GROUND WATER ANALYSIS AT EMMETT, IDAHO

Prepared for the
Idaho Department of Water Resources
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By

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ABSTRACT

A preliminary ground water study was conducted in Emmett, Idaho because of reports of possible ground water fecal contamination. Fourteen wells were sampled within the Emmett valley and three were found to be contaminated with *Escherichia coli* (E. coli) while four different wells had nitrate (NO_3^-) values greater than 1.50 milligram (mg) per liter. Currently, the *E. coli* contamination was found to be restricted to three wells within 50 feet of each other, while the elevated nitrate (NO_3^-) levels was more prevailing among wells in the valley. The fecal contamination source direction of flow was determined by ground water mapping to be an area approximately 10-50 meters east of the *E. coli* contaminated wells. Specific remediation recommendations were made and follow-up actions, such as tracer tests on nearby septic discharge and repeat sampling of the *E. coli* contaminated wells, were undertaken. No tracer detections were made from the contaminated wells and one well tested positive for *E. coli* in repeat sampling.

INTRODUCTION

The Idaho Department of Water Resources (IDWR) was notified that a well serving a resident in Emmett has consistently failed the coliform potable water test; however, many nearby wells test coliform free. In addition, trying to use either a shallow or deep well at this location leads to the same coliform contamination test results. In order to help determine the source of this phenomenon, IDWR undertook a brief collaborative study with the University of Idaho to analyze ground water samples collected near this well. This report summarizes the initial testing results along with follow-up sampling and investigative work done in the study area.

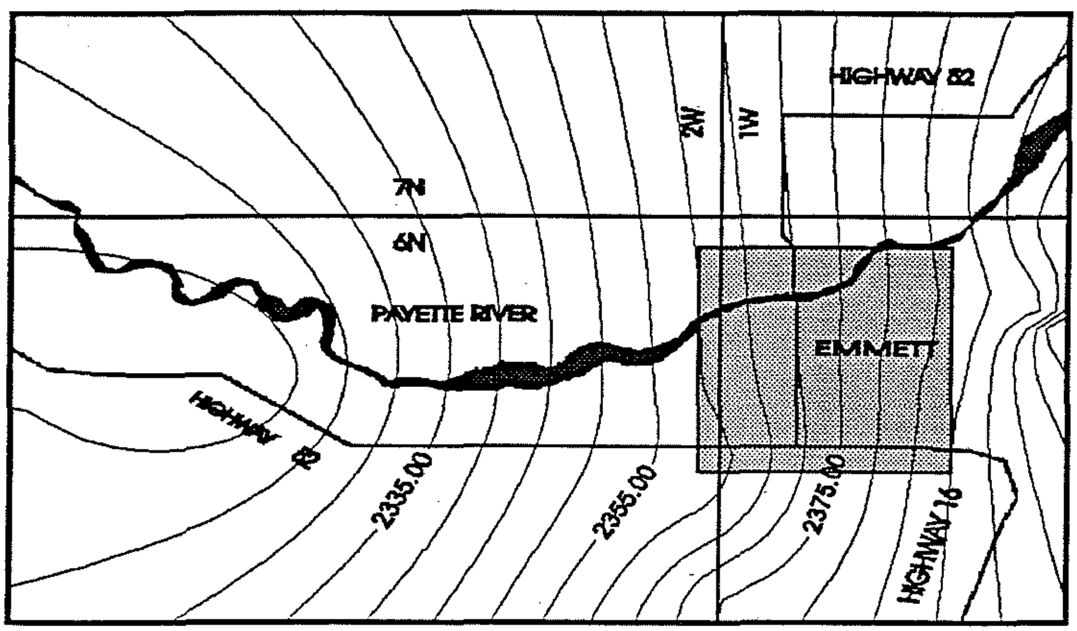

Figure 1. Ground surface elevation contours of Emmett Valley

MATERIALS AND METHODS

Study Area and Hydrogeological Setting Emmett is a southwestern Idaho community with a population of approximately 4,600 and is located about 30 miles northwest of Boise, the states largest city and capitol. It is situated about 2,375 feet above sea level along the banks of the Payette River. The Emmett valley shown in Figure 1 is a broad terraced alluvial plain with a gently rolling to flat topographic surface.This topography lends itself to the existence of a large agricultural base which includes livestock grazing, small grains production and orchards as well as many small hobby farm acreages. A few feet of relief occurs along the Payette River, which runs down the center of the valley and provides the major drainage for the basin. The direction of flow of the river is west towards the Snake River. Surface drainage for the area is generally toward the Payette River, but is complicated by the presence of extensive diversions to irrigation canals. The valley is bordered by a steep elevation gradient of the overlooking bluffs that run parallel to the river and is an erosional product of the downcutting of the river. Formations of fluviatile, eolian and surficial deposits of Quarternary age sands, gravels, clays and silts along the nearby Payette River (Savage, 1961) dominate the near-surface geology. Together these surficial deposits comprise the major aquifer of the area. Most ground water wells in the valley are completed within the aquifers of the near-surface deposits with a large number of wells being fifty feet deep or less. A few wells have been drilled to depths close to 400 feet, but these wells are almost all high capacity city wells.

