

**NELSON WATER WELL INVESTIGATION REPORT  
LOGAN COUNTY COLORADO**

Terracon Project No. 25087038  
December 3, 2008

*Prepared for:*

**COLORADO OIL AND GAS CONSERVATION COMMISSION  
1120 Lincoln Street  
Denver, Colorado 80203-2136**

*Prepared by:*

**TERRACON  
10625 WEST I-70 FRONTAGE ROAD NORTH, SUITE 3  
WHEAT RIDGE, COLORADO 80033**

**Terracon**

December 3, 2008

Mr. John Axelson  
Colorado Oil and Gas Conservation Commission  
9203 E. 155th Drive  
Brighton, CO 80602

**Re: Final Report: Nelson Water Well Investigation Report  
Logan County, Colorado  
P.O. # 09000000019  
Terracon Project No. 25087038**

Dear Mr. Axelson:

Please find enclosed four copies of Terracon's final Nelson Water Well Investigation report for your use and distribution.

If you have questions or require additional information, please do not hesitate to contact us at (303) 423-3300.

Sincerely,  
**Terracon Consultants, Inc.**



John C. Dellaport, P.E., P.G.  
Senior Environmental Engineer



Russell Pickering, M.S.  
Environmental Department Manager

Enclosure:

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**NELSON WATER WELL INVESTIGATION REPORT  
LOGAN COUNTY  
DECEMBER 3, 2008  
PROJECT NO. 25087038**

**1.0 PROJECT BACKGROUND**

In September 2008, the Colorado Oil and Gas Conservation Commission (COGCC) retained Terracon Consultants, Inc. (Terracon) to investigate the potential source(s) of groundwater impacts to the domestic water well located on the Ron Nelson residential property (the Site). The Site is located in the northeast quarter of the northeast quarter of Section 6, Township 11 North, Range 52 West. The physical address of the Site is 18852 County Road in Logan County, Colorado (Figure 1). The area immediately surrounding the Site is used for agriculture (cropland). Several oil and gas (O&G) production wells are located north, west and south of the Site. The closest O&G production facilities are operated by Coral Productions (Coral) and include the Schwake A-1, A-2 and A-3 production wells, the Schwake tank battery and overflow water pits, and the Gillham #5 injection well. The relative locations of these O&G facilities to the Site are depicted on Figure 1.

A review of COGCC file information indicated that Gulf Oil Company permitted and installed the three Schwake production wells in 1952. The wells are completed in the Dakota Formation (J Sand) unit at a depth of approximately 5,300 feet. The wells have grouted surface casing to a depth of approximately 220 feet and inner casing to their total depth. Of the three wells, Schwake A-2 is the only remaining active production well. Schwake A-3 was plugged and abandoned in 1957 and Schwake A-1 has been inactive (shut-in) since March 2001. In 1971, two overflow water pits were permitted and constructed 500 feet northeast of Schwake A-1 at the Schwake tank battery. According to COGCC records, the water pits have been inspected on several occasions, and sometimes were found to contain water covered with oil.

In 1984, Melvin Nelson filed a complaint with the COGCC concerning a noticeably "salty taste" in his well water. A November 1985 letter from the Northeast Colorado Health Department to the COGCC cited an increase in specific constituents (calcium, magnesium, sodium, potassium, bicarbonate, chloride, and total dissolved solids [TDS]) in the Nelson well water and indicated that the Schwake overflow water pits may be the source of the impacts to the Nelson water well.

Between December 1984 and January 2008, the Schwake operators (Gulf Oil, then Coral Productions) and COGCC collected several water samples from the Nelson water well, the O&G production facilities and nearby residential wells. The water samples were analyzed for constituents commonly found in oil field brine solutions and included major cations, major anions, and BTEX (benzene, toluene, ethylbenzene and xylenes), methane, specific metals, and TDS. Increases in chloride, TDS, calcium and magnesium concentrations had been observed in the Nelson water well samples over this time period. However, the increases of these

constituents were not conclusively attributed to O&G activities, primarily because of the absence of O&G marker constituents (i.e., BTEX and methane) in the Nelson well water.

In January 1986 after preliminary review of collected water quality data, COGCC did not find enough evidence to conclude that there were impacts to the Nelson water well from nearby O&G activity.

Terracon reviewed the COGCC Piper Diagrams and Stiff Plots for the Schwake injection water, Schwake water pits and the Nelson well water. These plots indicated dissimilar water chemistries between the Schwake produced water and Nelson well water.

In September 2008, the COGCC retained Terracon to assist the COGCC with evaluating the potential source(s) of impacts to the Nelson water well. This work was completed in accordance with the COGCC statement of work dated September 16, 2008 and Purchase Order No. OE PHA 09000000019.

## **2.0 PROJECT OBJECTIVE AND SCOPE**

The objective of this study was to determine the potential source(s) of groundwater impacts to the Nelson water well. Possible sources identified early on in the study included the nearby Coral O&G production facilities (water pits and/or injection well), the Nelson septic leach field, and surface water impacts from a possible faulty well seal. Terracon prepared an analyte list that would aid in distinguishing impacts from O&G production facilities and surface water impacts resulting from Site activities.

## **3.0 REGIONAL GEOLOGY AND HYDROGEOLOGY**

### **3.1 Geology**

Several sources of information were consulted to assess the geology at the Site. Regionally, the Site is located on loosely-cemented sand and gravel deposits belonging to the Tertiary-aged Ogallala Formation (USGS 1979). A 1971 permit application to construct the Schwake tank battery water pits indicated that the subsoil is sandy soil and sand from ground surface to a depth of 130 feet. Additionally, a November 8, 1985 letter from the Northeast Colorado Health Department to COGCC indicated that the Schwake overflow water pits were completed into gravel. The Ogallala Formation is approximately 225 feet thick near the Site and is underlain by the White River Formation. According to the driller's log for Schwake well A-3, the underlying bedrock consists of shale from 225 to 4,545 feet, shale and limestone to 4,922 feet and sandstone and shale to 5,344 feet. The J Sand of the Cretaceous-aged Dakota Formation is at a depth of approximately 5,330 feet near the Site.

## 3.2 Hydrogeology

The Nelson water well is completed to a depth of approximately 250 feet in the High Plains aquifer, consisting of unconsolidated to semi-consolidated sands, gravels, clays and silts of the Ogallala Formation. The water from this aquifer is typically a calcium carbonate type and generally of good quality. TDS ranges from 250 to 500 milligrams per liter (mg/l) within most areas of the aquifer (CGS 2003). Based on a 1980 potentiometric surface of the aquifer, regional groundwater flow is to the southeast (CGS 2003). Depth to shallow groundwater at the Site is expected to range from 62 to 75 feet, based on driller's logs from three nearby water wells. Groundwater flow direction at the Site is not known.

## 4.0 FIELD ACTIVITIES

### 4.1 Interviews

Ron Nelson (son of Melvin Nelson) was interviewed on October 7, 2008 to obtain information about the supply well and historic activities around the Site domestic well. The well is approximately 250 feet deep and has an 8-inch diameter galvanized steel casing to a depth of 180 feet. A submersible pump is set at a depth of approximately 140 feet and was replaced in September 2008. The water well is located about 100 feet east of the residence. Water is pumped from the well to a pressure tank (within a storage shed), then pumped to the residence. The septic leach field is located about 150 feet west of the residence. Figure 2 illustrates the relative locations of these features. The Nelson family grazed about twenty head of cattle on the Site from the 1920's until approximately 2003. The livestock watering tank was located about 50 feet south of the storage shed. No livestock have grazed on the Site since 2003. According to Mr. Nelson, deicing materials or road salts were not used or stored on the Site.

