Biogeochemical Behavior of Dissolved Arsenic and Uranium Concentrations in Public Water Supply Wells

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BIOGEOCHEMICAL BEHAVIOR OF DISSOLVED ARSENIC AND URANIUM CONCENTRATIONS IN PUBLIC WATER SUPPLY WELLS

by

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ABSTRACT

Public water supply (PWS) wells currently contain dissolved uranium concentrations above the federally mandated maximum contaminant level (MCL) of 30 ppb (parts per billion) and dissolved arsenic concentrations above the 10 ppb MCL. Both uranium and arsenic are known to cause various forms of cancer in humans. Removal of the trace metals from groundwater systems may cost hundreds of thousands of dollars per town to achieve compliance with the MCLs. Variations in total uranium concentrations in PWS wells in Nebraska indicate a relationship to the duration and rate of pumping in specific wells. Although total arsenic concentrations show some variability over time in specific wells, the relationship to pumping is not as clear. Previous studies show that iron and sulfur bacteria present in aquifer systems affect the redox state of both uranium and arsenic species. Variable pumping conditions create an environment that is conducive to the growth of these microorganisms in and adjacent to the PWS wells. The chemical reactions contributing to the uranium and arsenic concentration variations observed in these PWS wells are hypothesized to be mediated by the microbial populations present within the groundwater. Chemical extractions indicate uranium and arsenic concentrations in well precipitates are more strongly bound to organic material than exchangeable metals. Scanning electron microscopy and microprobe analyses verified the presence of poorly-ordered iron oxyhydroxides bound to organic materials. These organometal complexes adsorb uranium and arsenic species. Microbial populations were characterized using culture techniques and DNA methodology on groundwater samples and well screen precipitates collected from pump intakes. Samples cultured with selective media yield microorganisms representative of iron-oxidizing, iron-reducing, and sulfur-reducing bacterial groups. Phylogenetic techniques indicate diverse communities of iron-oxidizing, iron-reducing, and biofilm-forming bacteria within and around sampled PWS wells. Management of high uranium and arsenic concentrations in PWS wells may be enhanced by a thorough understanding of PWS well biogeochemistry and its ability to influence the behavior of uranium and arsenic.

DEDICATION

I would like to dedicate this research to all of my family, friends, and colleagues who have supported me throughout my education and continue to be an inspiration to me.

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EXECUTIVE SUMMARY

Naturally-occurring dissolved arsenic and uranium concentrations pose drinking water quality issues to public water supply (PWS) systems. Concentrations exceed the federally mandated maximum contaminant level (MCL) of 10 parts per billion (ppb) for arsenic and 30 ppb for uranium in public water supply and private wells nationwide. This research focuses on arsenic and uranium concentrations found in PWS wells in Nebraska, and has implications for water quality issues with the contaminants in the contiguous U.S. PWS systems are single or multiple well systems which supply potable drinking water to small rural communities. We hypothesize that the biogeochemical environment created by the installation and operation of a PWS well is responsible for the elevated concentrations of these naturally occurring contaminants. The influence of well pumping on this biogeochemistry was examined with regard to both uranium and arsenic in this study. The geochemistry and mineralogy of iron-related biofilm encrustations observed in many of these well systems have the potential to trap and concentrate these contaminants. The makeup of microbial communities present within these wells and their potential effects on metal accumulation and/or dissolution were also examined. Overall, this research contributes to a better understanding of the hydrologic, geochemical, and biological factors affecting behavior of naturally occurring arsenic and uranium in water supplies in Nebraska and throughout the United States.

Examination of pumping factors and water chemistry related to uranium behavior and mobilization were examined in five public water supply systems in Nebraska. The dynamic environment created by pumping of these wells concentrates mobile uranyl carbonate and metal complexes derived from alluvial materials in the surrounding aquifer. Data from a monitoring well in the village of Clarks suggests high concentrations of U(VI)-carbonate complexes are present surrounding the Clarks PWS well, and reflect background concentrations of uranium in the aquifer. Geochemical modeling supports this based on chemical speciation of water samples. High volume pumping of public water supply wells draws mobile uranium to the wells. Short-term pump tests indicate that stabilization of uranium concentrations occurs within the first 30 minutes of pumping. Following pumping, residual dissolved uranium and colloidal uranium are adsorbed to iron-oxyhydroxides and organic biofilm materials. Once adsorbed, this uranium may be remobilized by reductive dissolution of mineral oxides and complexation with available carbonate species in solution. Multiple-depth interval sampling indicated a lack of variability between aquifer units in wells, suggesting uranium is not concentrated in any one alluvial unit around the sampled wells. The potential for manipulation of uranium concentrations with pumping was observed at the towns of Beemer and York, where extended well downtime decreased the amount of uranium in the well samples. Further examination of geochemistry surrounding PWS and other industrial wells with uranium contamination issues is suggested.

Observations of arsenic behavior during pumping were conducted for twenty-three public water supply systems. Short-term sampling results indicate the behavior of

dissolved arsenic is variable within the first 30 minutes of pumping, with stabilization of arsenic concentrations thereafter. To obtain samples of arsenic more representative of what the public may be exposed to, it is recommended to sample after 30 minutes of pumping. Long-term/seasonal stability of arsenic concentrations was observed in various regions around Nebraska, supporting previous research documenting stability of arsenic concentrations over time. Chemical and filter analyses indicated the majority of arsenic reaching the wells is in the dissolved form, which becomes trapped within organic biofilm materials within wells. Sediment leaching experiments indicate arsenic is adsorbed to these organic materials in sampled well. Arsenic data from the town of Wauneta indicate that decreasing the time between pumping events may aid in controlling arsenic mobility within water supply and other industrial wells. Weekly pumping limited well water residence times, discouraging arsenic desorption from iron oxides and mobilization. This lowered mobile arsenic concentrations from 12 ppb to below the 10 ppb MCL. Further experimentation with pumping frequency is required at high-capacity wells to develop pumping schedules which may meet community needs and minimize public exposure to arsenic in drinking water.

The geochemistry and mineralogy of well encrustations were examined to better understand their association with arsenic and/or uranium in six public water supply wells. Selected wells contained high volumes of encrusted materials documented by down-hole videotaping. Dispersive array mapping and point analyses of well samples using WDS and EDS indicated high concentrations of iron oxides and oxyhydroxides in all PWS wells; however the connection to high uranium and arsenic concentrations is not clear. Detection limits using array mapping were in the part per million range. This limited the ability to detect arsenic and uranium concentrations in the part per billion range associated with well sediments. However, high concentrations of arsenic were detected in Haigler and Stromsburg well sediments. Massive accumulations of globular and poorly-ordered iron oxyhydroxides indicate plentiful sorption sites for available arsenic and uranium in these wells. Sequential sediment leaching of solids indicated association of the highest uranium and arsenic concentrations with organic material from biofilms. This supports the hypothesis that arsenic and uranium adsorptive and desorptive processes are biologically mediated reactions. Filamentous and spiral-like materials observed are believed to be iron oxide and organic traces of the iron oxidizing bacteria, however presence of these bacteria were not verified in this study. The growth of biofilms and oxide accumulation are influenced by the cyclic oxidative-reductive environment created by well pumping. Further investigation is recommended to better understand the influences of biofilm growth on arsenic and uranium accumulation in wells.

Microbial communities were examined in six public water supply systems in Nebraska, and provided a glimpse at bacteria affecting redox states of metals concentrated in PWS and monitoring wells. Fluctuating oxidation and reduction periods during well pumping create biogeochemical conditions conducive to microbial diversity. Selective culturing and fluorescent microscopy of well samples indicated microbial populations capable of reducing ferric iron. Evidence of abundant iron-reducing microorganisms was observed during culturing and phylogenetic analyses, which may

indicate stronger links to iron metabolism in the sampled PWS well environments. Phylogenetic techniques indicated unique microbial communities at each well sampled, with several species of iron-reducing bacteria such as *Geobacter metallireducens* and iron oxidizing bacteria such as *Leptothrix sp.* which were common in multiple well systems. Statistical correlation of microbial family structure indicated a monitoring well from the town of Clarks, NE contained the most statistically different microbial populations, indicating populations are exposed to different biological stimuli in active pumping wells than monitoring wells, which are more reflective of natural aquifer conditions. Previous mineralogical analyses indicated plentiful metal oxides concentrated in biofilms. The redox states of these metal phases are influenced by the complex microbial populations present within these biofilms. These biofilms flourish in the well environment due to steep redox gradients created by cycles of well operation. This directly influences the sorption and concentration of toxic trace metals such as arsenic and uranium. To obtain a better understanding of the microbial influences on the sorption and concentration of toxic trace metals in these biofilms, further experimentation with pumping regimes reflective of the operational history, microbial community structure, and local geology of each individual well is required.

I. The Effect of Pumping on Uranium Concentrations in Public Water Supply Wells: Observations from Nebraska

Introduction

Dissolved uranium derived from rock-water interaction poses drinking water quality issues to communities in Nebraska and other states in the western United States (Snow and Spalding, 1994). Concentrations greater than the federally mandated maximum contaminant level (MCL) of 30 parts per billion (ppb) were reported in 17 public water supply (PWS) well systems throughout Nebraska as of 2005. The current number has decreased to 13 systems due to shutdown of contaminated wells (NHHS, 2008). These single or multiple well systems supply potable drinking water to rural communities. High-cost treatment facilities are not viable options for many communities affected by the high uranium concentrations, especially in rural areas. As a result, we have been exploring the factors that may influence uranium concentrations. Understanding these factors have implications for communities nationwide affected by high dissolved uranium concentrations.

Dissolved uranium concentrations in PWS wells may be affected by a variety of factors including pumping rate and duration, geochemistry of the groundwater and the groundwater-bearing materials, in addition to the biologic environment within and surrounding the PWS wells (Fig. 1). The installation of a pumping well influences the hydrology of the aquifer, altering groundwater velocity and direction. This, in turn, disturbs the natural geochemical environment, and influences the occurrence of metals, carbon, and oxygenated water, all of which may affect uranium. The installation of water wells creates a well-documented vertical hydrochemical short circuit that connects the subsurface environment to the atmosphere (Jagucki et al., 2008, Landon et al., 2008). This short circuit is enhanced by the pumping of the groundwater system. Biological

growths may also be encouraged within and surrounding a well due to changes in water chemistry. These growths, or biofilms, are potential sinks for metals, organics, and contaminants.

This paper presents the results of a cooperative effort between the Environmental Protection Agency Region VII, Nebraska Department of Health and Human Services and villages with historical uranium issues across Nebraska. The purpose of this paper is to (1) assess the factors that influence uranium mobility in and around PWS wells, and (2) investigate the occurrence and behavior of uranium under varying pumping conditions within and surrounding PWS wells.

Background: High Plains Aquifer and Uranium Occurrence

The High Plains Aquifer System is the single most important water source in the midwestern United States, supplying freshwater to eight adjoining states. Groundwater pumped from the High Plains Aquifer is obtained from the Ogallala Group, Arikaree Group, and other geologic units (Table 1). Aquifer materials range from medium-grained sand to silty sand with interspersed lenses of silty clay and clayey sands (Appendix A). These silt and clay lenses function as small aquitards where present, forming separated aquifer units (Landon et al., 2008). The heterogeneous nature of the aquifer sediments creates diverse hydrogeological and geochemical environments surrounding pumping wells.

Naturally occurring uranium within the groundwater of the High Plains aquifer system occurs because of the interaction of water with sediments derived from the Colorado Front Range and Laramie Mountains in Wyoming. These sediments are derived from the chemical weathering of uraniferous rocks found in these mountains,

which have been transported and deposited via river systems (Rosholt et al., 1973, Nkomo et al., 1979, Spalding and Druliner, 1981).

Uranium has multiple oxidation states, however only the +6 form is soluble (Langmuir, 1997). In oxidized, circumneutral pH water, uranium occurs as the highly soluble uranyl species UO_2^{2+} (Duff et al., 2002). Uranium (VI) is often present in the solid phase uranyl mineral schoepite ($UO_3 \cdot 2H_2O$) in soils, groundwater, and in uranium-ore bodies (Duff et al., 2002). Under chemically reducing conditions, uranium may undergo biotic and chemical reduction to the sparingly soluble uraninite $UO_{2(s)}$ in the +4 state, and is removed from solution by precipitating insoluble uranium minerals or by sorbing to sediment surfaces (Lovley et al., 1991, Duff et al., 1999, Landon et al., 2008).

Uranium concentrations in groundwater are determined by the nature of U-bearing solids within the High Plains Aquifer, the geochemical conditions (Eh, pH, dissolved solids), and changes in these conditions. Previous studies of uranium source and transport in the Platte River System presented several theories for migratory behavior of mobile uranium within the aquifer. Verstraeten et al. (1995) investigated water quality in the North Platte Natural Resource District in Western Nebraska, and reported median total uranium concentrations of 11 parts per billion (ppb). High $U^{234/238}$ activity ratios, ~8.9, in aquifer units indicated local uranium mineralization (Verstraeten et al., 1995) (Table 1). Snow and Spalding (1994) investigated sources of uranium input into the Platte River system within the North and South Platte River Valleys in Western Nebraska. Dissolved uranium concentrations in surface water were suggested to be a function of mineral dissolution and chemical weathering, however concentrations in groundwater sources were thought to be controlled by desorption and/or oxidation (Snow

and Spalding, 1994). Landon et al. (2008) investigated dissolved uranium in PWS and agricultural wells in the vicinity of York, NE. Geologic profiles indicated several confined aquifers separated by silty clay layers from an overlying unconfined aquifer,. Wells screened in the confined aquifer had higher uranium concentrations than were expected for iron-reducing conditions. Water obtained from wells within the confined aquifer exhibited δD, $\delta^{18}O$, uranium, VOC, chloride, ^{15}N-nitrite, and groundwater-age-tracer values reflective of those sampled from the upper unconfined aquifer, suggesting leakage was occurring from this upper aquifer. Landon et al. (2008) concluded significant well-bore leakage through the confining layers was responsible for mixing of water between the units. This leakage occurred either through the annular spacing in multilayer wells connecting the separate aquifers, or through unsealed well bores. Where PWS wells are screened in multiple geologic intervals, they may experience these mixing effects due to wellbore leakage.

Sorption and mineral precipitation control the mobility of uranium in groundwater. These processes are influenced by pH, uranium concentration, and alkalinity. Soluble uranium (VI) may form complexes with carbonates, oxalates, hydroxides, organic matter, as well as Fe-oxide minerals (Grenthe et al., 1992, Hsi and Langmuir, 1985). After uranium has adsorbed, it may be reduced by mobile reductants such as CH_4 or H_2S, however it tends to remain in its hexavalent form (Fiedor et al., 1998). Langmuir (1978) states that increasing alkalinity and pH increases desorption of uranium. Hsi and Langmuir (1985) demonstrated uranium desorption from iron oxyhydroxides with increasing carbonate alkalinity, adding bicarbonate to water which increased dissolved uranium concentrations.

It has been suggested that uranium concentrations are affected by groundwater residence times. Szabo and Zapecza (1991) found with sufficient residence time and certain geochemical conditions, uranium concentrations increased in groundwater as long as waters were oxic enough to keep uranium in solution, even without U-rich rocks present. Sherman et al. (2007) found uranium concentrations were consistent over time, and the uranium content of aquifer materials was not enough to predict whether wells would produce water with high dissolved uranium.

Methods

PWS Well Selection and Sampling Techniques

Eight wells were sampled from five public water supply systems (Fig. 2). Each public water supply system was selected to improve the understanding of the occurrence and behavior of uranium under varying pumping conditions within and surrounding PWS wells. Pumping and sampling schedules were designed to duplicate normal operational conditions of each PWS well.

Prior to sampling to examine the influence of pumping on uranium concentrations at Bellwood 76-1, Clarks 2005-2, York 73-1, Bridgeport 76-1 and Clarks NTW, low-flow sampling techniques assessed the extent to which uranium concentrations varied with depth within individual wells. Profiling of individual wells occurred following the removal of the pumping column from the well casing. Nebraska Health and Human Services (NHHS) assessed the integrity of selected PWS wells using a down-hole camera. Sampled intervals for individual PWS wells were selected using geologic logs

and geophysical logging data (Appendix A). A dual well packer system was used to isolate screened intervals when available.

Low-flow sampling was performed at specific intervals to assess uranium variability along the vertical profile of selected wells. Low flow sampling at the Clarks North 4-inch Test Well and York 73-1 well was performed using a 2-inch Grundfos submersible pump at selected depths. Low-flow sampling involved pumping at 0.5-3.0 gpm for 30 minute durations. Samples were collected at 0, 15, and 30 minute sampling times at each interval depth. Low-flow interval sampling of the Clarks and Bellwood PWS wells was conducted using the Grundfos pump and a dual well packer system to isolate screened intervals. Following interval sampling, the PWS well at Clarks was modified based on the data collected. Tables 3a and 3b provide a summary of sampling dates and observations.

The investigation of Beemer 2002-1, Bellwood 76-1, and Bridgeport 69-1 examined the behavior of uranium concentrations using periods of well inactivity that ranged from 72 hours to several months. The inactivity was followed by the initiation of pumping and periodic sampling of the water from the time the well was turned on (0 minutes) to up to four hours after pumping started. Sampling was performed over these longer periods to examine the behavior of uranium and assess if it was similar to that of arsenic observed by Gosselin et al. (2006). Details of well inactivity and water sampling interval are in Tables 2a and 2b. The Beemer well was inactive for two weeks prior to each sampling event, taking place every 2 months for 22 months. These samples were collected at 0, 0.25, 0.5, 1.0, and 1.3 hours after the pump was started. Water samples from the wells at Bellwood and Bridgeport were collected at 0, 0.5, 1, 2, 3, and 4 hours

after the pump was started at each sampling event. The Bellwood 76-1 well was not pumped 19 days prior to the sampling event in June 2006. The Bridgeport 69-1 well was not pumped for 72 hours before the June 2005 sampling event.

The investigation of Clarks 2005-2 was designed to assess the response of uranium concentrations to variable pumping time and frequency. After the low-flow sampling experiments, a variable frequency drive (VFD) pump was installed in the lower two-thirds of the well screen (91-115 ft) that was isolated from the rest of the well using a permanent well packer. Details of the water sampling intervals are provided in Table 2.

The investigation of the York 73-1 well examined the response of uranium concentrations to changes in pumping rate and frequency. After low flow sampling and the installation of a VFD pump, the well was sampled at different flow rates. The experiment started by pumping the well continuously at 500 gpm and sampling every two days for one week. This was followed by pumping at 250 gpm every two weeks during continuous pumping for nine weeks. Samples were then taken once weekly at a pumping rate of 100 gpm during a two week continuous pumping period. Sampling and pumping was then performed every 2 weeks at 50 gpm at the York well over a 10 month period.

Water Sample Collection

Water samples were collected from sampling ports located along the distribution line of the PWS wells or from the hose of the Grundfos pump during interval sampling. Each water sample collected for laboratory analysis was analyzed for the following parameters in the field: field alkalinity, dissolved oxygen, electrical conductivity, pH, temperature, and dissolved Fe^{2+}/Fe^{3} (filtered, 0.2 µm). Ninety-six samples were analyzed for major cations (Ca, Mn, Mg, K) and anions (Cl, SO_4, NO_3, P), total organic carbon

(TOC), and total uranium concentration. Samples were collected in 125 ml polypropylene bottles provided by NHHS and 250 ml polypropylenes bottles. TOC samples were collected in 250 ml amber glass bottles. Complete sampling data can be found in Appendix B.

The PWS samples in this study were collected in the context of the regulatory environment emphasizing total uranium exposure, and therefore the samples were not filtered. Specific conductance was calibrated three times per day. Temperature was measured using glass thermometers in addition to a pH probe thermometer for comparison. QA/QC methods included analysis of standards, field, trip, and lab blanks, and duplicate samples. (Appendix C). Water samples collected for uranium, cations, anions, and TOC were analyzed by Nebraska Health and Human Services Laboratories and Midwest Laboratories according to U.S. EPA Method 200.8. PhreeqC was used to calculate various chemical species, partial pressure of carbon dioxide (pCO_2), and saturation indices based on major ion chemistry and field parameters (Parkhurst and Appelo, 1999) (Appendix D).

Results

Vertical Profiling and Interval Selection

Tables 3a and 3b provide a summary of sampling dates and observations for the low-flow profiling at Bellwood 76-1, Clarks 2005-2, and York 73-1 following removal of the pumping column and from the monitoring wells at Bridgeport 76-1 and Clarks NTW. Uranium concentrations were lowest in the deepest intervals sampled at Bellwood 76-1, Bridgeport 69-1 MW, and Clarks 2005-2 wells as opposed to York 73-1, where uranium

concentrations increased with sampling depth (Table 3a and b). The Clarks 2005-2 uranium concentrations were notably lower than those sampled at the Clarks NTW intervals (Fig. 5). Intervals sampled on August 18, 2006 at the Clarks 2005-2 well were significantly higher than those from intervals sampled in September 2005 and October 2006 (Fig. 5)

Variation of Pumping Rate, Duration, and Frequency

Results from pumping tests of the Beemer 2002-1, Bellwood 76-1, Bridgeport 69-1, Clarks 2005-2, and York 73-1 well can be found in Tables 2a and 2b. Short term pumping experiments indicated uranium concentrations increased during the first 30 minutes of pumping in the Bellwood 76-1, Clarks 2005-2, and York 73-1 wells (Fig. 4). Uranium concentrations increased at the Clarks 2005-2 well during two-four hour pump tests, but decreased during a 30 minute pump test. Following a two month period of well inactivity, uranium concentrations increased at the York 73-1 well during a four hour pump test. Uranium concentrations also decreased during 8 and 12 hour pump tests at the Bellwood 76-1 well

Long-term sampling was performed at the Beemer 2002-1 well. The Beemer well was pumped every two months for 30 minutes at 500 gpm, and uranium concentrations decreased from 197 to 31 ppb over a two year period (Fig. 3).

