Ground-Water Quality in Corrales, Middle Rio Grande Basin, New Mexico

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Abstract

Septic tank effluents have adversely impacted ground-water quality in the Village of Corrales. This contamination is manifested by two contrasting, and mutually exclusive, types of ground-water geochemistry: anoxic conditions and elevated nitrate. Anoxic (oxygen deficient) conditions are characterized by objectionable levels of iron and hydrogen sulfide gas, and have long existed in ground water in the inner valley (generally west of the Rio Grande and east of Loma Larga Road). Nitrate is chemically unstable in anoxic ground water and typically occurs at low to non-detectable levels. Shallow aquifers in New Mexico river valleys are sometimes naturally anoxic. Septic tank effluents, however, can cause worsening of natural conditions, resulting in even greater concentrations of iron and hydrogen sulfide, and this has occurred in Corrales. Up to 1.64 mg/L iron was detected, and the recommended aesthetic limit for potable water is 0.3 mg/L. West of Loma Larga Road, in the piedmont area, most wells do not contain detectable iron or hydrogen sulfide, but there is a natural background nitrate-N level of 0.5 to 2 mg/L. Septic tank effluents have increased background nitrate-N levels at some piedmont locations. Up to 6.5 mg/L nitrate-N was detected, and the human health standard for potable water is 10 mg/L. It is possible that higher nitrate levels exist in wells that were not tested. Continued nitrate monitoring in the piedmont area is recommended. At the present time, however, development with one-acre lots in the piedmont area has not caused widespread nitrate contamination in excess of the health standard, if at all.

Ground-water contamination from septic tank effluents is technically and economically impractical to clean up with an engineered remediation system. Natural attenuation and source control are the only practical means of aquifer restoration. Source control can be achieved by the construction of public sewer systems, or by the replacement of conventional septic systems with non-discharging systems or advanced treatment units. The adverse effects of ground-water contamination can be mitigated by the construction of public water supply systems, by drilling deeper wells, or by the installation of water treatment devices.

Introduction

Ground-water contamination from on-site septic systems is a widespread problem in New Mexico (McQuillan, 2004). Septic tank effluents have contaminated more water supply wells, and more acre-feet of ground water, than all other sources in the state combined. The New Mexico Environment Department (NMED) is conducting hydrogeologic investigations throughout the state to identify and map ground-water resources impacted by on-site systems.

Redox (reduction-oxidation) reactions involve the transfer of electrons, and can strongly influence the geochemistry of septic system effluents and ground water. In oxic or aerobic conditions, where dissolved oxygen is present, the ammonia in sewage can be oxidized to nitrate (nitrification), which can contaminate ground water. Nitrification often occurs in the vadose zone before effluent percolates to ground water. Septic systems have polluted ground water with nitrate at concentrations exceeding the allowable human-health standard of 10 milligrams per liter (mg/L) as nitrate-N in numerous areas of New Mexico, including areas west of the inner valley in Albuquerque (Gallaher et al., 1987; McQuillan et al., 1989).

Anoxic ground water lacks dissolved oxygen and may not support ammonia nitrification. Ammonia, as the ammonium ion however, can be removed by cation exchange. Anoxic conditions can occur naturally, such as in soils that contain decaying plant material or in rocks containing organic carbon. Indigenous microbes use this organic matter for energy production and cell growth. The organic matter serves as an electron donor and is oxidized. In this process, another material must serve as an electron acceptor, and undergo reduction. Ground-water microbes preferentially utilize (respirate) electron acceptors that yield the highest energy. Electron acceptors that yield greater energy are consumed first. The sequence of electron-acceptor consumption is shown in Figure 1, and begins with aerobic respiration, consumption of dissolved oxygen. De-nitrification, the conversion of nitrate to nitrogen gas (N_2), only occurs in anoxic conditions after dissolved oxygen has been consumed (Figure 1). This fact has long been known to wastewater professionals who use de-nitrification for tertiary treatment. If nitrate is discharged into anoxic ground water, or if oxic ground water containing nitrate either migrates into anoxic conditions or is made anoxic by anthropogenic discharges, de-nitrification can occur. Once dissolved oxygen and nitrate have been consumed, microbes will utilize manganese oxides in the soil or rock as the electron acceptor (Figure 1). Manganese contained in the insoluble oxide mineral is chemically reduced to Mn^{2+} and can then dissolve into ground water as a free ion. Iron oxide minerals also can be respirated in this manner (Figure 1). Sulfate, which is a common natural ground-water anion and is added to sewage by domestic use, can be reduced to hydrogen sulfide, "rotten egg" gas. Sulfate reduction yields less energy to the microbes than manganese and iron reduction (Figure 1). Methanogenesis, the production of methane, a reaction long known to petroleum geologists, yields the least energy of these reactions.

Ground-water microbes also will oxidize anthropogenic sources of organic matter (sewage discharges, petroleum spills, etc.) as a carbon-energy source. These discharges can make oxic ground water become anoxic, a phenomenon observed at some industrial pollution sites. This alteration to anoxic conditions, however, can be temporary with oxic conditions returning after the carbon source has been consumed. Discharges of organic matter to existing anoxic ground water also can cause microbes to consume greater amounts of electron acceptors, thereby increasing concentrations of manganese, iron, and hydrogen sulfide gas. In the Albuquerque South Valley, the highest concentrations of ground-water manganese (greater than 1 mg/L) are associated with areas having the highest densities of on-site septic systems (Gallaher et al., 1987), and there appears be a similar association with ground-water iron (Anderholm, 1987). Hydrogen sulfide gas occurs in many wells in this area, and some wells are methanogenic. Manganese, iron, and hydrogen sulfide can seriously impair the aesthetic qualities of domestic water by imparting unpleasant tastes and odors, and by staining laundry and plumbing fixtures. High levels of manganese in drinking water also may cause neurotoxicity (ATSDR, 2000). A lifetime health advisory for manganese in drinking water has been set at 0.3 mg/L (U.S. EPA, 2004).