Jim Wieger (Coral Productions) was interviewed on October 7, 2008 to obtain information about O&G operations on the Schwake lease. Coral Productions took over the Schwake operations in 1998. A mixture of water and oil are produced from the Schwake A-2 well. Produced water/oil is pumped through an underground fiberglass pipeline to the tank battery where the oil is separated from the water. The fiberglass pipeline replaced an earlier steel pipeline that had several minor leaks. The oil is stored in an aboveground tank at the tank battery and the produced water is pumped through an underground pipeline approximately 2,000 southwest to the Gillham #5 injection well. According to Mr. Wieger, the Gillham #5 well is used for water disposal and not for the enhanced recovery of oil. Mr. Wieger reported that Coral Production has never operated the water pits since they took over operation of the Schwake lease in 1998. However, during several inspections in 2008, COGCC noted that the skim pit was full of water. In 2003 and 2006, mechanical integrity tests were performed on the Gillham #5 injection well and these tests were accepted by COGCC. These test summaries were reviewed by Terracon

and are available on the COGCC database. Schwake A-1 has not been tested for mechanical integrity.

#### **4.2 Site Inspection**

Terracon inspected the Site and area surrounding the well for evidence of surface staining, stressed vegetation or other indications of chemical storage. There was no evidence of chemical storage, spillage or staining in the area of the well. The wellhead was not accessible for inspection because a steel drum had been placed over the well. The area around the well is relatively flat. Surface drainage around the wellhead appeared to be adequate and no evidence of ponding near the well was observed.

#### **4.3 Well Sampling**

On October 13, 2008, Terracon sampled the Nelson water well and Schwake A-2 production water. The Nelson water well was sampled downstream from the pressure tank which is located in the storage shed south of the residence (Sample I.D. = "Nelson Well"). Water was purged from the well and monitored for the field indicator parameters temperature, specific conductance, dissolved oxygen, and pH. When the parameters stabilized, water samples were collected. Parameter stabilization was achieved when parameter measurements varied by less than 10 percent from the previous measurement per Terracon's standard operating procedure. Field indicator parameters stabilized after 30 minutes of pumping at a rate of six gallons per minute (approximately 200 gallons purged).

The Schwake A-2 production well water was sampled at the Gillham #5 injection well (Sample I.D. = "Injection Well"). Water samples were collected from a tap on the injection pipe. Because the Schwake A-2 well was producing and injecting water at the time of sampling, it was not necessary to purge the pipeline of stagnant water.

Water well samples were collected in laboratory-prepared bottles and packaged on ice in a cooler. Water samples were hand delivered to Evergreen Analytical Laboratory (Evergreen) in Wheat Ridge, Colorado.

The Nelson well water sample was analyzed for total extractable petroleum hydrocarbons as diesel fuel #2 (TEPH, Method SW8015B Modified), anions (bromide, nitrate-N, nitrite-N, sulfate, and chloride, Method E300.0), dissolved metals (calcium, magnesium, sodium, iron, manganese, potassium, and selenium, EPA Methods 6010B and 6020), TDS (Method SM 2540C), fluoride (Method SM 4500-FC), surfactants (Method SM5540C), fecal coliform (Method SM9221 C/E) and total coliform (Method SM 9221 B). The injection well water sample was analyzed for TEPH, anions, dissolved metals, TDS, and fluoride. The laboratory analysis report is included in Appendix A.

#### 4.4 Soil Sampling

As part of the investigation, Terracon reviewed soil sample results provided by COGCC. On March 3, 2008, COGCC personnel collected two soil samples from the bottom of the first produced water pit (0 to 0.5 and 2.5 to 3.5 foot depth) and one background soil sample from surficial soil (0 to 1.0 foot depth) near the Nelson water well. The purpose of the soil sampling was to determine if there is a potential source of contaminants in soils underlying the water pits and/or near the Nelson water well. The three soil samples were analyzed by Evergreen for sodium adsorption ratio, specific conductance, dissolved metals (calcium, magnesium, sodium and potassium), anions (chloride, bromide and sulfate), and pH. The soil analytical results are summarized in Table 2.

### 5.0 DATA SUMMARY

For each analyte, data from the October 13, 2008 sampling event of the Nelson well and the Schwake injection water are presented followed by a summary of historical data for that analyte. The historical data includes nine sampling events for the Nelson well, four sampling events for the injection water and three sampling events for neighboring domestic wells.

#### 5.1 Petroleum Hydrocarbons

TEPH: The Nelson well water sample contained 6 mg/l as TEPH and the injection water sample contained 13 mg/l as TEPH. Quantifying TEPH as diesel fuel #2 can be a useful analytical tool for tracing migration of petroleum crude oil in groundwater. Diesel fuel is refined from crude oil and is composed mostly of alkane hydrocarbons in the C11 to C20 range. These hydrocarbons represent a significant fraction of crude oil, they dissolve easily in groundwater, and they are less prone to volatilization than lighter fraction hydrocarbons. TEPH is not a regulated constituent in groundwater.

BTEX and Methane: In July 2007 and January 2008, COGCC sampled the Nelson water well and analyzed samples for BTEX and methane. No BTEX or methane were detected in the July 2007 water sample. No BTEX and a low concentration of methane (0.0011 mg/l) were detected in the January 2008 water sample.

#### 5.2 Anions

Chloride: Chloride concentrations in the Nelson well water and injection water samples were 2,050 and 3,870, respectively. Previous chloride concentrations in injection water and water pit samples collected from the Schwake operations ranged from 3,995 to 4,600 mg/l between 1971 and 2008. From December 1984 to October 2008, chloride concentrations in the Nelson well water increased from 304 to 2,050 mg/l. Chloride concentrations in the Nelson water samples have consistently exceeded the Colorado Department of Public Health and Environment Water Quality Control Division (CDPHE) secondary drinking water standard for chloride (250 mg/l). Chloride concentrations in three nearby domestic wells ("neighbor well", Lewis Creek Well and

Lewis Creek Nonpotable Well) ranged from 19 to 147 mg/l (see Table 1 and Chart 1). These three nearby wells are believed to be unaffected by O&G operations and are assumed to represent baseline Ogallala aquifer water quality conditions.

Sulfate: Sulfate concentrations in the Nelson well water and injection water samples were 43.9 and 380 mg/l, respectively. Previous sulfate concentrations in the Nelson water samples fluctuated between 25 to 47.3 mg/l from December 1984 to January 2008.

Fluoride: Fluoride concentrations in the Nelson well water and injection water samples were 0.22 and 2.3 mg/l, respectively. Fluoride concentrations in the Lewis Creek Well and the Lewis Creek Nonpotable Well were 2.5 and 0.53 mg/l in 2007.

Nitrate/Nitrite: No nitrite-N was detected in either the Nelson well water or the injection water samples. Nitrate-N was detected in the Nelson water sample at a concentration of 1.73 mg/l. In 1985 and 1986, nitrate-N concentrations in the Nelson well ranged from 25 to 34 mg/l.

Anionic Surfactants: Anionic surfactants were detected in the Nelson well water sample at a concentration of 0.082 mg/l, slightly above the lower quantitation limit of 0.025 mg/l. Anionic surfactants are indicative of laundry detergents and cleaning agents and are commonly found in municipal sewerage and septic leach fields. Concentrations of anionic surfactants in municipal sewerage typically range from 5 to 35 mg/l (Zoller 2004).