Post Well Modification Sampling

Following interval sampling, the PWS wells of Clarks 2005-2 and York 73-1 were modified based on respective data collected. Sampling at these locations resumed to monitor dissolved uranium behavior following well column reinstallation. Tables 2a and 2b provide a summary of sampling dates and observations. Clarks 2005-2 was

sampled at 50 gpm following well modifications. Uranium concentrations decreased from February to March 2007, but with variability from March to May 2007 (Fig. 6). Increasing uranium concentrations were observed at the York 73-1 well when the well was pumped continuously at high flow rates. The well sampling schedule was modified to only be pumped every 2 weeks at a lower pumping rate, allowing uranium concentrations to drop below 30 ppb over time (Fig. 7).

Uranium and General Water Chemistry

Groundwater samples had temperatures from 10-20º C and circumneutral pH (6.5-8.5) observed in all PWS wells. Dissolved oxygen levels ranged from <0.1 mg/L to 10 mg/L during pumping, with the lowest concentrations at the start of pumping. Waters are classified as calcium- and sodium-bicarbonate type (Helsel and Hirsch, 1992). Table 5 provides the average chemical concentrations sampled at 30 minutes from each well. Due to the regulatory environment, samples were not filtered to separate dissolved uranium from potentially colloid-bound uranium.

PhreeqC was used to calculate relative concentrations of uranium and metal species, saturation indices of potential mineral phases, and pCO2 concentrations (Appendix D). Well samples were notably saturated with $UO_{2(s)}$, schoepite, and U_4O_9 as well as with iron phases including goethite, hematite, maghemite, magnetite, and other iron hydroxides. Iron hydroxides are well-known scavengers of dissolved uranium. Partial pressure of carbon dioxide did not vary between wells, nor showed much variation with changes in pumping conditions or over pumping time. Concentrations reflected bicarbonate saturation at near-neutral pH in all wells. Uranyl carbonates, $UO_2(CO_3)_3^{-4}$, $UO_2(CO_3)_2^{-2}$, and hydroxides, $UO_2(OH)_3^{-}$, are the dominant U(VI) forms in wells, and

are present in concentrations several orders of magnitude greater than U(IV) species. The dominant U(IV) include uranyl hydroxides. Billon et al. (2005) presumed calculated uranyl carbonate and hydroxide concentrations in MINEQL represented U(VI) aqueous species, which may be used as a proxy for a lack of filtered samples in this study. However, these concentrations are numerical estimations and subject to verification by filtration. Filtration of arsenic samples in McVey, Chapter 2 (Unpublished Data) demonstrated little to no statistical difference between unfiltered and filtered sampled down to 0.2 microns, suggesting that arsenic was primarily in the dissolved phase. However, we cannot assume filtered arsenic is a proxy for uranium behavior, nor disregard the possibility of colloidal transport. PhreeqC speciation of uranium in this study suggests the greatest concentrations of uranium are associated with dissolved carbonates, however concentrations are still categorized as total uranium.

Sequential leaching experiments performed on various well solids sampled from selected wells indicate that the a significant proportion of uranium is occurs adsorbed as exchangeable metals in all wells and is primarily bound to organic material at the Bellwood well (McVey, Chapter 3, Unpublished Data). The term “exchangeable metals” refers to association with surface sites of metals and other particulates. Plentiful metal oxides observed in McVey Chapter 3 (Unpublished Data) serve as potential sorption sites for uranium. Uranium was also found to be associated to organic biofilm material within sampled wells in the Bellwood sample (McVey, Chapter 3, Unpublished Data).

Uranium concentrations tended to increase with increasing ferrous iron levels at Beemer, Bellwood, and Clarks NTW (Fig. 8, Appendix B). Conversely, ferric iron concentrations were small (0.1-0.2 mg/L) compared with ferrous iron (0.5-1.0 mg/L) in

solution, typical of more reduced waters. Interval sampling in the Bellwood 76-1 well displayed higher total uranium when ferrous iron concentrations approached 1 ppm at specific depths. Interval sampling of the Clarks NTW monitoring well showed increasing uranium in conjunction with increasing ferrous iron concentration from 0 to 1 ppm (Fig. 8).

Relationships between chloride concentrations and uranium concentrations were not observed in well samples. Samples having the highest uranium concentrations did not have noticeably different chloride levels when compared to samples having relatively lower uranium concentrations. Chloride concentrations measured during interval sampling of selected wells were not unique to sampled depth intervals.

Changes in uranium concentrations were observed as dissolved oxygen content changed during the pumping of the Clarks 2005-2 well. Clarks 2005-2 had high concentrations of uranium (91-147 ppb) and dissolved oxygen concentrations (3.2-8.6 mg/L) on August 18th 2006, and lower dissolved oxygen and uranium concentrations October 15th, 2006 (Fig. 5). Other well locations did not show any clear relation between uranium and dissolved oxygen concentrations over time.

The partial pressure of carbon dioxide calculated from water samples indicate saturation of carbon dioxide in groundwater at the measured pH in all wells. Uranium concentrations were variable, but bicarbonate concentrations were stable in all wells except the Clarks NTW, which had higher uranium concentrations than the Clarks 2005-2 PWS well located 50’ away (Fig. 9). Increasing total uranium concentrations were associated with increasing bicarbonate at this well, however bicarbonate measured in the Clarks 2005-2 showed no relation to changes in uranium concentrations.

Discussion

Major Factors Affecting Uranium Mobility

PWS well installation and operation creates a dynamic environment that influences aquifer biogeochemistry and the availability of metals. The well borehole is a complex environment that is conducive to microbiological growth and biogeochemical reactions (Gotkowitz et al. 2004). The presence of the biofilm encrustations observed during downhole videotaping of wells are sinks for mobile uranium, ferrous and ferric iron, and sulfides (Houben 2003, 2006; McVey, Chapter 3, Unpublished Data). Operational changes such as the amount of water pumped, rate of pumping, and the redox gradients created by pumping of wells influence growth of these encrustations (Houben, 2006, Applin and Zhao, 1989). The act of pumping draws in dissolved uranium, colloids, and metals from the surrounding aquifer units becoming trapped in biofilms within pumping wells. Uranium transported by colloids was unable to be distinguished from dissolved uranium, however total uranium discussed in this study is suggested to be a component of both sources.

A lack of filtration data limit the ability to distinguish between modes of uranium transport within the aquifer. Chemical modeling data indicates greater concentrations of dissolved U(VI) associated with carbonates in the dissolved form, however this does not eliminate the possibility of transport via attachment to colloids. When considering the water chemistry, reducing conditions and high carbonate concentrations are observed in all well locations. If uranium is bound to colloids consisting of mineral oxides, iron-reducing conditions can potentially dissolve these metals, breaking up colloids and releasing the sorbed uranium. Landon et al. (2008) suggested plentiful carbonate

complexes in the water may be responsible for uranium mobility under reducing conditions at York. Available dissolved carbonate can complex the free uranium obtained from the break down of mineral oxides, enhancing transport in the dissolved form. However, the behavior of colloids under iron reducing conditions and uranium transport is speculative and requires further investigation in these wells.

Observations from PWS and monitoring wells indicate no relationship between uranium and chloride concentrations. Landon et al. (2008) used chloride as a conservative tracer and indicated that uranium concentrations in a municipal well in York were the result of the mixing of water between a confined aquifer unit and an overlying unconfined aquifer unit, which had distinctly different chloride values. Chloride data collected in this study from different interval depths at York spanned the concentrations in the upper unconfined and confined aquifers documented in Landon et al.'s (2008) study. The chloride concentrations from the separate interval depths at York and other wells did not show any relationship to uranium concentrations. This suggests that uranium concentrations the York well sampled in this study may be controlled by other factors besides mixing.

Differences in uranium concentration in conjunction with dissolved oxygen levels at two sampling events were observed in the wells at Clarks, NE. The event at the Clarks 2005-2 PWS well in August 2006 involved an equipment malfunction injecting air into the base of the well. As a result there was a dramatic increase in total uranium levels (Fig. 5). Two potential explanations are suggested. One hypothesis is that the immediate oxidation mobilized previously reduced uranium sorbed to oxide minerals on the well screen and at the bottom of the well. This is suggested to occur under natural conditions

favoring oxidation of ferrous to ferric iron (Duff et al., 1997). However, data from Landon et al. (2008) suggests that the mobilization of the uranium may be more complicated than a simple change in oxidation. Landon et al. (2008) found relatively higher uranium concentrations in reduced zones at the town of York and lower concentrations in more oxidized zones. This suggests dissolved oxygen was not associated with mobile uranium. An alternative hypothesis is that cavitation generated from the leaking air hose stirred up reduced uranium and other particulates which were subsequently pumped out of the well.

Uranium concentrations in Beemer, Bellwood, and Clarks PWS wells and a monitoring well from Clarks increased with ferrous iron levels (Fig. 8). This may be linked to reductive dissolution of iron minerals found in biofilms within these wells. Duff et al. (2002) suggested formation and dissolution of Fe minerals may occur on a cyclic (oxidation-reduction) basis, which is potentially conducive to the pumping environments observed in PWS wells. The formation of oxidation products are enhanced in zones of elevated flow velocities (areas with high entrance velocities). Typical reaction products include poorly ordered Fe(III)-oxides such as ferrihydrite that may be converted via solution to the more ordered Fe(III)-oxyhydroxide, goethite with time (Grenthe et al., 1992). These mineral encrustations, dominated by iron oxyhydroxides and iron sulfides, can become enriched in naturally occurring contaminants such as uranium as observed in McVey Chapter 3 (Unpublished Data). Mobile uranium (dissolved and colloidal) brought within the wellbore during pumping adsorbs to these metal surfaces, becoming trapped within biofilm materials along the casing and at the base of these wells. This sorption to mineral surfaces creates highly concentrated sources

of uranium within well casings and the surrounding aquifer sediments, creating sinks for the trace metal. Under reducing conditions, this uranium may be desorbed and released, which is then free to complex with available dissolved carbonates and ferrous iron, keeping the uranium in solution. This mobile ferrous iron, potentially derived from dissolution of pyrite and other such minerals, has been suggested to complex with and mobilize U(VI) by adsorption to available surface sites (Waite et al., 1994, Liger et al., 1999). This results in the higher uranium concentrations associated with ferrous iron observed at the Beemer, Bellwood, and Clarks wells. This surface sorption to the iron is supported by the high concentrations of uranium associated with exchangeable metals from selected wells (McVey, Chapter 3, Unpublished Data). These factors effectively allow wells to function as in-situ sinks for uranium.

The highest concentrations of uranium were contained in uranyl-carbonate complexes in all wells, estimated using PhreeqC (Appendix D). Carbonate complexes play a major role in U(VI) subsurface transport due to an affinity to form aqueous complexes with U(VI) (Grenthe et al., 1992). Wazne et al. (2003) states between pH 5-8, aqueous U(VI) is present as uranyl mono, di, and tricarbonates. Uranium present as a mobile uranyl ion, UO_2^{2+}, may be complexed with carbonate and bicarbonate ligands, (Zhou and Gu, 2005). In the pH range observed at sampled wells (~6.5-8.5), uranium affinity for minerals such as ferrihydrite may be inhibited due to formation of uranyl carbonate complexes (Hsi and Langmuir, 1985; Waite et al., 1994; Wazne et al., 2003). The pH and calculated pCO_2 values from all wells indicate saturation of these carbonate complexes in surrounding groundwater, resulting in ideal conditions for uranium

complexation and mobilization. These data may be an indication of high uranium concentrations being mobilized by carbonate complexes in the aquifer water.

Differences between total uranium were observed between the Clarks 2005-2 PWS well and the Clarks NTW monitoring well. The high uranium concentrations coupled with high bicarbonate in the Clarks NTW may indicate high dissolved uranyl-carbonate concentrations in the aquifer surrounding PWS wells (Fig. 9, Appendix D). High-velocity pumping of the Clarks 2005-2 well draws this higher uranium water from the aquifer, increasing uranium concentrations over time (Fig. 4), however uranyl-carbonate complex concentrations were lower than those calculated from the Clarks NTW data (Appendix D). The 2005-2 well does not contain uranium concentrations comparable to the NTW, but discrepancies in uranium concentrations between the Clarks 2005-2 PWS and the NTW can be attributed to pumping (Fig. 5). While the NTW is within the radius of influence of the PWS, intermittent pumping of the PWS did not draw as much high-U water into the wellbore during the pumping experiments. However, increases in uranium concentration in early pumping time suggest the well draws in water with higher uranium concentrations from the aquifer as the area of pumping influence extends.

Occurrence and Behavior of Uranium Under Varying Pumping Conditions

Short-term sampling of PWS wells demonstrated uranium variability within the first 30 minutes of pumping at Bellwood and Clarks, and stability thereafter. Increasing uranium concentrations were observed at the Bellwood 76-1 well to 175 ppb after 30 minutes of pumping, followed by a decrease to 147 ppb after 4 hours (Fig. 4). Short-term sampling after cleaning and sonication of the Bellwood PWS well resulted in small

fluctuations in uranium during the first 30 minutes of pumping. The well cleaning, however, was ineffective at significantly decreasing concentrations (Table 2a). Increasing uranium concentrations were observed at the Clarks 2005-2 well over 30 minutes pumping at 400 gpm, followed by stability (Fig. 4). The intake of higher-U water from the surrounding aquifer is responsible for the short-term uranium increase in these wells, followed by a period of stabilization with aquifer water as the area of pumping influence stabilized.

Uranium concentrations increased during an oxidation event August 18th 2006 during Clarks 2005-2 well interval sampling (Fig. 5). During interval sampling in October 2007, uranium concentrations had decreased to background levels. This suggests either ample oxygen was supplied to oxidize iron coated grains and sorbed uranium, elevating mobile uranium concentrations, or that cavitation at this depth stirred up uranyl precipitates settled at the base of the well casing, which were subsequently sampled.

Variations in uranium concentrations were observed in the Clarks PWS wells following well modifications. Following installation of a VFD and a packer system isolating the lower 2/3 of the wellscreen in the Clarks 2005-2 well, uranium concentrations decreased over 30 minutes pumping at 50 gpm. However, from March to July 2007 uranium concentrations were highly variable over time during 30 minute pump tests (Fig. 6). This modification proved ineffective at isolation of the lower screened interval, as high-U waters are still drawn into the well from the aquifer.

Regulated pumping schedules and extended pump downtime at the Beemer well and following modifications at the York well allowed uranium concentrations to decrease

over time. Modification of pumping rates and frequency at the York PWS demonstrated a low pumping rate of 50 gpm for 30 minutes coupled with 2 week periods of inactivity between pump tests allowed uranium concentrations to decrease below the MCL over time (Fig. 7). Similar decreases in uranium concentrations were observed at the Beemer well during long-term pumping experiments (Fig. 3). Results indicated uranium concentrations decreased following a two week period of well inactivity, and were the lowest concentrations recorded. The extended periods of pumping downtime at these wells decrease the amount of higher-U water withdrawn from the aquifer, essentially decreasing pumping stresses on groundwater system. This downtime also provides sufficient time for uranium pumped into the well to adsorb to available metals or precipitate out of solution. Alteration of pumping frequency and rate produced variable uranium behavior, and suggests that decreasing the frequency of pumping events is beneficial for the management of uranium concentrations over time at Beemer and York, NE. Note that these results are specific to respective geochemistry and operational history for each well.

Conclusions

The mobility of uranium within and surrounding Nebraska PWS well systems is affected by multiple chemical and biological factors. The dynamic well environment concentrates carbonate and metal complexes derived from alluvial materials as well as organic materials during pumping (Fig. 2). Geochemical modeling indicated reducing conditions, saturation of water with carbonate species, and the greatest concentrations of uranium in uranyl-carbonate complexes. Mechanism of transport via colloids versus

dissolved transport was not tested in this study, however geochemical modeling and previous studies of the York area suggest dissolved uranium is a major component of uranium transport in these wells. Biofilm materials found in these environments concentrate metal oxides and transported uranium within the well and in the surrounding aquifer (McVey, Chapter 3, Unpublished Data). Under reducing conditions, these oxides may undergo reductive dissolution within the aquifer, releasing sorbed uranium from mineral surfaces and colloids. Uranium (VI) can then be mobilized by available carbonate complexes, or undergo further reduction and precipitate out of solution. Under oxidizing conditions, the uranium may be mobilized in these wells. In theory, concentration of minerals and uranyl carbonates in a pumping well allow it to function as a sink for uranium in an aquifer. Further examination is suggested to investigate mechanisms of uranium sorption, mobilization, and transport in these wells.

The affect of pumping on the behavior of uranium in PWS and industrial wells is subject to further investigation. Interval sampling of selected wells attempted to isolate lower uranium bearing aquifer units, however results proved inconclusive with isolating these units. Relatively lower uranium concentrations were observed in deepest water bearing zones of the Bridgeport and Clarks wells. Isolation of the zone at Clarks proved unsuccessful at obtaining lower uranium concentrations, and further investigation of these zones is suggested. Short-term pump tests indicate increasing uranium concentrations within the first 30 minutes of pumping, as aquifer water is drawn to the well and the area of pumping influence stabilizes. Following this period, stabilization with aquifer conditions and stable uranium concentrations were observed. Pumping of the Beemer PWS well demonstrated a decrease in uranium after extended well

downtimes, however further testing of this well is required. Periods of extended well downtime between pumping events observed at the Beemer and York PWS wells reduced the amount of high-uranium water brought into the well casing, and provided sufficient time for residual uranium to precipitate or become sorbed to mineral surfaces within the wellbore. Increasing the time between pumping events may therefore reduce the amount of uranium sampled during pumping. However, this is dependent upon background concentrations within the surrounding aquifer media. This has implications for future well management, though further examination of background uranium concentrations surrounding PWS and other industrial wells is suggested.

Tables

Table 1 – Stratigraphy and hydrogeologic properties of alluvial units within the High Plains Aquifer System. From the Nebraska Conservation and Survey Division, 1986.

			Age	Unit	Lithology	Hydrogeologic Properties
CENOZOIC	QUAT.	Holocene	10 ka	Multiple stratigraphic units	clay, silt, loess, glacial till, sand and gravel	Principal groundwater reservoir, is generally equivalent to High Plains Aquifer; Ogallala Group is absent in eastern and northwestern Nebraska. Arikaree Group is present primarily in west.
		Pleistocene	1.8 Ma			
	TERTIARY	Pliocene	5 Ma			
		Miocene	24 Ma	Ogallala Group	sand, sandstone, siltstone and some gravel	
		Oligocene		Arikaree Group	sandstone and siltstone	
			34 Ma	White River Gp. / Brule Fm.	siltstone, sandstone and clay in lower part	Secondary aquifer in western Nebraska; water may be highly mineralized.
		Upr. Eocene	65 Ma		*UNCONFORMITY*	
MESOZOIC	CRETACEOUS	UPPER CRET.		Lance and Fox Hills formations	sandstone and siltstone	Generally not an aquifer; yields water to a few wells in western Nebraska.
				Pierre Shale Formation	shale, some sandstone in west	Generally a confining unit; sandstones in west yield highly mineralized water to a few industrialized wells.
				Niobrara Fm.	shaly chalk and limestone	Secondary aquifer where fractured and at shallow depths, primarily in east.
				Carlile Shale Formation	shale; in some areas, contains sandstones in upper part	Generally not an aquifer; sandstones yield water to a few wells in northeast.
				Greenhorn & Graneros form's	limestone and shale	Generally not an aquifer; yields water to a few wells in east.
		LOWER CRET.	98 Ma	Dakota Fm.	sandstone and shale	Secondary aquifer; primarily in east; water may be highly mineralized.

Table 2a – Observations of uranium behavior during pumping of public water supply systems around Nebraska. Complete pumping and water chemistry data can be found in Appendix B.

PWS well	Sampling Date	Pumping Rate	Uranium Concentration Variations
Beemer 2002-1	Jan 20 2006* (after 2 weeks of inactivity)	500 gpm 250 gpm 100 gpm	Decreased 158-148 μg/L Decreased 177-167 μg/L Decreased 271-185 μg/L
	Oct 2005 to Aug 2007 (sampled every ~2 months)	500 gpm	Decreased 199-31 μg/L
Bellwood 76-1	June 19 2006** (offline 19 days prior)	275 gpm	Decreased 175-147 μg/L
	Jul 16 2006, 12 hr pumping (after well cleaning)	275 gpm	Decreased 147-141.4 μg/L
	Oct 20 2006, 12 hr pumping	200 gpm	Decreased 200-163 μg/L
	Feb 10 2007, 8 hr pumping	275 gpm	Decreased 230-199 μg/L
Bridgeport 69-1	June 8 2005** (offline 3 days prior)		Decreased 75-70 μg/L
Clarks 2005-2	Jan 25 2006**	400 gpm	Increased 28-40.2 μg/L
	Aug 17 2006**	100 gpm	Increased 29.6-39.8 μg/L
	Feb 10 2007****	100 gpm	Decreased 51.6-36.9 μg/L
	Feb 12 to March 2 2007**** (after installation of variable frequency drive and packer isolation of lower 2/3 of well screen; sampled weekly)	50 gpm	Decreased 43.5-31.2 μg/L
	March to July 2007**** (irregular pumping and sampling schedule)	50 gpm	Fluctuated 47.9 to 31.2 μg/L

*At each pumping rate, samples were collected at 0, 0.25, 0.5, 1.0, and 1.3 hours.
**Samples were collected at 0, 0.5, 1, 2, 3, and 4 hours after the pump was turned on.
***Samples were collected at 0, 0.5 and 1 hour after the pump was turned on.
****Samples were collected at 0 and 0.5 hours after the pump was turned on.

Table 2b – Observations of uranium behavior during pumping of public water supply systems around Nebraska. Complete pumping and water chemistry data can be found in Appendix B.

PWS well	Sampling Date	Pumping Rate	Uranium Concentration Variations
York 73-1	July 19 2005** (offline since May 24 2005)	500 gpm	Increased 2-16 μg/L
	May 22 to June 2 2006*** (continuous pumping; sampled every 2 days)	500 gpm	Increased 14-80 μg/L
	June 6 to Aug 15 2006*** (continuous pumping; sampled every 2 weeks)	250 gpm	Decreased 82-71 μg/L; then increased to 96.5 μg/L
	Sept 5 to Sept 19 2006**** (continuous pumping; only sampled on Sept 5 and 19)	100 gpm	Decreased 85-82 μg/L
	Sept 26 2006 to June 19 2007**** (well pumped and sampled every 2 weeks)	50 gpm	Decreased 76-29 μg/L

**Samples were collected at 0, 0.5, 1, 2, 3, and 4 hours after the pump was turned on.
***Samples were collected at 0, 0.5 and 1 hour after the pump was turned on.
****Samples were collected at 0 and 0.5 hours after the pump was turned on.