Figure 1. Decreasing Energy Yield of Electron-Acceptor Reduction Reactions Used by Ground Water Bacteria for Respiration.

Reduction Reactions decreasing energy yield
• Aerobic respiration • Denitrification • Manganese reduction • Iron reduction • Sulfate reduction • Methanogenesis

The Village of Corrales lies within the Albuquerque Basin of central New Mexico and is located in Sandoval County, between the Rio Grande, which forms its easternmost boundary and the City of Rio Rancho to the west, approximately 15 miles north of downtown Albuquerque. The Village was incorporated in 1971 and has a population of 7334 according to the 2000 US Census. The majority of the 6000 acres that make up the Village is predominantly residential with some light commercial and agricultural activity. Most residential areas within the Village are currently zoned for a minimum lot size of 1 acre, and most of the newer homesteads west of Loma Larga were developed at this density. Some older areas of the community, however, were developed with smaller residential lots, in some cases less than 0.2 acre. Current zoning ordinances and available land indicate the Village can support a total population exceeding 10,400. Recent growth rates indicate that the Village will attain the maximum population within the next 10 years. Approximately one-third of the Village residences and the bulk of the commercial core were constructed prior to 1960, located mostly in the Village center and the southeast sections (Grollman, 2005). All drinking water within the Village is from individual or shared groundwater wells located at various depths. Wastewater disposal is via septic tank/leachfield systems.

Corrales was selected for a hydrogeologic investigation because of the large number of small lots (less than ¾ acre) developed with on-site wells and septic systems. Additionally, there have been many historical reports by well users in the area of water quality problems such as high iron and the presence of hydrogen sulfide gas. Many well users in the area have installed water softeners (cation exchange treatment units).

Physical Setting

Corrales is located on the floodplain west of the Rio Grande, and on a slope rising westward above the valley. A geologic map of Corrales and vicinity is shown in Figure 2. Floodplain alluvium, (Qa, Figure 2) consisting of sand, gravel, silt and clay, was deposited in an incision cut by the Rio Grande into underlying deposits of the Santa Fe Group (QTs), Arroyo Ojito Formation. The alluvium inter-fingers with piedmont deposits (Qp, Figure 2) consisting of aeolian (windblown) sands, coalescing alluvial fans, and tributary alluvium deposited to the west of the inner valley. The contact between alluvial and piedmont deposits occurs close to the break in slope on the western inner valley margin, which also coincides with the Corrales main irrigation canal and Loma Larga Road which runs parallel to the canal. The Arroyo Ojito Formation underlies both the alluvial and piedmont deposits, and consists of fluvial deposits of the ancestral Jemez River. These sediments are generally unconsolidated to poorly cemented, although some caliche cemented sandstones occur in this area.

Ground water occurs within both floodplain alluvium and the Santa Fe Formation. Regional water level elevations (Plummer et al., 2004, Figure 10) indicate that ground water flows to the southwest in the Corrales area. Aquifer sensitivity ratings for the Corrales area range from high (less than 100 fee to ground water) in the inner valley to moderate (100 to 300 feet to ground water) in the Piedmont area (Figure 3).

Methods

Historical data from Water Fairs and public water system monitoring were assembled and reviewed, along with published ground-water quality information from the U.S. Geological Survey and other sources. Well water samples were collected from 100 water supply wells throughout the community. Well owners granting permission for sampling were interviewed as to the well depth and age, number of people using the well as a source of drinking water, well driller, and distance from well to septic system. If a water treatment system had been installed, water was sampled prior to treatment if possible. Field measurements of conductivity, temperature, and dissolved oxygen (DO) were conducted on-site using a YSI Model 85 meter. DO measurements were calibrated daily for 100% air saturation for the Corrales elevation. Wellhead coordinates were determined with Garmin Etrex GPS units. HACH 2000-Series spectrophotometers were used to determine iron, sulfate and fluoride, using 1,10 phenanthroline, barium, and red zirconium dye reagents, respectively. Nitrate-N was determined using a HACH Model 4000 ultraviolet absorption spectrophotometer. The instruments were calibrated on a daily basis with de-ionized water and factory prepared standard solutions. Well owners were provided with a written report of test results for their well water, along with a bilingual information sheet explaining the significance of the parameters that were analyzed. In order to protect homeowner confidentiality and property rights, NMED does not publicly disclose the names, addresses and phone numbers of well owners who participate in community surveys such as this.

Results

Test results are listed in Appendix A and summarized in Table 1. Most wells located west of Loma Larga Road contained detectable nitrate levels. Nitrate was not detected in excess of the health standard of 10 mg/L as N, although one well contained 6.5 mg/L nitrate-N. Iron was detected in a number of wells in the inner valley (east of Loma Larga Road) at levels sometimes exceeding the recommended aesthetic limit of 0.3 mg/L for domestic water supply. Fluoride was detected in all samples, but at concentrations within the health standard of 2 mg/L (Table 1).