Bromide: Bromide concentrations in the Nelson well water and injection water samples were 9.3 and 17.6 mg/l, respectively. Previous bromide concentrations in the Nelson water samples ranged from 9.9 to 10.5 mg/l. Bromide concentrations in the Lewis Creek Well and the Lewis Creek Non Potable Well were 0.51 and 1.04 mg/l in 2007.

### 5.3 Dissolved Metals

Calcium: Calcium concentrations in the Nelson well water and injection water samples were 660 and 12 mg/l, respectively. Previous calcium concentrations in injection water and water pit samples ranged from 14.2 to 80 mg/l between 1971 and 2007. Between December 1984 and October 2008, calcium concentrations in the Nelson water samples increased from 127 to 660 mg/l. Calcium concentrations in the three nearby domestic wells ranged from 4.8 to 110 mg/l (See Table 1 and Chart 2).

Magnesium: Magnesium concentrations in the Nelson well water and injection water samples were 230 and 2.5 mg/l, respectively. Previous magnesium concentrations in injection water and water pit samples ranged from 5 to 580 mg/l between 1971 and 2007. Between December 1984 and October 2008, magnesium concentrations in the Nelson water samples increased from 42 to 230 mg/l. Magnesium concentrations in the three nearby domestic wells ranged from 1.8 to 40 mg/l (See Table 1 and Chart 3).

Sodium: Sodium concentrations in the Nelson well water and injection water samples were 200 and 3,700 mg/l, respectively. Previous sodium concentrations in injection water and water pit samples ranged from 3,280 to 4,326 mg/l between 1971 and 2008. Between December 1984

and October 2008, sodium concentrations in the Nelson water samples increased from 27 to 200 mg/l. Sodium concentrations in the three nearby domestic wells ranged from 30 to 230 mg/l (See Table 1 and Chart 4).

Iron: The iron concentration in the Nelson well water sample was 0.17 mg/l. No iron was detected in the injection water sample.

Manganese: Manganese concentrations in the Nelson well water and injection water samples were 0.023 and 0.022 mg/l, respectively.

Potassium: Potassium concentrations in the Nelson well water and injection water samples were 36 and 25 mg/l, respectively.

Selenium: Selenium concentrations in the Nelson well water and injection water samples were 0.012 and 0.0068 mg/l, respectively.

#### 5.4 Other Analytes

TDS: TDS concentrations in the Nelson well water and injection water samples were 3,840 and 9,360 mg/l, respectively. Previous TDS concentrations in injection water and water pit samples ranged from 9,123 to 14,040 mg/l between 1971 and 2008. Between December 1984 and October 2008, TDS concentrations in the Nelson water samples increased from 607 to 3,840 mg/l. TDS concentrations in the three nearby domestic wells ranged from 346 to 725 mg/l (See Table 1 and Chart 5).

Total and Fecal Coliform Bacteria: No total coliform bacteria or fecal coliform bacteria were detected in the Nelson water well sample above method detection limits. Total and fecal coliform bacteria give a general indication of the sanitary condition of a water supply. Fecal coliform bacteria are indicative of animal or human wastes and can be present in surface water or septic leach fields. One or both of these types of bacteria can be found in well water that is affected by surface water.

## 6.0 DATA EVALUATION

The increasing trend of O&G indicator parameters in the Nelson water well suggests that the well has been impacted by O&G production. Chloride, TDS and sodium are used as chemical indicators of O&G impacts because these constituents exist in oil field brines typically at much higher concentrations than the overlying shallow aquifers. Chloride, TDS and sodium concentrations have increased significantly in the Nelson well from December 1984 to October 2008. In 2007, concentrations of these constituents in the neighboring Lewis Creek and Lewis Creek Nonpotable Wells were low in comparison to Nelson water well. TEPH is an indicator of O&G impacts. This constituent was found in both the injection water (13 mg/l) and the Nelson water well (6.0 mg/l).

Calcium, magnesium and potassium concentrations have increased in the Nelson water well since 1984. We believe that these cations have increased in the Nelson well because of cation exchange occurring in the soil column. Sodium-rich brine solution that percolates through the unsaturated soil column can exchange the sodium cation with calcium, magnesium and potassium cations naturally occurring in the Ogallala formation. This cation exchange process has been documented in other oil field brine solutions (Zoller 2004). The Ogallala formation is known to have caliche layers rich in calcium carbonate. Continued percolation of brine solution through the Ogallala Formation could produce groundwater enriched in calcium, magnesium and potassium constituents.

The observed impacts to the Nelson water well are not believed to be attributed to the Site septic leach field or surface water impacts. Fecal coliform, total coliform, nitrate, nitrite and anionic surfactants are constituents that are typically elevated in surface waters, livestock areas, and septic leach fields. These surface sources can impact a water well if the surface seal is faulty or if the surface impacts can migrate into shallow groundwater. These constituents were either not detected or were detected at insignificant concentrations in the Nelson well.

The most likely source for the O&G impacts is the overflow water pits at the Schwake tank battery. The pits are unlined and constructed over permeable sand and gravels likely extending into the shallow water table. Brine solutions leaking from the pits may have entered shallow groundwater. Assuming 30 years of pit operation and brine leakage, flow of contaminated groundwater through permeable materials may have impacted the Nelson water well 1,200 feet away from the pit operation.

The O&G brine constituents sodium, chloride and sulfate are significantly higher in soils beneath the overflow water pits than in surficial soils near the Nelson water well. Maximum sodium, chloride and sulfate soil concentrations beneath the water pits were 6,500 mg/l, 792 mg/kg, and 3,280 mg/kg, respectively. Whereas, sodium, chloride and sulfate concentrations in surficial soil near the Nelson water well were 23 mg/l, 6.3 mg/kg, 13 mg/kg, respectively. The concentrations of these constituents in soils beneath the water pits present a threat to shallow groundwater.

The Schwake production wells (A-1, A-2, and A-3) and the Gillham #5 injection well are not believed to be sources for O&G impacts because these wells are cased and sealed to a depth of at least 5,000 feet below ground surface. Moreover, the horizontal hydraulic conductivity of the Ogallala Formation is expected to be significantly higher than the vertical hydraulic conductivities of the relatively impermeable shale and sandy shale units between the Ogallala formation and the J Sand.

## **7.0 CONCLUSIONS AND RECOMMENDATIONS**

COGCC retained Terracon to investigate the potential source(s) of groundwater impacts to the Nelson water well located in the northeast quarter of Section 6, Township 11 North, Range 52 West in Logan County, Colorado. The conclusions from this study are presented below:

- O&G operations began on the Schwake lease in 1971.
- Melvin Nelson filed a water well complaint with COGCC in 1984.
- Chloride, sodium, and TDS are indicators of O&G impacts and these constituents have increased in the Nelson water well since 1984.
- TEPH is an indicator of O&G impacts and this constituent was detected in both injection water and the Nelson water well.
- Results of coliform bacteria, nitrate/nitrite and anionic surfactants testing do not support the conclusion that the Nelson water well has been impacted surface water or by the Site septic leach field.
- O&G impacts to the Nelson water well are believed to originate from the Schwake tank battery overflow water pits.