Table 3a – Results of interval sampling of selected depths from public water supply systems around Nebraska. Interval depths are the top and bottom of the sampling intervals. Sampling of wells occurred over a 30 minute pumping time. Complete pumping and water chemistry data can be found in Appendix B.

PWS well	Sampling Date	Interval Depths	Uranium Concentration Variations
Bellwood 76-1	June 21 2006*	104-109 ft	Increased 143-178 μg/L; both packers used
		109-114 ft	Decreased 196-175 μg/L; only used top packer
		104-114 ft	Decreased 208-182 μg/L; only used top packer
	June 23 2006*	114-119 ft	Decreased 218-101 μg/L; both packers used
		119-124 ft	Increased 143-191 μg/L; only used top packer
Bridgeport 69-1 MW	June 28 2005* (no packers)	30.9 ft	No change; 67 μg/L
		53.6 ft	No change; 68 μg/L
		76.6 ft	No change; 65 μg/L
		98.5 ft	No change; 63 μg/L
		122.2 ft	No change; 63 μg/L
	Aug 15 2005* (no packers)	53.6 ft	No change; 66 μg/L
		98.5 ft	No change 62 μg/L
		122.2 ft	No change 60 μg/L
Clarks 2005-2	Sept 22 2005* (no packers)	86 ft	Decreased 16-12 μg/L
		100 ft	Increased 28-32 μg/L
		117 ft	Decreased 58-52 μg/L
	Aug 18 2006* (packer leak; well aerated during sampling)	86-91 ft	Increased 128-147 μg/L; then decreased to 121 μg/L
		99-104 ft	Decreased 120-112 μg/L
		115-118 ft	Decreased 91-75 μg/L
	Oct 5 2006* (both packers)	85-91 ft	Increased 28-31 μg/L
		99-104 ft	Decreased 18-17 μg/L
		115-118 ft	No change; 9 μg/L

*Samples were collected at 0, 0.5 and 1 hour after the pump was turned on.

Table 3b – Results of interval sampling of selected depths from public water supply systems around Nebraska. Interval depths are the top and bottom of the sampling intervals. Sampling of wells occurred over a 30 minute pumping time. Complete pumping and water chemistry data can be found in Appendix B.

PWS well	Sampling Date	Interval Depths	Uranium Concentration Variations
Clarks NTW	Aug 17 2006*	86 ft	Decreased 260-229 μg/L
	(no packers)	100 ft	Increased 216-242 μg/L
		117 ft	Increased 226-247 μg/L
	Sept 25 2006*	80 ft	Increased 215-243 μg/L
	(no packers)	100 ft	Decreased 256-243 μg/L
		117 ft	Decreased 266-243 μg/L
York 73-1	Aug 2 and 3 2005*		
	(no packers)	364.8 ft	No change; 22 μg/L
		352.8 ft	No change; 18 μg/L
		318 ft	No change; 16 μg/L
		281 ft	No change; 16 μg/L
		270 ft	No change; 15 μg/L
		217 ft	No change; 16 μg/L
		190 ft	No change; 13 μg/L
		170 ft	No change; 12 μg/L

*Samples were collected at 0, 0.5 and 1 hour after the pump was turned on.

Table 4 – Mean chemical concentrations from sampled PWS and monitoring wells calculated from results in Appendix B. State Health Lab samples are indicated by SHL and Midwest Lab Samples are indicated by MWL. Concentrations are listed in parts per million (mg/L) and parts per billion (μg/L).

Town	Well ID	U μg/L SHL	U μg/L MWL	pH	EC μS per cm	DO mg/L	Temp C	HCO3 mg/L
Beemer	**2002-1**	190	183	7.2	426.0	0.5	9.1	303.1
Bellwood	**76-1**	178	156	7.5	563.8	1.5	13.1	303.0
Bridgeport	**691**	55	55	7.2	1219.8	2.9	12.2	384.4
Bridgeport	**691-MW**	63	64	7.2	1320.0	1.5	12.5	435.1
Clarks	**2005-1**	55	51	7.2	425.7	0.5	10.8	189.8
Clarks	**2005-2**	48	74	7.3	393.1	2.3	10.9	165.2
Clarks	**NTW**	210	253	7.3	661.8	4.1	12.7	377.0
York	**73-1**	15	45	7.3	549.7	2.1	13.4	307.8

Town	Well ID	Ca mg/L	Na mg/L	Mg mg/L	K mg/L	Mn mg/L	NO3 mg/L	Cl mg/L
Beemer	**2002-1**	82.6	23.3	17.2	5.3	0.1		8.0
Bellwood	**76-1**	96.7	23.6	16.4	10.0	0.4		11.1
Bridgeport	**691**	129.5	188.5	27.2	11.5	0.1	8.4	43.2
Bridgeport	**691-MW**	122.6	216.3	34.2	22.1	0.0	12.6	49.0
Clarks	**2005-1**	62.5	37.0	10.4	6.5	0.2	0.8	14.0
Clarks	**2005-2**	52.5	26.3	8.4	6.3	0.3	0.3	13.1
Clarks	**NTW**	112.3	78.7	19.3	13.9	0.2		19.0
York	**73-1**	76.8	28.9	12.3	5.9	0.1	2.3	10.6

Town	Well ID	SO4 mg/L	Fe Total mg/L	Fe 2+ mg/L	Fe 3+ mg/L	P mg/L	TOC mg/L
Beemer	**2002-1**	34.0	0.4	0.4		0.3	1.6
Bellwood	**76-1**	122.0	0.9	0.7	0.2	0.1	3.3
Bridgeport	**691**	355.7					
Bridgeport	**691-MW**	394.4				0.1	6.6
Clarks	**2005-1**	85.8	0.6	0.6		0.3	3.1
Clarks	**2005-2**	71.6	0.4	0.2	0.2	0.1	2.8
Clarks	**NTW**	192.6	0.9	0.5	0.5	0.1	2.3
York	**73-1**	39.5	0.2	0.1	0.1	0.2	4.0

Figures

Fig. 1 – Conceptual model of a public water supply system and various factors affecting dissolved uranium behavior in water supplies.

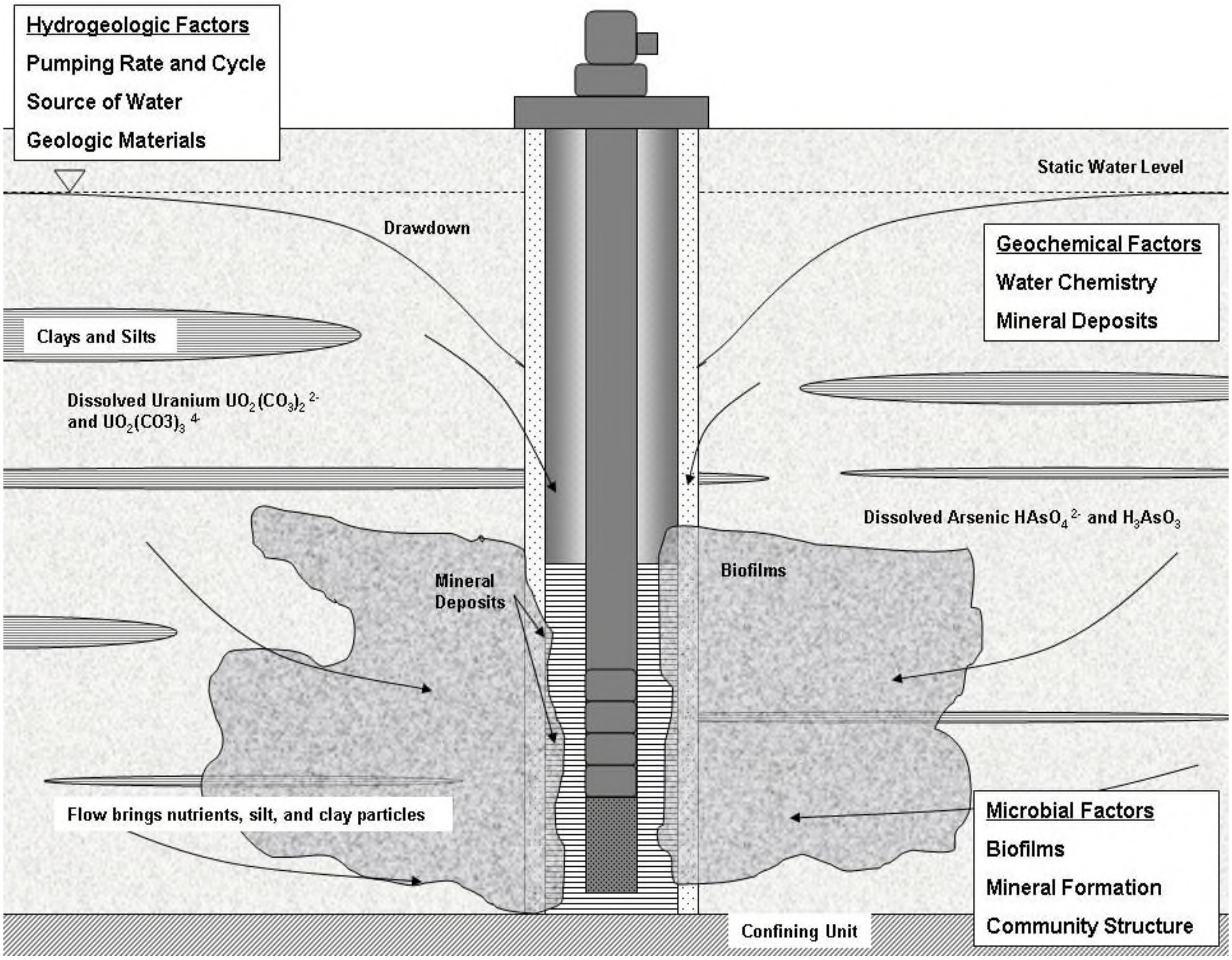


Fig. 2 – Map of Nebraska displaying study locations. Concentration ranges displayed are the highest recorded uranium levels sampled at each community.

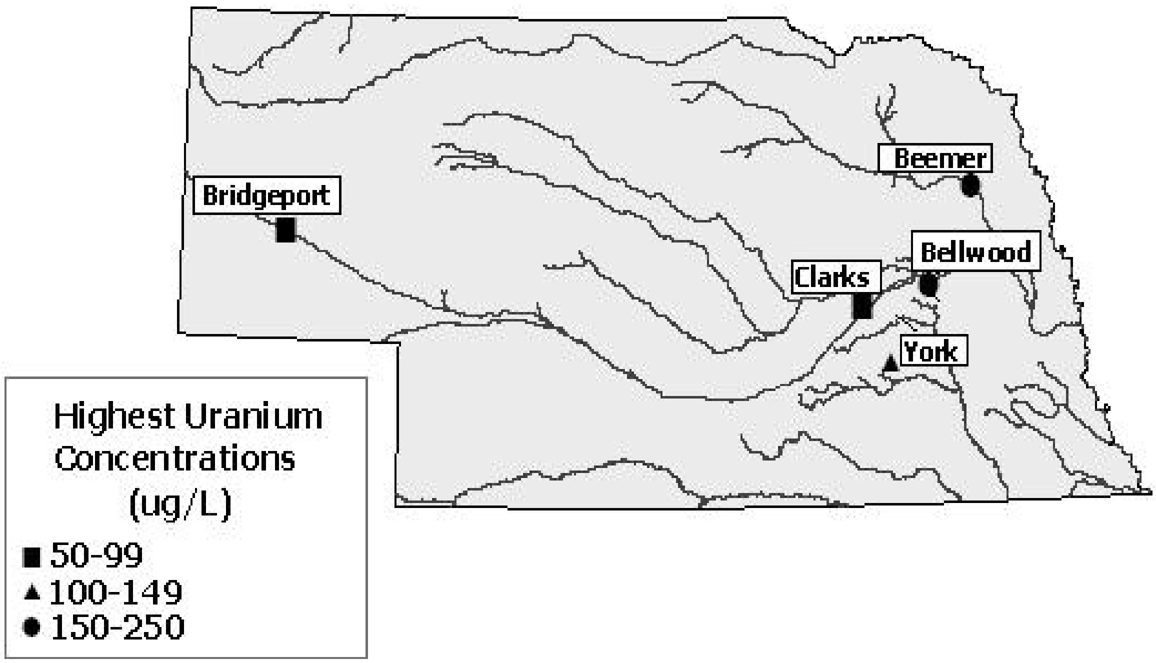


Fig. 3 –Uranium concentrations from 2005-2007 of the Beemer public water supply well. Samples were taken at 30 minutes during 2005 sampling events following stabilization of uranium concentrations. Sampling times of 2006-2007 were not documented. Complete pumping and water chemistry data can be found in Appendix B.

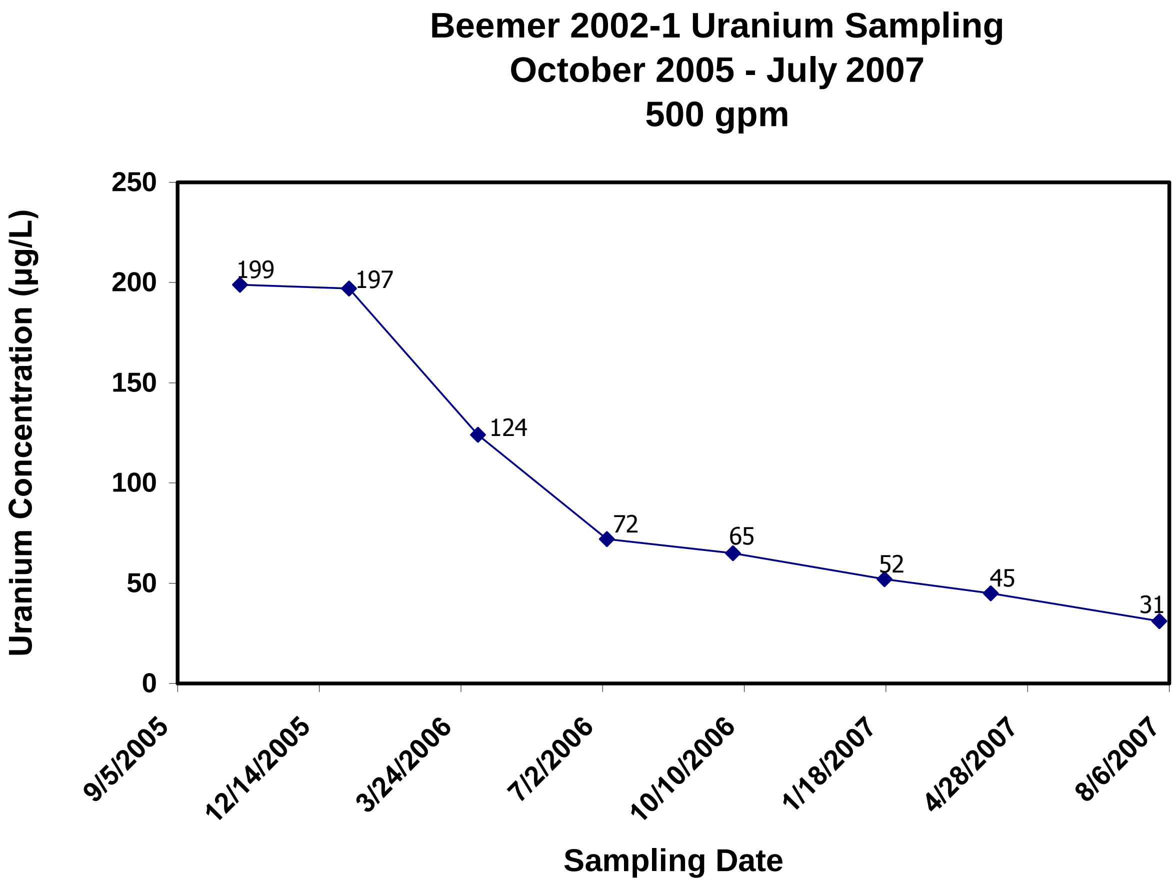


Fig. 4 –Uranium concentrations in wells from the Bellwood, Clarks, York public water supply systems. Sampling time indicates time after the start of pumping. Sample date, time when sample was collected, and pumping rate are listed for each sampling event. Complete pumping and water chemistry data can be found in Appendix B.

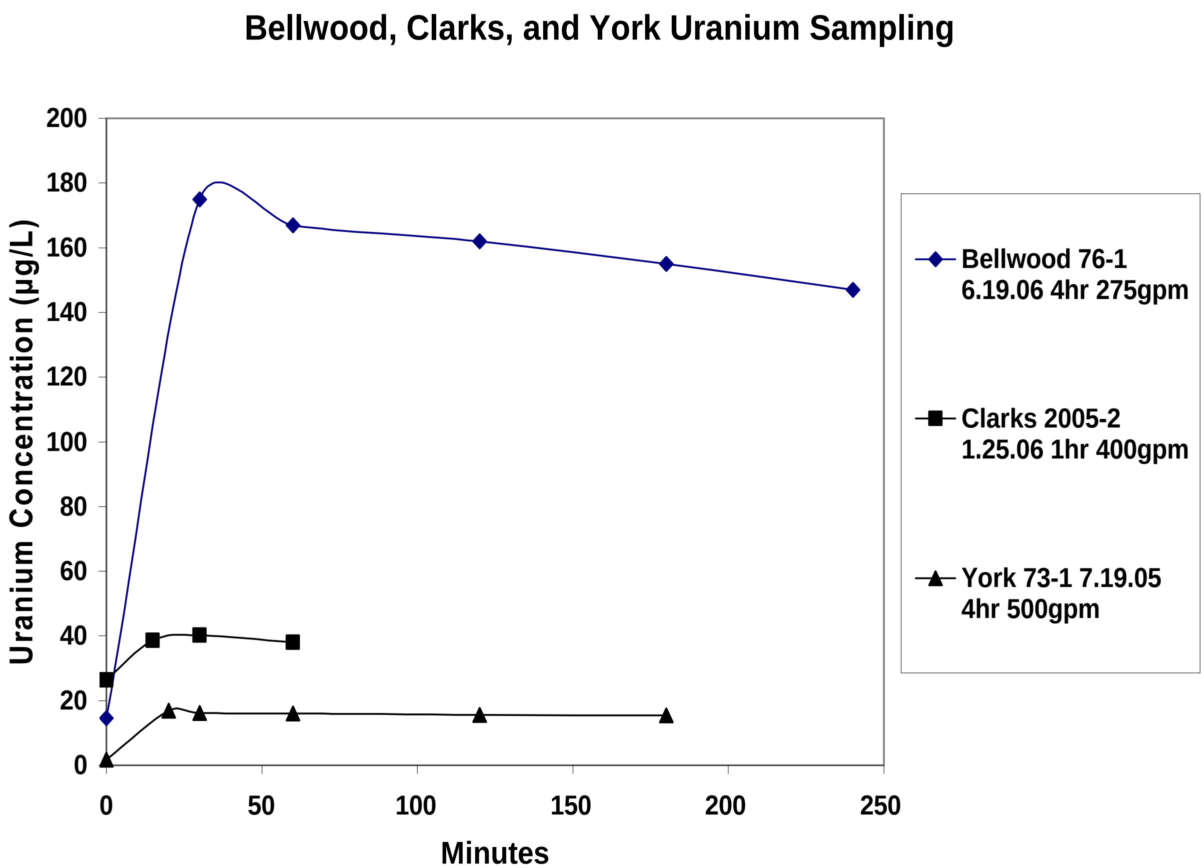


Fig. 5 – Uranium concentrations in the Clarks 2005-2 and NTW wells. Note that the NTW monitoring well is located ~50' from the Clarks 2005-2 PWS well. Samples were taken at 30 minutes following stabilization of uranium concentrations. Sampling date, time after the start of pumping sample was collected, and pumping rate are listed for each sampling event. Sampling depth in feet is indicated next to each data point. Complete pumping and water chemistry data can be found in Appendix B.

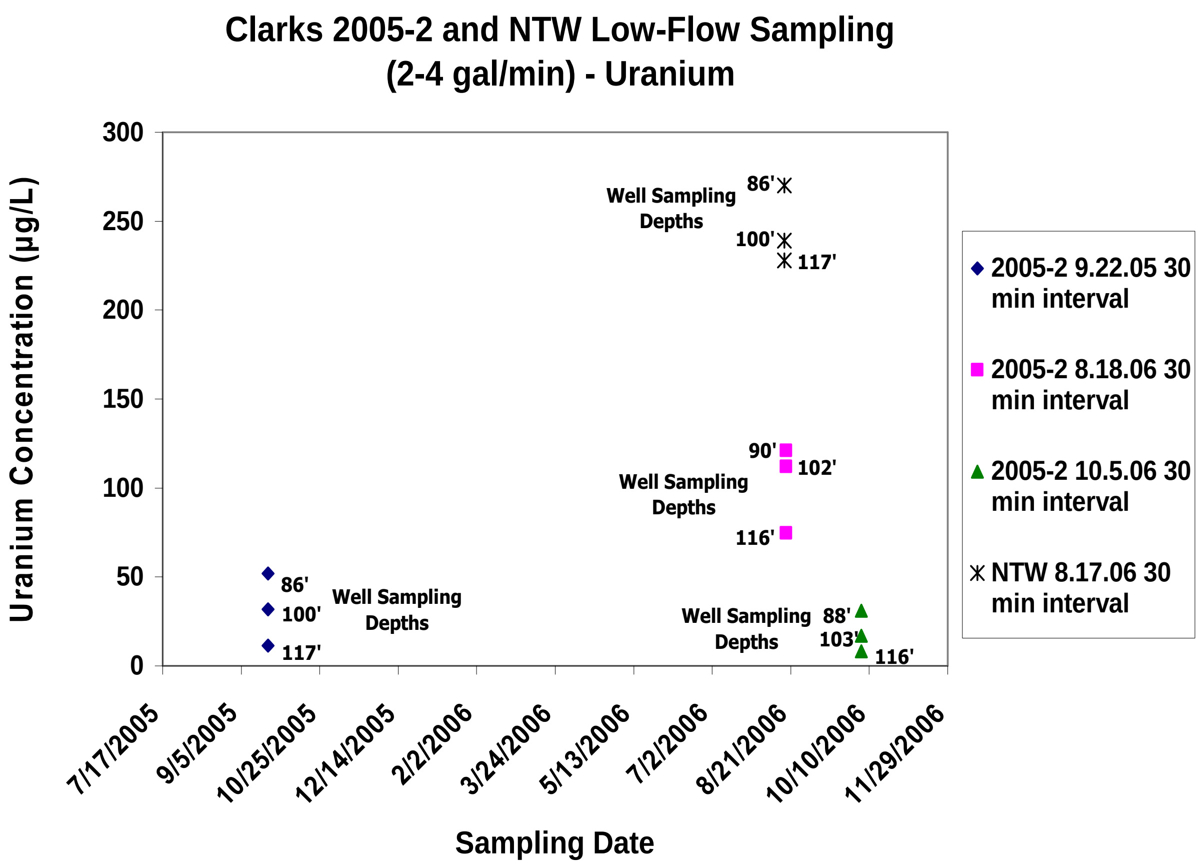


Fig. 6 – Observations from the Clarks 2005-2 well following well modifications. Samples were taken at 30 minutes following stabilization of uranium concentrations. Complete pumping and water chemistry data can be found in Appendix B.