Table 1. Summary of Corrales Well Water Quality.

Parameter	Low	High	Allowable or Recommended Standard
Conductivity, microSiemens (uS)	243	1130	1000 at 25°C
DO, mg/L	0.0	4.26	None Established
Nitrate-N, mg/L	0.0	6.5	10
Iron, mg/L	0.0	1.64	1
Sulfate, mg/L	35	380	250
Fluoride, mg/L	0.24	0.76	1.6

Discussion

There is a remarkable contrast in ground-water redox geochemistry between the inner valley and the piedmont areas as illustrated by iron and nitrate trends (Figure 4). A redox boundary between generally reducing conditions in the inner valley alluvium, and generally oxidizing conditions in the piedmont slope to the west, runs parallel and close to the sedimentary contact (ie. along Loma Larga/Canal area). The ammonia in percolating septic tank effluents west of the redox boundary undergoes nitrification. The greater vertical migration distance to ground water and the well-aerated piedmont deposits, relative to alluvial sediments, support this transformation. Background nitrate-N levels in the piedmont area are in the range of 0.5 to 2 mg/L (Plummer et al., 2004, Figure 41). We believe that septic tank effluents have increased nitrate levels above background at some locations in the piedmont area. Up to 6.5 mg/L nitrate-N was detected, and the human health standard for potable water is 10 mg/L. It is possible that higher nitrate levels exist in wells that were not tested. This level of nitrate contamination is moderate compared to what has been documented in the west mesa of Albuquerque (Gallaher et al., 1987; McQuillan et al., 1989). Possible explanations for this difference include differing nitrogen loading rates (i.e. residential lot sizes), times of residential development, and natural attenuation processes. Another hypothesis is that westward migration of anoxic, carbon-rich ground water from the inner valley is causing denitrification in the piedmont area.

Ground water within the inner valley may have been naturally anoxic to some degree due to oxidation of organic matter (plant roots and debris) contained in the alluvium. An earlier study found evidence of anoxic conditions north of Bernalillo that became worse as ground water flow south through the community (Gallaher et al., 1987). The addition of septic tank effluent laden with organic matter, both in Bernalillo and in Corrales, increased the consumption of electron acceptors needed for the oxidation process beyond background conditions. Consequently, shallow inner valley ground water is contaminated with iron, hydrogen sulfide gas, typical of anoxic conditions. Up to 1.64 mg/L iron was detected in Corrales, and the recommended aesthetic limit for potable water is 0.3 mg/L. Manganese, which was not tested for in this preliminary study, also is most likely present in alluvial ground water. Since manganese has been identified as a potential neurotoxin (ATSDR, 2000), it should be included in future geochemical studies.

Conclusions

Septic tank effluents have adversely impacted ground-water quality in the Village of Corrales. Septic tank effluents have worsened natural anoxic conditions in inner valley ground water, resulting in even greater concentrations of iron and hydrogen sulfide. The piedmont area west of Loma Larga Road is vulnerable to nitrate contamination from septic tank effluents, although concentrations exceeding the health standard were not detected. Continued testing for ground-water nitrate in the Corrales piedmont area is recommended to monitor changes in nitrate concentrations over time, and to test more wells. At the present time, however, development with one-acre lots in the piedmont area has not caused widespread nitrate contamination in excess of the health standard, if at all.

Ground-water contamination from septic tank effluents is technically and economically impractical to clean up with an engineered remediation system. Natural attenuation and source control are the only practical means of aquifer restoration. Source control can be achieved by the construction of public sewer systems, or by the replacement of conventional septic systems with non-discharging systems or advanced treatment units. The adverse effects of ground-water contamination can be mitigated by the construction of public water supply systems, by drilling deeper wells, or by the installation of water treatment devices.

