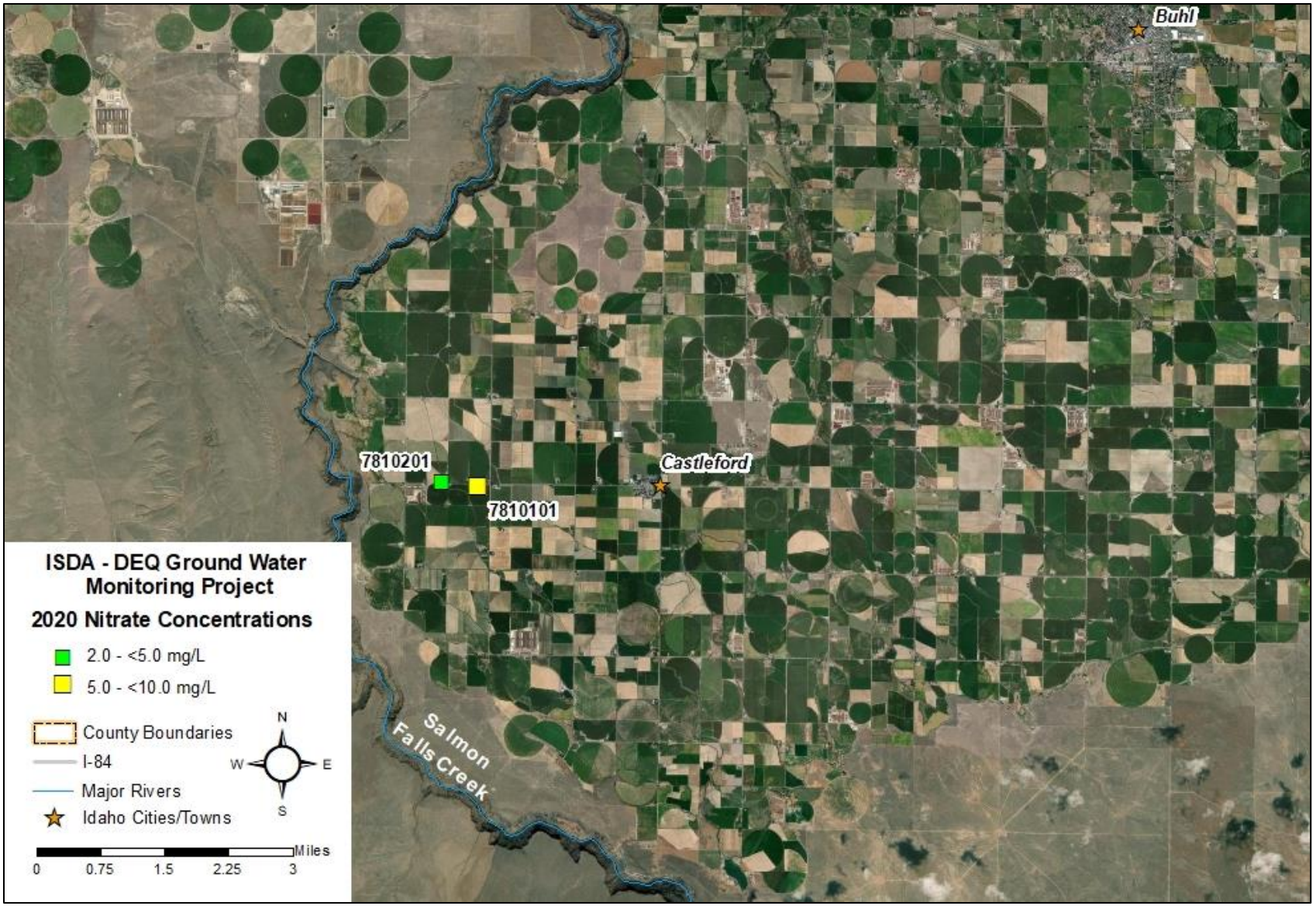


Figure B11. Project 781 (Twin Falls County) nitrate concentrations, 2020 ISDA data.