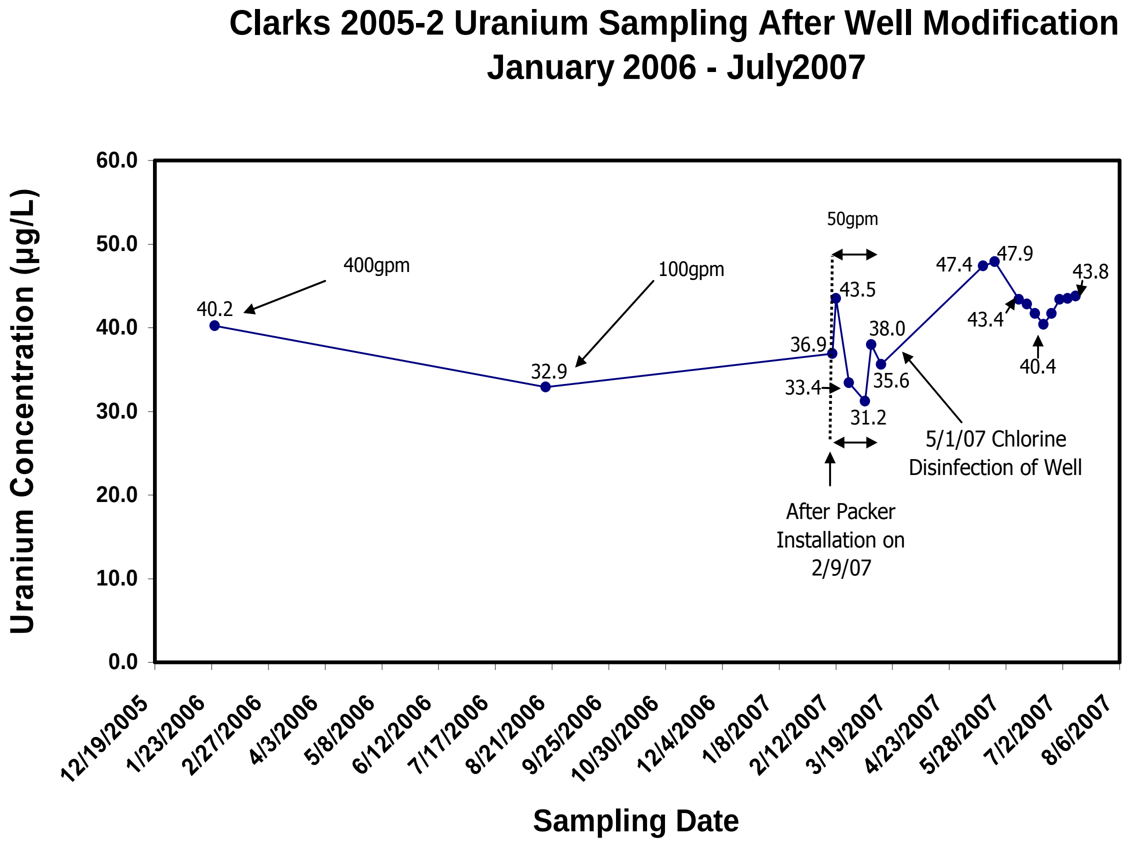


Fig. 7 – Observations of uranium variability at the York public water supply well. Samples were taken at 30 minutes following stabilization of uranium concentrations. Pumping rates are listed for each series of pumping tests. Complete pumping and water chemistry data can be found in Appendix B.

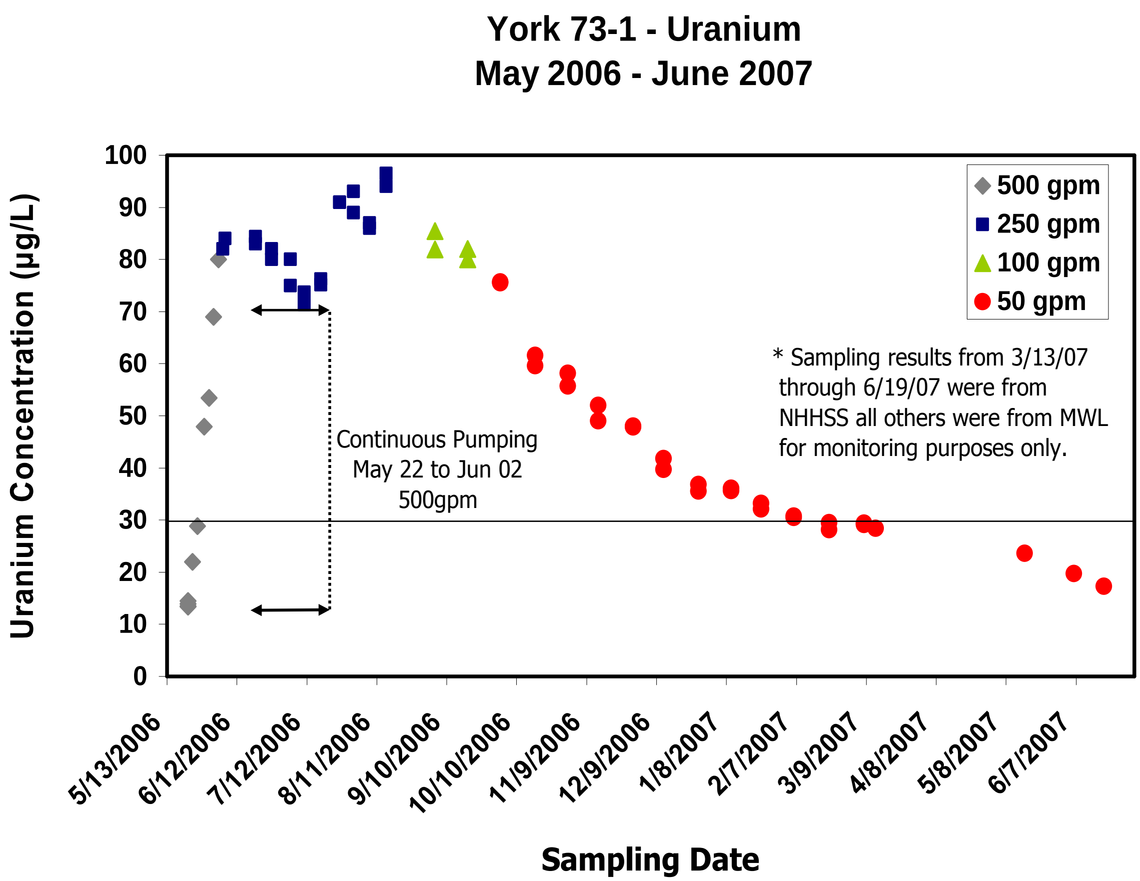


Fig. 8 – Uranium versus ferrous iron in the Clarks NTW speciated in the field by UNL personnel. Sampling date, time after the start of pumping sample was collected, sampling depth, and pumping rate are listed for each sampling event.

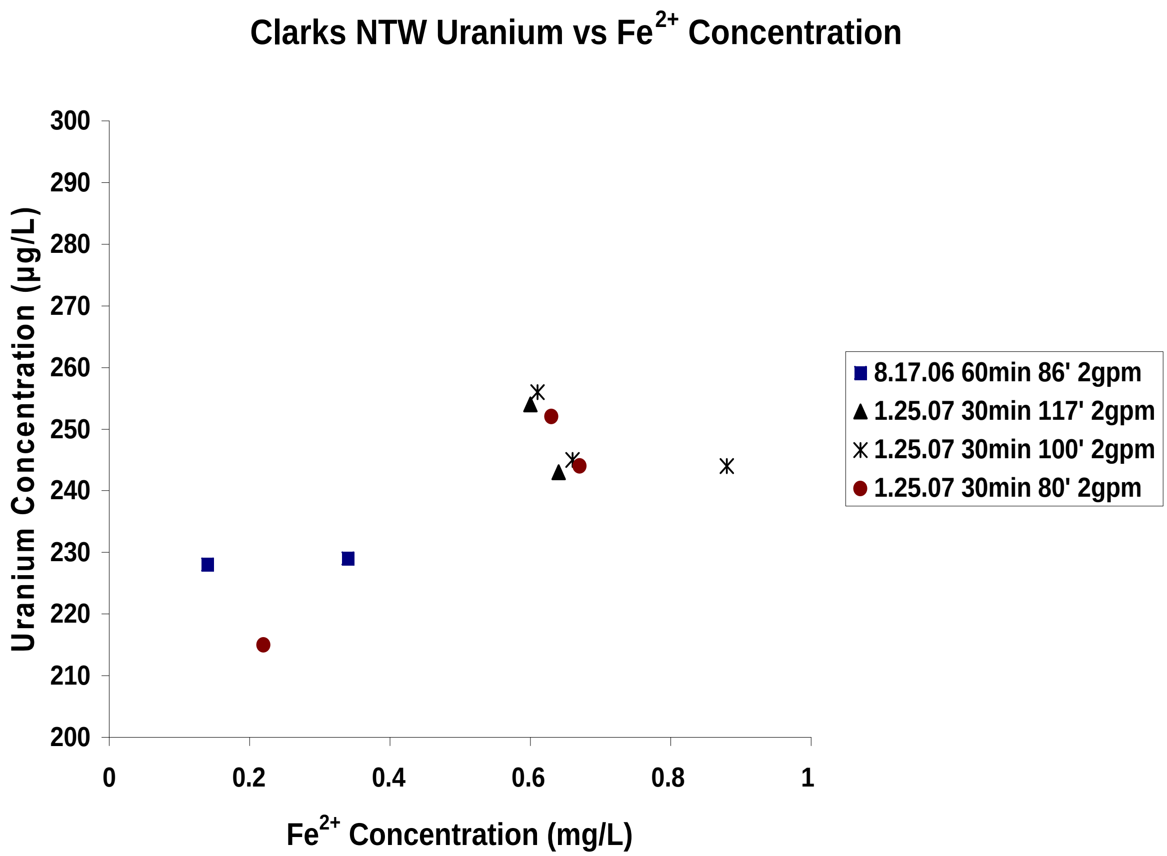
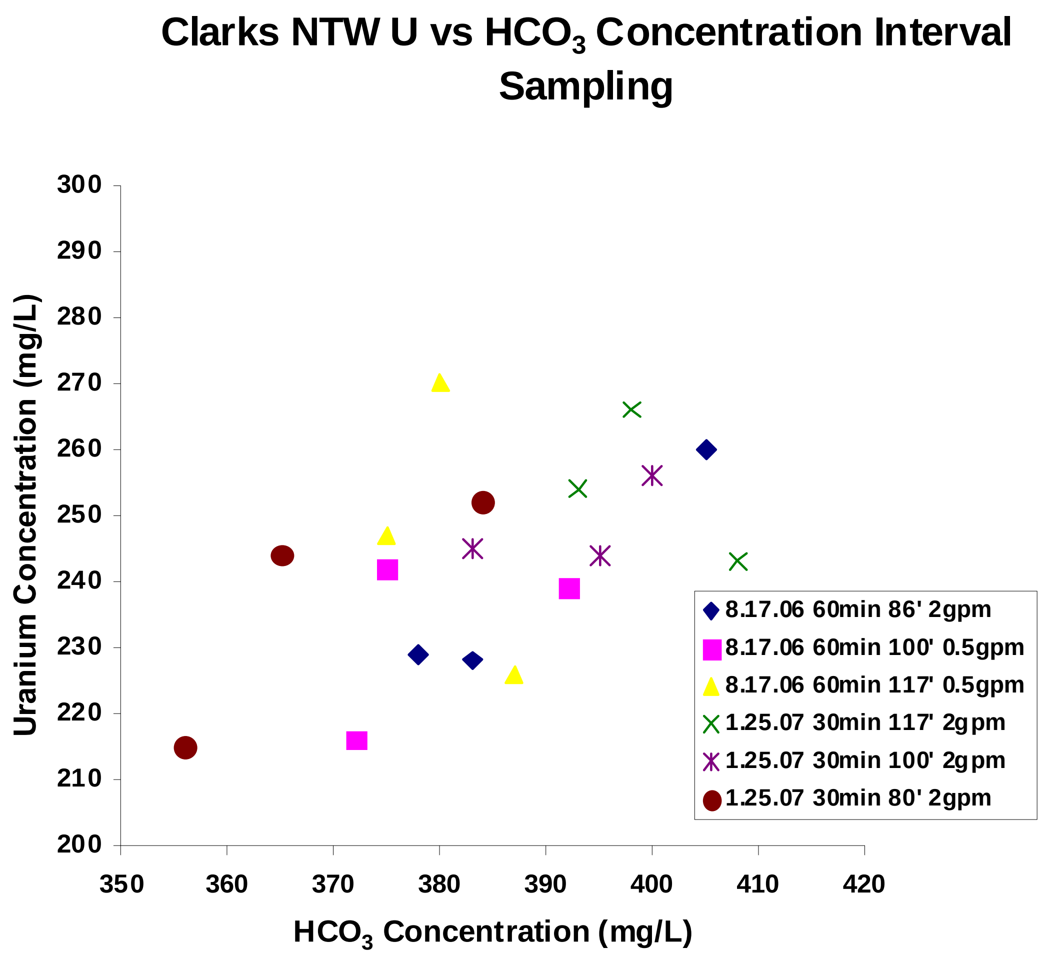


Fig. 9 – Uranium concentrations plotted versus bicarbonate concentrations sampled at the Clarks NTW in August 2006 and January 2007. Sampling date, duration of pumping in minutes, sampling depth, and pumping rate are listed for each sampling event. For thirty minute pump tests, samples were collected at 0, 15, and 30 minutes; for sixty minute pump tests samples were collected at 0, 30, and 60 minutes.



II. The Effect of Pumping on Arsenic Concentrations in Public Water Supply Wells: Observations from Nebraska

Introduction

Dissolved arsenic derived from rock-water interaction poses drinking water quality issues to communities in the United States (Focazio et al., 2000). Over 7% of public water-supply groundwater systems are affected by arsenic concentrations between 10 and 50 µg/L (Focazio et al., 2000). Concentrations greater than the federally mandated maximum contaminant level (MCL) of 10 parts per billion (ppb) were reported in over 84 public water supply (PWS) well systems throughout Nebraska as of 2005 (NHHS, 2008). These single or multiple well systems supply potable drinking water primarily to rural communities. High-cost treatment facilities are not viable options for many communities affected by the high arsenic concentrations. As a result, we have been exploring the factors that influence the arsenic concentrations in PWS wells. Understanding these factors may have implications for communities nationwide affected by high arsenic concentrations.

Arsenic concentrations in PWS wells may be affected by a combination of factors that influence the geochemical environment around the well, in turn, they influence the mechanisms that release and/or remove from arsenic from groundwater. These factors include pumping conditions, the geochemistry of water and groundwater-bearing deposits, in addition to the biologic environment within and surrounding the PWS wells (Fig. 1). The installation of a pumping well influences the hydrology of the aquifer, altering groundwater velocity and direction. This, in turn, disturbs the natural geochemical environment, and influences the occurrence of metals, carbon, and oxygenated water, all of which may affect arsenic. The installation of water wells creates a well-documented vertical hydrochemical short circuit that connects the subsurface

environment to the atmosphere (Jagucki et al., 2008, Landon et al., 2008). This short circuit is enhanced by the pumping of the groundwater system. Biological growths may also be encouraged within and surrounding a well due to changes in water chemistry, presenting potential sinks for metals, organics, and contaminants.

This report is a continuation of research conducted by Gosselin et al. (2006). It presents the results of a cooperative effort between the Environmental Protection Agency Region VII, Nebraska Department of Health and Human Services and thirty-five villages with historical arsenic issues across Nebraska. The purpose of this paper is to (1) assess the factors that influence arsenic mobility in and around PWS wells and (2) investigate the occurrence and behavior of arsenic under varying pumping conditions within and surrounding PWS wells.

Background: High Plains Aquifer, Arsenic Occurrence, and Conceptual Model

The High Plains Aquifer System is the single most important water source in the midwestern United States, supplying freshwater to eight adjoining states. The occurrence of arsenic in the High Plains Aquifer is related to the interaction of groundwater and volcanoclastic sediments within the Ogallala, Arikaree, and White River groups (Gosselin et al., 2006) (Table 1). Aquifer materials within these geologic groups range from medium-grained sand to silty sand with interspersed lenses of silty clay and clayey sand (Appendix A).

Arsenic is a component of many minerals, including sulfides, arsenides, some oxides, but also occurs as elemental As. It is found most frequently in association with sulfur as arsenopyrite, FeAsS (Cullen and Reimer, 1989). When As is found in aquifers it means that the geochemical and physical conditions are favorable for As mobilization

and accumulation (Smedley and Kinniburgh, 2001). In groundwater, arsenic occurs as the reduced species, arsenite (As^{3+}) and the oxidized species, arsenate (As^{5+}). It is also present as oxyanions (arsenate species $H_2ASO_4^-$, $HAsO_4^{2-}$ with pKa = 7.0 and arsenite species H_3AsO_3, and $H_2AsO_3^-$ with pKa = 9.2) in solution. Major elements binding arsenite and arsenate in sediments are metal oxides, particularly those of Fe, Al, and Mn (Sullivan and Aller, 1996). Clays may also absorb As because of the oxide-like characteristics of their edges. Fe oxides, however, are the most important absorbents in sandy aquifers because of their great abundance and strong binding affinity (Smedley and Kinniburgh, 2002).

Mobilization of arsenic in groundwater occurs when the hydrogeologic system becomes anaerobic (Langmuir, 1997). At the near neutral pH of many groundwaters, As(III) is expected to be less strongly sorbed than As (V), so some desorption of As may occur due to the onset of reducing conditions (DPHE/BGS/MML, 1999). One of the principal causes of As release and high concentrations in near-neutral pH groundwater is the reductive dissolution of hydrous Fe-oxides and/or the release of adsorbed and combined As (Smedley and Kinniburgh, 2002). Arsenic (V) or arsenate reduction is thermodynamically expected to occur following Fe(III) reduction. Iron from Fe-oxides is solubilized as Fe(II) , giving rise to characteristically higher Fe waters. Arsenic release during this reduction has been attributed to Fe-oxide dissolution. Deuel and Swoboda (1972) proposed As release from a reduced clay soil was primarily due to reduction and dissolution of ferric arsenates rather than changes in As speciation. Guo et al. (1997) found As was released after dissolution of Fe and Mn, suggesting that dissolution rather than desorption released As (or that both occurred simultaneously). Mascheleyn et al.

(1991) found As was released rapidly following increases in Fe-oxide dissolution. The principle mechanism is uncertain, however both reductive dissolution of As and reductive desorption both play a role in As mobilization.

The study of arsenic concentrations in public water supply wells has yielded mixed results with regard to its behavior. The United States Geological Survey sampled 353 wells nationwide including public water supply, agriculture, and industry wells for dissolved arsenic concentration and examined the variability of arsenic over time (Focazio et al., 2000). Relationship of arsenic concentration with pumping time and no relationship to mean arsenic concentrations and well depth were found (Focazio et al., 2000). Variability of arsenic over year-long time periods were found in the USGS study according to Focazio et al. (2000), however Gosselin et al. (2006) observed no variability at similar time scales. Gosselin et al. (2006) showed that during twenty-four hour sampling experiments that variations in arsenic concentrations may occur early in the pumping cycle. However, arsenic concentrations varied little over year long sampling. The general absence of long-term temporal variability in arsenic concentrations suggested that the collection of one sample per year from most of these wells in this study will adequately characterize the As concentration to which the population drinking this water will be exposed (Gosselin et al., 2006).

Methods

PWS Well Selection and Sampling Techniques

Thirty-five wells were sampled from twenty-three public water supply systems (Fig. 2). The public water supply systems were selected to improve the understanding of

arsenic occurrence and behavior under varying pumping conditions within and surrounding PWS wells. Pumping and sampling schedules were designed to simulate normal operational conditions of each PWS well.

To assess the extent to which arsenic varied during early pumping times when samples are often taken for regulatory purposes, samples were collected at different times after pumping commenced. Sampling was performed to document arsenic behavior in response to short-term pumping times in support of arsenic variations observed by Gosselin et al. (2006).

In an effort to evaluate specific intervals that may yield higher arsenic concentrations, we used the geologic logs to indentify intervals to sample (Appendix A). Nebraska Health and Human Services (NHHS) assessed the integrity of selected PWS wells using a down-hole camera. Low-flow interval sampling was performed to measure arsenic variability along the vertical profile of selected wells. Low-flow sampling methods involved pumping at rates between 0.5-3.0 gpm for 30 minutes during which samples were collected at 0, 15, and 30 minute intervals. A dual well packer system and a 2-inch Grundfos submersible pump were used to isolate screened intervals of in PWS wells at Stromsburg, Haigler, and Wauneta.

Following interval sampling, the PWS wells of Haigler, Stromsburg, and Wauneta were modified based on respective data collected. A variable frequency drive (VFD) was installed after vertical profiling of arsenic concentrations at Haigler 65-1 to vary the pumping rate. Following interval sampling at Stromsburg 3 well, the pump was relocated to 121 ft. The Wauneta 3 well was modified with a permanent packer system to isolate the screen below 171 feet following interval sampling. Following modification, the

Haigler, Stromsburg, and Wauneta wells were sampled at 0 0.5 hours after the pump was started.

