



Memo

To: Kathy Moore, Melanie Reynolds

From: James Swierc

CC:

Date: 12/29/15

Re: Raven Road Project and Sampling Results

Project Summary

Upon request from the Montana Department of Environmental Quality (DEQ), the Lewis & Clark Water Quality Protection District (LCWQPD) developed and coordinated a ground (drinking) water sampling project near Raven Road. The goal of the project was to investigate the source of elevated nitrates in shallow ground water detected in a Public Water Supply (PWS) well, and in a residential well sampled as part of a regional study by the Montana Bureau of Mines and Geology (MBMG) in 2010. The PWS is the Last Chance Chapel, a transient non-community system. The project was completed as a cooperative effort with students and faculty from the Environmental Studies program at Carroll College. Well sampling was completed by students, faculty and LCWQPD staff. Funding for laboratory analyses was provided by both LCWQPD and DEQ. The results were presented by Carroll College students at a college student research forum, and at the Montana Environmental Health Association (MEHA) conference in September 2015.

The project included two sampling events, with 16 wells sampled in March 2015, followed by resampling of 8 of the wells in September 2015. Landowner permission was not obtained for the 8 wells which were not resampled in the September event. The study results are consistent with regional data showing that arsenic is present in shallow ground water in bedrock areas at concentrations exceeding the state and federal drinking water standards of 10 ug/L. The study also indicated that manure piles from livestock and/or chickens represent significant local sources of nitrate to ground water. However, the study results support the conclusion that the nitrate source for the PWS well is the septic system at the facility.

Introduction

The Raven Road area is located approximately 8 miles northeast of Helena, in an upland area on the western side of the Scratchgravel Hills as shown in Figure 1. The area is located on a local drainage divide between the Threemile and Sevenmile Creek drainages. Water quality concerns were initially identified in 2010, with results from the single well sampled in this area showing elevated arsenic and nitrate above state and federal drinking water standards. Additionally, routine monitoring of water quality for a small, transient non-community PWS, the Last Chance Chapel, showed elevated nitrate above the drinking water standard in several samples. The sampling program was developed with a goal to identify the nitrate source for the PWS .

The project was developed with staff input from the Montana DEQ Source Water Protection and Public Water Supply programs, faculty with the Environmental Studies Program at Carroll College, and LCWQPD staff. The project was implemented with sampling conducted by Carroll College students with assistance from faculty and LCWQPD staff. Sampling was conducted following protocols outlined in the quality assurance documents for the Helena Ground Water Project and Helena Valley Non-Point Source Assessment Project; two recently completed LCWQPD grant funded projects which included ground water sampling components. Consistent with these projects, laboratory analyses of ground water samples was completed at Energy Laboratories, in Helena, Montana. Samples were managed by LCWQPD staff after collection, and hand delivered to the laboratory with proper chain of custody procedures.