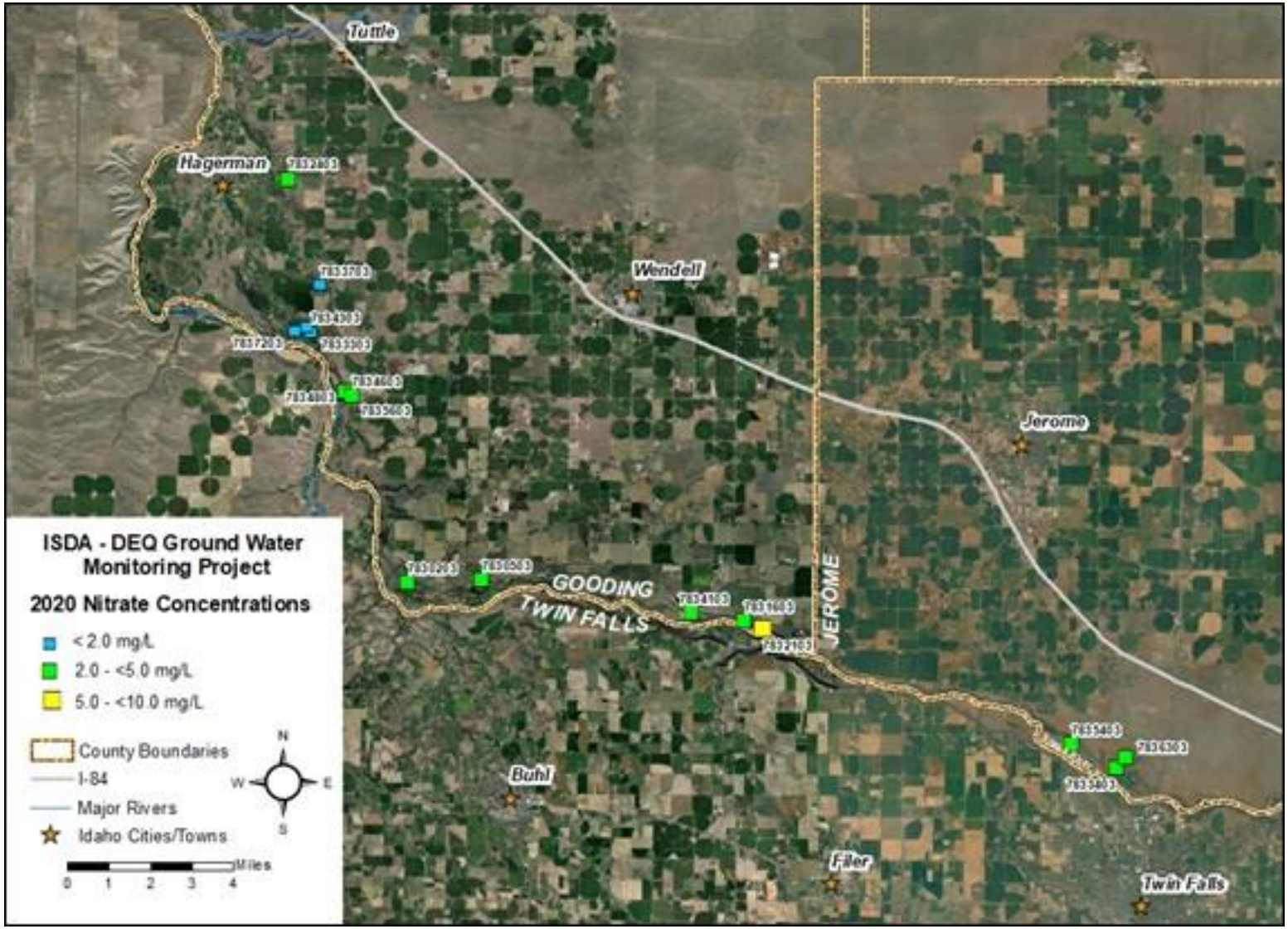


Figure B12. Project 783 (Gooding and Jerome Counties) nitrate concentrations, 2020 ISDA data.