Water Sample Collection

Water samples were collected from sampling ports located along the distribution line of the well pumps and from the hose of the Grundfos pump during interval sampling. Complete sampling data can be found in Appendix B. Each water sample collected for laboratory analysis was analyzed in the field for the following parameters: field alkalinity, dissolved oxygen, electrical conductivity, pH, temperature, and dissolved Fe^{2+}/Fe^{3}. Ninety-seven samples were analyzed for major cations (Ca, Mn, Mg, K) and anions (Cl, SO_4, NO_3, and P), total organic carbon (TOC), and total arsenic concentration.

PhreeqC was used to calculate saturation indices based on major ion chemistry and field parameters (Parkhurst and Appelo, 1999) (Appendix D). Samples were collected in 125 ml polypropylene bottles provided by NHHS and 250 ml polypropylenes bottles. TOC samples were collected in 250 ml amber glass bottles. Selected arsenic samples in this study were filtered at UNL to differentiate between dissolved arsenic and colloid-bound arsenic concentrations (Table 8). Two sets of samples were taken for each filter size; one preserved using nitric acid and one unpreserved to examine effects of arsenic precipitation in sample bottles. Arsenic samples from selected wells were also filtered in the field for speciation of $As^{3+/}As^{5+}$. Field instruments for pH and DO were calibrated at each PWS. Specific conductance was calibrated three times per day. Temperature was measured using glass thermometers in addition to a pH probe thermometer for comparison. QA/QC samples including standards, field, trip, and lab

blanks, and duplicates were used to evaluate analytical variability (Appendix C). Water samples were analyzed for total arsenic, cations, anions, and TOC by Nebraska Health and Human Services Laboratories and Midwest Laboratories according to U.S. EPA Method 200.8.

Distribution coefficients (K_d) were calculated to determine arsenic sorption to various sediments sampled from PWS wells. A ratio of the arsenic adsorbed versus arsenic in solution is obtained from the following equation:

$$K_d = As_{ads}/As_{aqu}$$

where Kd is measured in (mL/g) (U.S. Geological Survey, Menlo Park, Curtis et al., 2006). Adsorbed arsenic (As_{ads}) concentrations were obtained by sequential sediment leaching of arsenic from solid materials collected from each well performed (Gosselin et al. unpublished data). Aqueous arsenic (As_{aqu}) values were calculated from average 30 minute dissolved arsenic concentrations for each well from which solids were collected. This time interval was chosen due to a general stabilization of chemical parameters observed at PWS wells following 30 minutes of continuous pumping (Gosselin et al., 2006).

Results

Arsenic and General Water Chemistry

Groundwater samples from all wells had temperatures that ranged from 10-20º C and circumneutral pH (6.5-8.5). Dissolved oxygen levels ranged from <0.1 mg/L to 10 mg/L during pumping. The lowest concentrations occurred at the start of pumping. Waters are classified as calcium-sodium-bicarbonate-type (Helsel and Hirsch, 1992).

Filtering experiments performed from various PWS wells examined the difference between colloidal and dissolved arsenic concentrations in water samples (Table 8). The arsenic concentrations from filtered samples (1, 0.45, and 0.2 micron filters) were not significantly different than those of unfiltered samples. Percent differences between filtered and unfiltered did not exceed 10% in most wells. However, percent differences between filtered and unfiltered from the Cambridge 531 well were as high as 20%, but sampling and filtering difficulties were reported for this sample. The Stromsburg PWS well samples contained notably higher arsenic concentrations than other wells sampled, however filtering results were consistent with those wells having lower arsenic concentrations. Preservation in nitric acid did not affect the difference between preserved and non-preserved filtered arsenic concentrations.

Although there was a limited amount of arsenic associated with Fe and Mn oxides, distribution coefficients calculated from selected PWS wells indicated that arsenic was preferentially adsorbed to organic materials (Table 7). This association with organic material is consistent with the presence of biofilms observed during videotaping of these three wells.

PhreeqC was used to assess the saturation of various mineral phases in the water samples. Arsenite and arsenolite are As(III) forms present whereas As(V) forms include various arsenates and scorodite (Appendix D). All samples were saturated with iron phases including goethite, hematite, maghemite, magnetite, and other iron oxyhydroxides. Various arsenic mineral phases were undersaturated in all wells sampled. Calculated concentrations of arsenite and arsenate species in PhreeqC were consistent in

all wells, with no clear relation to wells with high or low dissolved arsenic concentrations.

Despite saturation of various metal phases indicated by PhreeqC in all wells, changes in dissolved iron, sulphur, and phosphate concentrations did not affect dissolved arsenic concentrations. Differences in concentration of these metals were observed between PWS wells. However, the link to differences in arsenic concentrations between these wells was unclear.

The relationship between dissolved oxygen content and dissolved arsenic was unclear from the data (Tables 6a-6c). Total arsenic concentrations increased at Benkelman 72-1 with increasing dissolved oxygen. Similarly, at Wauneta well 3, arsenite levels decreased and arsenate levels increased with rising DO concentrations, however an insufficient number of data points leave results questionable. Wells from Haigler and Oshkosh exhibited opposite trends to those of Benkelman and Wauneta, with arsenate levels dropping as DO increased. Again, sample numbers were inadequate to yield solid results with regard to the relationship between arsenic and dissolved oxygen concentrations.

Regional/ Seasonal Variability

PWS wells were sampled from Dec. 2002 through Nov. 2003 as described by Gosselin et al. (2006). Pumping rates used were identical to rates used during normal pumping operation. Chemical and physical groundwater data were grouped into Republican River Valley, Upper Platte NE Panhandle, Central NE Platte, and Eastern NE Platte regions. The Central NE Platte PWS systems sampled include Anselmo wells 64-1 and 87-1, Elwood wells 71 and 88-1, and Shelton wells 49 and 97 (Fig. 3a). Arsenic

concentrations in the Central NE Platte wells increased ~3 ppb and stabilized from January to May, then decreased 1-2 ppb from May to mid-June.

The Eastern NE Platte PWS systems sampled include Colon well 66-1, Shelby well 64-1, Osceola wells 72-1 and 85-1, and Stromsburg wells 1 and 3. No distinct trends in arsenic behavior were observed. The Republican River Valley PWS systems sampled include Benkelman wells 96-1 and 96-2, Cambridge wells 53-1 and 83-1, and McCook wells 4 and 6 (Fig. 3b). Arsenic concentrations in the Republican River Valley wells were stable from January to May, decreased ~2 ppb from May to mid June, and then increased in July.

The Upper NE Panhandle PWS systems sampled include Broadwater wells 55-1 and 75-1, Lodgepole wells 64-1 and 75-1, and Oshkosh wells 1451 and 1741. From May to late June, arsenic concentrations decreased 1-2 ppb in the Upper NE Panhandle wells. Table 2a provides a summary of sampling dates and observations.

Short term variability

Short-term variability in arsenic concentrations was observed at various PWS systems between the time of pump initiation and stabilization of arsenic concentrations. Sampling was performed at the communities of Benkelman, Haigler, Stromsburg, and Wauneta prior to well column removal for geophysical logging and interval sampling. Table 3 provides a summary of sample collection dates and observations. Arsenic concentrations were stable in the Haigler and Wauneta wells pumping at low flow rates over 4 hours (Fig. 4). However, arsenic concentrations varied during the first 30 minutes of pumping of the Benkelman and Stromsburg wells at 400 and 490 gpm, respectively

(Figs. 4 and 5). At both of these wells, dissolved arsenic concentrations decreased within the first 30 minutes of pumping, and then stabilized after 30 minutes.

Vertical Profiling and Interval Selection

Low-flow profiling of PWS wells was limited to Benkelman, Haigler, Stromsburg, and Wauneta following removal of the pumping column from the well casings to measure arsenic variability along the vertical profile of the wells. Intervals selected for each well were based off of geologic logs (Appendix A). A dual well packer system was used when available to isolate screened intervals. Table 4 provides a summary of sample dates and observations. The arsenic concentrations in the Haigler, Stromsburg, and Wauneta wells fluctuated over 30 minutes of pumping and there was no clear relation to geologic intervals sampled. Figure 5 illustrates arsenic behavior at variable depths in the Stromsburg 3 well. Benkelman arsenic concentrations exhibited little to no fluctuation over 30 minutes of pumping at all depths, with no relation to geologic intervals sampled.

Post Well Modification Sampling

Following interval sampling, the PWS wells of Haigler, Stromsburg, and Wauneta were modified based on respective data collected. Sampling at these locations resumed following well column reinstallation to monitor dissolved arsenic behavior. Table 5 provides a summary of sample dates and observations. Haigler 65-1 was pumped at variable pumping rates following isolation of the pump below 92 ft, and arsenic concentrations fluctuated between 18.7 and 20 ppb. Stromsburg 3 was sampled at a constant pumping rate 120 gpm following relocation of the well pump to 121 ft. There was no change in arsenic concentration over time. Following relocation of the pump to

171 ft at the Wauneta 3 well, arsenic concentrations decreased to 9 ppb during frequent pumping at 160 gpm, but increased during periods of well downtime (Fig. 6).

Discussion

Factors influencing Arsenic Mobility

Arsenic solubility within and surrounding PWS wells can be attributed to concentration, reduction, and mobilization of Fe-oxide bound arsenic. Results from filtering experiments indicate arsenic concentrations sampled are dissolved instead of colloidal. Mobile arsenic (Fig. 2) is drawn into the well casing during pumping, and may become adsorbed to biofilm encrusted materials within and around the well. Biofilms create surfaces conducive to the concentration of these metals (Houben, 2003). Biofilm encrustations observed on the casing and well screens at the Haigler, Stromsburg, and Wauneta wells, which contain Fe-oxide, hydroxide and Mn-oxide materials, provide a very good environment for the sequestration and concentration of arsenic species. The saturation of water samples with multiple Fe-hydroxide complexes and the affinity of arsenic for organic materials suggest that arsenic is sequestered within biofilms in sampled wells (Appendix D). Although the geochemical data does not indicate a direct relationship between dissolved iron concentrations and arsenic species, this does not discount the association of arsenic with iron phases trapped in organic biofilms. Houben (2003) states commonly elevated amounts of As and heavy metals found in encrustations often exceed legal limits for soils and solid industrial wastes. Sequestration of these metals allows PWS, private, and other industrial wells to function as potential in-situ sources for concentration of dissolved arsenic and, for that matter, other metals.

Arsenic trapped by biofilms may be remobilized during extended periods with little to no dissolved oxygen. These biofilms were observed attached to well casing and screens in sampled wells. These organic materials are present within aquifer sediments, but are concentrated in wells due to steep redox gradients created by pumping (Applin and Zhao, 1989). K_d values indicated the highest concentrations of arsenic were associated with organic materials in sampled wells. Dissolved arsenic may become sorbed to iron hydroxides trapped within these organic materials. During pumping, the addition of oxygen into the well environment and the surrounding aquifer can result in formation of iron oxides, hydroxides, and other metal oxides and hydroxides though a variety of biogeochemical reactions (Houben, 2003). Following pumping, the well environment returns to more reducing conditions. Bose and Sharma (2002), Guo et al. (1997), and others suggest arsenic can be mobilized as a result of desorption from arsenic-contaminated iron oxyhydroxides due to the onset of reducing conditions in the subsurface. Decreased levels of dissolved oxygen during pumping did not affect concentrations of dissolved arsenic, suggesting sampled metals were still in the oxidized state. During periods of well inactivity, reduction of these oxides can be microbially mediated by various iron and metal reducing bacteria. Tadanier et al. (2005) examined the potential impact of microbially-mediated reduction of Fe in ferrihydrite on the mobility of arsenic in the local water supply. Iron reducing bacteria including *Geobacter metallireducens* reduced Fe^{3+} in the ferrihydrite complexes without reducing As^{5+} to As^{3+}. This suggests that microbes could mediate arsenic desorption and mobilization through alteration of the ferrihydrite surface charge (Tadanier et al., 2005). Microbial reduction of ferrihydrite and other iron oxides concentrated within a supply well may

increase arsenic desorption and dissolution during reduced conditions. The onset of pumping draws in high volumes of desorbed arsenic relative to background concentrations within the aquifer, which was observed during early pumping times at multiple wells. Additional work needs to be conducted to define the areal extent to which the accumulation of arsenic occurs around a given pumping well.

Occurrence and Behavior of Arsenic Under Varying Pumping Conditions

Data from yearly sampling of regional PWS locales throughout Nebraska indicate little to no temporal variability in arsenic concentrations from regional sampling. This data concurs with Gosselin et al.'s (2006) observations of long-term stability of dissolved arsenic concentrations. Fluctuations in mobile arsenic concentrations at sampled PWS wells were only ~1-3 ppb, which suggest that there are little to no seasonal geochemical changes that affect arsenic in the study areas (Figs. 3a and 3b). Although we do not have the data to assess it with any detail, it is possible that surface irrigation practices during spring and summer could contribute recharge and younger waters to regional aquifers. Harvey and Sibray (2001) indicate the Interstate Canal near the Scottsbluff, NE region is filled for irrigation early spring and refilled mid to late summer, and indicated canal leakage during these periods recharged the local aquifer. Recharge events such as this could induce small fluctuations in arsenic concentrations due to influxes of metals; however further observation of long-term variability in necessary to determine seasonal effects.

Differences in dissolved arsenic behavior with short term variability were observed in various PWS wells following the onset of pumping. Arsenic concentrations remained relatively stable at the Haigler 65-1 and Wauneta 3 wells during the initial 30

minutes of pumping, and through the remaining 4 hour pumping time (Fig. 4). The lack of fluctuation in the wells may be attributed to the low-flow sampling protocols used, where pumping rates did not sufficiently purge the wellbore of residual water and draw in water representative of background aquifer chemistry. Gotkowitz et al. (2004) indicated that increasing borehole residence times and reduction of arsenic-bearing iron hydroxides leads to the greater potential for higher arsenic concentrations.

Differences in short term arsenic behavior were observed in the Benkelman and Stromsburg wells. Dissolved arsenic concentrations decreased from ~21 to 12 ppb at Benkelman 72-1 during the first 30 minutes and concentrations remained stable thereafter (Fig. 4). Initial pumping of the Benkelman well potentially drew in arsenic desorbed from biofilms concentrated within the well. As pumping continued, arsenic concentrations reflective of aquifer background levels were observed. However, at Stromsburg well 3, a 2 ppb increase in arsenic concentration was observed in the initial 30 minutes of pumping, however concentrations remained relatively stable throughout the 4 hour pumping time. The Stromsburg well was shut off two days prior to pumping. This minor increase is more likely due to sampling practices than residual arsenic in the wellbore. However, data is not available for the Benkelman well prior to sampling, and it may have been pumped more recently. Short term pumping tests indicate variability of arsenic concentrations can occur during early pumping times. Arsenic concentrations then stabilized as pumping time approached 30 minutes. Sampling following this stabilization may provide a better indication of the level of public exposure to arsenic concentrations in water supply wells.

Low-flow interval sampling of the Benkelman, Haigler, Stromsburg, and Wauneta PWS systems led to inconclusive results as far as arsenic availability within targeted geologic intervals. Measured chloride concentrations did not indicate differences in groundwater source from sampled depth intervals in wells. Benkelman results indicate lower arsenic concentrations at each interval than concentrations measured during 4 hour sampling, however these concentrations were stable over 30 minutes of pumping. Arsenic concentrations in the Haigler, Stromsburg, and Wauneta wells fluctuated 2-3 ppb on average over the 30 minute pumping intervals, but remained relatively stable. The use of the packer system and low-flow sampling conditions at these locations contributed to the differences in arsenic versus sampling at higher pumping rates. The ~3 gpm pumping rate most likely did not draw sufficient water representative of aquifer chemistry. Interval sampling of wells did not indicate any relationship of arsenic concentrations to sampling depth, which suggests dissolved arsenic concentrations do not vary along the vertical profile at these wells. However, further investigation is recommended due to the limitations of low-flow sampling methods.

Little to no variability in arsenic concentrations was observed at the Haigler and Stromsburg PWS wells following well re-installation, pump intake relocation, and permanent packer placement at respective wells. The Haigler 65-1 well displayed stability between 18.7 and 20 ppb during 30 minute pump tests from November 2006 to April 2007 following packer installation and pump relocation. However, concentrations never dropping close to the 10 ppb MCL. The irregular pumping events at Haigler do not allow any conclusions to be drawn from these tests. The Stromsburg 3 well also had relatively stable arsenic concentrations during weekly pumping events, though never

dropping close to the 10 ppb MCL. Data from Haigler and Stromsburg do not indicate that changes in pumping strategy can be used to modify arsenic concentrations.

The pump intake relocation and permanent packer placement coupled with weekly pumping at the Wauneta 3 well generated stable arsenic concentrations followed by a 1-2 ppb decrease in arsenic concentrations to below 10 ppb. The weekly pumping rate kept water relatively oxidized, preventing reductive dissolution of Fe-oxides and mobilization of arsenic. When the well was inactive for two weeks, the arsenic concentration increased. These observations suggest that scheduled, weekly pumping may keep this particular well environment oxidized, reducing the extent of arsenic desorption from biofilms and iron hydroxides in this well. This could be used to manage arsenic concentrations.

Conclusions

Arsenic mobility within and surrounding sampled public water supply wells is affected by chemistry, sorption reactions, and microbiological growth. Interval sampling of selected wells did not isolate aquifer units with low-As bearing water, suggesting interconnected alluvial units and common water chemistry throughout the vertical profiles of sampled wells. Filtering experiments demonstrated arsenic concentrations sampled were of the dissolved form, and colloidal transport may not be a major factor in controlling arsenic mobility within these particular PWS wells. Observations from multiple wells indicate the presence of organic biofilms, which facilitate formation of various iron oxides within well casings as dissolved metals including arsenic are pumped to the wells. Distribution coefficients indicate the highest concentrations of arsenic were

associated with organic materials. Iron oxyhydroxide phases such as ferrihydrite and goethite may undergo reductive dissolution while trapped in these biofilms, mobilizing adsorbed arsenic (Guo et al., 1997). Although dissolved oxygen levels were not directly related to changes in dissolved arsenic concentrations, residual concentrations coupled with microbial influences in the aquifer control the extent of reductive dissolution of these adsorbed metals following well shutdown.

The behavior of dissolved arsenic varied during various pumping experiments in this study. Long-term/seasonal stability of arsenic concentrations was observed in various regions around Nebraska. This evidence supports observations of long-term temporal stability of arsenic by Gosselin et al. (2006). Modifications to the Haigler and Stromsburg PWS wells did not effectively lower dissolved arsenic concentrations below the 10 ppb MCL at all wells. However, limited success with the Wauneta well supports the need for further experimentation with pumping schedules.

Short-term pumping tests demonstrated arsenic variability within the first 30 minutes of pumping at different well locations, followed by stabilization of arsenic concentrations. Pumping of PWS and other industrial wells has been found to vary with each specific well system, as each well environment is subject to differences in aquifer geochemistry and operational practices. Gosselin et al. (2006) suggest the best sampling scheme for a given system would be to design it around the typical operational history of the wells within a system if the objective is to provide an assessment for public exposure. Further observation of short-term pumping effects on arsenic behavior is suggested to develop sampling strategies for individual wells which meet the water quality and quantity needs of individual communities.

Tables

Table 1 - Stratigraphy and hydrogeologic properties of alluvial units within the High Plains Aquifer System. From the Nebraska Conservation and Survey Division, 1986.

			Age	Unit	Lithology	Hydrogeologic Properties
CENOZOIC	QUAT.	Holocene	10 ka	Multiple stratigraphic units	clay, silt, loess, glacial till, sand and gravel	Principal groundwater reservoir, is generally equivalent to High Plains Aquifer; Ogallala Group is absent in eastern and northwestern Nebraska. Arikaree Group is present primarily in west.
		Pleistocene	1.8 Ma			
	TERTIARY	Pliocene	5 Ma			
		Miocene	24 Ma	Ogallala Group	sand, sandstone, siltstone and some gravel	
		Oligocene		Arikaree Group	sandstone and siltstone	
			34 Ma	White River Gp. / Brule Fm.	siltstone, sandstone and clay in lower part	Secondary aquifer in western Nebraska; water may be highly mineralized.
		Upr. Eocene	65 Ma		*UNCONFORMITY*	
MESOZOIC	CRETACEOUS	UPPER CRET.		Lance and Fox Hills formations	sandstone and siltstone	Generally not an aquifer; yields water to a few wells in western Nebraska.
				Pierre Shale Formation	shale, some sandstone in west	Generally a confining unit; sandstones in west yield highly mineralized water to a few industrialized wells.
				Niobrara Fm.	shaly chalk and limestone	Secondary aquifer where fractured and at shallow depths, primarily in east.
				Carlile Shale Formation	shale; in some areas, contains sandstones in upper part	Generally not an aquifer; sandstones yield water to a few wells in northeast.
				Greenhorn & Graneros form's	limestone and shale	Generally not an aquifer; yields water to a few wells in east.
		LOWER CRET.	98 Ma	Dakota Fm.	sandstone and shale	Secondary aquifer; primarily in east; water may be highly mineralized.

Table 2 – Arsenic seasonal sampling performed in various groundwater regions around Nebraska by Gosselin et al. (2006). Sampling periods are listed in addition to arsenic behavior. Complete arsenic and other chemical concentration data can be found in Appendix B.

Nebraska Region	Sampling Dates	Arsenic Concentration Variations
Central NE Platte River Valley	January to May 2003	Increase and stabilize
	May to mid-June 2003	Decrease
Eastern NE Platte River Valley		No distinct trends
Republican River Valley	January to May 2003	Stable
	May to mid-June 2003	Decrease
	July 2003	Increase
Upper NE Panhandle	January to February 2003	No distinct trends
	May to late June 2003	Broadwater, Oshkosh, Lodgepole decrease

Table 3 – Short-term observations of arsenic behavior in selected public water supply systems. Complete arsenic and other chemical concentration data can be found in Appendix B.