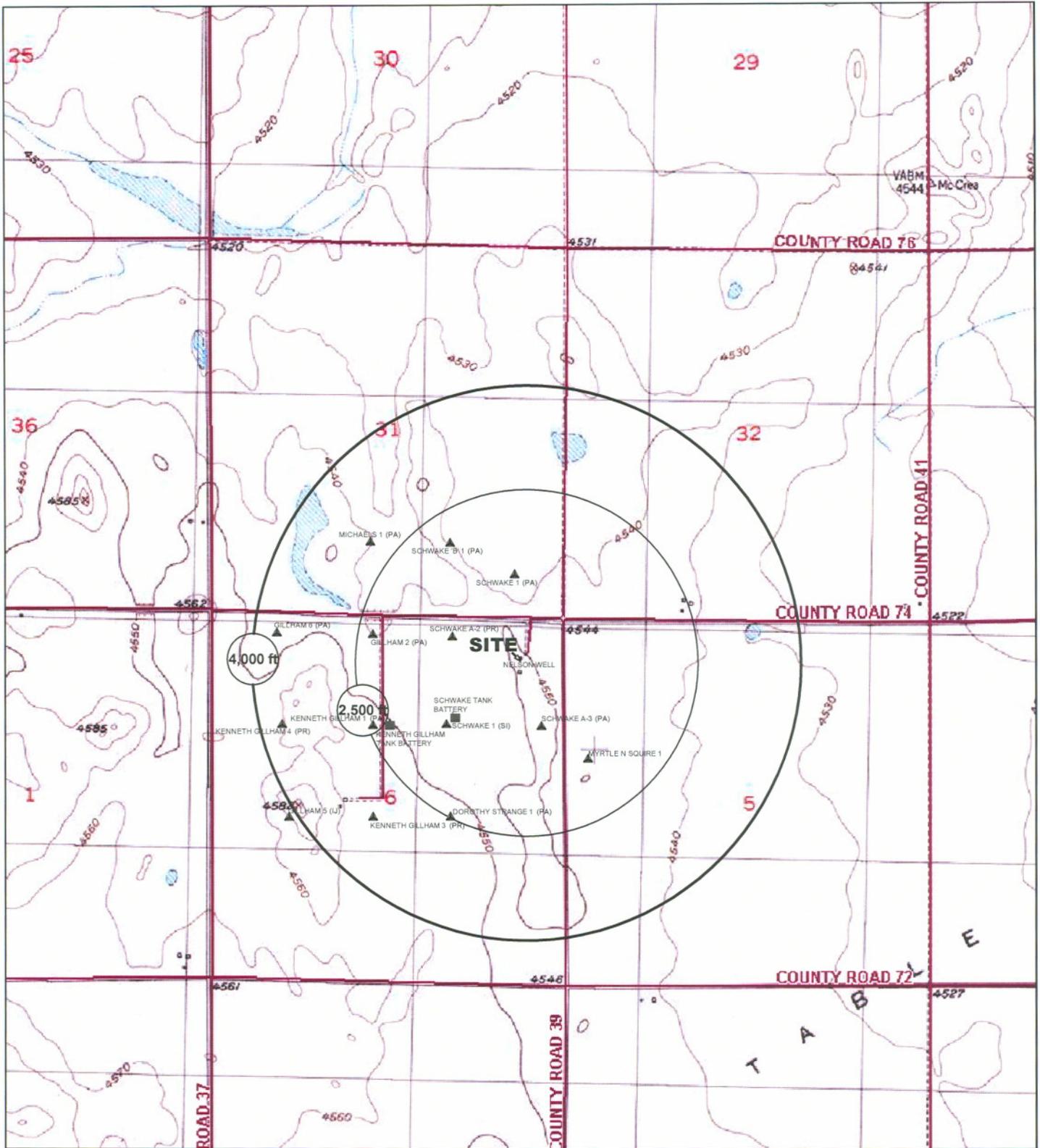
To eliminate the threat to shallow groundwater from residual soil contamination, Terracon recommends that the documented soil impacts associated with the produced water pits be fully delineated. Since the water pits are no longer used, once delineated, all contaminated soil should be properly remediated and the pits should be closed and reclaimed in accordance with COGCC regulations.

A shallow groundwater monitoring program would be necessary to more definitively determine if the overflow pits are the source(s) of O&G impacts to the Nelson water well. Groundwater monitoring wells should be installed near the overflow pits and sampled for O&G production fluid constituents. A minimum of three wells would need to be installed to a depth of approximately 100 feet or into the shallow water table. The two-inch diameter wells would be constructed with PVC casing and screened across the water table. The wells would be sampled for major cations, major anions, and O&G constituents. The wells would be surveyed and referenced to a site datum elevation so that the shallow groundwater flow direction can be estimated. Terracon can prepare a proposal to complete the described scope of services upon request from COGCC.

## 8.0 REFERENCES

- CGS (Colorado Geological Survey)  
2003 *Ground Water Atlas of Colorado*, Special Publication 53.
- USGS (United States Geologic Survey)  
1979 *Geologic Map of Colorado*, Tweto, Ogden.
- Zoller, et al.  
2004 *Handbook of Detergents: Environmental Impact*, CRC Press.

## FIGURES



**KEY**

- ▲ — COMMERCIAL OIL AND GAS WELL
- — WELL TANK BATTERY & WATER PITS
- (PR) - PRODUCING
- (SI) - SHUT IN SINCE 2001
- (IJ) - INJECTION WELL
- (PA) - PLUGGED AND ABANDONED

Source: USGS Padroni NW, Colorado,  
7.5-Minute Quardrangle Map



SITE LOCATION MAP  
18852 COUNTY ROAD 74  
TOWNSHIP II NORTH, RANGE 52 WEST  
PEETZ, COLORADO

Project Mngr: JCD  
Drawn By: JCG  
Checked By: JCD  
Approved By: RP

**Terracon**  
10625 West I-70  
Frontage Road North  
Wheat Ridge, CO 80033

Project No. 25087038  
Scale: 1" = 2000'  
Date: 11/3/08  
Figure No. 1

File Name: N:\Projects\2008\25087038\Environmental Support\Task 5 - Nelson Well\Figures\Fig 1