Sampling All ground water sampling (chemical or microbial) was conducted with existent well pumps that were first run for sufficient time (25-30 minutes) to obtain stable readings of pH, specific conductance, temperature and E_h. Fourteen samples were collected at well sites in sterile polypropylene bottles in April and May, 1995, for both microbiological and chemical analysis. Well water depths were measured with a graduated (1/100th foot) steel tape. Sampling site locations shown in Figure 2 were chosen randomly for spatial separation within the valley and were field located from the Emmett series United States Geological Survey 7.5 minute topographic maps. Elevations were obtained from map location. All but two well locations were established with a Trimble 3-channel Global Positioning System (GPS) receiver and the GPS data were differentially corrected with base station data obtained from the Department of Transportation in Boise. The wells with GPS readings were also tagged with an IDWR site tag for database reference.

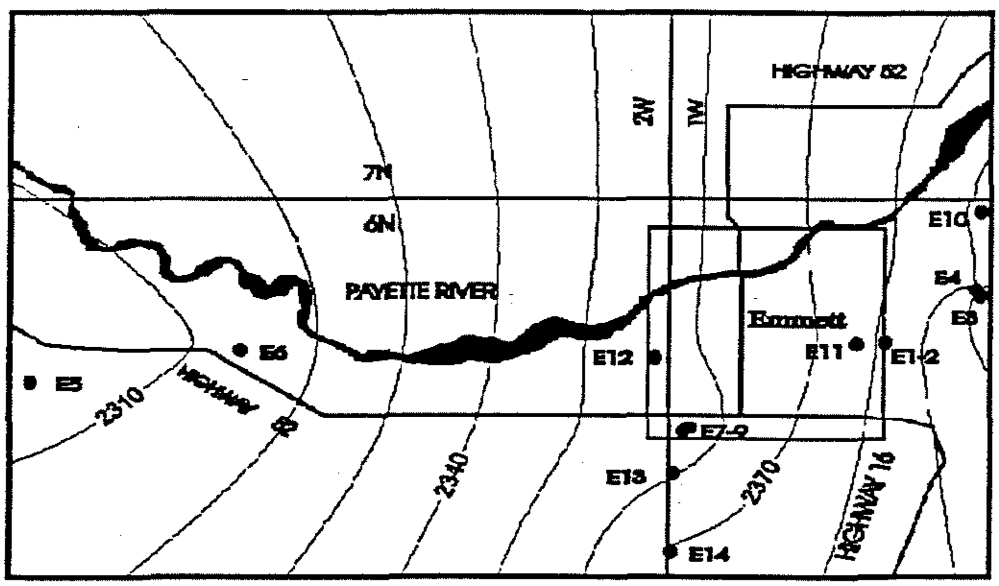

Figure 2. Location and Ground Water Contours of Wells

Habitat Analysis Field measurements were taken at sampling time with a portable meter (YSI, Yellow Springs, Ohio) for pH, temperature, E_h and conductivity. Prior to readings, either standard curves or single-point calibrations were made. All measurements were temperature corrected. Samples were stored and returned to the University of Idaho Microbiology laboratory in Moscow in a cooled ice chest, where both ammonia nitrogen (NH_4^+-N) and nitrate nitrogen (NO_3^--N) concentrations were determined by ammonia electrode (Orion). No preservatives were added to samples prior to shipping.

Bacterial Analysis Standard microbiological procedures were used in analyzing the ground water (Balkwill, 1990) and were performed on refrigerated samples as soon as possible in the laboratory. Total and fecal bacteria (including *E. coli*) are a subgroup of the Enterobacteriaceae family. Except for a few pathogenic strains of *E. coli*, the coliform bacteria are not disease causing. Both total coliforms and fecal coliforms were analyzed by standard methods via the lactose broth most probable number(MPN) method (Greenberg *et al.*, 1985) with confirmation with the *E. coli* presence/absence method.