PWS well	Sampling Dates	Arsenic Concentration Variations
Benkelman 72-1	July 12 2005	Decreased in first 30 min 21-12 μg/L; stable over next 3.5 hrs
Haigler 65-1	August 7 2006	Stable at ~18 μg/L for 4 hrs
Stromsburg 3	July 10 2006	Increased in first 30 min 19-21 μg/L; stable at ~21 ppb over next 3.5 hrs
Wauneta 3	Aug 6 2006	Stable at ~10 μg/L for 4 hrs

*Wells were sampled at 0, 0.5, 1, 2, 3, and 4 hours after the pump was started.

Table 4 – Interval sampling results from selected public water supply systems. Interval depths shown are top and bottom of selected sampling depths. Benkelman was sampled without well packers and interval depth is the depth of the submersible pump. Complete arsenic and other chemical concentration data can be found in Appendix B.

PWS well	Sampling Dates	Interval Depths	Arsenic Concentration Variations
Benkelman 72-1	July 14 2005	35.8 ft	Fluctuated 7-8 μg/L
	(no packers)	30.6 ft	Fluctuated 7-8 μg/L
		25.75 ft	Fluctuated 7-8 μg/L
		22 ft	Fluctuated 7-8 μg/L
Haigler 65-1	Aug 10 2006	90-98 ft	Decreased 15-15 μg/L
	(top packer N/A)	85-90 ft	Decreased 23-13 μg/L
		80-85 ft	Increased 5-15 μg/L
		74-79 ft	Decreased 16-14.5 μg/L
Stromsburg 3	July 12 2006 (both packers)	130-135 ft	Decreased 43.5-17 μg/L
	July 19 2006 (both packers N/A)	176-181 ft	Increased 22-27 μg/L then decreased to 21 μg/L
	Sept 7 2006	173-182 ft	Decreased 55-25 μg/L
	(both packers)	160-165 ft	Decreased 30-25 μg/L
		134-139 ft	Decreased 25-24 μg/L
Wauneta 3	Aug 9 2006	173-178 ft	Decreased 12-11 μg/L
	(both packers)	148-153 ft	Increased 13-16 μg/L
		142-147 ft	Decreased 12-11 μg/L
		113-118 ft	Decreased 11-10 μg/L

*Wells were sampled at 0, 15, and 30 minutes after the pump was started.

Table 5 – Post well-modification sampling at Haigler, Stromsburg, and Wauneta water supply systems. Complete arsenic and other chemical concentration data can be found in Appendix B.

PWS well	Sampling Dates	Modifications	Pumping Rate	Arsenic Conc. Variations
Haigler 65-1	Nov 2006 - March 2007	Pump isolated by packer below 92 ft	47-150 gpm	No distinct trends
Stromsburg 3	Dec 2006 - May 2007	Pump raised 161 to 121 ft	120 gpm	No distinct trends
Wauneta 3	Nov 2006 - Jan 2007 Sampled weekly	Pump isolated below 171 ft	160 gpm	Stable; 11 μg/L
	Jan 2007 - March 2007 Sampled weekly	Pump isolated below 171 ft	160 gpm	Decrease to 9 μg/L
	March 11 - 19 2007 well inactive	Pump isolated below 171 ft	160 gpm	Increase to 12 μg/L
	March 19 - June 2007 pumping resumed; weekly sampling	Pump isolated below 171 ft	160 gpm	Decrease to 10 μg/L

*Wells were sampled at 0 and 30 minutes after the pump was started.

Table 6a – Mean chemical concentrations from sampled PWS and monitoring wells calculated from results in Appendix B. State Health Lab samples are indicated by SHL and Midwest Lab Samples are indicated by MWL. Concentrations are listed in parts per million (mg/L) and parts per billion (μg/L).

Town	Well ID	As μg/L SHL	As μg/L MWL	As 3+ μg/L	As 5+ μg/L	pH	EC μS per cm	DO mg/L	Temp C
Anselmo	**64-1**	12	15		14	7.45	242.23	3.5	12.5
Anselmo	**87-1**	19	24		22	7.49	210.18	1.7	12.7
Benkelman	**72-1**	10	13	1		7.35	1043.60	3.6	14.0
Benkelman	**96-1**	11	13		11	7.53	806.54	1.9	13.1
Benkelman	**96-2**	10	11	4	5	7.38	1339.08	1.6	13.2
Broadwater	**55-1**	11	18		16	7.34	919.59	4.4	15.8
Broadwater	**75-1**	12	15		13	7.28	922.67	2.0	14.6
Cairo	**95-1**	12			11	7.15	679.07	2.9	16.8
Cairo	**95-2**	10				7.25	220.50	1.8	11.5
Cambridge	**53-1**	13	13	2	12	7.44	650.13	1.1	13.4
Cambridge	**83-1**	9	11		10	7.21	824.69	0.8	13.8
Cedar Bluffs	**57-1**	10	11		10	7.15	772.45	4.0	13.9
Colon	**66-1**	10		3	7	7.05	545.00	3.5	10.5
Culbertson	**78-1**	7		1	8	6.97	621.70	5.5	11.6
Elgin	**77-1**	12			13	6.88	414.50	3.1	11.1
Elwood	**71**	6	7		6	7.47	573.08	7.2	13.6
Elwood	**88-1**	6	8		7	7.35	573.23	4.1	14.8
Haigler	**65-1**	18	29	4	16	7.55	463.25	5.1	13.8
Humphrey	**2001-1**	8	7		10	7.14	616.91	6.3	13.2
Lodgepole	**64-1**	7	9		8	7.34	517.69	6.2	12.4
Lodgepole	**75-1**	10	13		11	7.46	447.69	7.7	12.8
Lyman	**47-1**	16	13		28	7.39	793.11	4.6	13.4
McCook	**4**	11	13		11	7.24	1043.50	3.0	13.2
McCook	**6**	11	14		13	7.18	922.85	2.7	13.2
Morrill	**53-1**	13	13		29	7.21	931.83	3.6	14.5
Osceola	**72-1**	8				7.33	680.43	5.7	12.6
Osceola	**85-1**	11			11	6.88	585.00	1.7	11.8
Oshkosh	**145-1**	13	16		14	7.16	718.31	2.0	14.2
Oshkosh	**174-1**	9	12		10	7.36	505.79	2.9	12.5
Palisade	**36-1**	10			9	7.15	563.88	5.6	14.2
Shelby	**64-1**	13			18	6.73	513.67	2.9	11.6
Shelton	**49**	4	5		4	7.08	1114.08	1.3	13.3
Shelton	**97**	10	12	3	8	7.30	433.54	0.5	13.0
Stratton	**75-2**	13	8		15	7.27	869.73	4.5	12.8
Stromsburg	**3**	31	193	3	20	7.23	666.74	1.9	13.7
Wauneta	**3**	11	13	7	10	7.72	372.11	6.0	13.3
Wauneta	**4**	10			11	7.29	323.00	6.5	14.1

Table 6b– Mean chemical concentrations from sampled PWS and monitoring wells calculated from results in Appendix B. State Health Lab samples are indicated by SHL and Midwest Lab Samples are indicated by MWL. Concentrations are listed in parts per million (mg/L) and parts per billion (µg/L).

Town	Well ID	HCO3 mg/L	Ca mg/L	Na mg/L	Mg mg/L	K mg/L	Mn mg/L	NO3 mg/L	Cl mg/L
Anselmo	**64-1**	188.9	52.4	12.8	6.3	13.6	0.2	3.1	2.3
Anselmo	**87-1**	165.6	44.1	13.0	5.6	13.7	0.1		1.5
Benkelman	**72-1**	304.6	108.8	100.0	37.8	29.3	0.6	0.8	103.6
Benkelman	**96-1**	357.7	102.7	152.5	32.3	18.6		4.6	52.3
Benkelman	**96-2**	325.4	203.5	239.0	60.7	23.5	0.0		100.3
Broadwater	**55-1**	316.6	121.4	117.0	25.2	22.1			25.0
Broadwater	**75-1**	334.6	114.0	110.0	25.0	18.6		16.2	27.2
Cairo	**95-1**	253.8	32.3	5.0	4.2	7.5		0.9	3.0
Cairo	**95-2**	114.0	33.2	5.2	4.4	7.4		1.3	2.0
Cambridge	**53-1**	324.3	78.8	73.5	24.3	20.4	0.3	1.6	35.1
Cambridge	**83-1**	459.2	109.5	104.3	33.5	29.3	0.4		42.1
Cedar Bluffs	**57-1**	394.8	112.5	22.1	22.4	13.5	0.1	4.5	7.5
Colon	**66-1**	311.5	106.0	32.0	22.9	13.1	0.2	12.1	4.0
Culbertson	**78-1**	344.4	105.8	30.8	24.7	14.1	0.2	9.3	7.5
Elgin	**77-1**	268.3	77.5	8.9	13.2	11.5		4.0	3.5
Elwood	**71**	267.0	98.9	44.8	20.3	16.9		14.7	17.1
Elwood	**88-1**	225.8	88.5	58.9	18.5	15.7			16.2
Haigler	**65-1**	248.1	58.5	16.9	12.2	14.2	0.0	2.4	3.8
Humphrey	**2001-1**	287.1	112.0	27.4	20.9	8.2		4.1	5.0
Lodgepole	**64-1**	253.9	69.1	39.4	15.0	13.7		23.7	25.2
Lodgepole	**75-1**	225.1	65.6	46.5	11.0	12.3			10.0
Lyman	**47-1**	351.4	75.7	259.0	22.3	12.3	0.1	4.1	33.0
McCook	**4**	466.3	116.8	129.8	37.4	41.1	0.0	11.9	40.0
McCook	**6**	427.5	147.5	120.5	30.7	28.5		85.3	42.3
Morrill	**53-1**	419.6	97.3	119.0	30.3	20.2	0.1	3.6	20.5
Osceola	**72-1**	380.0							
Osceola	**85-1**	353.3	109.0	20.3	16.7	7.4	0.2	5.3	9.0
Oshkosh	**145-1**	321.4	107.0	65.0	20.7	26.2		25.0	9.5
Oshkosh	**174-1**	242.3	75.4	28.3	11.1	16.1			5.7
Palisade	**36-1**	297.3	59.7	28.0	17.3	12.8		5.3	6.0
Shelby	**64-1**	290.7	87.8	18.9	13.5	8.4	0.1	2.8	6.5
Shelton	**49**	385.8	178.0	127.5	36.8	36.7	0.0	14.3	55.7
Shelton	**97**	313.8	71.7	36.1	14.8	9.9	0.7		5.3
Stratton	**75-2**	373.9	113.8	92.5	33.9	20.3	0.1	1.9	32.1
Stromsburg	**3**	353.2	105.2	25.4	16.1	8.7	0.1	3.2	9.7
Wauneta	**3**	215.1	44.2	16.9	13.0	11.4	0.0	2.0	1.5
Wauneta	**4**	205.7	43.0	18.0	12.7	10.3		1.8	2.0

Table 6c – Mean chemical concentrations from sampled PWS and monitoring wells calculated from results in Appendix B. State Health Lab samples are indicated by SHL and Midwest Lab Samples are indicated by MWL. Concentrations are listed in parts per million (mg/L) and parts per billion (μg/L).

Town	Well ID	SO4 mg/L	Fe Total mg/L	Fe 2+ mg/L	Fe 3+ mg/L	P mg/L	TOC mg/L	Eh mv
Anselmo	**64-1**	9.0	0.03		0.03			243.03
Anselmo	**87-1**		0.04		0.04	0.2		229.16
Benkelman	**72-1**	207.0	0.02		0.02	0.1	6.2	954.92
Benkelman	**96-1**	233.0	0.04	0.01	0.03			186.74
Benkelman	**96-2**		0.03		0.03	0.1		177.51
Broadwater	**55-1**		0.03		0.03			404.82
Broadwater	**75-1**	247.0	0.02		0.02			189.90
Cairo	**95-1**	14.0	0.01		0.01	0.6		-163.28
Cairo	**95-2**	14.0	0.02			0.5		-190.30
Cambridge	**53-1**	118.5	0.19	0.14	0.05	0.1	3.5	86.31
Cambridge	**83-1**		0.05	0.01	0.04	0.1		187.44
Cedar Bluffs	**57-1**	99.5	0.03	0.01	0.02	0.3		289.27
Colon	**66-1**	104.0	0.48	0.44	0.04	0.3		319.40
Culbertson	**78-1**	88.8	0.18	0.18	0.02	0.3		241.05
Elgin	**77-1**	7.0	0.02		0.01	0.3		566.03
Elwood	**71**	142.9	0.02		0.02			194.93
Elwood	**88-1**		0.04		0.04			187.65
Haigler	**65-1**	13.7	0.03	0.02	0.02	0.1		
Humphrey	**2001-1**	69.0	0.02		0.02	0.4		314.07
Lodgepole	**64-1**	36.0	0.03		0.03			168.48
Lodgepole	**75-1**		0.01		0.01			143.88
Lyman	**47-1**	281.0	0.07		0.07	0.2		326.30
McCook	**4**	227.5	0.01	0.01	0.01		3.4	214.40
McCook	**6**	211.5	0.02	0.01	0.01	0.1		206.50
Morrill	**53-1**	275.0	0.02	0.01	0.01	0.2		278.55
Osceola	**72-1**		0.04		0.04			-208.30
Osceola	**85-1**	56.0	0.11	0.07	0.04	0.2		213.40
Oshkosh	**145-1**	141.0	0.02		0.02			182.32
Oshkosh	**174-1**		0.02		0.02			190.62
Palisade	**36-1**	31.5	0.02		0.02	0.2		83.83
Shelby	**64-1**	31.5	0.02		0.02	0.3		-98.84
Shelton	**49**	417.0	0.03	0.01	0.02	0.1		214.23
Shelton	**97**		0.07	0.03	0.05			207.28
Stratton	**75-2**	209.4	0.13	0.06	0.07	0.2		18.72
Stromsburg	**3**	56.4	0.23	0.23	0.03	0.4	3.9	210.23
Wauneta	**3**	16.5	0.04	0.03	0.04	0.1		-115.52
Wauneta	**4**	16.0						-74.84

Table 7 – Calculated distribution coefficients (Kd) for arsenic concentrations for selected water supply systems. Solids were collected for sequential sediment extraction procedures described in Chapter 3. Sequential leaching experiments were performed by McVey and Gosselin, Unpublished.

PWS Well	**Method of Well Solid Collection**	**Kd values (mL/g)***		
		Kd = Cs/Ce (mL/g)		
		Exchangeable Metals	**Fe+Mn Oxides**	**Organics**
Stromsburg 3	Bailed from bottom of well	0.80	4.16	9.20
Stromsburg 3	Sonic Jetted off of well casing	0.00	1.64	5.80
Haigler 65-1	Sampled at 75' on well column	0.00	0.14	27.32
Haigler 65-1	Sampled at 90' on well tailpiece	0.14	0.23	19.68
Wauneta 3	Bailed from bottom of well	0.00	0.73	0.73
Wauneta 3	Sampled at 144' on well column	0.00	0.00	6.55

***Ce values were obtained from sediment leaching experiments of arsenic and uranium from well solids to calculate Kd values for As are associated with exchangeable metals, Fe+Mn oxides, and organic materials. Cs values were calculated from dissolved As concentrations measured after 30 minutes of pumping.**

Table 8 – Comparison of filtered vs. unfiltered arsenic concentrations. Filter sizes are listed in micrometers. Arsenic concentrations are listed in micrograms per liter (μg/L). Percent differences are calculated between unfiltered concentrations vs. filtered concentrations.

Town	Well	Filter size (μm)	Preservative	As Concentration (μg/L)	% Difference vs. non-filtered
Cambridge	**531**	not filtered		12.7	0
Cambridge	**531**	not filtered	HNO3	15.3	19
Cambridge	**531**	1	HNO3	15.6	20
Cambridge	**531**	1		13.8	8
Cambridge	**531**	0.45	HNO3	14.3	12
Cambridge	**531**	0.45		13.5	6
Cambridge	**531**	0.2	HNO3	13.6	7
Cambridge	**531**	0.2		12.6	1
Cambridge	**831**	not filtered		11.2	0
Cambridge	**831**	not filtered	HNO3	11.5	3
Cambridge	**831**	1	HNO3	11.5	3
Cambridge	**831**	1		11.1	1
Cambridge	**831**	0.45	HNO3	10.8	4
Cambridge	**831**	0.45		10.7	5
Cambridge	**831**	0.2	HNO3	10.3	8
Cambridge	**831**	0.2		10.6	6
McCook	**6**	not filtered		13.8	0
McCook	**6**	not filtered	HNO3	13.4	3
McCook	**6**	1	HNO3	13.4	3
McCook	**6**	1		13.3	4
McCook	**6**	0.45	HNO3	12.8	8
McCook	**6**	0.45		13.3	4
McCook	**6**	0.2	HNO3	12.6	9
McCook	**6**	0.2		13.4	3
Oshkosh	**1451**	not filtered		14.2	0
Oshkosh	**1451**	not filtered	HNO3	14	1
Oshkosh	**1451**	1	HNO3	14.3	1
Oshkosh	**1451**	1		13.9	2
Oshkosh	**1451**	0.45	HNO3	13.5	5
Oshkosh	**1451**	0.45		13.9	2
Oshkosh	**1451**	0.2	HNO3	13.6	4
Oshkosh	**1451**	0.2		13.6	4
Oshkosh	**1741**	not filtered		11	0
Oshkosh	**1741**	not filtered	HNO3	10.6	4
Oshkosh	**1741**	1	HNO3	10.5	5
Oshkosh	**1741**	1		10.5	5
Oshkosh	**1741**	0.45	HNO3	10	10
Oshkosh	**1741**	0.45		11	0
Oshkosh	**1741**	0.2	HNO3	10.2	8
Oshkosh	**1741**	0.2		10.5	5
Stromsburg	**1**	not filtered		26.2	0
Stromsburg	**1**	not filtered	HNO3	25.8	2
Stromsburg	**1**	1	HNO3	25.5	3
Stromsburg	**1**	1		25.9	1
Stromsburg	**1**	0.45	HNO3	25.1	4
Stromsburg	**1**	0.45		25.4	3
Stromsburg	**1**	0.2	HNO3	25.5	3
Stromsburg	**1**	0.2		24.6	6

Figures

Fig. 1 – Conceptual model of a public water supply system and various factors affecting dissolved arsenic behavior in water supplies. See text for additional details.

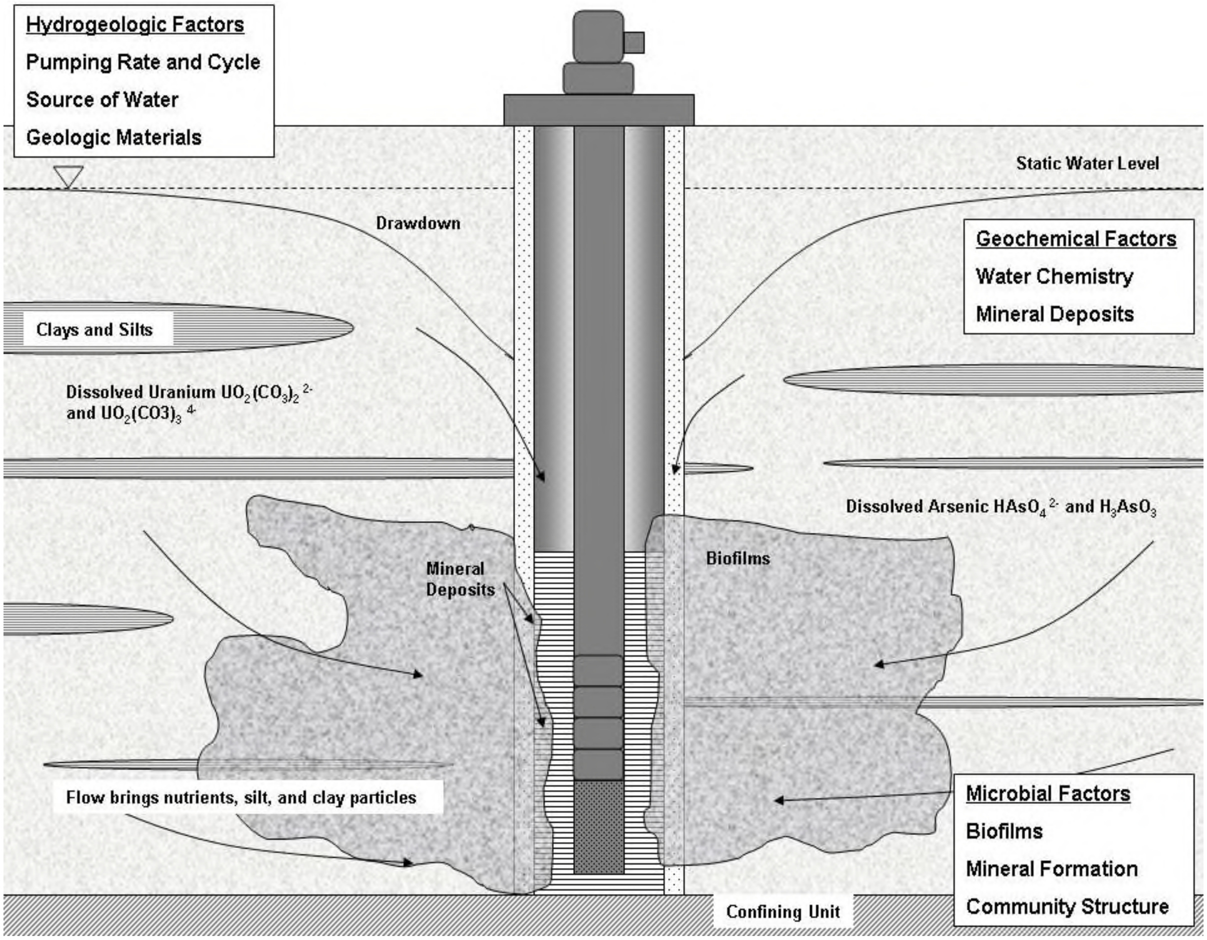


Fig. 2 – Map of Nebraska with study sites and locations of towns with current and historically high arsenic concentrations.