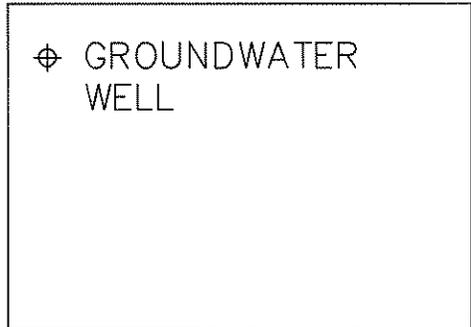
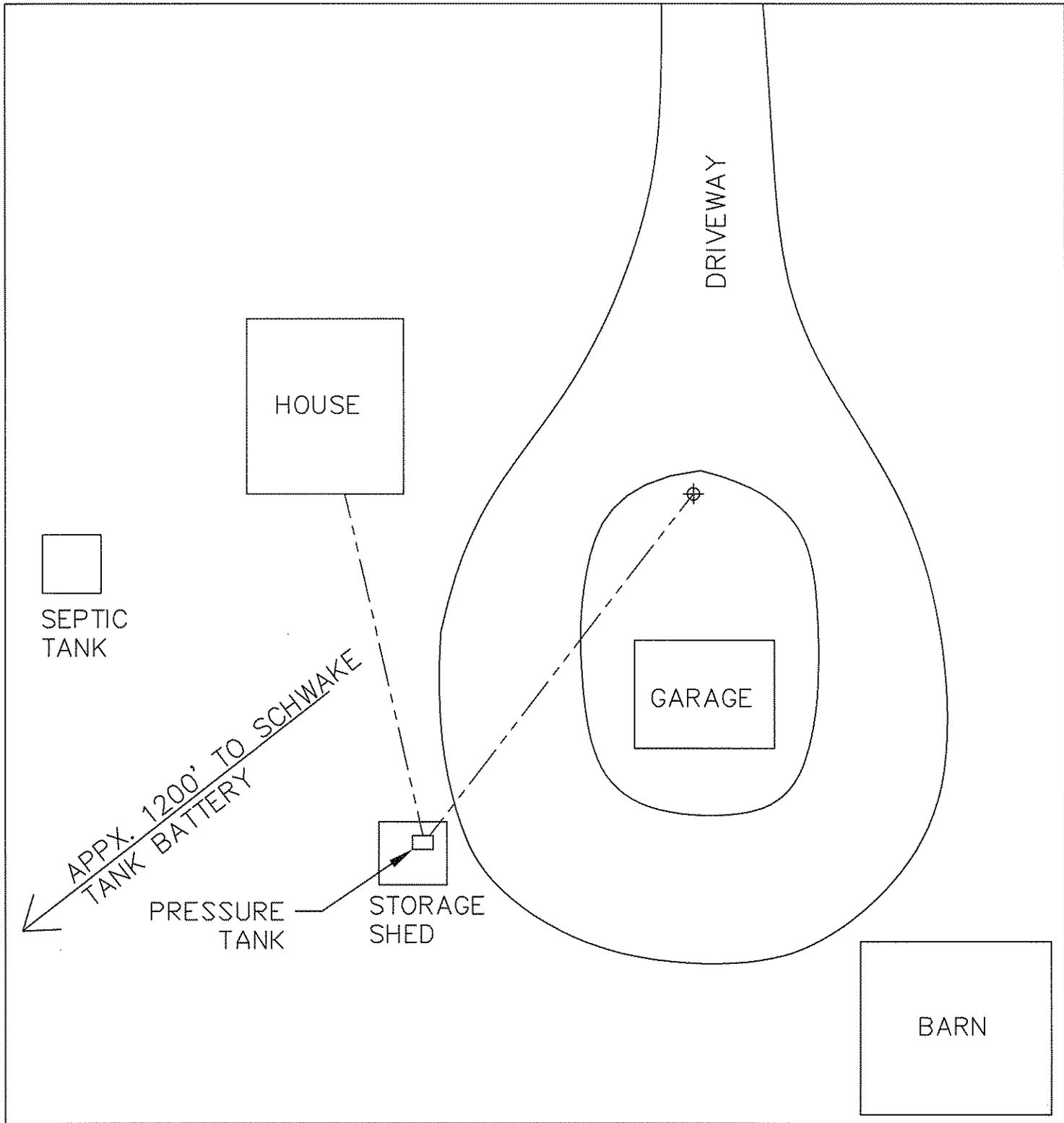


FIGURE 2: SITE DIAGRAM  
18852 COUNTY ROAD 74  
PEETZ, COLORADO

Project Mngr:	JCD	 10625 West I-70 Frontage Road North Wheat Ridge, CO 80033	Project No. 25087038
Drawn By:	JCG		Scale: NTS
Checked By:	JCP		Date: 11/3/08
Approved By:	RP		Figure: 2
File Name: N:\Projects\2008\25087038\Environmental Support\Task 5-Nelson Well\Figures\FIG2.dwg			

## TABLES

TABLE 1: GROUNDWATER ANALYTICAL SUMMARY - NELSON WELL WATER QUALITY STUDY

SAMPLE SOURCE	SAMPLE DATE	Chloride	Carbonate	Bicarbonate	Sulfate	Sodium	Potassium	Iron	Calcium	Magnesium	Manganese	TDS	Nitrate	Nitrite	Selenium	Boron	Bromide	Fluoride	BTEX	Methane	Total Coliform	Fecal Coliform	Surfactants	TPH	DESCRIPTION	
SCHWAKE A-1	10/27/1971	3900	192	2440	155	3639	28	ND	ND	7	NA	9123	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Chemical & Geological Laboratories, Casper, Wyoming	
NELSON WELL	12/4/1984	304	ND	122	34	27	13	NA	127	42	NA	607	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Nelson kitchen, Core Laboratories, Inc.	
SCHWAKE PIT	12/4/1984	4600	408	2050	630	4326	17	NA	20	5	NA	11015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Core Laboratories	
NELSON WELL	3/8/1985	333	0	147	30	40	15	NA	133	44	NA	776	34	NA	NA	0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	Colorado State University Domestic Water Analysis Report
NELSON WELL	10/29/1985	356	0	153	29	45	16	NA	146	48	NA	818	25	NA	NA	0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	Colorado State University Domestic Water Analysis Report
NELSON WELL	1/21/1986	400	0	150	26	46	15	NA	153	48	NA	863	25	NA	NA	0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	Colorado State University Domestic Water Analysis Report, Lab No. W1026
NEIGHBOR WELL	1/21/1986	19	0	166	35	30	8	NA	49	13	NA	346	26	NA	NA	0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	Colorado State University Domestic Water Analysis Report, Lab No. W1027
SCHWAKE PIT	8/22/1996	3595	ND	3517	616	3728	NA	1	80	580	NA	14040	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Rocky Mountain Region Laboratory, water from pit at tank battery, [Na & K] reported as [Na]
NELSON WELL	8/22/1996	425	ND	256	25	ND	ND	1	400	388	NA	3303	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Rocky Mountain Region Laboratory, water from well at farm house
NELSON BATHROOM	8/16/2005	1800	NA	NA	NA	180	NA	NA	NA	NA	NA	NA	8.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Nelson bathroom, Department of Public Health and Environment analytical report
LEWIS CREEK WELL	4/19/2007	33	ND	441	30.2	230	4.8	ND	4.8	1.8	ND	579	ND	ND	NA	NA	0.51	2.5	ND	0.62	NA	NA	NA	NA	NA	Williams potable water well, Evergreen Analytical, Inc.
LEWIS CREEK NP WELL	4/19/2007	147	ND	334	19.6	46	12	ND	110	40	0.87	725	0.12	ND	ND	NA	1.04	0.53	ND	0.0092	NA	NA	NA	NA	NA	Williams nonpotable water well, Evergreen Analytical, Inc.
NELSON WELL	4/26/2007	2070	ND	264	42.1	178	33.7	NA	630	222	NA	NA	1.85	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Evergreen Analytical, Inc.
SWD (DISPOSAL WELL)	4/26/2007	3790	ND	1810	580	3280	13.9	NA	14.2	2.77	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Evergreen Analytical, Inc.
NELSON WELL	7/10/2007	1900	NA	280	47	180	32	ND	580	200	0.019	2200	ND	ND	ND	NA	9.9	ND	ND	ND	NA	NA	NA	NA	NA	STL Denver
NELSON WELL	1/29/2008	1860	ND	275	47.3	180	34	ND	640	230	0.019	4100	1.89	ND	0.0094	NA	10.5	0.21	ND	0.0011	NA	NA	NA	NA	NA	Evergreen Analytical, Inc.
NELSON WELL	10/13/2008	2050	NA	NA	43.9	200	36	0.17	660	230	0.023	3840	1.73	ND	0.012	NA	9.93	0.22	NA	NA	ND	ND	0.082	6.0	NA	Evergreen Analytical, Inc.
INJECTION WELL	10/13/2008	3870	NA	NA	380	3700	25	ND	12	2.5	0.022	9360	ND	ND	0.0068	NA	17.6	2.3	NA	NA	NA	NA	NA	13	NA	Evergreen Analytical, Inc.