Statistical Analysis Environmental research yields a large amount of data involving many variables, often spatially organized. Multivariate statistical methods can be useful to summarize such data. Statistical analysis of this data included cluster analysis, multidimensional scaling (MDS) analysis, nearest neighbor analysis (minimum spanning tree; MST), and spatial analysis. Cluster analysis was performed on both habitat and community data for each of the study sites and was based on Euclidean distances. Euclidean distances (D) generalizes the common notion of distance to be applied in three dimensions. The definition is based on point locations (eg., the position of a study site/well) in the following way:

$$D = ||P_1 - P_2|| = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}.$$

By the equation above each point(P) having a x, y, and z coordinate will give a location for a site, as well as distance from other sites.

RESULTS

Habitats Fourteen wells were sampled and field measurements made in April and May, 1995. Field measurements and sampling results are presented in Table 1. Well construction depths ranged from 27 to 113 feet. However, static water depths were quite shallow, ranging from 2 to 13 feet below land with flowing artesian wells being quite common in the western end of the valley. Ground water temperatures shown in Figure 3 were fairly typical of shallow ground water, i.e., 14.5° ± 2.2° celsius (C), which reflects the mean air temperature of Emmett. Wells E7-E9 shown in Figure 2 had unusually high temperatures (17 to 18.7°C) that were several degrees higher than the other wells that were sampled. Conductivity, pH and ammonia (NH_3) were typical for ground water. Nitrate(NO_3^-) values ranged from 0.3 to 4.43

mg /liter. Even though many wells had typical nitrate values, some wells had higher nitrate values such as in wells E1, E10, and E12. In fact, well E12 had a nitrate value of 4.4 mg /liter, which is at an elevated level above natural background levels. Maximum contaminate levels (MCL) for nitrates in a public water supply well is listed as 10 mg/liter. The most striking field measurements were the E_h values which ranged from 155 millivolts (mv) to -531 mv. E_h is a measurement of the oxidation potential (redox) of chemical reactions. The transfer of electrons from one ion to another produces an electrical current or potential. A positive reading is oxidizing or losing electron(s) while a negative reading is reducing or gaining electron(s). Wells with positive E_h values were reported in the eastern end of the valley while the negative values are reported in the western end of the valley. During field sampling it was noted that a rotten egg smell was noticeable in some samples. This was associated with the presence of hydrogen sulfide. This smell has been reported in wells in the Emmett area and is a major factor in the determination of well owners satisfaction with water quality as most people find this odor