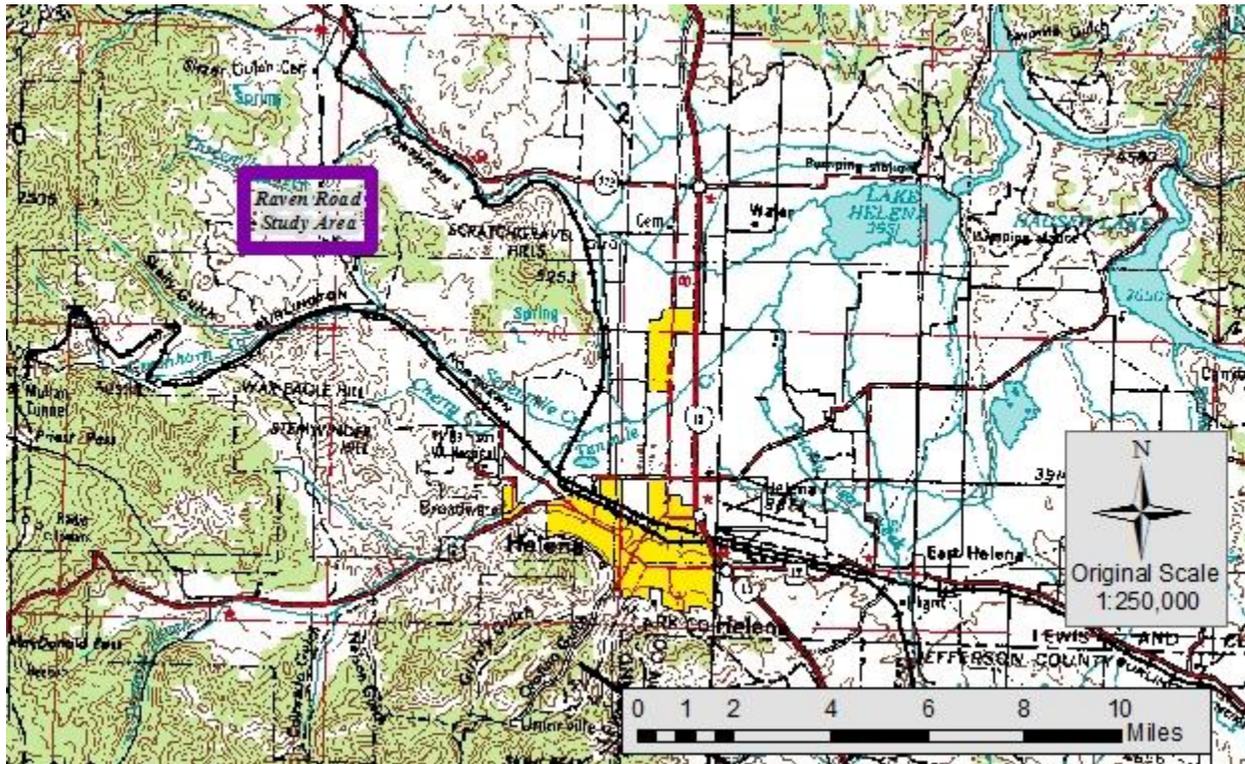


Figure 1 – Location Map for Raven Road Project

Project located in unincorporated Lewis & Clark County, within the Lewis & Clark Water Quality Protection District.

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Hydrogeologic Assessment – Aquifer and Ground Water Flow

The area is mapped by MBMG as predominantly argillite shale and limestone bedrock, with little alluvial cover over the bedrock, as depicted in Figure 2. The topography and subsurface geology is depicted in the East-West cross section through the area, prepared by Carroll College students from area well logs (Figure 3). Regionally, the geologic map shows both intrusive and extrusive igneous volcanic rocks. The volcanic rocks are linked to elevated levels of both arsenic and uranium in ground water in the Helena region. In addition, mineralization from the volcanics in the bedrock resulted in the metal deposits historically mined across the region. Elevated arsenic in ground water has also been linked to metal mining. The mines also indicate a potential for other trace metals to be present in ground water.

The water levels for the study area from the March 2015 sampling event are listed in Table 1. The data show shallow ground water in the southern area adjacent to Park Creek along Lone Pine Road, with varying water levels at other locations. Using surface elevations obtained from the USGS topographic map for the area, a general ground water flow map of the local water table surface was prepared as shown in Figure 4. The ground water flow map shows a general eastward flow direction, following topography, for the study area. The eastern part of the area, along Red Wing Road, is located along the drainage divide where flow will diverge to both the north and the south following topography.

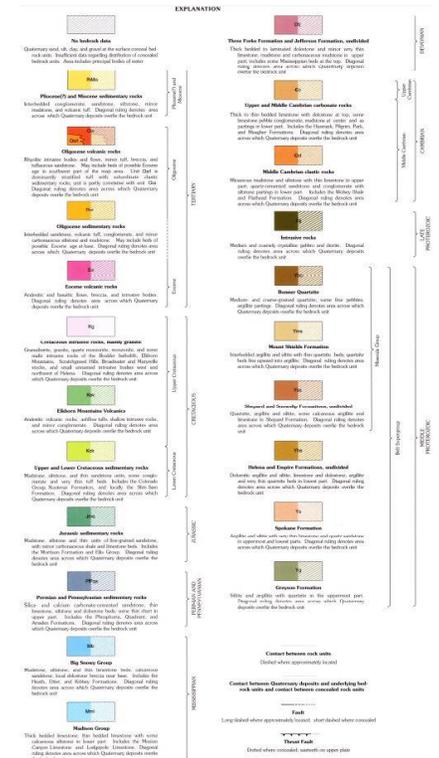
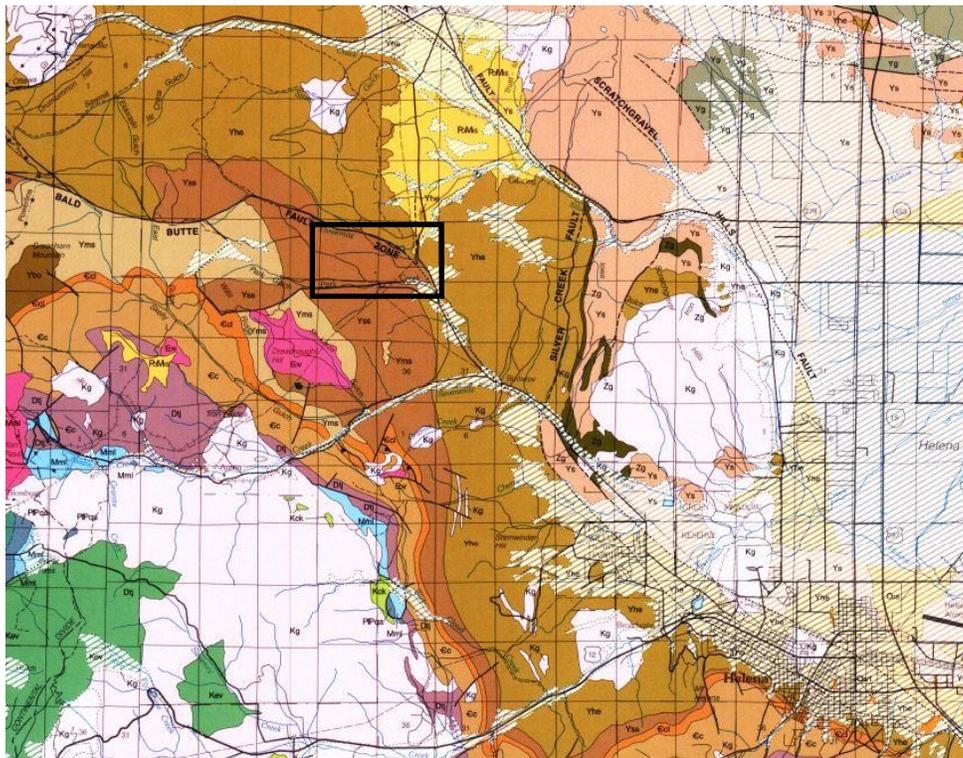