**NOTES:**

Concentration in milligrams per liter  
 ND = Not Detected  
 NA = Not Analyzed  
 TDS = Total Dissolved Solids  
 BTEX = benzene, toluene, ethylbenzene, and xylene  
 TPH = total petroleum hydrocarbons

TABLE 2: SOIL ANALYTICAL SUMMARY - NELSON WELL WATER QUALITY STUDY

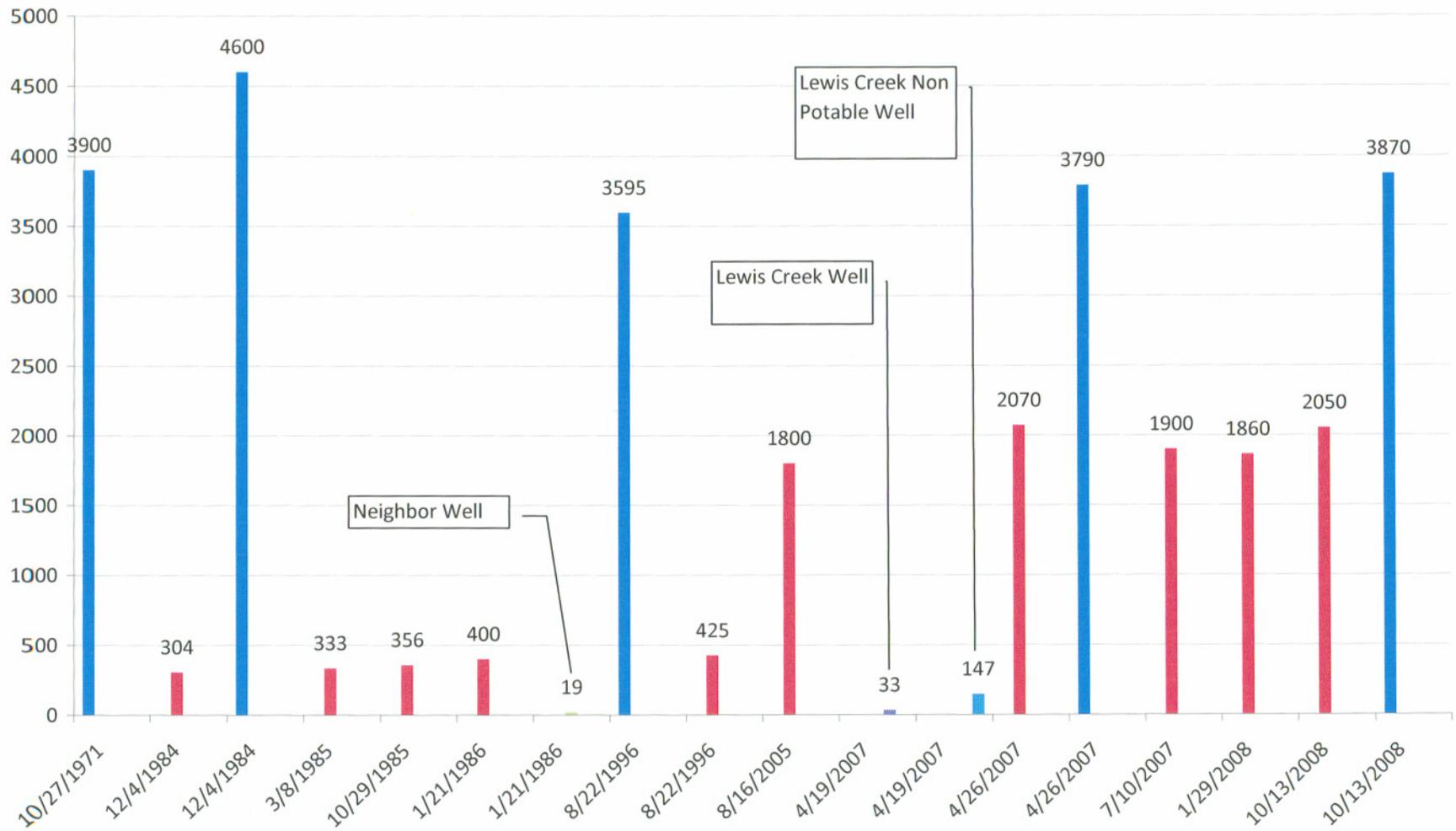
SAMPLE SOURCE	DEPTH (FT)	SAMPLE DATE	Sodium Adsorption Ratio (SAR)	Specific Conductance (umhos/cm)	pH	Calcium (mg/l)	Magnesium (mg/l)	Potassium (mg/l)	Sodium (mg/l)	Chloride (mg/kg)	Bromide (mg/kg)	Sulfate (mg/kg)
SCHWAKE PIT	0 - 0.5	3/12/2008	97	15,600	9.65	120	4.8	35	4,000	604	3.35	994
SCHWAKE PIT	2.5 - 3.5	3/12/2008	72	23,900	9.23	540	45	75	6,500	792	ND	3,280
NELSON BG-01	0 - 1.0	3/12/2008	0.51	969	7.76	130	14	28	23	6.3	ND	13

Notes: Soil samples collected by Colorado Oil and Gas Conservation Commission  
 mg/l = milligrams per liter, mg/kg = milligrams per kilogram, ND = not detected

## CHARTS

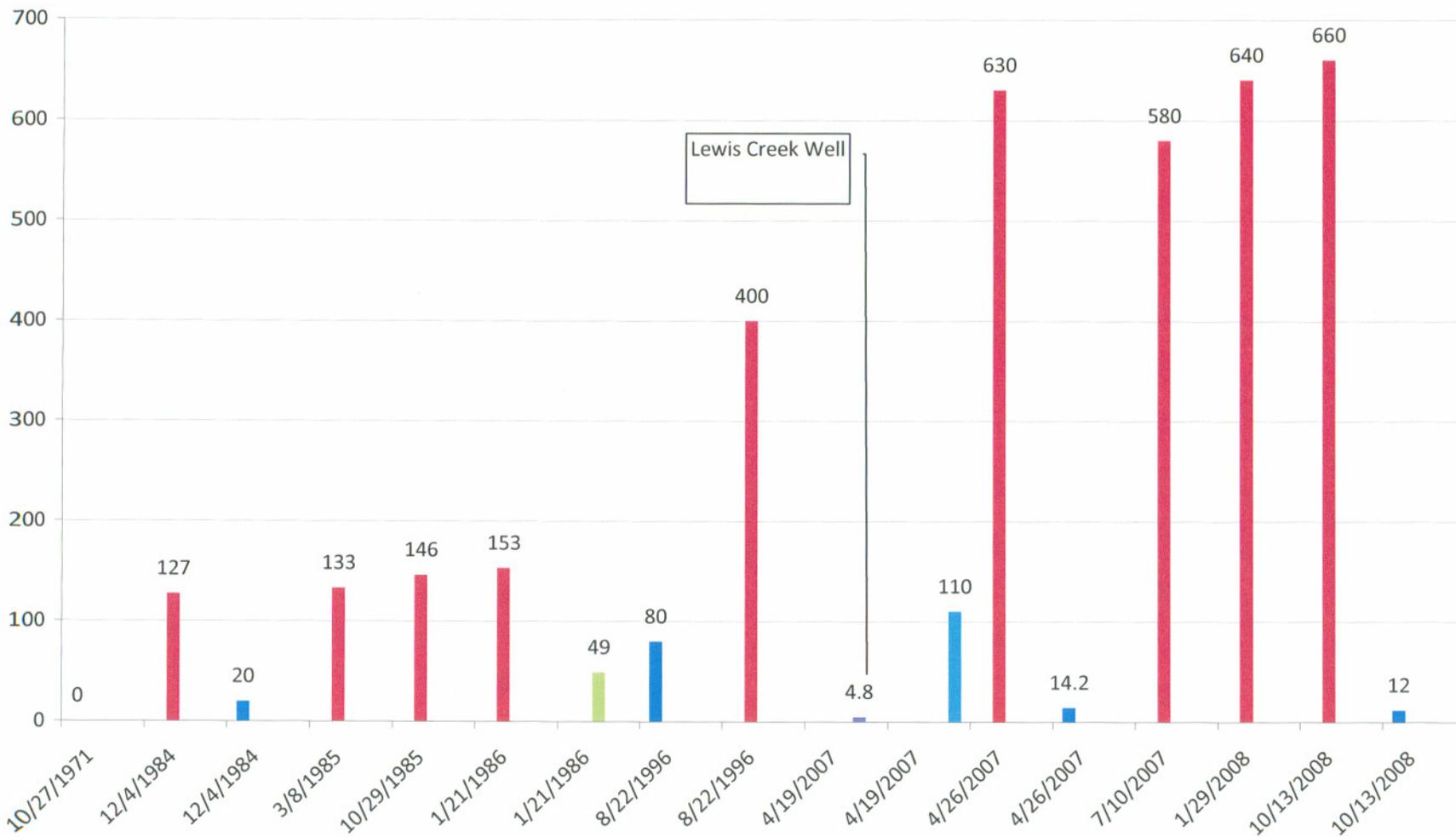
### Chart 1: Chloride Concentrations (mg/l)