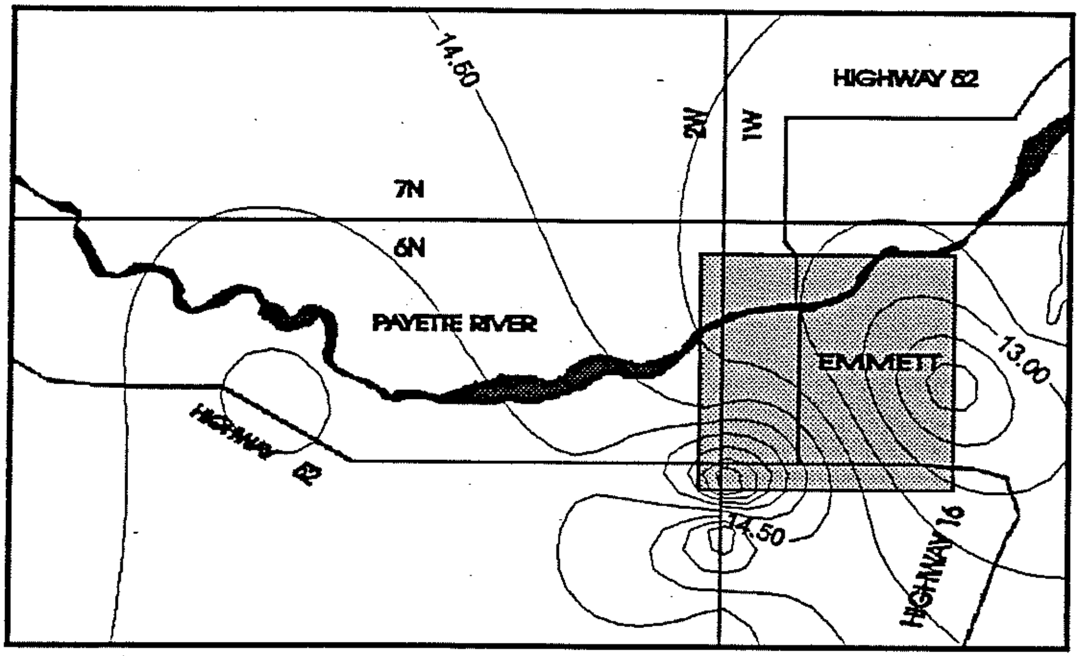

Figure 3. Temperature contours for wells sampled

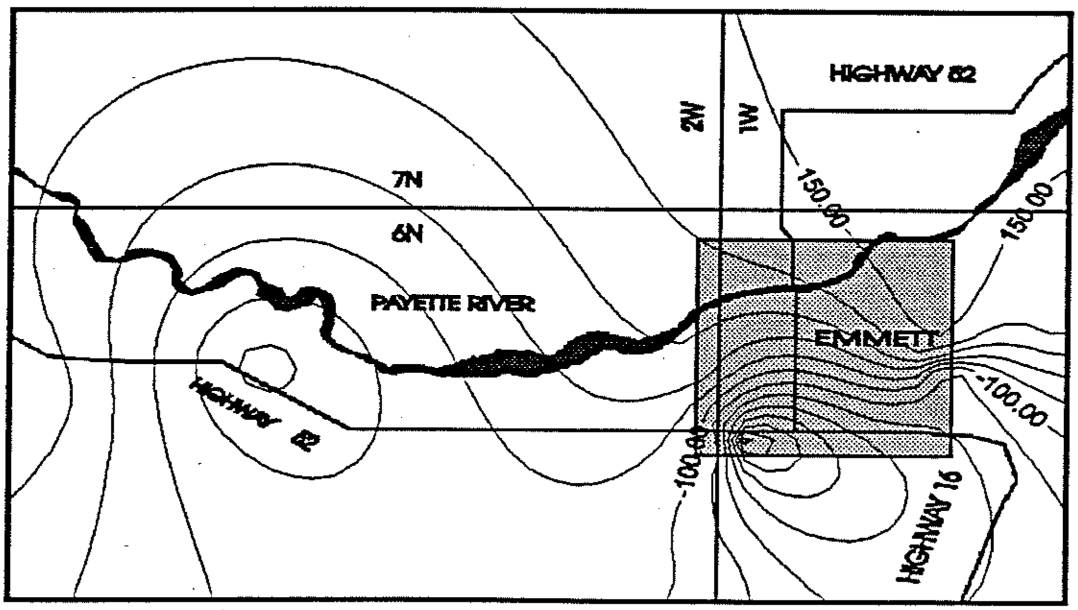

Figure 4. E_h contours for wells sampled

objectionable. Wells that were reported as having the negative E_h readings also were associated with the rotten egg smell. This would coincide with the presence of hydrogen sulfide in a reduced environment.

Microbiology Coliform and fecal coliform results are seen in Table 1. Fecal bacteria are measures of sanitary quality of water and are good "indicator bacteria" because they are applicible to all types of natural waters. They are not pathenogenic, but they correlate to the presence of water-borne pathogens. *E. coli* is strictly an inhabitant of the gastrointestinal tract of warm blooded animals and the presence of fecal and *E. coli* together are well correlated (Francy, Myers and Metzker, 1993). All but three wells showed no evidence of either total coliforms or fecal coliforms. Wells E7, E8 and E9 all were coliform positive, and these wells should be carefully tracked in the future and the appropriate agencies notified due to a potential health hazard.

Statistics All variables (Table 1) such as temperature, conductance, NH_3, NO_3^-, total coliform and *E. coli* were utilized to create a Euclidean distance matrix used for cluster analysis. The dendrogram in Figure 5. shows the relatedness of the sites, which reveals three major clusters or wells of similar sample and results. Cluster "A" contains wells E3-E12, while "B" contains E14-E2, and "C" contains E7 and E9. Well E8 lies between clusters B and C. When analyzing variable relatedness in Figure 6 all variables were fairly tightly clustered together except for E_h and total coliform counts, which did not correlate well with all the other variables. Additionally, E_h and total coliform counts were partially correlated with low E_h values and high total coliform values correlating together.