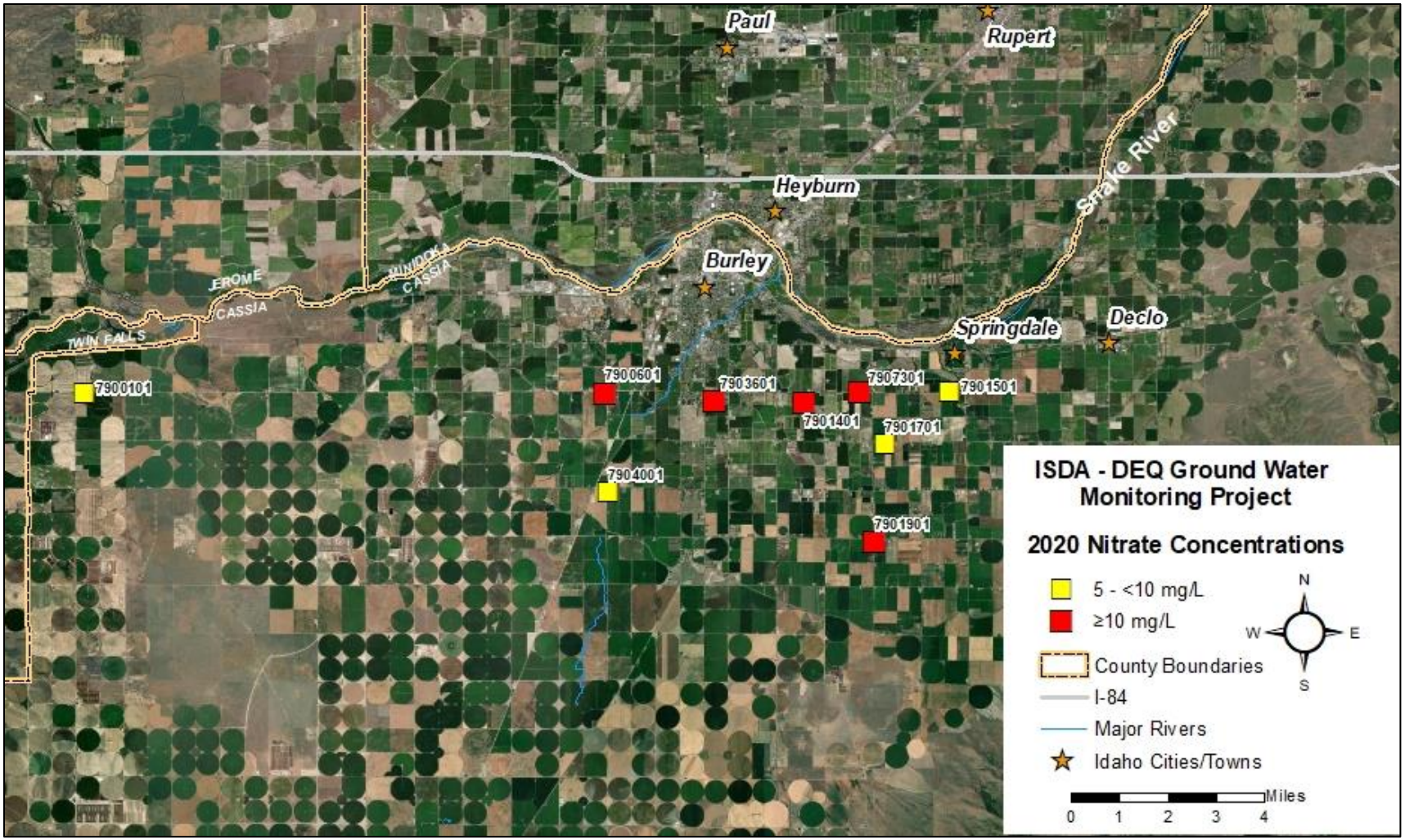


Figure B13. Project 790 (Cassia County) nitrate concentrations, 2020 ISDA data.