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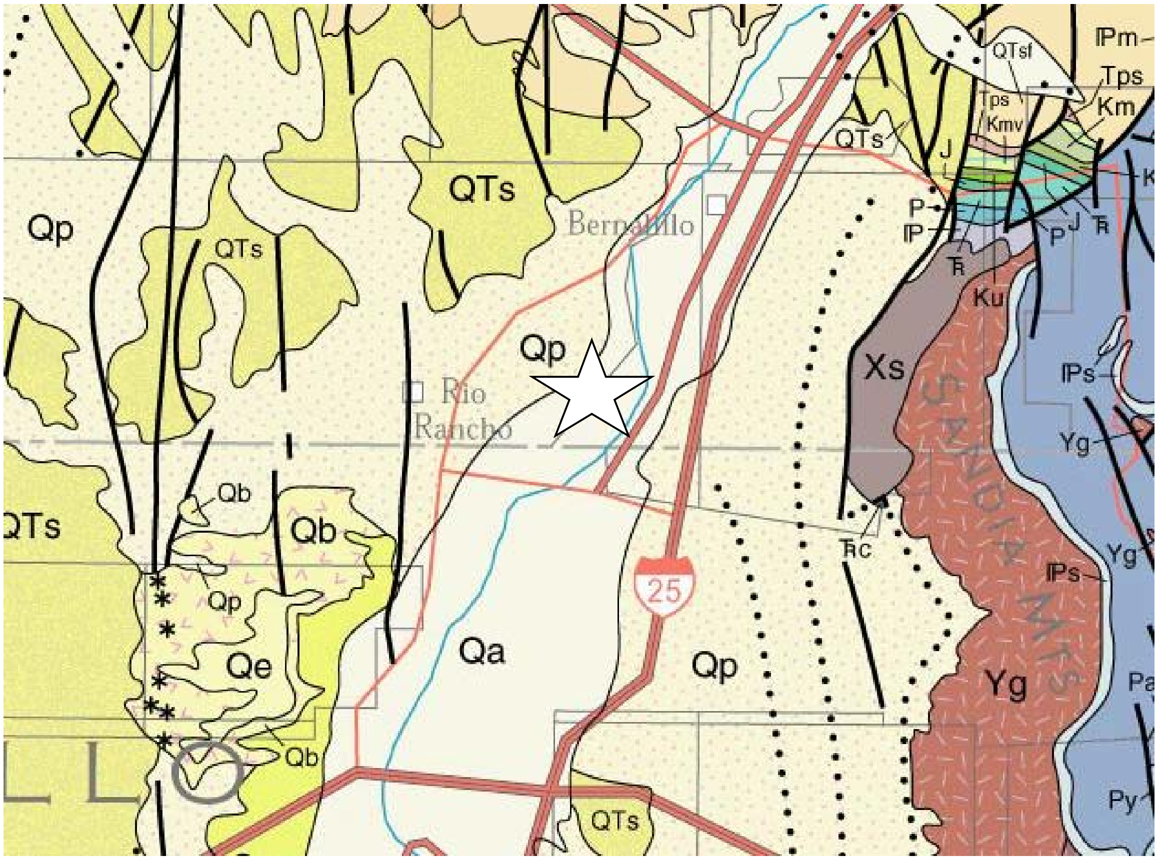
Figure 2. Geologic Map of Corrales and Vicinity. From NMBGMR (2003). For explanations of geologic units other than explained below, see NMBGMR, 2003.



Corrales

Qa Quaternary Alluvium
Qp Quaternary Piedmont Deposits
QTs Quaternary-Tertiary Santa Fe Group
Fault or Fault Zone (dotted where inferred)
Rio Grande

Figure 3. Aquifer Sensitivity of Corrales and Vicinity. From NMED Environmental Geographic Information System (eGIS) http://gis.nmed.state.nm.us/nmed/main.jsp. High sensitivity is means depth to ground water is less than 100 feet. Medium sensitivity means depth to ground water is 100 to 300 feet.