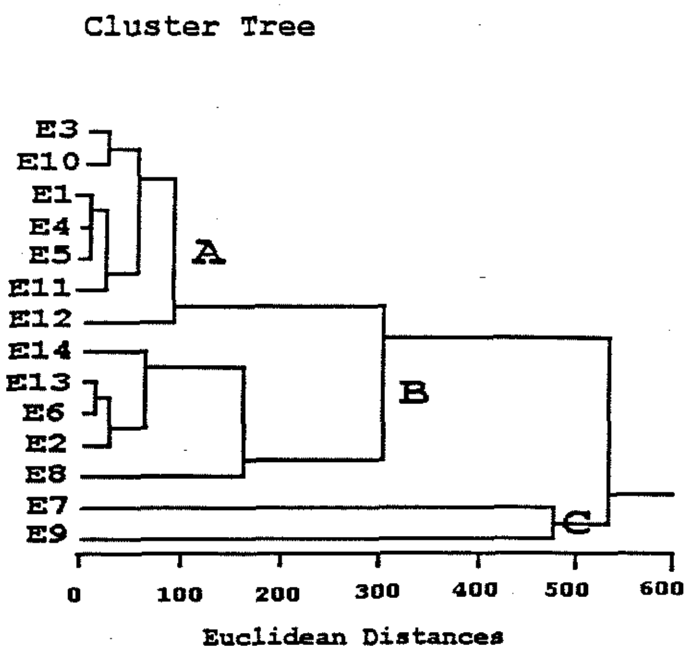

Figure 5. Dendogram of wells sampled

Hydrology After correcting for altitude, water depths were plotted in Figure 2 using a mapping program called Surfer (Golden Software). The general ground water flow direction is towards the west or northwest as ground water flows perpendicular to the contours shown on the map. This is especially evident in the region surrounding wells E7-E9, which are the contaminated wells. It also corresponds with a previous report done by Parliman (1986), who reported that the ground water movement is generally northward toward the Payette River, and then westward toward the Snake River

ANALYSIS

The discussion in this report will focus only on those wells and the area that is contaminated (*E. coli* positive). The values for depth, temperature, E_h and coliforms together indicate the possibility of ground water and surface water contact, although a leaking septic tank could be possible. These wells are located within an area of closely spaced mobile or modular homes, all of which are connected to private septic tanks. The existence of a continues clay layer to protect the ground water intake from wastewater effluent is not present or is questionable in the well log of the well E8 (figure 8).

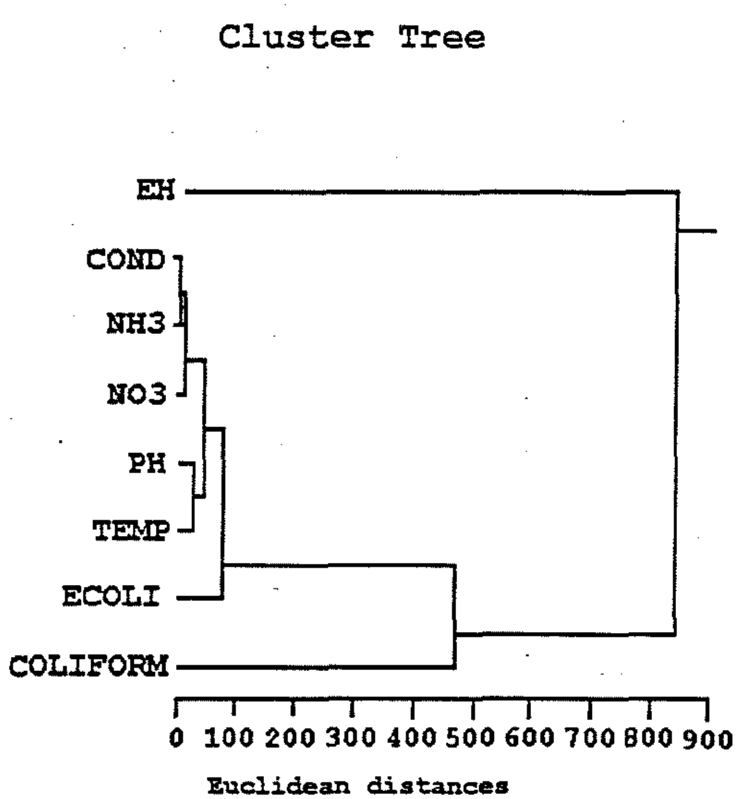

Figure 6. Physical dendogram of wells sampled

One E_h measurement stands out as particularly prominent. The low E_h values reported, especially -300 mv to -500 mv have never been seen by the investigators in any other field measurements. The values present in the ground water for the E7-9 wells show that they are in a highly reduced state. These readings are possible in the laboratory where specific reductants such as sodium sulfide (NaS) or cysteine are added to solutions, but are rare in nature with notable exceptions such as sewage treatment plants, ruminant stomachs, very organic-rich muds, etc.