Figure 2 – Geologic Map for Raven Road Project

Geology of the Helena area from USGS Report on Bedrock Hydrogeology of Helena Area. Raven Road study area noted with rectangle. Reader is referenced to Thamke (2000) for more information on geology. Note two faults with east-west trend, converging to single southeast trending fault across study area.

Table 1 – Water Levels in Wells Samples for Project

Address	Date	Water Level (ft)
5984 Red Wing	24-Mar-15	74.32
6040 Red Wing	23-Mar-15	89.22
6012 Eagle Ridge	24-Mar-15	47.45
5690 Birdseye Road	20-Mar-15	81
5697 Birdseye Road	23-Mar-15	61.62
6230 Lone Pine	20-Mar-15	5.34
6410 Lone Pine	20-Mar-15	12.57
6112 Raven Road	20-Mar-15	67.04
6179 Raven Road	24-Mar-15	93.91
6181 Raven Road	24-Mar-15	94.46
6199 Raven Road	19-Mar-15	102.86
6205 Raven Road	19-Mar-15	59.06
6240 Raven Road	20-Mar-15	77.86
6315 Raven Road	19-Mar-15	41.4
6335 Raven Road	20-Mar-15	--
6430 Raven Road	20-Mar-15	65.66

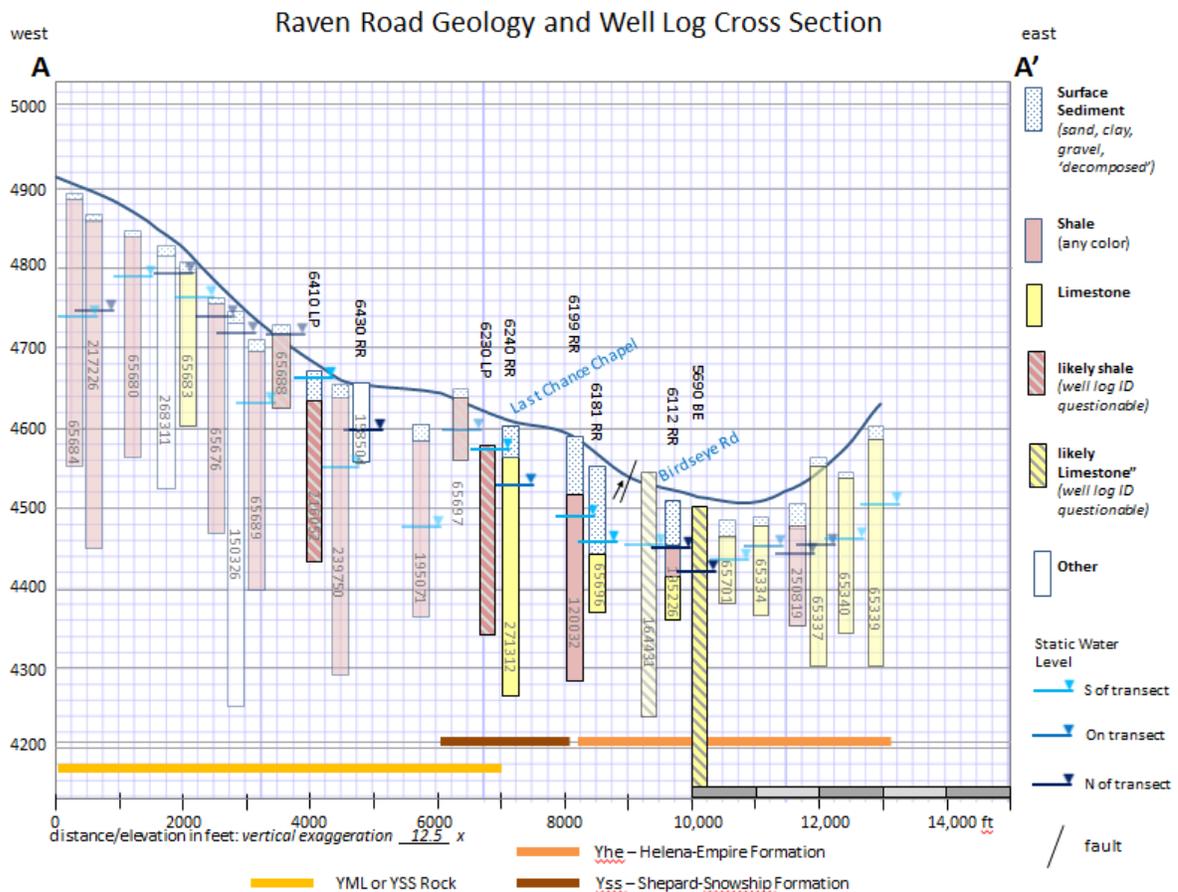


Figure 3 – East-West Geologic Cross Section

Cross section showing the geology of the area from available well logs through MBMG. The depth to water is shown, as well as the thickness of the alluvial cover. In the downgradient area, water levels are predominantly in the bedrock demonstrating that the alluvium does not represent a significant local aquifer.

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Table 2 – Water Quality Laboratory Results, Raven Road Project

Collection Date	pH S.U.	temp C	specific conductivity us/cm	Dissolved Oxygen mg/L	Solids, Total Dissolved TDS @ 180 C mg/L	Alkalinity, Total as CaCO3 mg/L	Bicarbonate as HCO3 mg/L	Cl mg/L	SO4 mg/L	Br mg/L	Hardness as CaCO3 mg/L	NO3+ NO2 as N mg/L	N- Total mg/L	Phosphorus, Total as P mg/L	As mg/L	Ca mg/L	Fe mg/L	Mg mg/L	K mg/L	Na mg/L	U mg/L	
																						<i>(secondary standards in italics)</i>
Drinking Water Standard																						
<i>(secondary standards in italics)</i>																						
500																						
<i>250 250</i>																						
10																						
<i>0.010 0.30</i>																						
0.030																						
Red Wing Road																						
5984 Red Wing	24-Mar-15	7.49	9.1	745	8.55	706	180	230	130	179	0.19	476	3.94	4.4	0.001	0.004	102	< 0.03	54	2	39	0.006
6040 Red Wing	23-Mar-15	7.33	9.7	1124	5.72	1100	180	220	210	357	0.3		9.54	9.7	0.013	0.007	142	< 0.03	88	3	68	0.0063
6040 Red Wing	10-Sep-15	6.77	10.1	1108	14.83	1190	180	220	200	337	0.25	677	11.8	12.8	0.004	0.007	130	< 0.03	86	3	67	0.0063
Eagle Ridge Road																						