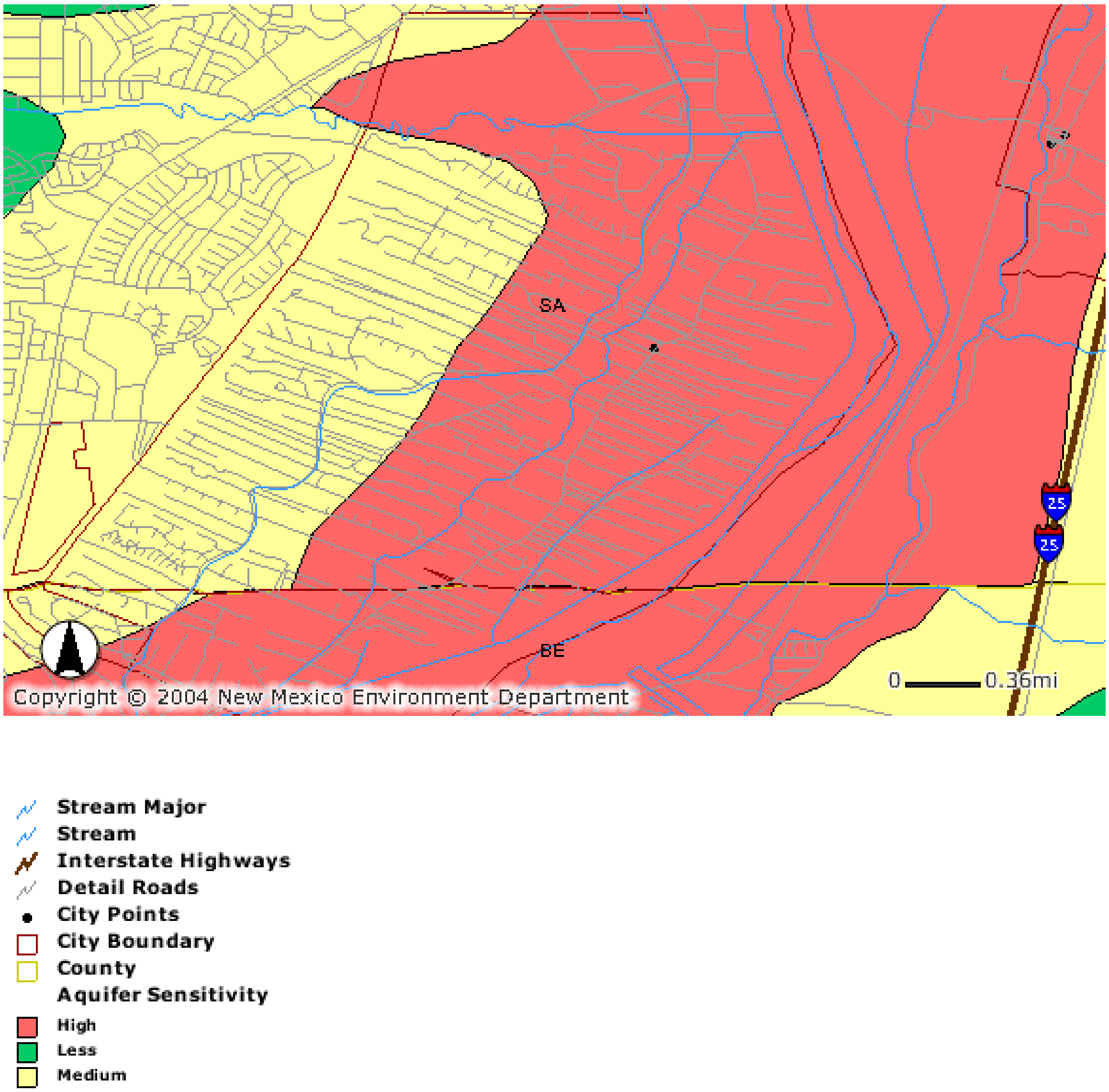
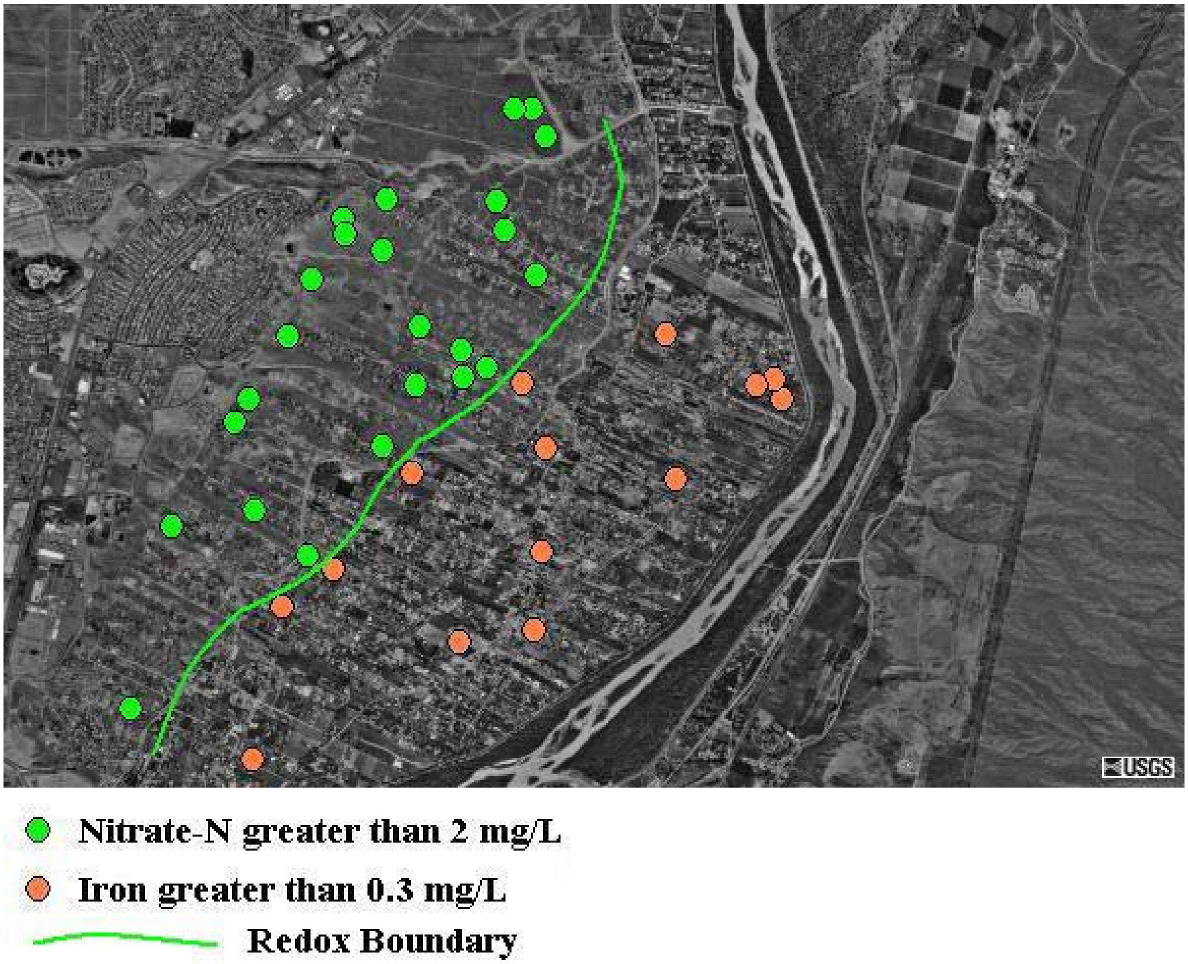


Figure 4. Nitrate and Iron Trends in Corrales Ground Water, 2003 to 2005.



Appendix A - Corrales Water Fair Results, 2003-05.