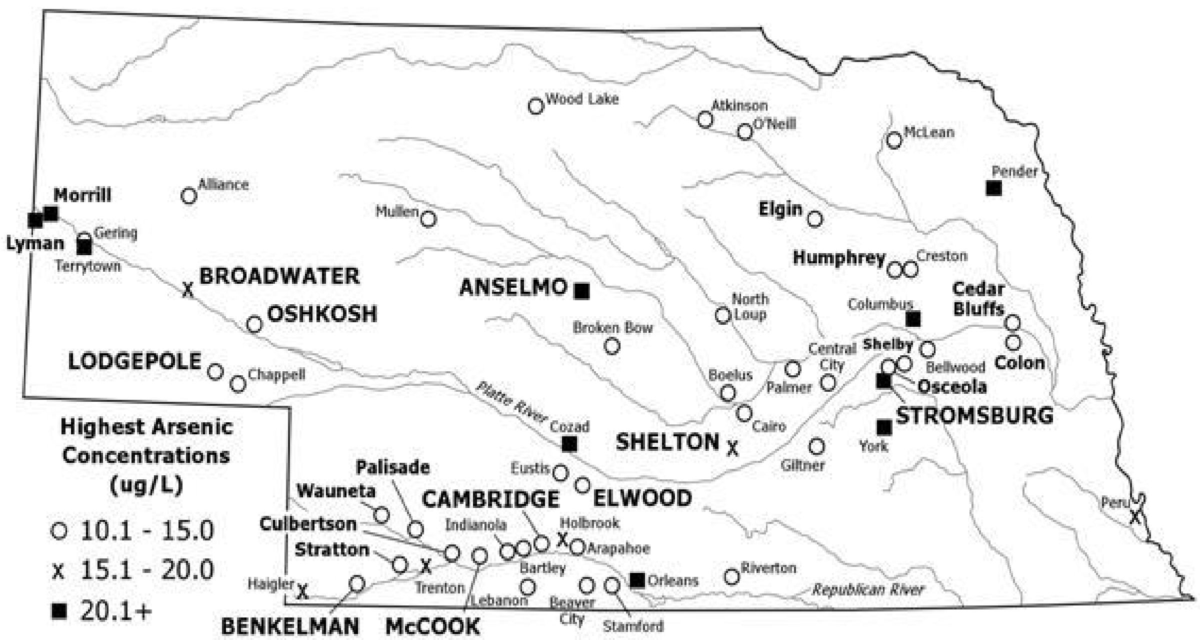


Fig. 3a – Central Nebraska Platte Valley Region arsenic seasonal variability, 2002-2003. Sample date, pumping rate, and pumping depth are listed for each sampling event.

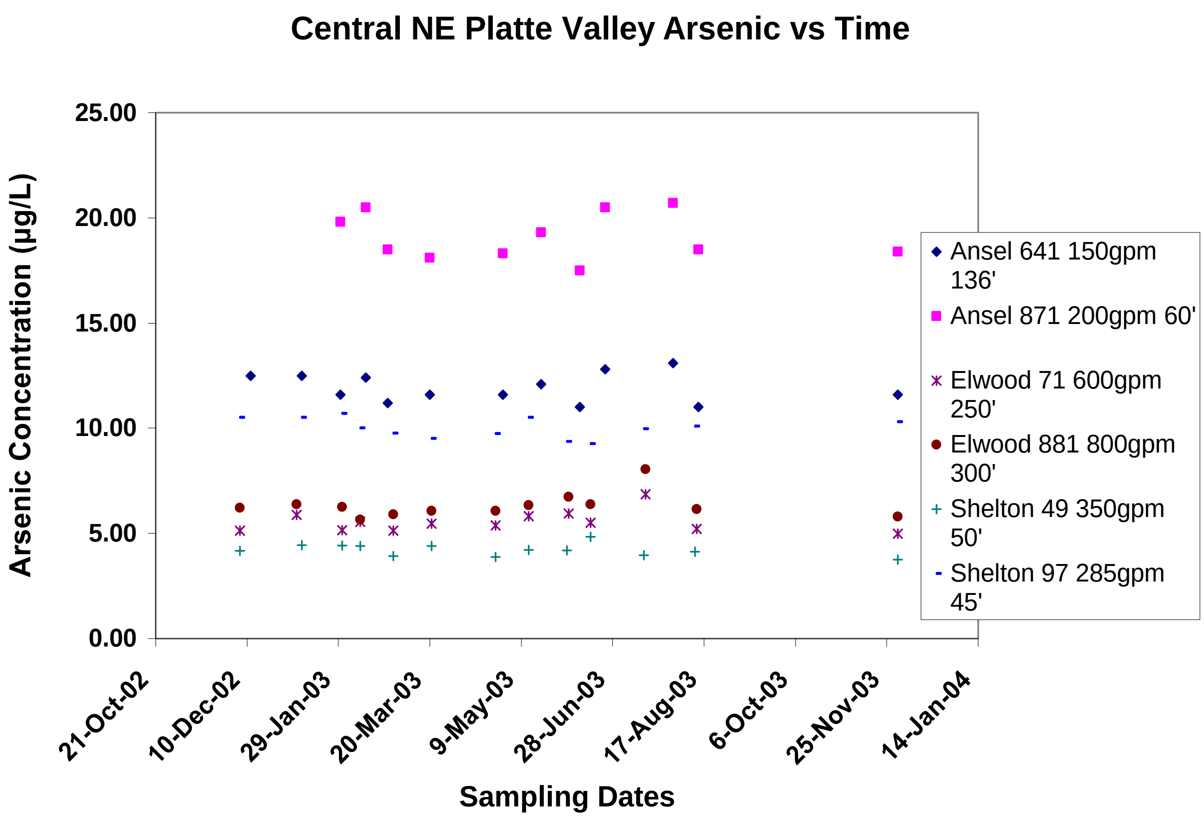


Fig. 3b – Republican River Valley Region arsenic seasonal variability, 2002-2004. Sample date, pumping rate, and pumping depth are listed for each sampling event.

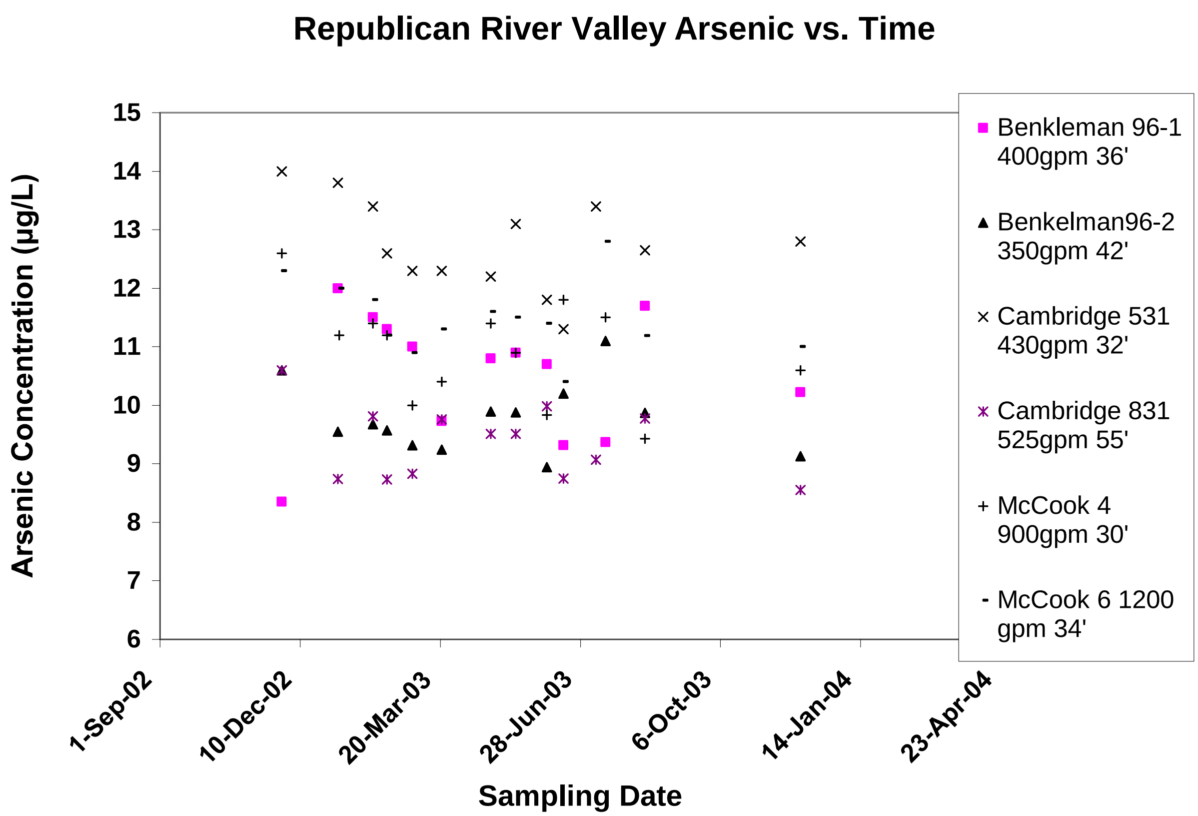


Fig. 4 – Short-term arsenic variability from selected public water supply systems. Sample date and pumping rate are listed for each sampling event. Complete pumping and water chemistry data can be found in Appendix B.

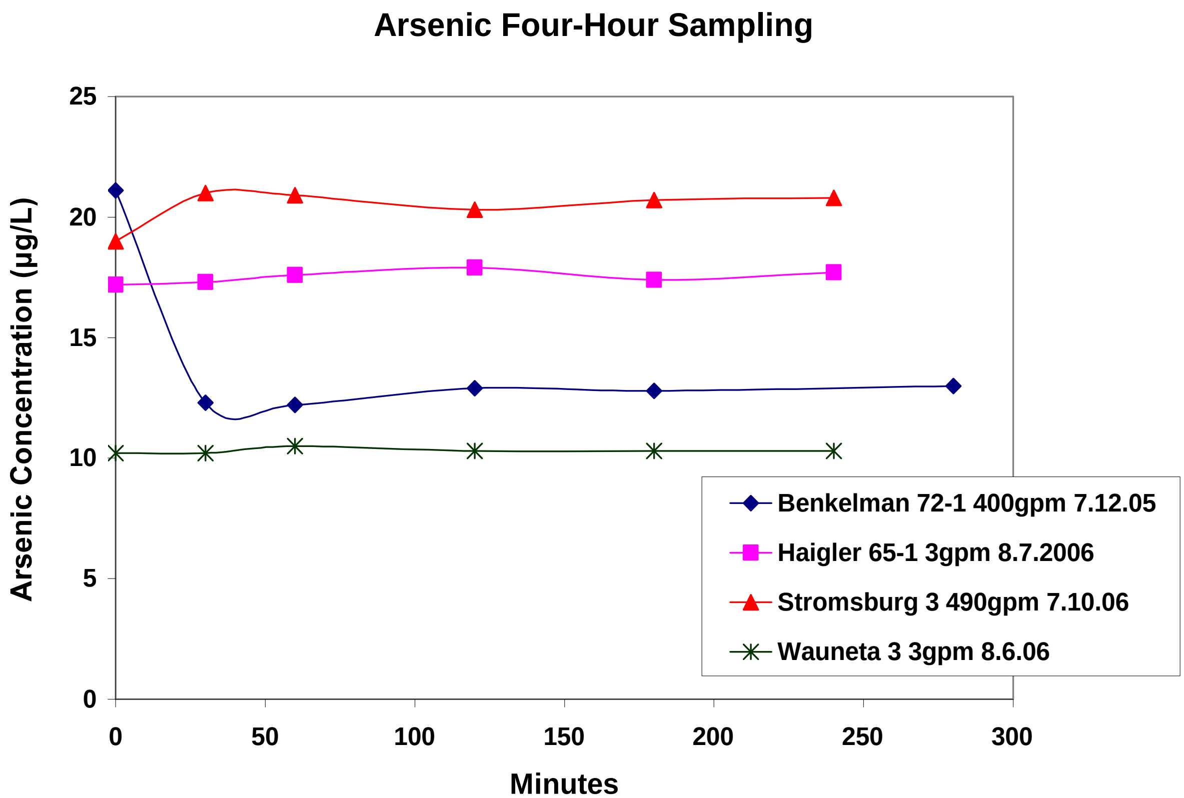


Fig. 5 –Interval sampling experiments at selected depths from the town of Stromsburg, NE. Sampling was performed over 30 minute pumping periods. Sampling depths are listed for each interval. Complete pumping and water chemistry data can be found in Appendix B.

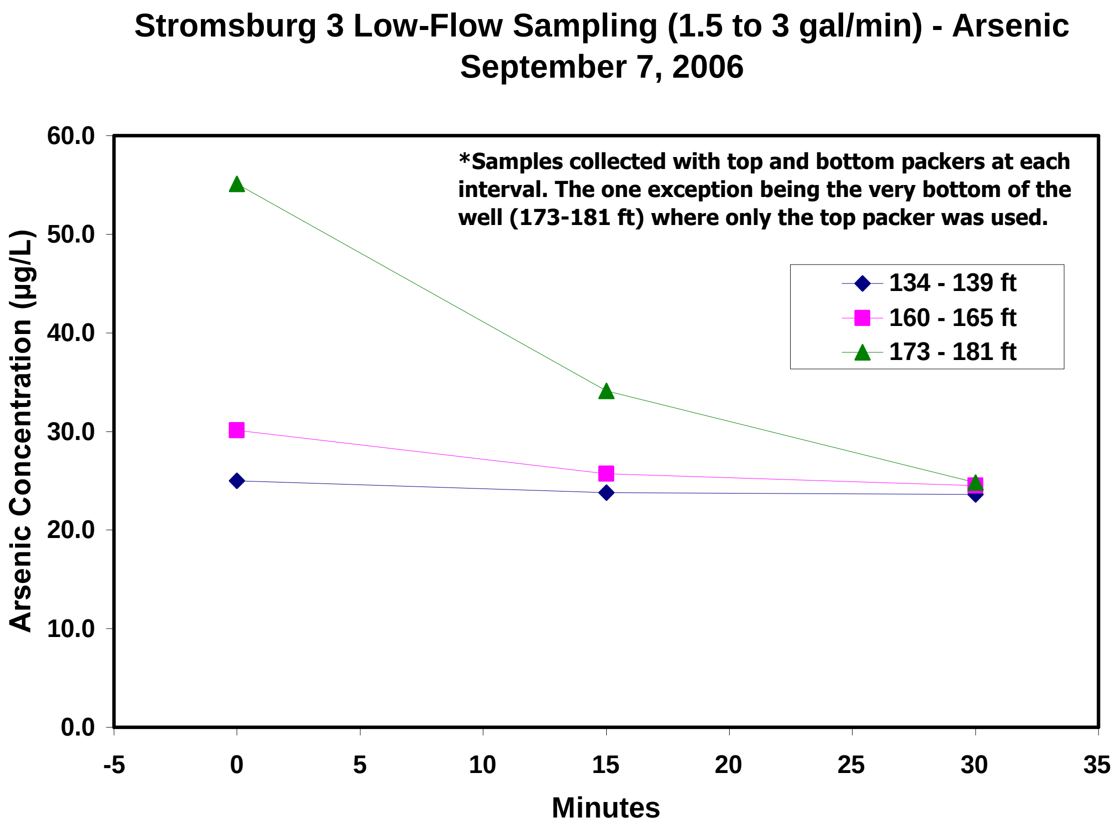
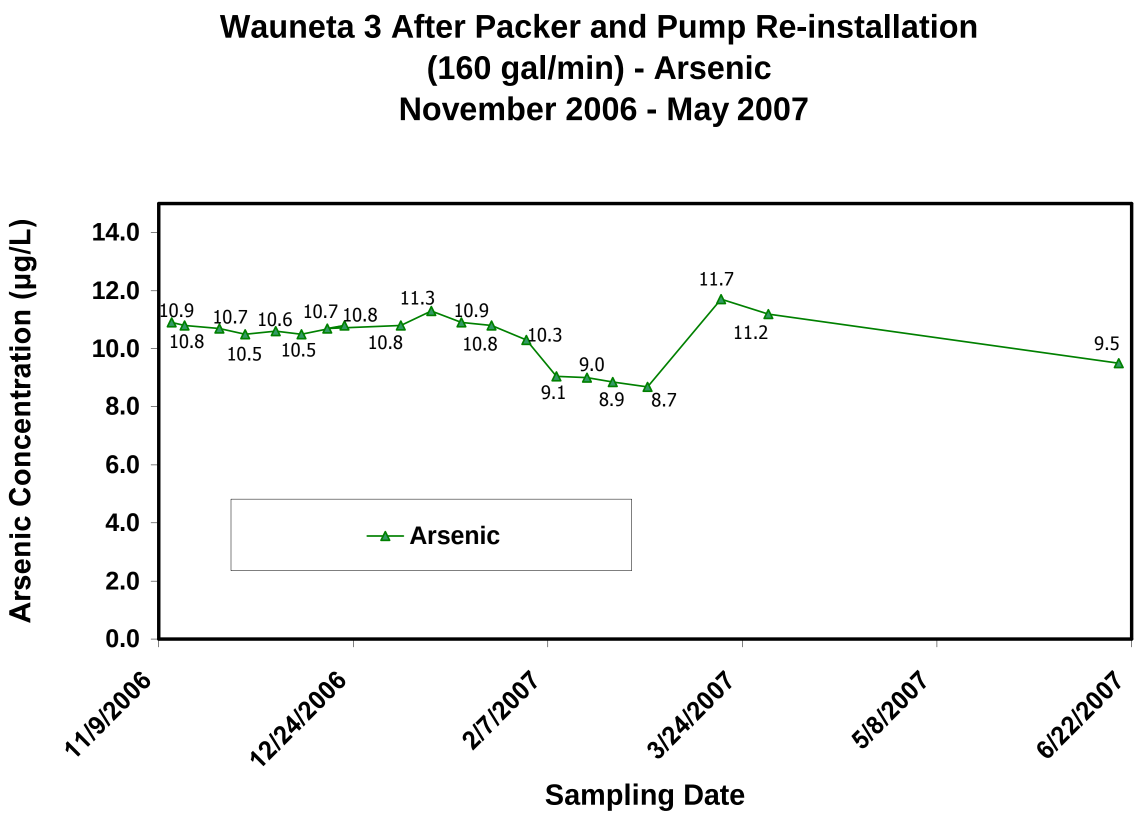


Fig. 6 –Long term arsenic variability following well modifications of the Wauneta public water supply. Samples were taken at 30 minutes following chemical stabilization of the well with surrounding aquifer water. Complete pumping and water chemistry data can be found in Appendix B.



III. Arsenic and Uranium in Well Encrustations: Examples from Nebraska Public Water Supplies

Introduction

Arsenic and uranium derived from water-rock interaction pose drinking water quality issues to communities in Nebraska and other regions of the Midwestern United States (Focazio et al., 2000, Snow and Spalding, 1994). Concentrations greater than the federally mandated maximum contaminant level (MCL) of 10 parts per billion (ppb) for arsenic and 30 ppb for uranium have been reported in multiple public water supply (PWS) well systems throughout Nebraska (NHHS, 2007).

The biogeochemical environment and the related formation of biofilms created by the installation and pumping of PWS wells may contribute to these elevated concentrations. Periods of oxidation during pumping coupled with increased residence times of reduced well water create conditions conducive to biofilm growth. The oxidative/reductive cycling during well operation (Applin and Zhao, 1989) allows for the accumulation of arsenic and uranium organometal complexes on biofilms that can become a source of these metals to PWS wells.

The buildup of iron-related encrustations in various well environments has been shown to be a direct consequence of well installation into an undisturbed aquifer system (Houben, 2003). The installation of a well allows oxygen to diffuse inside and around the well to support aerobic microorganisms. The operation of a well causes rapid and turbulent flow that delivers fresh nutrients to biofilms (Cullimore, 2000). Houben (2006) found the degree of inhomogeneous inflow coupled with elevated flow velocities created during heavy well pumping encouraged biofilm buildup on screened intervals. The increased amounts of inflow coupled with steep redox gradients encourage growth of diverse metal metabolizing microbial communities within these biofilms.

Iron precipitation on well screens and casing occur if chemical saturation conditions are reached. The conditions can be by the biological degradation of organic Fe-complexes (Tuhela et al., 1993). Walter (1997) suggested iron-related bacteria grow naturally in environments with steep Eh gradients, which can develop within the vicinity of a well when oxygenated water mixes with anoxic groundwater that contains ferrous iron. Bacteria implicated in well biofouling problems include *Gallionella ferruginea* and *Leptothrix sp.*, which promote extensive Fe-(III) precipitation on their sheaths and stalks (Tuhela et al., 1993).

The accumulation of iron oxides, hydroxides, and organics in these biofilm structures may serve to concentrate mobile arsenic and uranium present in the surrounding aquifer material. Sorption of trace metals to iron phases including goethite, hematite, and ferrihydrite occur in these organometal encrustations. In the absence of high levels of complexing ligands, uranium sorbs to Fe-oxide minerals such as hematite, goethite, and organic matter over a wide range of solution pH conditions (Duff et al., 2002). Jain et al. (1999) and Bowell (1994) observed arsenic sorption to hematite, goethite, and lepidocrocite mineral phases at near neutral pH conditions.

Variable geochemical conditions related to pumping practices may allow for the release of these trace metals into solution. The development of strongly reducing conditions at near neutral pH leads to desorption of arsenic from mineral oxides and reductive dissolution of iron (Smedley and Kinniburgh, 2002). These conditions can be produced in a well during extended periods of well inactivity. Oxidation of reduced waters during pumping may directly release iron-sorbed uranium in the U(VI) form into

solution. This process is suggested to occur under natural conditions favoring oxidation of ferrous to ferric iron (Duff et al., 1997).

The purpose of this report is to present results from a combination of field and laboratory investigations of mineral encrustations collected from selected PWS in Nebraska. More specifically, we (1) document occurrence, chemical and biological makeup of encrusted materials obtained from biofilms in PWS systems, and (2) assess the affinity of arsenic and uranium for these materials.