6012 Eagle Ridge	24-Mar-15	7.31	8.7	535	6.19	493	270	330	37	79	< 0.015	378	3.51	3.7	0.019	0.002	87	< 0.03	39	3	20	0.0023
Birdseye Road																						
5690 Birdseye Road	20-Mar-15	7.39	10.3	1002	2.42	972	220	260	151	324	0.2		1.15	1.25	0.046	0.069	151	< 0.03	28	2	124	0.024
5690 Birdseye Road	11-Sep-15	7.32	10.7	990	5.89	980	150	180	147	373	0.05	472	1.22	1.38	0.006	0.031	152	< 0.03	23	2	108	0.0139
5697 Birdseye Road	23-Mar-15	7.39	9	501	8.29	452	220	270	45	88	0.036		2.91	2.96	0.016	0.004	74	< 0.03	41	2	19	0.0029
Lone Pine Road																						
6230 Lone Pine	20-Mar-15	7.18	7.8	336	1.42	296	240	290	7	22	0.028	240	0.61	0.67	0.073	0.006	52	< 0.03	27	3	11	0.0023
6410 Lone Pine	20-Mar-15	7.06	9.5	1689	3.07	2210	250	310	135	1160	< 0.015	1350	< 0.01	< 0.04	< 0.001	0.010	289	1.63	153	3	89	0.0115
6410 Lone Pine	11-Sep-15	7.09	9.7	1724	5.88	2150	260	310	155	1070	< 0.015	1320	< 0.01	0.09	< 0.001	0.004	285	0.39	148	3	89	0.0123
Raven Road																						
6112 Raven Road	20-Mar-15	7.56	9.5	677	2.77	693	180	220	78	256	0.32	381	0.24	0.27	0.014	0.017	68	0.1	51	4	65	0.0011
6179 Raven Road	24-Mar-15	7.47	9.7	655	0.22	517	230	280	36	232	0.14	412	< 0.01	< 0.04	0.017	0.032	86	0.39	48	2	47	0.0012
6181 Raven Road	24-Mar-15	7.3	18.1	888	6.47	655	320	380	42	71	0.07	297	1.33	2.34	0.019	0.008	62	< 0.03	35	2	66	0.0164
6181 Raven Road	11-Sep-15	7.33	10.1	635	5.16	650	230	280	33	213	0.08	385	< 0.01	< 0.04	0.006	0.029	79	0.17	46	2	46	0.0012
6199 Raven Road	19-Mar-15	7.43	10.6	506	0.18	464	210	250	23	136	0.09	281	< 0.01	< 0.04	0.013	0.009	59	0.28	33	2	43	< 0.0001
6205 Raven Road	19-Mar-15	7.38	9.6	463	0.3	390	230	280	24	79	0.06	198	< 0.01	< 0.04	0.01	0.077	39	< 0.03	25	2	70	0.015
6240 Raven Road	20-Mar-15	7.59	10.8	469	0.79	417	170	210	32	99	0.09		2.31	2.25	0.007	0.025	47	< 0.03	18	2	68	0.0056
6240 Raven Road	10-Sep-15	7.37	10.7	450	5.98	434	180	220	27	91	0.06	180	1.14	< 0.04	0.004	0.023	45	< 0.03	16	2	65	0.0028
6315 Raven Road	19-Mar-15	7.34	9.3	977	9.29	930	290	350	88	89	0.038	462	46.7	59	0.016	0.030	79	< 0.03	65	3	106	0.0288
6315 Raven Road	11-Sep-15	7.38	9.3	990	12.72	1010	290	360	93	93	< 0.015	507	53.8	59	0.006	0.030	87	< 0.03	71	3	105	0.0288
6335 Raven Road	20-Mar-15	7.51	9.1	666	6.26	587	330	400	40	63	0.022	344	18.1	19.9	0.013	0.017	64	< 0.03	45	4	72	0.04
6335 Raven Road	10-Sep-15	7.3	9.6	656	10.43	608	300	370	38	66	< 0.015	343	19.3	< 10	0.004	0.015	66	< 0.03	43	4	71	0.034
6430 Raven Road	20-Mar-15	7.66	9.2	354	2.34	325	170	210	12	58	0.017	147	2.6	1.55	0.016	0.053	35	< 0.03	14	1	51	0.002
6430 Raven Road	10-Sep-15	7.8	9.5	330	12.79	323	160	200	11	55	< 0.015	130	0.78	0.5	0.005	0.049	34	< 0.03	11	1	54	0.001