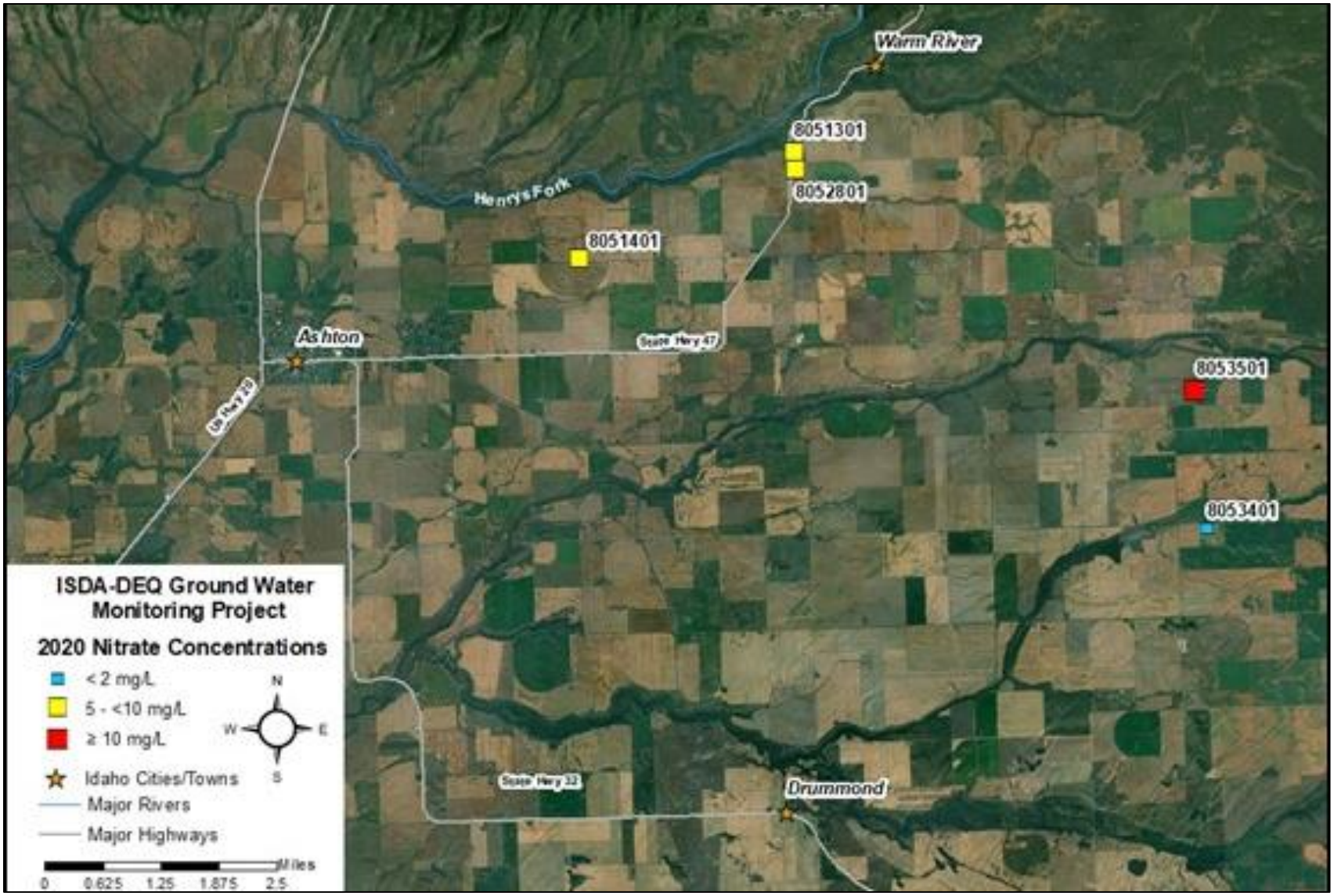


Figure B14. Project 805 (Fremont County) nitrate concentrations, 2020 ISDA data.

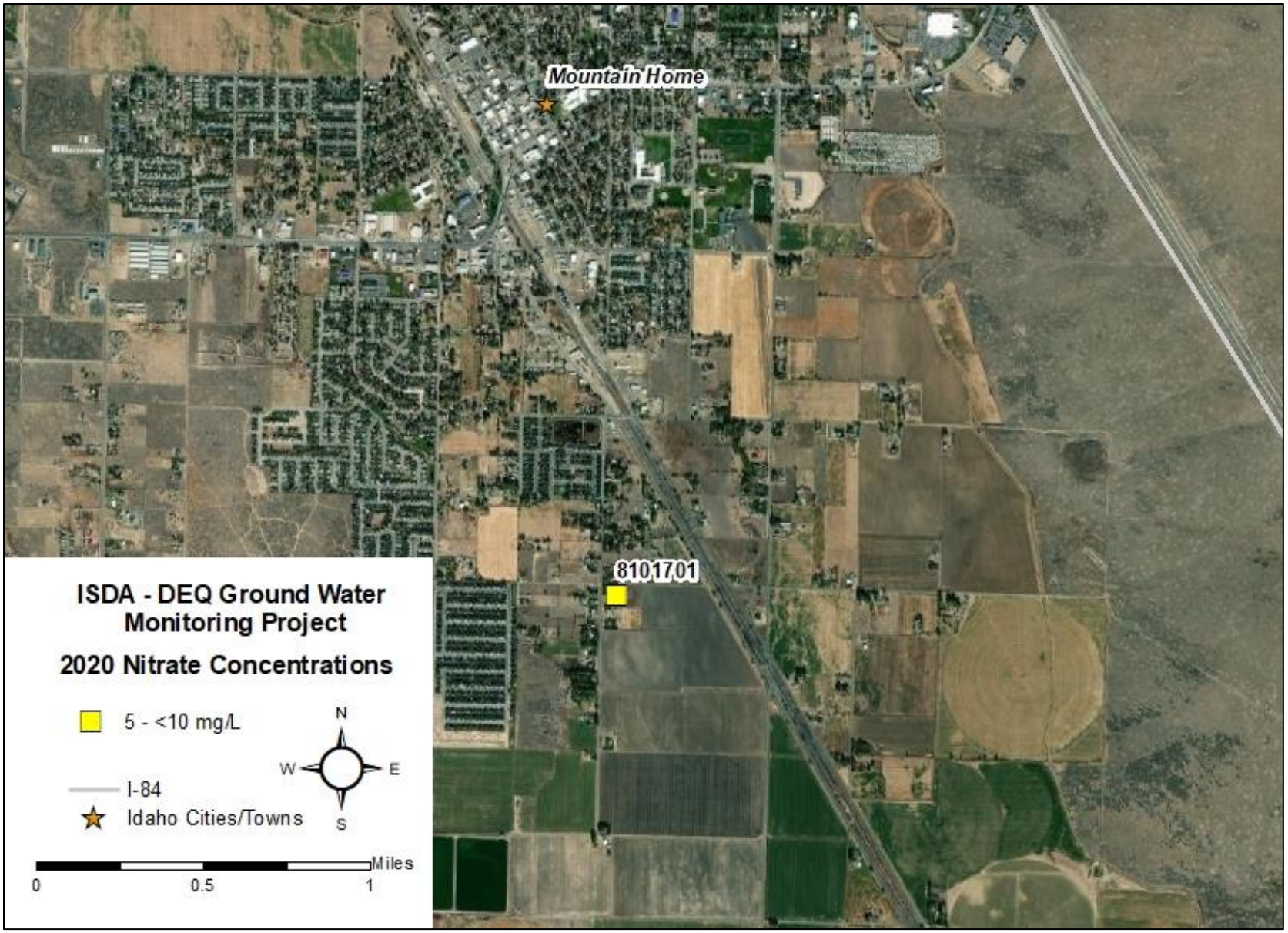


Figure B15. Project 810 (Elmore County) nitrate concentrations, 2020 ISDA data.