Sample Location: Street	Sampling Date	Total Depth of Well [ft]	Depth to Water [ft]	DO [mg/L]	pH	T [C]	Conductivity [uS/cm]	Organic Vapor [Y/N]	NO3-N [mg/L]	Fe [mg/L]	SO4 [mg/L]	F [mg/L]
ALAMO RD	11/18/2005	300		0.06	8.02	15.9	426	N	0.0	0.00	118	0.36
ALAMOS RD	11/21/2003	~250			7.56	20.5	498	N	0.5	0.00	90	0.53
ALARY FARM RD	11/21/2003	130	10		7.41	17.1	227	N	0.0	0.00	67	0.36
ANGEL RD	11/17/2005	125		0.87	7.65	15.4	512	N	**2.8**	0.00	104	0.36
ANYA RD	11/17/2005			4.26	7.53	16.9	634	N	**3.2**	0.00	120	0.35
APPLEWOOD RD	11/18/2005	100	15	0.17	7.71	16.6	**1300**	N	0.3	0.01	**380**	0.5
ASHLEY LANE	11/17/2005			1.2	7.69	22.9	904	N	0.1	0.00	**265**	0.5
ASHLEY LANE	11/17/2005			1.09	7.92	18.8	835	N	0.1	0.00	**295**	0.47
ASHLEY LN	11/18/2005			0.14	7.86	17.1	634	N	0.0	0.10	152	0.45
BALBOA CT	11/17/2005			2.0	7.62	31.2	**1015**	N	**4.6**	0.00	225	0.39
BARNARD	11/21/2003	200	90		7.44	18.0	358	N	**2.6**	0.01	108	0.29
BARNARD RD	11/21/2003				7.42	15.4	746	N	0.4	0.00	94	0.31
BARNARD RD	11/21/2003				7.59	16.4	441	N	0.0	0.00	100	0.39
BARNARD RD	11/21/2003				7.61	20.6	763	N	1.4	0.00	86	0.28
CALLE BONITA	11/18/2005	75		1.75	7.9	15.7	653	N	0.0	0.00	132	0.29
CALLE CONEJO	11/21/2003				7.62	4.5	603	N	0.2	0.00	100	0.43
CALLE ROJA	11/21/2003	325			7.49	17.8	531	N	**2.3**	0.00	82	0.45
CAMINO ALLO IRIS	11/18/2005	210		2.9	7.96	18.5	478	N	0.5	0.00	96	0.41
CAMINO ALTO	11/21/2003				7.39	17.9	634	N	0.0	0.17	**448**	0.47
CAMINO DE LA POLAMA	11/17/2005		14	0.13	7.94	14.5	327	N	0.0	0.00	72	0.59
CAMINO DE LA TIERRA	11/21/2003	240			6.62	20.7	29	N	0.0	0.00	1	0.05
CAMINO DE LA TIERRA	11/21/2003	180	80		7.61	18.5	428	N	0.0	0.00	98	0.34
CAMINO DE LA TIERRA	11/7/2005			1.97	7.7	17.4	448	N	0.0	0.03	112	0.48

CAMINO DE LA TIERRA	11/17/2005	240		0	7.65	18.9	439	N	0.5	0.00	108	0.41
CAMINO DE LA TIERRA	11/18/2005			0.6	7.8	18.8	210	N	**2.6**	0.00	75	0.42
CAMINO DE LA TIERRA	11/18/2005	120		0.63	7.63	23.2	619	N	0.0	0.00	124	0.28
CAMINO DE LA TIERRA	11/18/2005	140		0.49	7.81	16.3	599	N	**3.0**	0.00	106	0.24
CAMINO DE LUCIA	11/17/2005	185		1.6	7.79	18.8	243	N	0.0	**0.88**	35	0.33
CAMINO DE LUCIA	11/17/2005	140		4.2	7.56	13.9	334	N	0.0	**0.59**	51	0.41
CAMINO DE LUCIA	11/17/2005	178		0.9	7.67	16.5	272	N	0.0	**0.35**	43	0.61
CAMINO DE LUCIA	11/17/2005			1.00	8.06	15	293	N	0.0	0.12	62	0.47
CAMINO HERMOSA	11/18/2005	320	120	0.09	7.92	14.7	539	N	**3.9**	0.00	110	0.49
CAMINO HERMOSA	11/18/2005			0.13	8.14	17.8	338	N	0.9	0.01	72	0.46
CAMINO RAYO DEL SOL	11/17/2005	400		1.4	7.84	13	486	N	0.5	0.04	116	0.39
CAMINO RAYO DEL SOL	11/17/2005			1.21	7.77	17.8	557	N	0.2	0.01	120	0.4
CAMINO VERDE	11/18/2005			0.7	7.92	17.5	807	N	0.0	0.00	**305**	0.48
CAMNIO ARCO IRIS	11/18/2005	60		0.57	7.51	16.9	1132	N	**2.4**	0.00	320	0.65
CAREY RD	11/21/2003				7.60	14.9	602	N	0.0	0.01	102	0.42
CHIMAJA	11/21/2003				7.69	15.6	727	N	1.4	0.00	94	0.39
CIELO	11/18/2005			1.45	7.91	17.6	384	N	0.0	0.00	68	0.4
CIELO AZUL	11/18/2005			0.16	7.79	16.4	505	N	0.0	0.00	104	0.53
CORONADO PL	11/21/2003	70	30		7.52	9.8	**1572**	N	**4.2**	0.03	**270**	0.84
CORONADO RD	11/21/2003	>150			7.46	21.6	934	N	0.0	**1.69**	212	0.39
CORONADO RD	11/21/2003	120	40		7.59	17.5	**1101**	N	0.0	0.20	240	0.49
CORRALES	11/18/2005	128		0.68	8.08	12.9	388	N	0.0	0.07	76	0.38
CORRALES RD	11/21/2003	117	8		7.88	17.9	165	N	0.0	0.02	29	0.00
CORRALES RD	11/17/2005	430		0.81	7.35	20.9	960	N	0.6	**0.40**	132	0.36
CORRALES RD	11/17/2005	430		2.67	7.43	17.7	685	N	0.0	**1.64**	122	0.33
CORRALES RD	11/17/2005	260	6		7.51	15.2	631	N	0.2	**0.65**	138	0
CORRALES RD	11/18/2005				8.11	13.5	549	N	0.0	0.00	132	0.37
CORRALES RD	11/18/2005				7.71	17.2	465	N	0.0	0.01	96	0.33
CORRALES RD	11/18/2005				7.84	17	634	N	0.0	0.00	138	0.35
CORRALES RD	11/18/2005			1.04	7.91	11.4	525	N	0.0	0.06	146	0.31
CORRALES RD.	11/17/2005			0.14	7.81	15.7	352	N	0.4	0.00	71	0.43
CORRALES RD.	11/17/2005			0.19	7.86	15.3	300	N	0.0	0.00	56	0.52