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Table 3 – Major Ion Milli-Equivalents and Percentages, Raven Road Project

	Collection Date	Milli-equivalents											Percentages							
		Na	K	Ca	Mg	Fe	Cl	HCO3	SO4	CO3	NO3	PO4	Sum Cations	Sum Anions	Na+K	Ca	Mg	Cl	HCO3	SO4
Red Wing Road																				
5984 Red Wing	24-Mar-15	1.70	0.06	5.09	4.44	0.00	3.67	3.77	3.73	0.00	0.28	0.00	11.29	11.16	0.16	0.45	0.39	0.33	0.34	0.33
6040 Red Wing	23-Mar-15	2.96	0.09	7.08	7.24	0.00	5.92	3.61	7.43	0.00	0.68	0.00	17.38	16.96	0.18	0.41	0.42	0.35	0.21	0.44
6040 Red Wing	10-Sep-15	2.91	0.09	6.49	7.08	0.00	5.64	3.61	7.02	0.00	0.84	0.00	16.57	16.26	0.18	0.39	0.43	0.35	0.22	0.43
Eagle Ridge Road																				
6012 Eagle Ridge	24-Mar-15	0.87	0.09	4.34	3.21	0.00	1.04	5.41	1.64	0.00	0.25	0.00	8.51	8.10	0.11	0.51	0.38	0.13	0.67	0.20
Birdseye Road																				
5690 Birdseye Road	20-Mar-15	5.39	0.06	7.53	2.30	0.00	4.26	4.26	6.75	0.00	0.08	0.00	15.29	15.26	0.36	0.49	0.15	0.28	0.28	0.44
5690 Birdseye Road	11-Sep-15	4.70	0.06	7.58	1.89	0.00	4.14	2.95	7.77	0.00	0.09	0.00	14.24	14.86	0.33	0.53	0.13	0.28	0.20	0.52
5697 Birdseye Road	23-Mar-15	0.83	0.06	3.69	3.37	0.00	1.27	4.42	1.83	0.00	0.21	0.00	7.95	7.53	0.11	0.46	0.42	0.17	0.59	0.24
Lone Pine Road																				
6230 Lone Pine	20-Mar-15	0.48	0.09	2.59	2.22	0.00	0.20	4.75	0.46	0.00	0.04	0.01	5.39	5.41	0.11	0.48	0.41	0.04	0.88	0.08
6410 Lone Pine	20-Mar-15	3.87	0.09	14.42	12.59	0.09	3.81	5.08	24.15	0.00	0.00	0.00	31.06	33.04	0.13	0.46	0.41	0.12	0.15	0.73
6410 Lone Pine	11-Sep-15	3.87	0.09	14.22	12.18	0.02	4.37	5.08	22.28	0.00	0.00	0.00	30.38	31.73	0.13	0.47	0.40	0.14	0.16	0.70
Raven Road																				
6112 Raven Road	20-Mar-15	2.83	0.12	3.39	4.20	0.01	2.20	3.61	5.33	0.00	0.02	0.00	10.55	11.13	0.28	0.32	0.40	0.20	0.32	0.48
6179 Raven Road	24-Mar-15	2.04	0.06	4.29	3.95	0.02	1.01	4.59	4.83	0.00	0.00	0.00	10.37	10.43	0.20	0.41	0.38	0.10	0.44	0.46
6181 Raven Road	24-Mar-15	2.87	0.06	3.09	2.88	0.00	1.18	6.23	1.48	0.00	0.10	0.00	8.91	8.89	0.33	0.35	0.32	0.13	0.70	0.17
6181 Raven Road	11-Sep-15	2.00	0.06	3.94	3.79	0.01	0.93	4.59	4.43	0.00	0.00	0.00	9.80	9.95	0.21	0.40	0.39	0.09	0.46	0.45
6199 Raven Road	19-Mar-15	1.87	0.06	2.94	2.72	0.02	0.65	4.10	2.83	0.00	0.00	0.00	7.61	7.58	0.25	0.39	0.36	0.09	0.54	0.37
6205 Raven Road	19-Mar-15	3.04	0.06	1.95	2.06	0.00	0.68	4.59	1.64	0.00	0.00	0.00	7.11	6.91	0.44	0.27	0.29	0.10	0.66	0.24
6240 Raven Road	20-Mar-15	2.96	0.06	2.34	1.48	0.00	0.90	3.44	2.06	0.00	0.17	0.00	6.85	6.40	0.44	0.34	0.22	0.14	0.54	0.32
6240 Raven Road	10-Sep-15	2.83	0.06	2.24	1.32	0.00	0.76	3.61	1.89	0.00	0.08	0.00	6.45	6.26	0.45	0.35	0.20	0.12	0.58	0.30
6315 Raven Road	19-Mar-15	4.61	0.09	3.94	5.35	0.00	2.48	5.74	1.85	0.00	3.34	0.00	14.00	10.07	0.34	0.28	0.38	0.25	0.57	0.18
6315 Raven Road	11-Sep-15	4.57	0.09	4.34	5.84	0.00	2.62	5.90	1.94	0.00	3.84	0.00	14.84	10.46	0.31	0.29	0.39	0.25	0.56	0.19
6335 Raven Road	20-Mar-15	3.13	0.12	3.19	3.70	0.00	1.13	6.56	1.31	0.00	1.29	0.00	10.15	8.99	0.32	0.31	0.36	0.13	0.73	0.15
6335 Raven Road	10-Sep-15	3.09	0.12	3.29	3.54	0.00	1.07	6.06	1.37	0.00	1.38	0.00	10.04	8.51	0.32	0.33	0.35	0.13	0.71	0.16
6430 Raven Road	20-Mar-15	2.22	0.03	1.75	1.15	0.00	0.34	3.44	1.21	0.00	0.19	0.00	5.15	4.99	0.44	0.34	0.22	0.07	0.69	0.24
6430 Raven Road	10-Sep-15	2.35	0.03	1.70	0.91	0.00	0.31	3.28	1.14	0.00	0.06	0.00	4.98	4.73	0.48	0.34	0.18	0.07	0.69	0.24