As to the microbiology, wells E7-E9 are significantly contaminated from wastes either from animals because of surface infiltration, or human wastes from leaking septic tanks. It should be assumed that a problem with fecal bacteria and a surface connection does exist at these well site. Elevated values for wells E7 and E9 could be attributed to possible sampling equipment contamination. The E7-E9 well sequence was sampled in the order of E8, E7 and E9 without decontamination of the equipment after each site. The equipment however, was purged by running water at 10 pounds per square inch (psi) while parameter readings stabilized. The E9 well had not tested positive in previous tests. The magnitude of the increase in fecal colonies from the first well sampled to the second and on to the third well sampled, made the investigators believe that possible contamination of the sample equipment occurred from well E8 to well E9. Well E8 has had positive coliform results in previous tests and does show positive numbers for fecal coliform in this battery of tests.

Well E13, which is slightly south of the contaminated region and well E12, which is slightly north of the contaminated region, both showed no evidence of contamination. Therefore, the contamination is localized to the E7-9 well sites and computer-predicted location of the contamination source is a region of about 900 meters diameter centered 600 meters or less eastwards from E7-E9. Since *E. coli* usally does not travel more than 50 meters in soil, the contamination source probably is 10-50 meters east of E7-E9. If the aquifer was largely sand as the case in these wells, then *E. coli* may travel further distances. It is somewhat surprising that the elevated NO_3^- levels do not coincide with the coliform contamination, as nitrate is usually a co-contaminant with *E. coli* because of the presence of nitrogenous organics that are converted to NO_3^-. During the review of the limited data in this study, the possibility of a geothermal source near E7-E9 was considered. This stemmed from the possible presence of hydrogen sulfide ("rotten egg smell"), low E_h and elevated temperatures. A slight geothermal presence could also account for possible subducting current of warm water rising to near the ground surface, cooling and returning to greater depth, such as in a convection cell. This cell could account for the movement of contaminated surface water to the E7-E9 aquifer region. *E. coli* will also survive better in nature if kept at a lower E_h. However, the lack of artesian outflow from the wells in the general vicinity or other sources near E7-E9 does not verify the existence of any geothermal sources. Area well drillers have never reported any geothermal water encountered within the valley except far to the east near Black's Canyon where some warm springs exist.

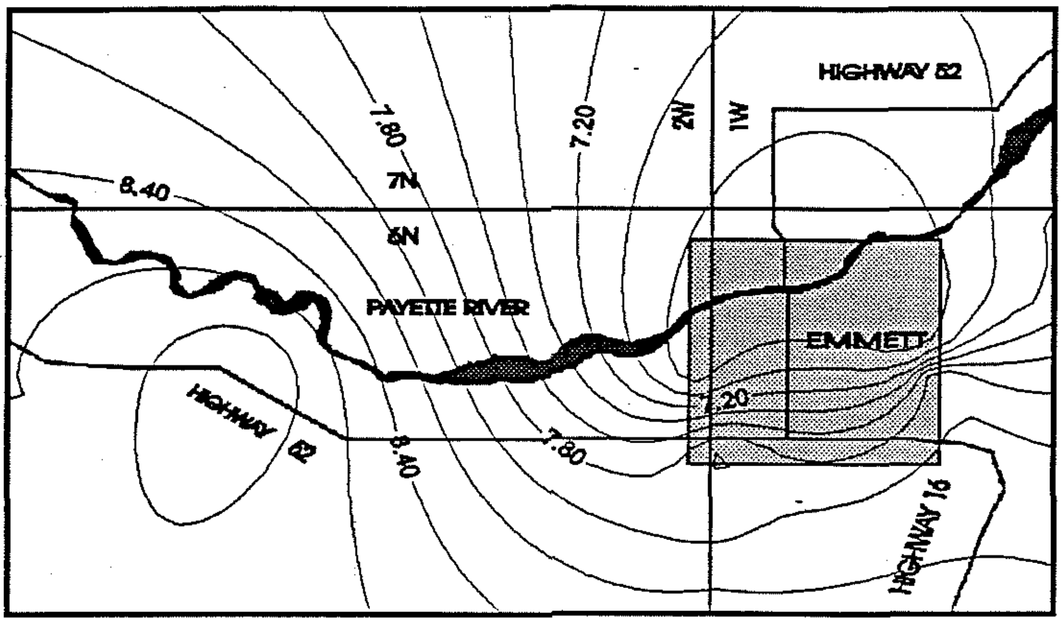

Figure 7. pH contours of wells sampled

RECOMMENDATIONS

The recommendations for the contaminated areas in Emmett are as follows:

1. Immediately act to prevent any health hazards from wells E7-E9.
2. Perform a site examination to determine the probable source that meets the designated source location criteria stated above.
3. Confirm the high NO_3^- and low E_h values.
4. Secure better hydrology data. This will require more accurate altitude data and better water depth data (to within 5 millimeter or less throughout the year).
5. Consider a tracer test in any proximal surface water and septic tanks to the E7-E9 wells that may be the possible contamination source.
6. Carefully review the geology and geothermal nature of the Emmett area because the geology may reveal unique or explanatory features.
7. To protect the affected citizens the nearby contamination source (either septic or surface stream source) must be eliminated. If it is an animal source, then surface waters must be protected by fencing and a sufficient buffer zone must be established near surface waters. If it is a leaking septic tank then this will require correction. If animal versus human source cannot be identified, there are newer methods available that could be pursued to differentiate the sources.
8. Plan for the future. With the growth that is occurring in southwestern Idaho, specifically in the Emmett Valley, some future planning will be needed. The possibility of central sewer and public water supply wells should be considered in future planning models.

FOLLOW-UP WORK

After initial results were received from the laboratory work, test results and explanatory letter were sent to all well owners. The owners of wells E7-E9 were advised to resubmit water samples to the local health district as well as a private lab for confirmation. They were also advised to start investigating possible water filtration and point-of-source or use treatment methods such as chlorination or ozonination. A filtered sample for the E8 well was submitted to a private lab for confirmation of the efficiency of a water filter system. The filtering device was an above the counter self contained filter with an activated charcoal filter for taste. The laboratory results indicated that the filter did not remove the bacteria (Table 2)from the sample, but the owner did state that the "rotten egg" smell was not noticeable in the filtered sample, which could have been removed by the activated carbon filter.

The local district health official performed a series of dye tracer tests on five neighboring septic tank located within the immediate area of E7-E9. In the time period from June 2 - 14, 1995 five 32 oz. primary color dyes were added to neighboring septic tanks with each tank receiving a separate color. As of July 19, 1995 no visible trace of any dye had been seen in the owners well water (E8). No tracer tests were conducted on any surface water canals because of high flows during the irrigation year. A tracer test could be attempted on surface water canals as flows are reduced at the end of the irrigation season.

Because of elevated ground water temperatures of the E7-E9 wells the presence of geothermal waters or an abandoned oil or gas well were contemplated. The follow-up water samples taken were submitted to a private lab where fluoride levels were determined. The level was detected below the MCL's for fluoride in drinking water (Table 2). Some geothermal wells, however, do not have fluoride values which exceed MCL's (2.00 mg/l) (Parliman, 1992) The presence of a geothermal source could be responsible for the elevated temperature, high E_h, and as stated earlier *E. coli* can live longer in wells with reduced E_h.

The presence of earlier exploration for oil and gas had the potential of a possible connection for warmer water to reach near the surface by a unused unabandoned well. Will Pitman of the Department of Land acknowledged (phone conversation) that some oil and gas exploration had occurred, but no work was closer than 4 miles upgradient of the E7-E9 wells. This was confirmed in the work done by Savage (1961), which listed all oil and gas exploration work in the Emmett Valley up to the date of the report.

At this time more work still needs to be done. The owner of the contaminated wells cannot use the water source for culinary or hygienic use. Tracer tests on all nearby surface sources should be done, as well as a sulfide assay to correlate a possible surface-ground water connection. Filtration and treatment methods should also be used and tested by the owner to determine a treatment system which could eliminate the serious bacterial contamination at the house. IDWR has received numerous calls in the past few years concerning ground water quality in the Emmett Valley. The city of Emmett should consider the viability of extending the city water and/or the city sewer. Because of the population growth within the Emmett Valley the city may need to consider future alternatives for the safety the citizens.

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[redacted]

Form 238-7
1/94

IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT

[redacted]

Use Typewriter or Ball Point Pen

1. DRILLING PERMIT NO. [redacted]
Other IDWR No. ____

2. OWNER:
Name [redacted]
Address [redacted]
City [redacted] State [redacted]

3. LOCATION OF WELL by legal description:
Sketch map location must agree with written location.

Twp. 6 North ☒ or South ☐
Rge. 2 East ☐ or West ☒
Sec. 18, SE 1/4 NW 1/4 ____ 1/4
Gov't Lot ____ County Gem

Address of Well Site [redacted]

Lt. ____ Blk. ____ Sub. Name ____

4. PROPOSED USE:
☒ Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other ____

5. TYPE OF WORK
☒ New Well ☐ Modify or Repair ☐ Replacement ☐ Abandonment

6. DRILL METHOD
☐ Mud Rotary ☐ Air Rotary ☒ Cable ☐ Other ____

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD
no Envirop[illegible]	0	18	6	overbore