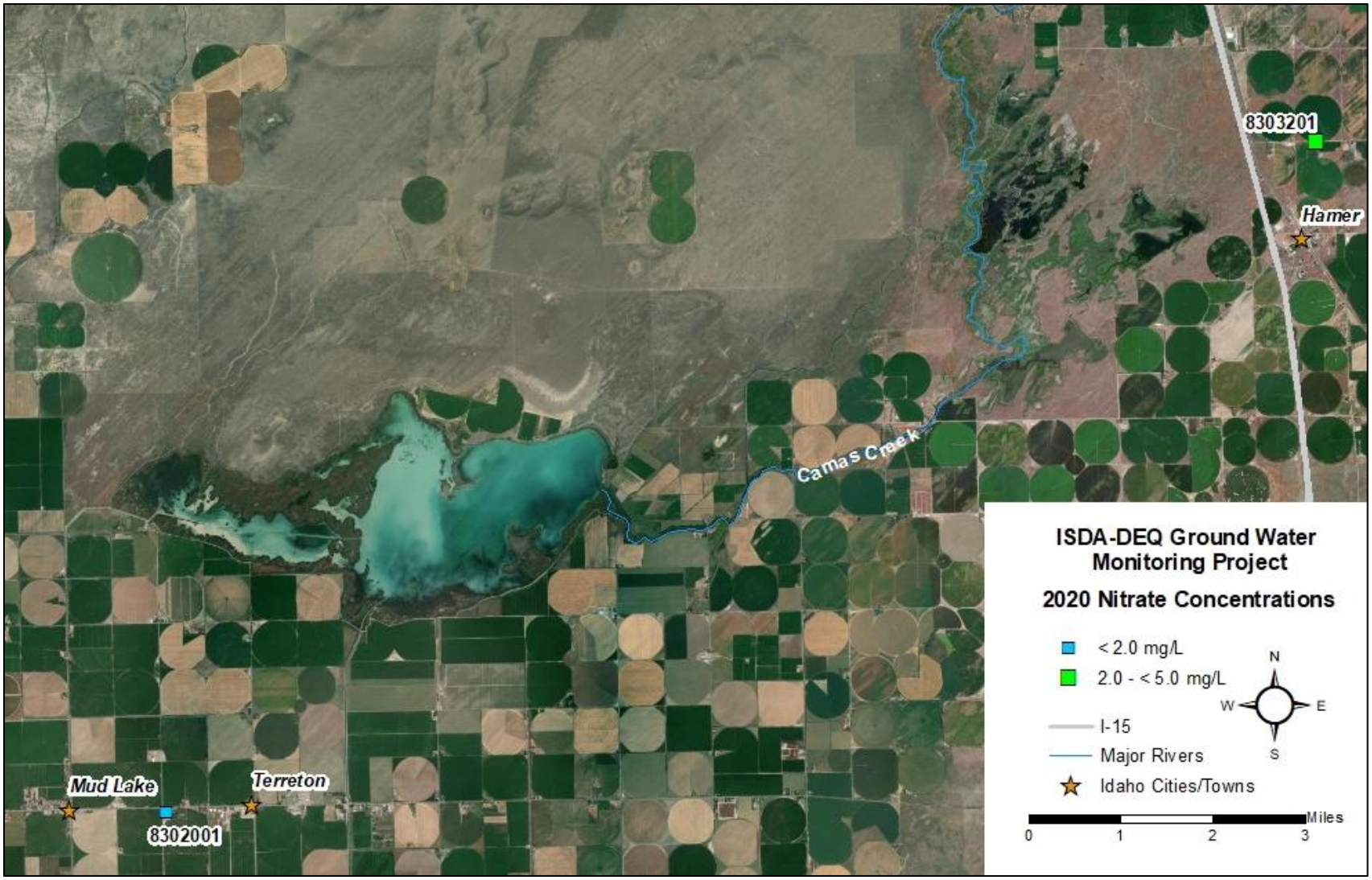


Figure B16. Project 830 (Jefferson County) nitrate concentrations, 2020 ISDA data.