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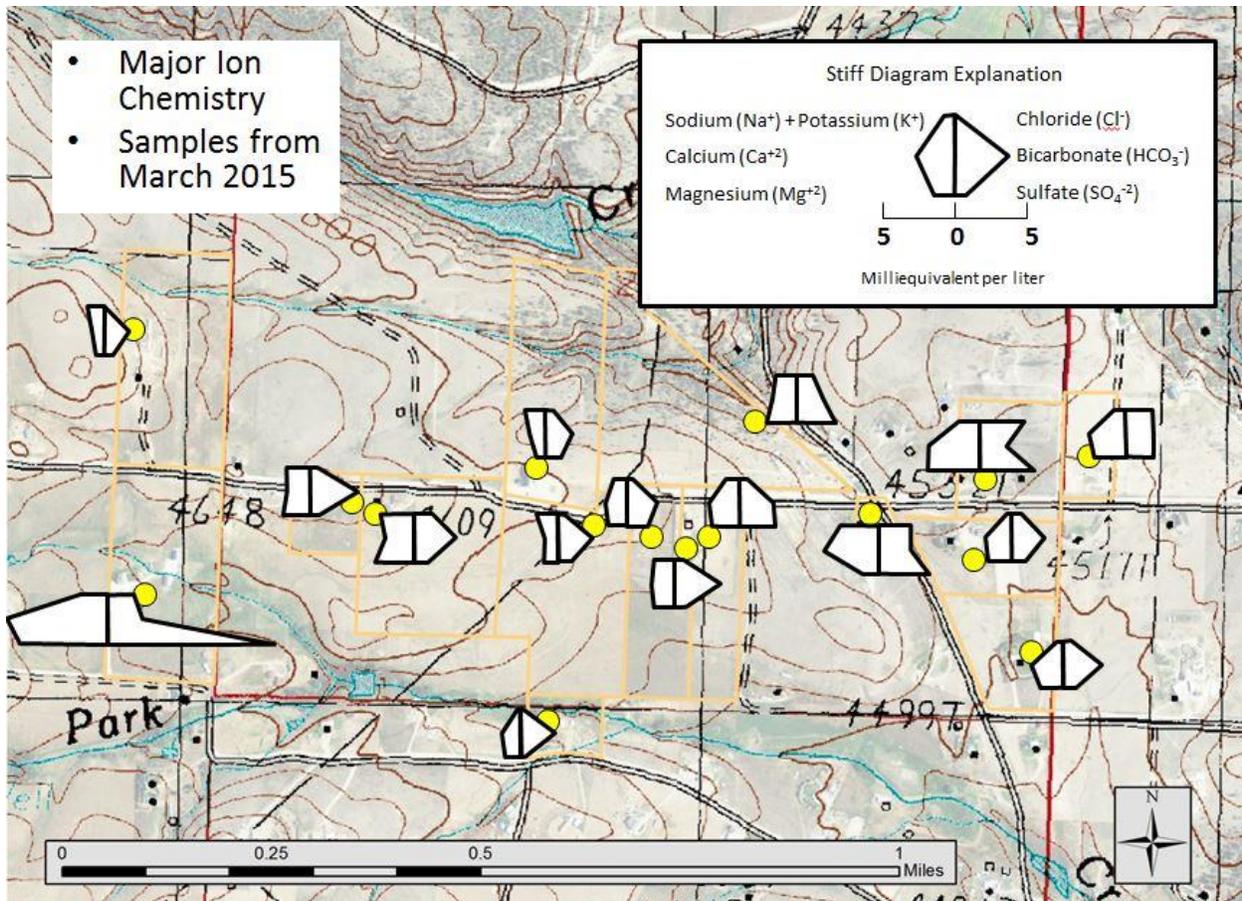