DOOLITTLE	11/17/2005			4.1	7.54	20.7	551	N	0.0	0.00	108	0.39
EAST ELLA	11/21/2003				7.53	18.6	842	N	0.0	0.00	148	0.34
EAST LA ENTRADA	11/21/2003				7.38	16.9	482	N	0.0	0.07	62	0.49
EAST LA ENTRADA	11/21/2003	65	5		7.56	18.1	349	N	0.0	0.00	67	0.45
EAST MEADOWLARK LN	11/21/2003	30	10		7.49	20.5	306	N	0.0	0.15	114	0.43
EL CAMINO CAMPO	11/21/2003	230	30		7.52	18.9	548	N	0.4	0.11	**368**	0.46
EL CAMINO VERDE	11/21/2003	60	~10		7.69	21.7	420	N	0.0	0.18	59	0.51
EL DORADO CT	11/17/2005	93	235	1.85	7.49	23.2	732	N	**2.8**	0.00	122	0.34
EL DORADO CT	11/17/2005			3.2	8.16	26.4	871	N	**2.7**	0.00	100	0.35
EL REY DR	11/17/2005			1.12	7.29	16.3	406	N	0.1	0.00	**350**	0.41
ESMERALDA CT	11/21/2003	210	85		7.60	23.6	322	N	0.1	0.00	78	0.39
FACULTY LN	11/17/2005	180		10.1	7.6	15.8	254	N	0.0	**0.45**	0	0.48
GONZALES RD	11/18/2005	300		1.4	8.1	11.6	275	N	0.0	0.00	57	0.38
GUITERREZ RD	11/21/2003	215	150		7.49	16.1	335	N	0.0	**0.40**	94	0.46
LA ENTRADA	11/17/2005	210	50	1.81	7.47	13.1	684	N	0.1	0.00	148	0.31
LENA CT.	11/17/2005			2.7	7.61	21.7	719	N	**3.3**	0.00	122	0.3
LOMA LARGA	11/21/2003	150			7.21	15.9	**1301**	N	**2.1**	0.07	**300**	0.70
LOMA LARGA	11/17/2005	75	44	1.15	7.41	19	647	N	1.0	0.01	104	0.71
LOMA LARGA RD	11/21/2003	70	15		7.23	15.9	838	N	0.0	**0.44**	100	0.47
LOMA LARGA RD	11/17/2005	365		1.9	7.52	25.1	433	N	0.1	0.02	66	0.44
LOMA LARGA RD	11/17/2005			1.1	7.84	18.1	568	N	0.0	0.00	120	0.33
LOS MANZANOS	11/21/2003				7.46	19.1	893	N	0.0	0.28	136	0.36
MANZANOS	11/18/2005	160		0.36	7.63	15.9	743	N	0.0	0.15	136	0.34
MARIQUITA RD	11/21/2003				7.72	23.9	328	N	0.0	0.00	118	0.32
MEADOWLARK LN	11/21/2003	>200			7.69	20.0	310	N	0.0	**0.33**	120	0.37
MERRIAM ACRES	11/18/2005	280		0.69	7.68	18.3	653	N	0.7	0.00	144	0.5
MIKAELA	11/17/2005			3.8	7.58	15.2	340		0.4	0.03	106	0.35
MIKAELA	11/17/2005	300		4.1	7.96	11.1	476	N	0.0	0.00	98	0.5
MIKAELA	11/17/2005	500		2.1	8.22		594	N	0.5	0.00	110	0.4
MIRA SOL RD	11/18/2005			1.14	8.1	17.9	398	N	0.0	**0.85**	77	0.35
MISSION VALLEY	11/21/2003				7.75	16.2	221	N	1.4	0.01	42	0.51
MISSION VALLEY	11/17/2005			1.97	7.63	13	400	N	1.7	0.00	124	0.48