Was drive shoe used? Y ☒ N ☐
Was drive shoe seal tested? Y ☐ N ☒ How? ____

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
6"	+1	110	250		☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐

Length of Headpipe 5' Length of Tailpipe 0

9. PERFORATIONS/SCREENS
☐ Perforations Method ____
☒ Screens Screen Type Johnson Stainless

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
110	115	15		6" [illegible]		☐	☐
						☐	☐
						☐	☐

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
3 ft. below ground Artesian pressure ____ lb.
Depth flow encountered ____ ft. Describe access port or control devices: ____

11. WELL TESTS:
☒ Pump ☐ Bailer ☒ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
25	10'	30'	2hrs

Water Temp. 50 Bottom hole temp. ____
Water Quality test or comments: Sulfer Smell

12. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Dia.	From	To	Remarks: Lithology, Water Quality & Temperature	Water Y	Water N
8	0	5	TOPSoil		X
8	5	6	hardPan		X
8	6	18	Gravel	X	
6	18	30	Sand + Gravel	X	
6	30	40	Pea Gravel + Sand	X	
6	40	48	Sand	X	
6	48	54	Pea Gravel + Sand	X	
6	54	64	Sand	X	
6	64	85	Pea Gravel + Sand	X	
6	85	87	Sandy Clay ?		X
6	87	108	Course Sand	X	
6	108	110	Sandy Clay ?		X
6	110	115	Sand	X	

RECEIVED
DEC 1 4 1994
Department of Water Resources

RECEIVED
AUG 0 4 1994
WATER RESOURCES
WESTERN REGION

Completed Depth 115' (Measurable)
Date: Started Dec 22-93 Completed June 15-94

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name [redacted] Firm No. [redacted]
Firm Official [redacted] Date 7-28-94
and
Supervisor or Operator [redacted] Date 6-18-85

FORWARD WHITE COPY TO WATER RESOURCES

Figure 8. Well log of well E8

Site	Location (TRsec.)	Depth (ft)	Static Water (ft)	Alt. (ft)	Temp. (^0C)	Cond. (S/cm)	E_h (mv)	pH	N-NH3 (mg/l)	N-NO3 (mg/l)	Total Coli (MPN/100ml)	E.coli (MPN/100ml)	E.coli (CFU/100ml)
E1	6N1W09BC			2386	11.5	0.231	98.6	7.0	0.283	2.28	0	0	0
E2	6N1W09CB	30	3.1	2386	11.5	0.370	-193	8.1	0.355	<0.7	0	0	0
E3	6N1W09AA	27	8.9	2415	13.6	0.197	155	7.3	0.784	1.10	0	0	0
E4	6N1W04DD	43	4.5	2393	14.1	0.164	100	7.2	0.355	<0.7	0	0	0
E5	6N2W07CD	73	13.2	2320	14.5	0.181	96.8	8.6	0.462	0.708	0	0	0
E6	6N2W09CB	55	5.0	2316	15.7	0.203	-174	9.0	0.732	0.708	0	0	0
E7	6N1W18BA	39	5.3	2360	17.3	0.203	-531	8.0	0.291	0.732	150	20	45
E8	6N1W18BA	113	5.1	2360	17.0	0.208	-321	8.1	0.246	<0.7	15	9	1
E9	6N1W18BA	43	5.4	2360	18.7	0.211	-173	8.1	0.407	<0.7	460	75	64
E10	6N1W04AA	35	10.8	2403	14.0	0.291	134	7.2	0.294	3.63	0	0	0
E11	6N1W08CB	40	11.0	2385	12.1	0.240	79.4	6.9	0.369	1.64	0	0	0
E12	6N2W12CA	30	2.0	2360	14.2	0.162	26.6	6.7	0.625	4.43	0	0	0
E13	6N1W18CC	32	2.0	2361	12.8	0.238	-163	7.8	0.123	1.34	0	0	0
E14	6N1W19CC	39	4.7	2375	15.3	0.219	-117	8.2	0.558	<0.7	0	0	0

TABLE 1. Ground water physical, chemical, and microbial variables for wells sampled

Results from Wells Analyzed by Health Districts				
Well ID	**Heterotrophic**	**Total Coliform**	**E. Coli**	**Fluoride**
E9	21 CFU/1 ml		absent	
E8	760 CFU/1 ml	present	absent	
Results of Tests done by Private Lab (including filtered sample)				
E9		<1 col/100ml	<1	1.48 mg/l
E8		7	<1	1.73
E7		<1	<2	1.44
Filtered E8		5	<1	1.77

Table 2. Results from Follow-up Sampling of Contaminated Wells E7- E9 Including Filtered Sample.