Figure 5 – Major Ion Stiff Diagrams for March 2015 Sampling Data

Stiff diagrams reflect the ionic balance in chemistry for the ground water samples. Polygon size indirectly reflects total dissolved solids since they are based on equivalents, and not concentrations. The changes in shape and size reflect the variability in major ion chemistry in samples from across the study area.

The following general conclusions are made regarding water quality in the area with respect to state and federal drinking water standards (a/k/a maximum contaminant levels, or MCLs). Primary standards are based on health impacts, while secondary standards reflect aesthetic properties such as taste and smell.

Primary drinking water standard exceedences include:

- Nitrate, with exceedences at 3 locations, with data results in Figure 6.
- Arsenic, with exceedences at 10 locations, with data results in Figure 7.
- Uranium, with exceedences at 1 location

Secondary drinking water standard exceedences include:

- Total dissolved solids (TDS), with exceedences at 9 locations
- Sulfate, with exceedences at 4 locations
- Iron, with exceedences at 2 locations

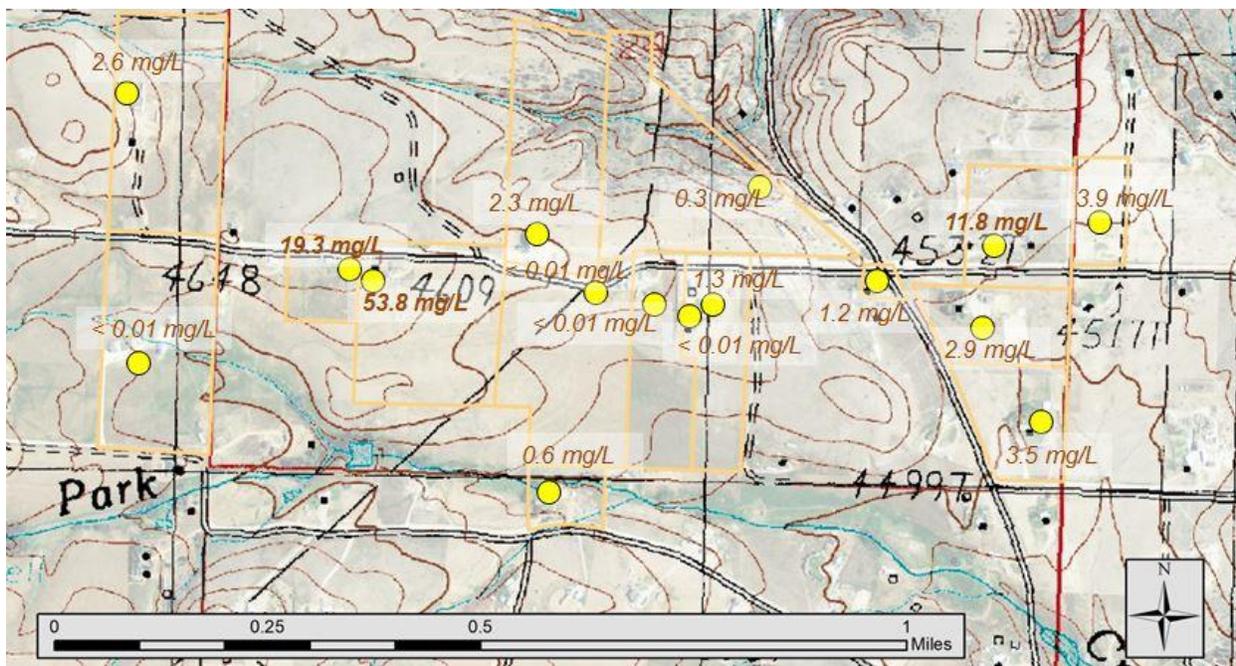


Figure 6 – Maximum Detected Nitrate Concentration for Sample Locations.
 Nitrate exceeding the drinking water standard of 10 mg/L was detected at 3 locations in study area.