MOCKINGBIRD LN	11/17/2005			0.16	7.33	19.6	770	N	0.0	**0.63**	126	0.53
MT. SHADOWS	11/17/2005	115	15	2.72	7.6	14.5	799	N	0.2	0.00	144	0.32
NOBLES LANE	11/17/2005	220		0	7.43	18.8	517	N	0.0	0.00	124	0.36
NOBLES LN	11/21/2003	220	85		7.71	20.2	258	N	0.0	0.00	104	0.36
OLD CHURCH	11/18/2005			1.01	7.35	17.5	799	N	0.5	0.01	165	0.76
OLGUIN RD	11/17/2005			1.41	7.47	15.8	585	N	0.8	0.00	122	0.36
PASEO DE CORRALES	11/18/2005	320		0.95	7.71	19.9	903	N	**6.5**	0.01	**280**	0.46
PERA LANE	11/17/2005			0.64	7.71	15.8	602	N	0.0	0.00	134	0.33
PERA LANE	11/17/2005			0,90	7.72	16	588	N	0.0	0.23	146	0.33
PEREA LANE	11/17/2005			0.72	7.80	15.5	545	N	0.0	**0.30**	120	0.41
RINCON	11/17/2005	42	3	1.71	7.58	13.8	383	N	0.0	0.12	75	0.43
RIVERA LANE	11/17/2005		5	0.08	7.66	14.9	338	N	0.0	0.01	67	0.45
RUFFLES	11/18/2005			1.81	7.8	19.5	897	N	0.2	0.03	240	0.49
SAGE BRUSH	11/18/2005				7.85	32.7	678	N	**2.4**	0.00	120	0.31
SAGEBRUSH	11/17/2005	170	140	3.62	7.71	18.6	605	N	0.9	0.00	114	0.33
SAGEBRUSH	11/18/2005				8.18	24.6	719	N	0.0	0.00	154	0.27
SAGEBRUSH	11/18/2005				8.1	19.1	644	N	0.1	0.00	118	0.35
SAGEBRUSH	11/18/2005	200	80		8.04	16.5	632	N	**3.6**	0.00	124	0.27
SAGEBRUSH	11/18/2005	100		2.27	7.98	19.4	668	N	**3.3**	0.00	112	0.38
SAGEBRUSH DR	11/17/2005	180		0.87	7.76	17.4	644	N	**4.2**	0.00	114	0.34
SAGEBRUSH DR	11/18/2005	250	80		799	12.4	544	N	1.5	0.00	116	0.36
SAN ANDRES RD	11/17/2005			0.7	7.53	12.4	519	H2S	0.1	0.20	148	0.36
SANDIA VIEW	11/17/2005			1.31	7.55	17.4	607		0.8	0.15	124	0.47
SANDIA VIEW	11/17/2005			1.13	7.64	16.8	611		0.8	0.01	124	0.42
SERENO RD	11/18/2005			0.05	7.84	16.5	665	N	**2.6**	0.00	136	0.37
SIERRA VISTA	11/18/2005				7.86	16.8	609	N	**3.3**	0.00	126	0.3
SIERRA VISTA	11/18/2005				7.04	22.5	88.1	N	1.4	0.00	1	0
SIERRA VISTA	11/18/2005				8.02	25	**1043**	N	1.7	0.00	205	0.35
SIERRA VISTA	11/18/2005				7.52	22.4	505	N	1.0	0.00	146	0.41
SIERRA VISTA RD	11/18/2005	220			7.9	29.9		N	0.0	0.00	76	0.3
SIERRA VISTA RD	11/18/2005			0.12	7.9	17.4	535	N	0.0	0.00	142	0.3
TENORIO RD	11/21/2003	300	110		7.62	15.3	736	N	0.0	**1.84**	106	0.39

TIERRA ENCANTADA	11/21/2003				7.66	23.1	225	N	**4.2**	0.00	73	0.40
TIERRA ENCANTADA	11/17/2005	333	230	1.32	7.76	14.1	409	N	**2.7**	0.00	120	0.42
TIERRA ENCANTADA	11/17/2005	228	120	3.61	7.62	16	378	N	**3.1**	0.00	78	0.46
WEST ELLA	11/17/2005			0.58	7.53	15.7	620	N	1.8	0.00	132	0.43
WEST ELLA	11/18/2005	55		2	7.37	18.9	330	N	0.0	0.19	116	0.5
WEST ELLA DR	11/17/2005			2.68	7.84	16.5	648	N	1.0	0.00	120	
WEST ELLA DR	11/17/2005			1.37	7.86	16.8	550	N	1.0	0.00	122	0.42
WEST LA ENTRADA	11/21/2003	196	30		7.60	17.5	278	N	0.0	0.03	102	0.33
WEST LA ENTRDEA	11/18/2005	200	26	0.03	7.96	14.5	452	N	0.0	0.02	77	0.35
WEST MEADOWLARK	11/17/2005	250	15	0.23	7.56	15.3	707	N	0.0	0.00	230	0.42
WEST MEADOWLARK LN	11/21/2003				7.69	19.5	738	N	0.0	0.00	**280**	0.48
WESTERN MESA RD	11/21/2003	200	95		7.56	19.3	622	N	1.6	0.00	192	0.39
WESTERN MESA RD	11/17/2005			0.13	7.53	18	809	N	1.5	0.00	230	0.5
WESTERN MESA RD	11/18/2005	120		1.1	7.81	21.5	**1012**	N	**2.4**	0.02	**255**	0.58
WESTERN MESA RD	11/18/2005	120		2.65	7.9	20.3	**1004**	N	**2.2**	0.00	210	0.57
WHITE HORSE LN	11/21/2003	110	9		7.77	17.9	196	N	0.0	0.00	59	0.42
WINDOVER LANE	11/21/2003	150			7.53	18.9	953	N	0.0	0.05	236	0.45
WINDOVER LN	11/21/2003	190			7.84	15.2	918	N	0.0	0.00	200	0.58
	11/17/2005	106	5	0.21	7.68	15	460	N	0.0	0.90	96	0.28
	11/18/2005				7.74	27.8	663	N	0.0	0.00	140	0.36
	11/18/2005											