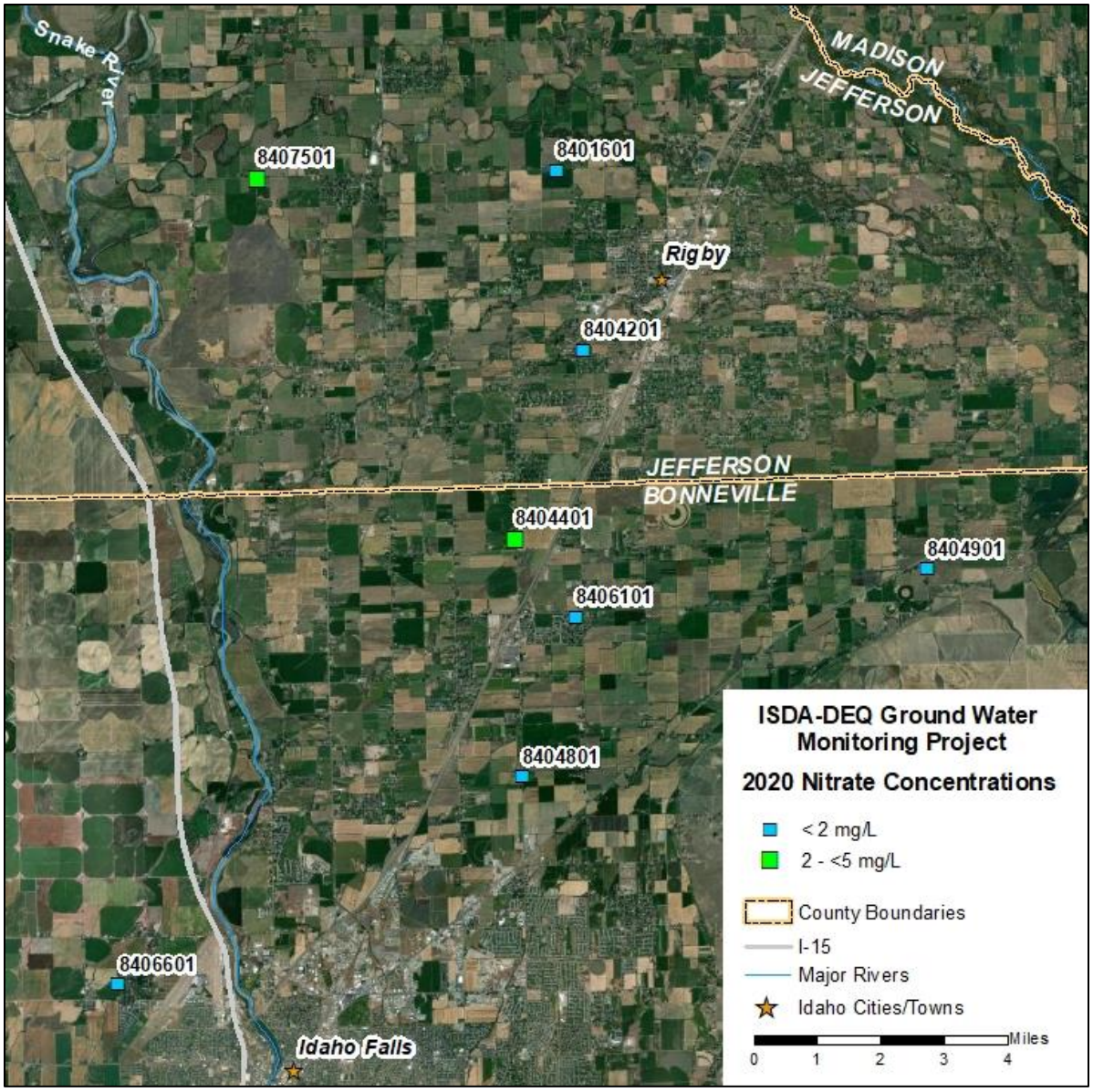


Figure B17. Project 840 (Bonneville, Jefferson, and Madison Counties) nitrate concentrations, 2020 ISDA data.