■ Schwake A-1 Well   
 ■ Nelson Well   
 ■ Neighbor Well   
 ■ Lewis Ck Well   
 ■ Lewis Ck Non Potable Well



### Chart 2: Calcium Concentrations (mg/l)

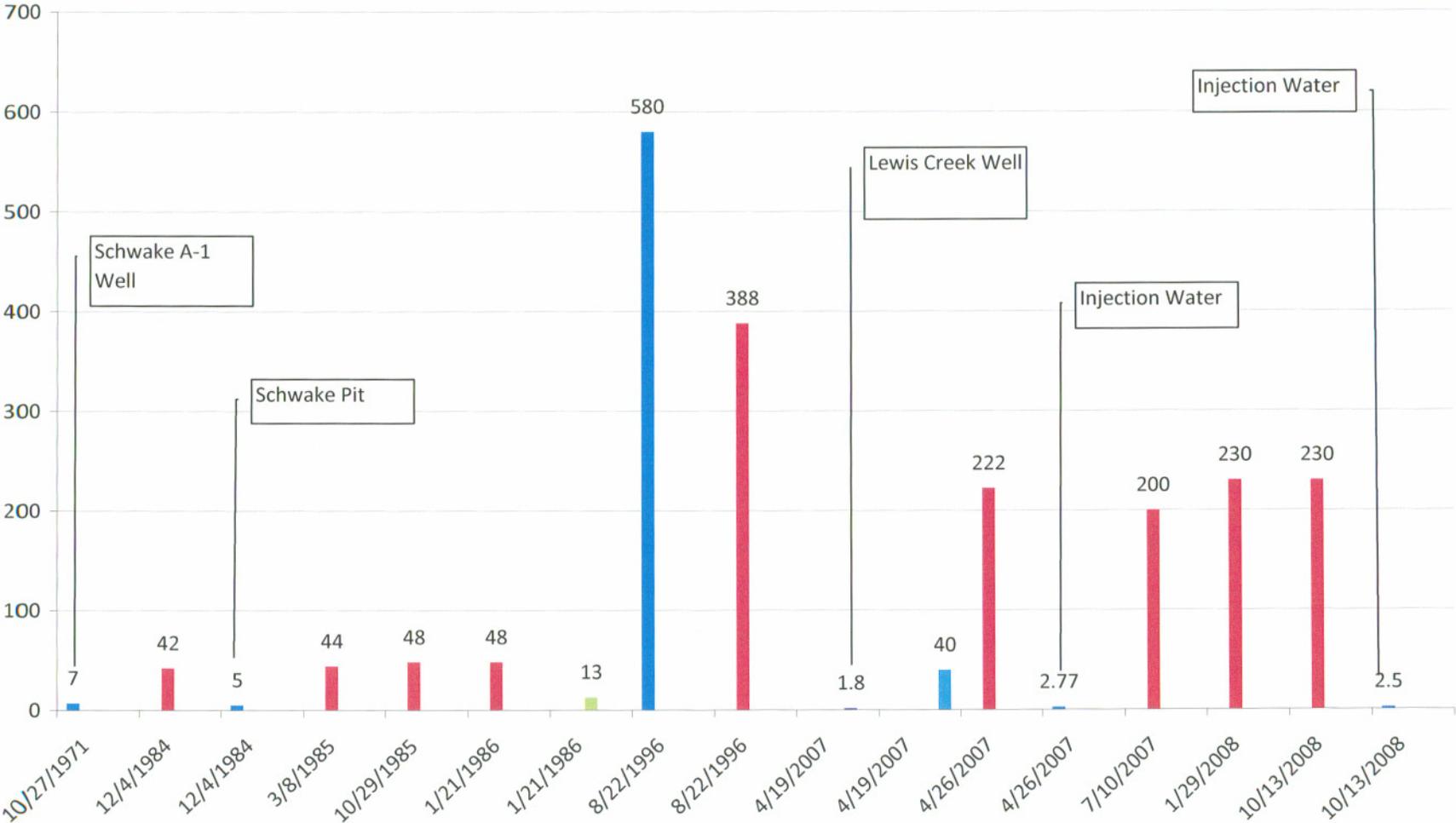
Schwake A-1 Well   Nelson Well   Neighbor Well   Lewis Ck Well   Lewis Ck Non Potable Well



Lewis Creek Well

### Chart 3: Magnesium Concentrations (mg/l)

■ Schwake A-1 Well   
 ■ Nelson Well   
 ■ Neighbor Well   
 ■ Lewis Ck Well   
 ■ Lewis Ck Non Potable Well