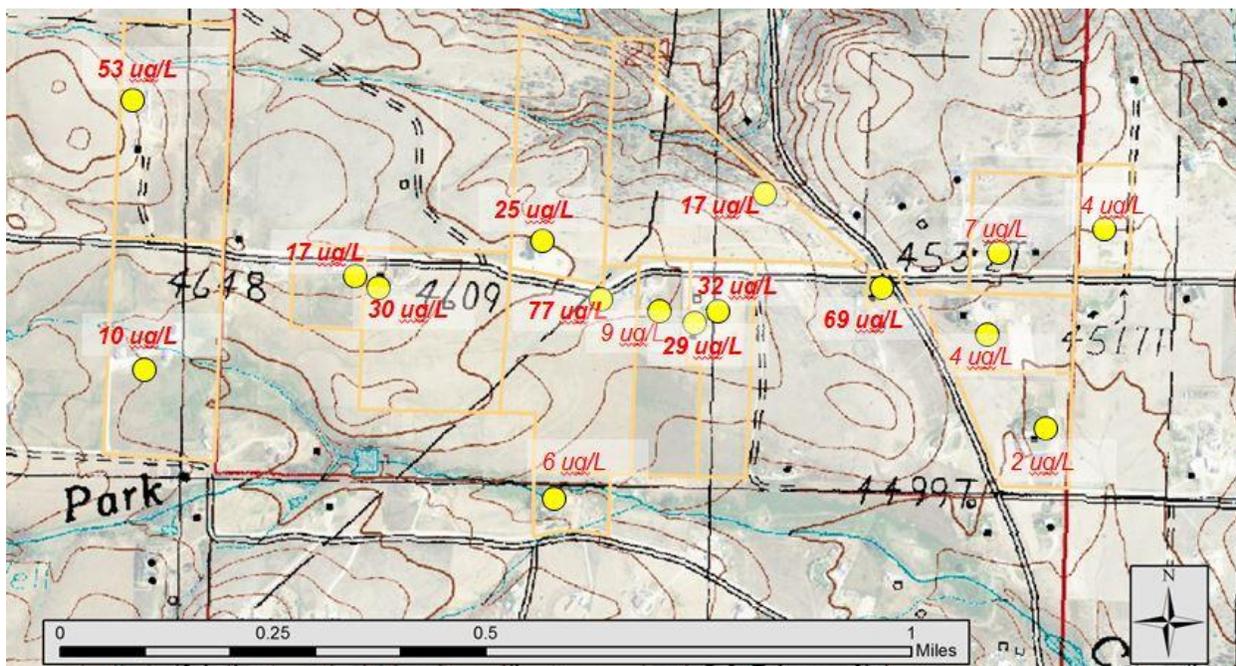


Figure 7 – Maximum Detected Arsenic Concentration for Sample Locations.
 Arsenic exceeding the drinking water standard of 10 ug/L was detected at 10 locations in study area.

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Conclusions and Recommendations:

The data results show a complex ground water system within a fractured bedrock aquifer. Arsenic is present at concentrations exceeding the drinking water standard in deeper bedrock wells, consistent with regional data results from previous LCWQPD and other state and federal agency projects. The highly elevated nitrate in the central part of the area does not appear to be impacting other wells downgradient, suggesting that dilution and/or denitrification are efficient to limit exposure to the nitrate. The source of nitrate is considered to be manure piles located near the wells, although septic systems may contribute as well.

This project serves as a pilot project to identify the health hazards from drinking water constituents at concentrations exceeding drinking water standards. The elevated arsenic is attributed to regional background conditions, and local residents were provide information on both the health hazards and treatment for arsenic in drinking water. With elevated nitrate attributed to local sources, residents are advised to better manage animal manure as well as obtaining treatment for drinking water.

After completion of the initial sampling event, the project planning group met to discuss the implications of the results. The nitrate source for the PWS was determined to likely be their own septic system, as the closest potential contaminant source. This notes that sampling at the PWS well for the study was completed after purging the well for an extended time period, compared with grab samples collected with limited purging for PWS compliance. The extended purging period for the sampling with this study results in drawing water from a greater radius of influence and outside of the vicinity of the PWS. DEQ staff are working with the PWS to mitigate the water quality problems.

Copies of the sampling results were sent to all residents with letters explaining the results. For exceedences of drinking water standards, information pamphlets specific to the analytes were included in the mailings. A copy of a letter with attachments is appended to this letter. The attachments comprise fact sheets regarding elevated constituents in ground water, as published by the National Ground Water Association.