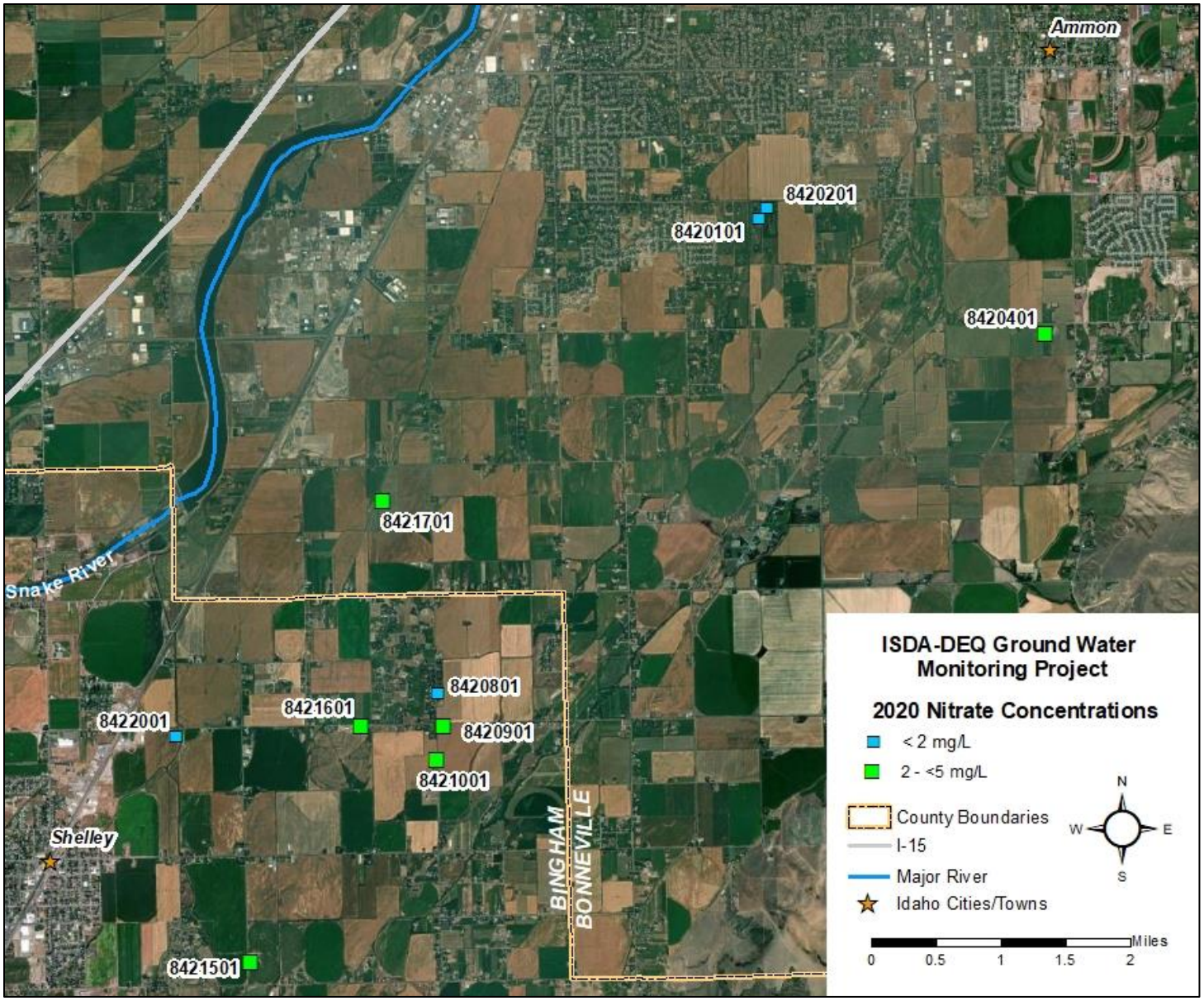


Figure B18. Project 842 (Bingham and Bonneville Counties) nitrate concentrations, 2020 ISDA data.



Figure B19. Project 860 (Owyhee County) nitrate concentrations, 2020 ISDA data.