Schwake A-1 Well

Schwake Pit

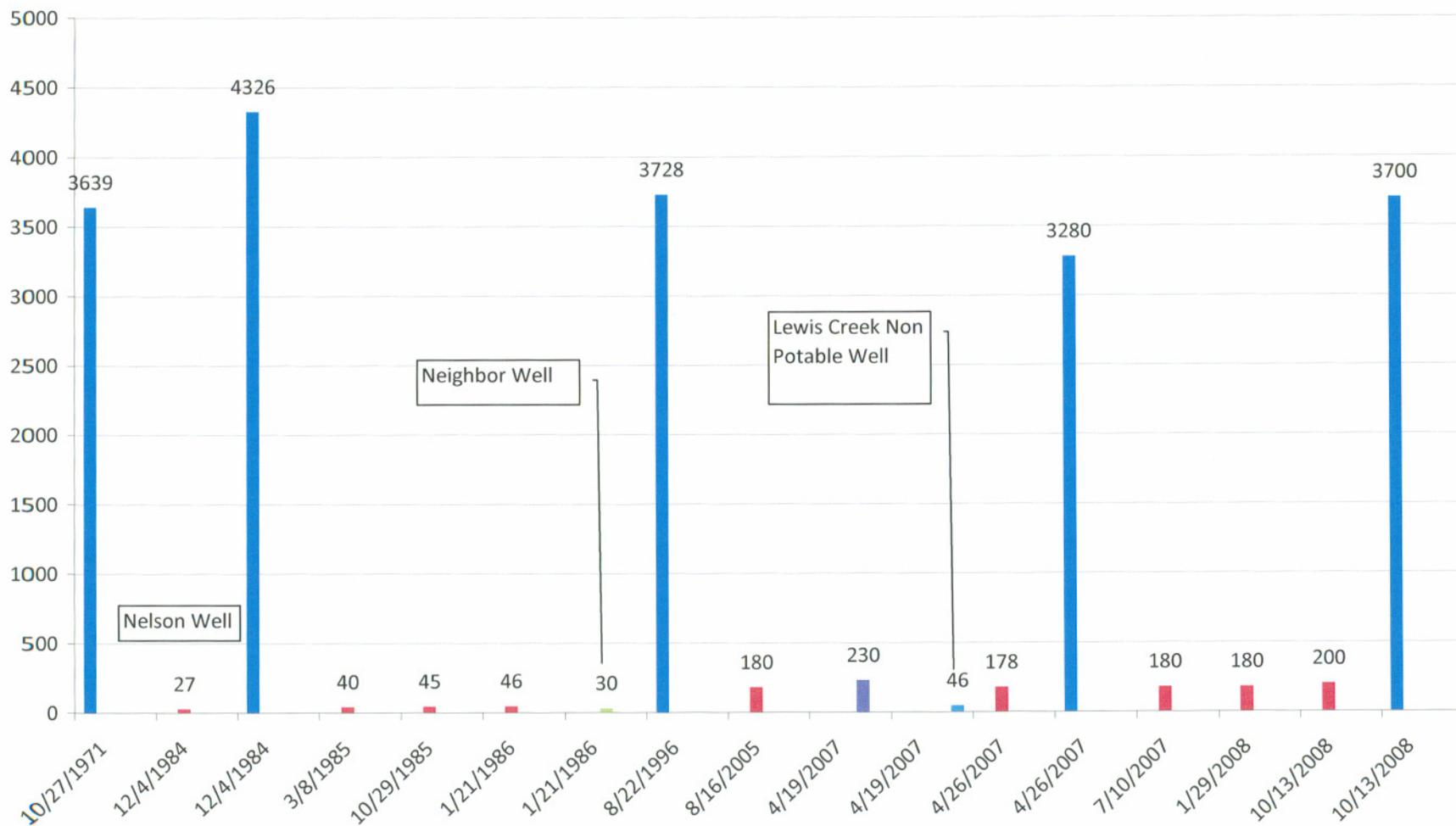
Lewis Creek Well

Injection Water

Injection Water

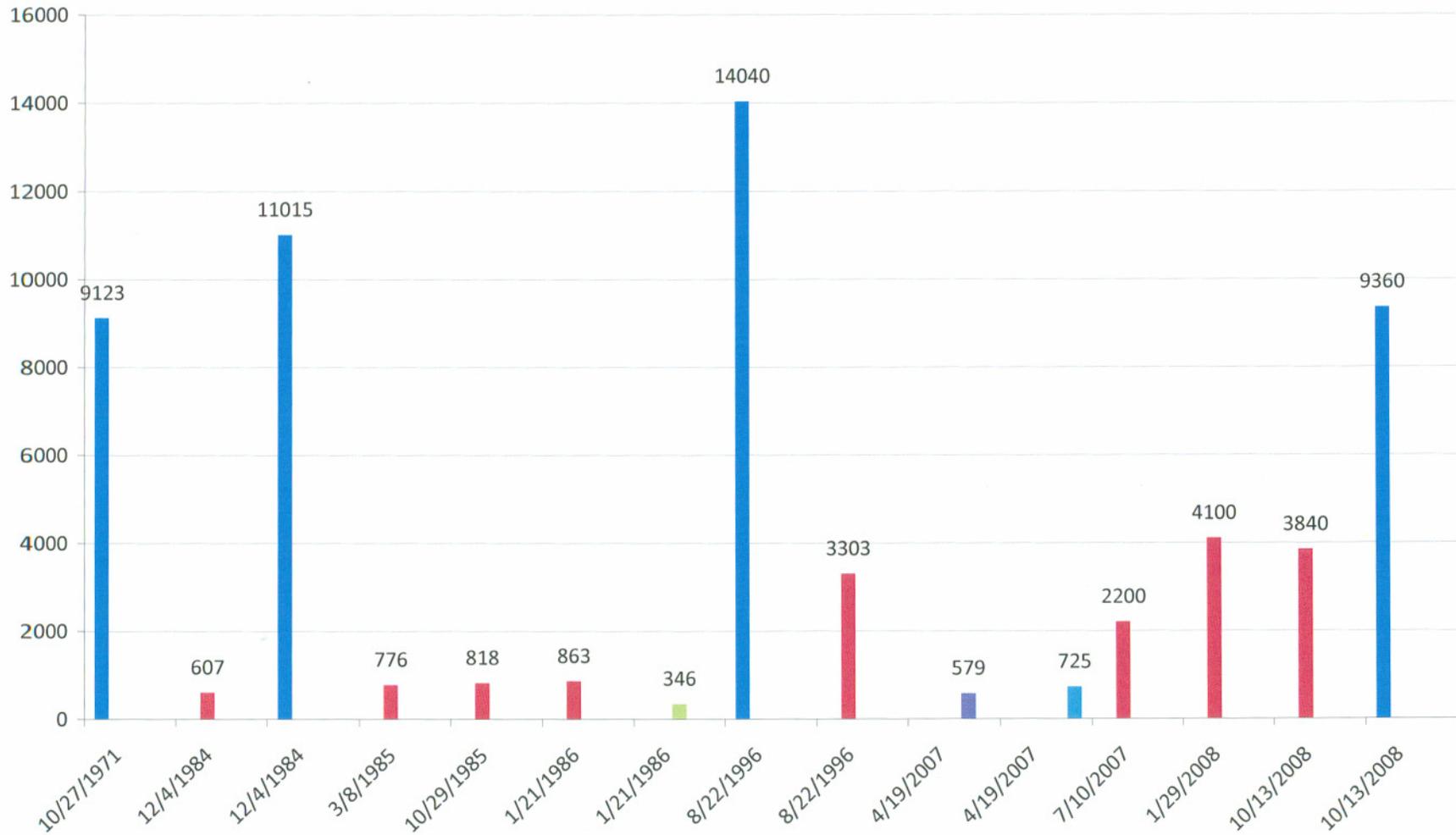
### Chart 4: Sodium Concentrations (mg/l)

■ Schwake A-1 Well   
 ■ Nelson Well   
 ■ Neighbor Well   
 ■ Lewis Ck Well   
 ■ Lewis Ck Non Potable Well



### Chart 5: Total Dissolved Solids Concentrations (mg/l)

■ Schwake A-1 Well   ■ Nelson Well   ■ Neighbor Well   ■ Lewis Ck Well   ■ Lewis Ck Non Potable Well



**APPENDIX A**  
**LABORATORY ANALYSIS REPORT**