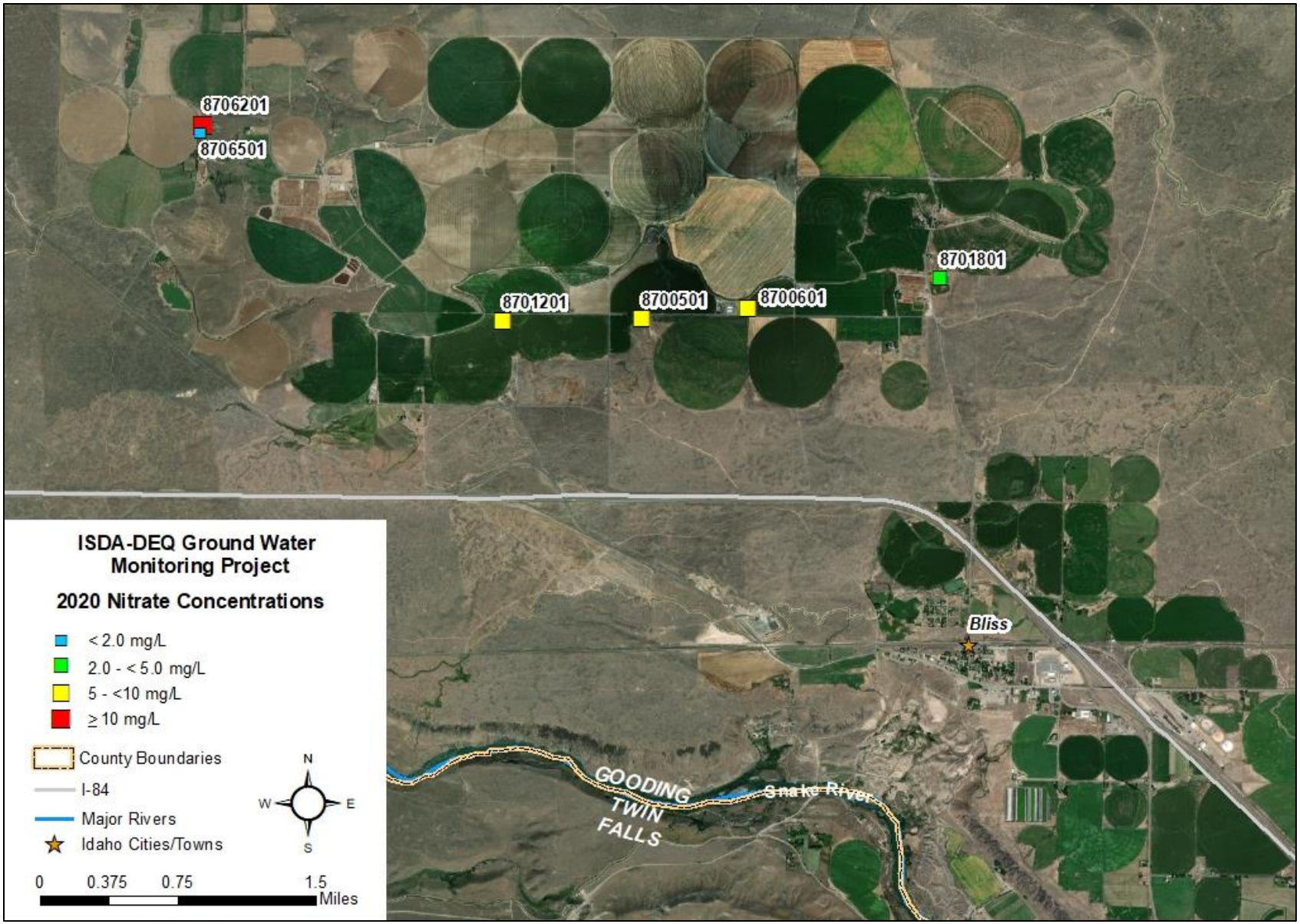


Figure B20. Project 870 (Gooding County) nitrate concentrations, 2020 ISDA data.

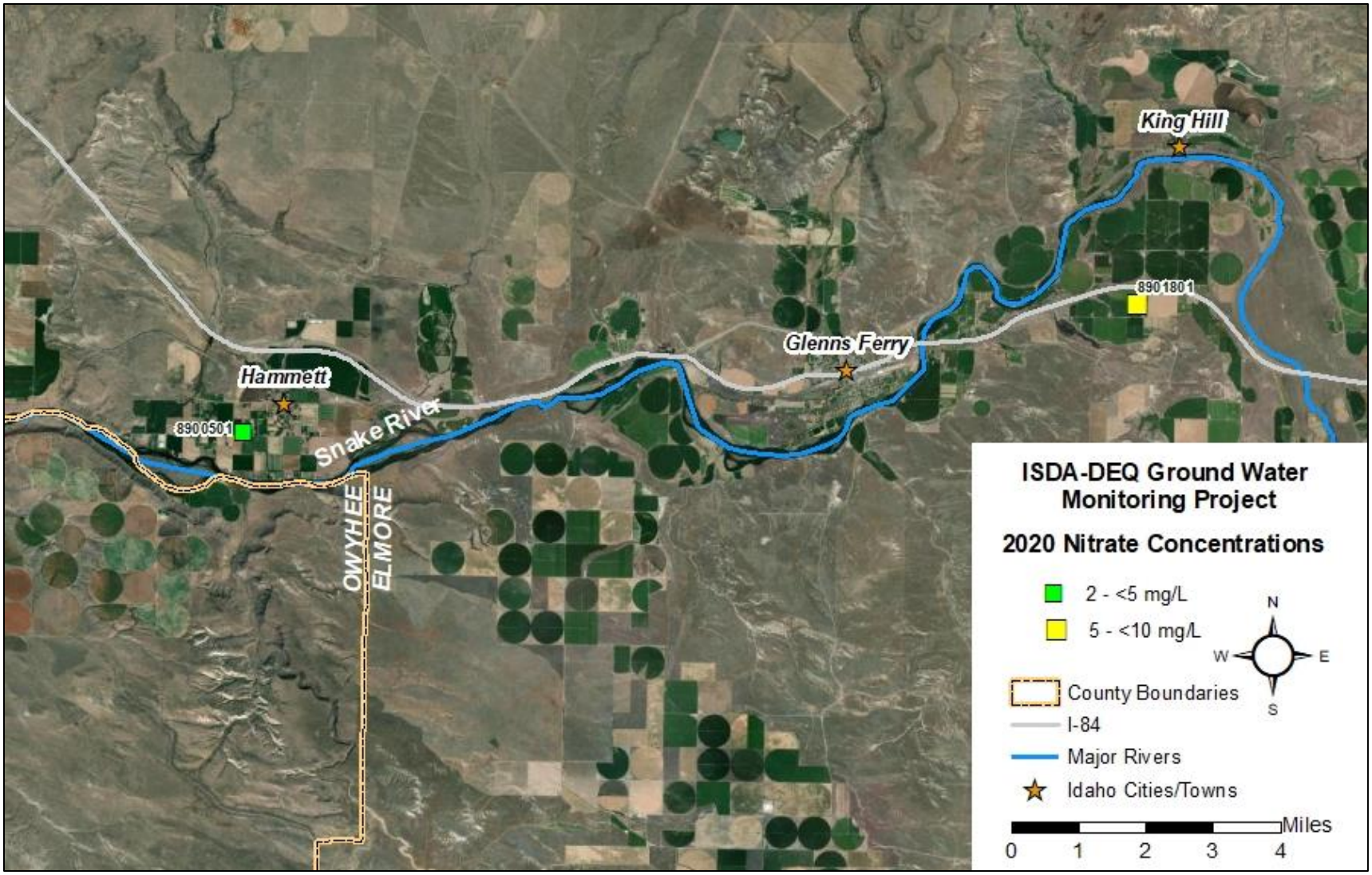


Figure B21. Project 890 (Elmore County) nitrate concentrations, 2020 ISDA data.