Methods

Sample Collection and Preparation

Encrustation material, suspended solids, and/or sediments from the bottom of the wells were collected from the following PWS wells: Bellwood 76-1, Clarks 2005-2 and DP-B4, Haigler 65-1, Stromsburg 3, Wauneta 3, and York 73-1. Samples were collected following well column removal and prior to well cleaning (Fig. 1). Down-hole videotaping performed prior to well cleaning by Nebraska Health and Human Services (NHHS) personnel indicated significant buildup of encrusted material on screens and casing in these wells. Well precipitate samples were collected prior to the well cleaning process by bailing and by scraping of the well casing and screens. Suspended solids were collected during pumping via inline filtration on 0.45 micron filters. Sediment and filter samples to be used for spectral analyses were prepared in a nitrogen atmosphere glove chamber. Sediment samples were pulverized and left to dry overnight. Filter samples were cut in half and left to dry overnight. All samples were preserved in glass vials under nitrogen until analysis.

Sequential Extraction of Well Sediments

Sequential leaching was performed on encrustation samples to gain an operational understanding of the extent to which arsenic and uranium are associated with various geochemical phases in the sediments and materials collected from wells. We used Paganelli et al.'s (2004) methodology, which is outlined here. Step one of the sequential leaching procedure determined the arsenic and uranium that were bound to the sediment as exchangeable metals. Exchangeable metal is an inclusive term for any metals that are weakly bound to the surface of a sediment sample. This step involved treatment with 45mL 1M ammonium acetate with acetic acid and centrifugation to separate solid and liquid (Paganelli et al., 2004). Step two determined the arsenic or uranium that were bound specifically to iron and manganese oxides. This step involved treatment with 22.5 mL of hydroxylammonium chloride and 22.5 mL 1M acetic acid followed by centrifugation to separate solid and liquid. Step three determined if arsenic or uranium were weakly bound to organic (humic) matter. This step involved treatment with 12.5 mL of 0.1M hydrochloric acid and centrifugation to separate solid and liquid. Samples from each step were sent to Midwest Laboratories for analyses of respective arsenic and uranium concentrations according to U.S. EPA method 200.8

EDS/WDS Spectral Analyses

Spectral analyses were performed using JEOL JXA 733 electron microprobe at the Department of Earth and Planetary Sciences/Institute of Meteoritics, University of New Mexico (Appendix E). The microprobe is equipped with 5 wavelength dispersive X-ray spectrometers (WDS) and an Oxford Instruments eXL II analytical system. Filter and sediment samples were mounted directly on a sample stub while in the cave and coated

by evaporation with carbon and/or Au-Pd in the lab prior to imaging. Analyses were conducted at 15 kV and ~20 nA with a spot size of 1 µm. EDS (energy dispersive spectrometry) was used for qualitative elemental analyses and WDS (wavelength dispersive spectrometry) was used for detailed compositional analyses of selected sample areas. WDS map detection limits were relatively high, approximately 600 ppm for uranium and ~1600 ppm for arsenic, because of a relatively short (0.25 second) residence time per pixel. WDS point analyses of samples were performed following WDS mapping for longer point counts of arsenic, uranium, and other metal concentrations. Detection limits for uranium were calculated at ~125 ppm on average at 1-sigma on average. Detection limits for arsenic were much higher and more variable, ranging from ~300-400 ppm at 1-sigma on average.

SEM Analyses

In addition to bulk analytical techniques, samples were examined on a JEOL 5800 scanning electron microscope (SEM) equipped with an Oxford (Link) Isis Energy Dispersive X-ray Analyzer (EDX) for qualitative elemental analysis. Wet sediment and rock samples were mounted directly on an SEM sample stub. After mounting, the samples were examined using secondary and backscattered electron imaging.

Results

Leaching Experiments

Sequential leaching of arsenic and uranium from bottom sediments was performed on samples from Bellwood 76-1, Haigler 65-1, Stromsburg 3, Wauneta 3, and York 73-1 wells. Over all these results indicate that there is a potentially significant amount of

arsenic and/or uranium available from the materials and sediments accumulating in and around the well. Uranium concentrations exceeded 600 ppb for all extractions from Bellwood and ranged from 5 ppb to about 300 ppb for the York materials (Fig. 2a). At Bellwood, 2600 ppb and 3700 ppb uranium was extracted, respectively, from the material on the pump column and the sediment airlifted from the bottom of the well (Fig. 2a). These values are about 1000 times higher than the 30 ppb MCL for uranium. In addition, at Bellwood, over 4000 ppb of uranium is associated with organic matter.

Arsenic concentrations extracted from materials obtained from the Stromsburg, Haigler, and Wauneta wells ranged from undetectable to 600 ppb, which is 60 times higher than the 10 ppb MCL. In all six samples the highest arsenic concentrations were associated with metals extractable from organic matter. The Stromsburg and Haigler samples had arsenic concentrations that exceeded 145 ppb and 433 ppb, respectively, in the organic phase (Fig. 2b). There was progressively less arsenic found associated with the iron- and manganese oxide and weakly bound metal extractable phases. In contrast to the uranium extraction experiments, less than 20 ppb arsenic was associated with the weakly bound metal extractable phases.

Microprobe/EDS Mapping

EDS mapping of selected areas of sediment samples and filters displayed evidence of iron oxide and iron sulfide mineral formation in all well locations, with the exception of the Clarks DP-B4 monitoring well. Samples from this newly installed well were comprised of a mixture of grout and sediment from well development, and displayed peaks evident of aluminosilicates, silicates, and phosphates. Silicates and phosphates in trace amounts were present in Clarks, York, and Stromsburg samples. Hexagonal,

angular iron oxides were observed in all PWS well samples indicative of hematite. Octahedral iron oxide crystals were also observed at Clarks 2005-2 and Stromsburg 3, most likely magnetite. Various hexagonal iron sulfides were observed particularly in the Clarks 2005-2 filter sample with a ~1:1 Fe:S ratio, potentially pyrrhotite (Fig. 3). Octahedral and pyritohedral iron sulfides, indicative of pyrite, were present in all PWS well samples (Fig. 4). Excess carbon was measured from various York 73-1 and Stromsburg 3 sediment samples, which is evident of organic carbon; however this may be excess carbon coating.

All wells with the exception of Clarks DP-B4 displayed globular/amorphous solids and filamentous structures heavy in iron oxide content (Figs. 5). Globular and filamentous materials from Stromsburg were heavy in iron oxide but had significant silicate present in their structures (Fig. 6). The Clarks 2005-2 filter displayed globular materials with iron and traces of aluminosilicates. York 73-1 sediment contained these filamentous structures, high in iron oxide and carbon.

Microprobe/WDS Mapping

WDS mapping and point analyses of selected map locations were performed on all well samples with the exception of the Clarks DP-B4 monitoring well. Complete results of WDS experiments can be found in Appendix E. Maps of the Stromsburg 3 and York 73-1 sediments indicated highly concentrated areas of iron oxides. Both arsenic and uranium concentrations were below detection limits on Bellwood, Clarks, Wauneta, and York WDS maps. However, association of arsenic and uranium with iron oxide, hydroxide, and sulfide complexes is expected at the part per billion levels. Point analyses were better indicators of arsenic and uranium concentrations, as they had lower limits of

detection for arsenic and uranium than WDS maps. Point analyses of Haigler and Stromsburg samples displayed detectable arsenic concentrations associated with both globular and angular iron oxides (Table 1). Point analyses of Bellwood, Clarks, and York samples indicated detectable uranium concentrations associated with both globular and hexagonal, platy iron oxides (Table 1).

SEM

Scanning electron microscopy was performed on wet sediment from Bellwood 76-1, Stromsburg 3, and York 73-1 samples. Angular hexagonal and octagonal iron oxide bearing crystals were observed, with mineral composition estimated by EDX analyses. All well samples displayed flat, rhombohedral iron oxide crystals representing hematite (Fig. 7). Large, striated fibrous structures heavy in iron oxide content were observed in the Bellwood well, indicative of goethite formation (Fig. 8). Globular iron, associated with filaments observed previously on the microprobe and helical organic material, was observed in all wells (Fig. 9), indicative of bacterial presence.

Discussion

Well Encrustations in Public Water Supplies

EDS, WDS, and SEM spectroscopy indicate high concentrations of iron oxides, hydroxides, and sulfides present in all well encrustation samples. The presence of silica and phosphate in multiple well samples indicate these elements are potentially available for forming complexes with Fe(III), can enhance the oxidation of ferrous iron in the environment (Lowson 1982, Stumm and Morgan 1996). Imagery indicates sample mineralogy indicative of hematite, goethite, globular iron oxyhydroxides, as well as

various iron sulfides present in well screen encrustations indicating high amounts of ferrous iron oxidation. These globular structures may be poorly-ordered ferrihydrite complexes. Houben (2003) suggests iron oxyhydroxides present as ferrihydrite recrystallize to the more stable goethite phase over time, however this time scale is difficult to quantify. The dynamic, irregular pumping environment of the PWS wells coupled with the presence of biofilm communities may facilitate this mineral formation. Walter (1997) found dissolved iron removed by bacterial biofilms and supersaturation of waters by goethite and hematite. This suggests some iron oxyhydroxide mineral phases may precipitate during periods of well operation.

High amounts of organic carbon coupled with a multitude of filamentous organic structures coated with globular iron oxides indicate microbial influence of iron accumulation in these wells. Filamentous and spiral-like materials observed are believed to be evidence of the presence of the iron oxidizing bacteria *Gallionella ferruginea* among others. This bacteria produces long extracellular filaments, which are coated by inorganic iron oxyhydroxides (Ghiorse, 1986), much like the aforementioned filaments observed in all sampled wells. Heterotrophic iron bacteria, such as the filamentous *Leptothrix sp.* or *Spaerotilus sp.*, require organic carbon as a carbon source and may catalyze the oxidation of ferrous iron (Ghiorse, 1984). Walter (1997) suggests the presence of *Gallionella ferruginea* is indicative of a mature biofilm in these organic rich environments. The presence of these bacteria were not verified in this study, however SEM imagery is highly suggestive of their presence along with other filamentous bacterial in these encrusted biofilms.

Association of Arsenic and Uranium with Well Encrustations

Results from WDS mapping and point analyses of samples indicate high concentrations of iron oxides and oxyhydroxides in all PWS wells; however the connection to high uranium and arsenic concentrations was not clear. Detection limits of the arrays in the part per million range restricted estimation of heavy metal association with iron minerals on most wells, with the exception of Haigler 65-1 and Stromsburg 3 samples (Table 1). Point analyses indicated high concentrations of arsenic bound to iron-oxyhydroxide precipitates from these wells. Arsenic and uranium concentrations are associated with poorly-ordered iron complexes, most likely ferrihydrite. There are scattered occurrences of hematite, magnetite, and goethite crystals associated with uranium and arsenic at part per billion concentrations. Iron oxides have high sorptive capacities for uranium and/or arsenic due to high surface areas, and commonly occur as grain coatings (Waite et al., 1994, 1992). Bruno et al. (1995) and Ohnuki et al. (1997) report uranium uptake during formation of crystalline and amorphous Fe oxides. Fuller et al. (1993) found adsorption of arsenic on co-precipitating ferrihydrite is about 2-3 times higher than on pre-existing crystals. Iron oxides and oxyhydroxides are found as coatings on silicates in the well samples and likely facilitate trace metal adsorption. Massive accumulations of globular and poorly-ordered iron oxyhydroxides also provide plentiful sorption sites for available arsenic and uranium in these wells. Although WDS mapping did not indicate uranium and arsenic concentrations above detection limits, these iron mineral accumulations function as sinks for the trace metals within biofilm samples. In addition to functioning as a sink, ferrihydrite can also serve as a source of metals because as it recrystallizes there is a decrease in surface area (Houben, 2003), which results in the release of the majority of sorbed trace metals.

The association of the highest concentrations of both uranium and arsenic with organic matter supports the concept that the accumulation of these metals is the result of biologically mediated geochemical reactions. These reactions are facilitated by the construction of the well and the connection that a well makes between the surface and groundwater environment. In addition, the pumping of the well brings additional organic carbon and nutrients to facilitate growth of biofilms. Evidence for continued growth of the biofilm material was first observed prior to well cleaning of the Stromsburg 3 well, which were seen in down-hole video obtained in 2006 (Fig. 10). If the concentrations of uranium and/or arsenic associated with organic matter are representative of the uranium and/or arsenic available in and around the well, then an argument can be made for these organic biofilms contributing in a potentially significant way to the uranium and/or arsenic concentrations observed in the water samples analyzed.

Biofilms typically observed on the well casing, also extend out into the aquifer media and can potentially contribute arsenic and uranium to well water as the water passes by during well pumping. The areal extent of the occurrence of biofilms around the wells is unknown, however it is assumed that native biofilm formers like those observed as grain coatings are present in the aquifer as observed under SEM and suggested by Waite et al. (1992,1994). Therefore the presence of organics on aquifer sediments can not be discounted. Leaching experiments demonstrated the highest ratio of sorbed uranium and arsenic to that in solution was associated with these organics. Uranium concentrations were commonly associated with mineral surface sites, however the highest single concentration was associated with organics. Arsenic concentrations were all highest associated with organic materials. If these concentrations represent trace metals

potentially sorbed to geologic and organic materials in the well casing and aquifer media, then geochemical and physical alterations to the natural groundwater system can potentially desorb these trace metals. The degree to which these trace metals may be desorbed under changing aquifer conditions has not been investigated in these well sediments thus far. However, we can assume the presence and concentration of arsenic and uranium in these biofilms serve as sources to some extent for high dissolved concentrations.

Well Pumping Effects on Biofilm Accumulation

The dynamic environment created in and surrounding the PWS well during pumping facilitates the accumulation of biofilms/encrustations in wells. Wells serve as "hydrochemical short-circuits", responsible for the conversion of dissolved ferrous iron to insoluble ferric iron due to the introduction of oxygenated water (Houben, 2003). Ferrous iron may bind to available sorption sites of newly accumulated ferric iron, fostering expansion of encrusted metal complexes. The continual cycles of oxidizing and reducing conditions due to irregular pumping may influence these reactions. Tamura et al. (1976) suggest that ferric iron hydroxides on the well screen may have an autocatalytic effect on ferrous iron oxidation, thereby enhancing buildup. Also contributing are the inhomogeneous flow regimes created by the act of pumping. The screened intervals facing the natural direction of groundwater flow receive elevated proportions of the total inflow to the well (Houben, 2006). Experimentation with a suction flow control device (SFCD) to homogenize this inflow to the well pump more evenly distributed flow velocities along the well screen, but reduced well yield (Houben, 2006). These screened intervals may also receive elevated inorganic and organic carbon,

enhancing microbial metabolism and biofilm growth. Encrustations have been known to also start at the top of the filter screens, as increased amounts of relatively oxygenated water are introduced at these depths (Houben, 2003). These factors combined are responsible for the continual buildup of encrusted biofilm materials during pumping.

To counter the physical and geochemical heterogeneities created by inconsistencies in existing PWS well operation, further examination of the temporal effects of pumping on biofilm and mineral accumulation is recommended.. Experimentation with different pumping schedules on biofilm-affected systems would further the understanding of biogeochemical effects of pumping on biofilm accumulation. Prevention of a cyclic oxidative-reductive environment due to irregular pumping may affect biofilm microbial diversity, which may affect rates of arsenic and uranium sorption and accumulation to iron oxides and hydroxides. Experimentation with pumping rates may also increase the understanding of mineral precipitation rates in these wells. Applin and Zhao (1989) suggested the minimum pumping rates required to avoid the precipitation of iron at the well screens can be estimated by comparing the half-time of iron oxidation for the pH and DO content of the alluvial waters with the residence time of waters in the well. The greatest rate of iron oxidation will occur when pumping stops and resident waters become oxygenated. When pumping is stopped, the reduced iron remaining in the column of water within the well oxidizes and encrusts the well screen and casing (Applin and Zhao, 1989). Applin and Zhao (1989) suggest decreasing water residence times within PWS wells may decrease rates of iron precipitation. This may also prevent additional sorption and concentration of mobile arsenic and/or uranium.

Conclusions

Examination of sediments and encrusted materials for mineralogy, geochemistry, and association with arsenic and/or uranium was performed on samples from six public water supply systems. Selected wells contained high volumes of encrusted materials documented by down-hole videotaping. Dispersive array mapping and point analyses of well samples indicated high concentrations of iron oxides and oxyhydroxides in all PWS wells; however the connection to high uranium and arsenic concentrations is not clear. Detection limits of the arrays in the part per million range limited our estimation of arsenic and uranium association with iron complexes on most wells, with exception of high concentrations detected with iron precipitates at the communities of Haigler and Stromsburg. Massive accumulations of globular and poorly-ordered iron oxyhydroxides provide plentiful sorption sites for available arsenic and uranium in these wells. Sequential sediment leaching of solids indicated association of uranium with miernal surface sorption, however the highest uranium and arsenic concentrations were associated with organic material from biofilms. This suggests arsenic and uranium adsorptive and desorptive processes are biologically mediated reactions. Filamentous and spiral-like materials observed are believed to be iron oxide and organic traces of the iron oxidizing bacteria, however presence of these bacteria were not verified in this study.

The growth of biofilms and oxide accumulation are influenced by the cyclic oxidative-reductive environment created by well pumping. Further experimentation with pumping practices can alter the microbially-influenced geochemistry. This change in aquifer geochemistry due to pumping experimentation affects the accumulation of metals and mineral formation and/or dissolution within biofilm structures. This directly affects

arsenic and uranium sorption/accumulation to metal oxides in these biofilms and/or desorption into the water supply.

Tables

Table 1 – WDS Point Analyses calculated at the University of New Mexico, Albuquerque.

	WDS Point Analyses of Selected Map Targets		
Element	**Mass Percent %**		
	Bellwood 76-1 Fe-Oxide Plates	**Bellwood 76-1 Fe-Ox Globules**	**Clarks 2005-2 Hexagonal Crystal**
Al_2O_3	0.29	0.13	1.07
P_2O_5	0.55	0.73	0.54
As_2O_5			
UO_2	0.05	0.08	0.05
MnO	0.8	1.2	0.55
SiO_2	4.2	8.36	5.07
SO_3	0.16	0.06	0.47
MgO	0.42	0.39	0.16
Fe_2O_3	75.58	82.59	81.84
CaO	15.45	10.03	1.41
	Clarks 2005-2 Fe-Ox Clusters	**Haigler 65-1 Fe-Ox Clusters**	**Stromsburg 3 Fe-Oxide Plates**
Al_2O_3	0.2	0.01	1
P_2O_5	0.44		3.49
As_2O_5		0.54	0.19
UO_2	0.06		
MnO	0.55	0.31	0.16
SiO_2	2.3	3.14	15.77
SO_3	0.52	2.48	0.62
MgO	0.3		0.14
Fe_2O_3	86.53	68.49	61.87
CaO	1.18	0.08	4.45
	Stromsburg 3 Fe on Gallionella sp.	**Wauneta 3 Fe-Ox Clusters**	**York 73-1 Fe-Ox Clusters**
Al_2O_3	0.08	0.02	0.27
P_2O_5	2.5		2.63
As_2O_5	0.37	0.21	
UO_2			0.01
MnO	0.3		14.78
SiO_2	13.56	8	6.7
SO_3	0.21	6.17	0.18
MgO	0.24	0.06	0.21
Fe_2O_3	65.52	53.09	49.51
CaO	4.21	0.13	3.02

Detection Limits at 1-Sigma (ppm)

As	**~300-500**
U	**~110-130**

100 ppm = 0.01 mass %

Figures

Fig. 1 – Map of selected public water supply sampling locations displaying historically high ranges of arsenic and uranium concentrations.

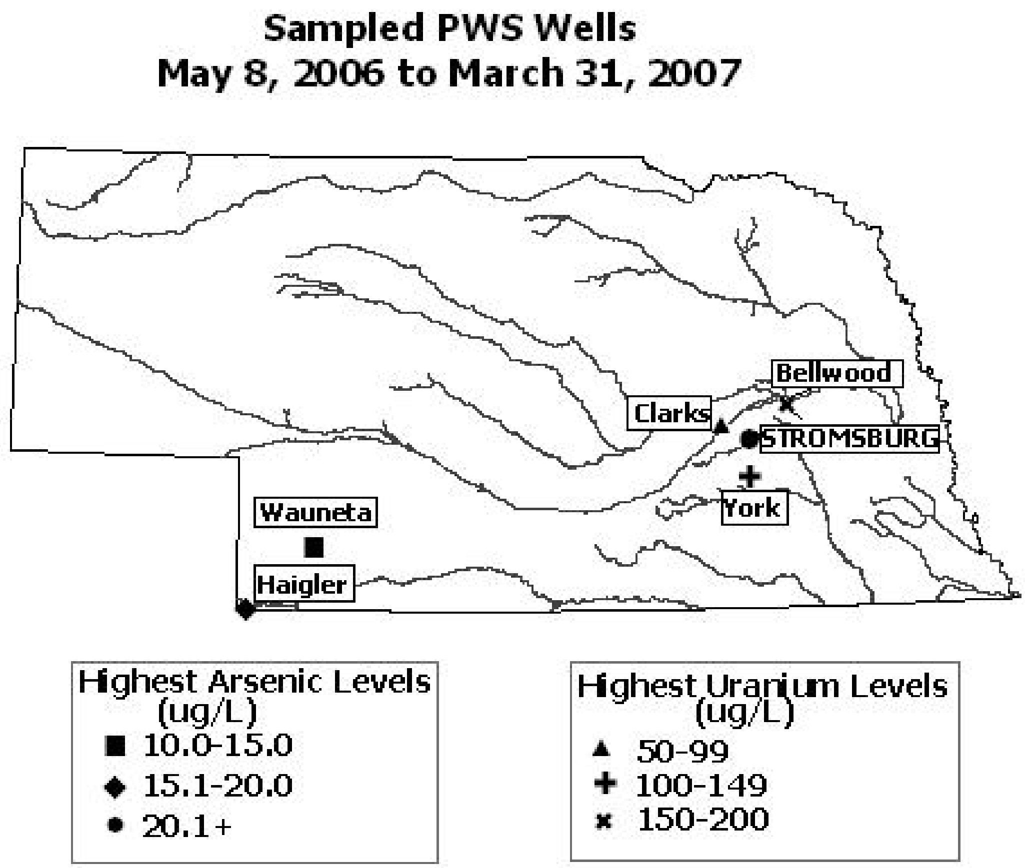


Fig. 2a –Sequential sediment extraction of well sediments from the Bellwood and York public water supplies. Uranium concentrations in ppb are indicated at the top of each column.

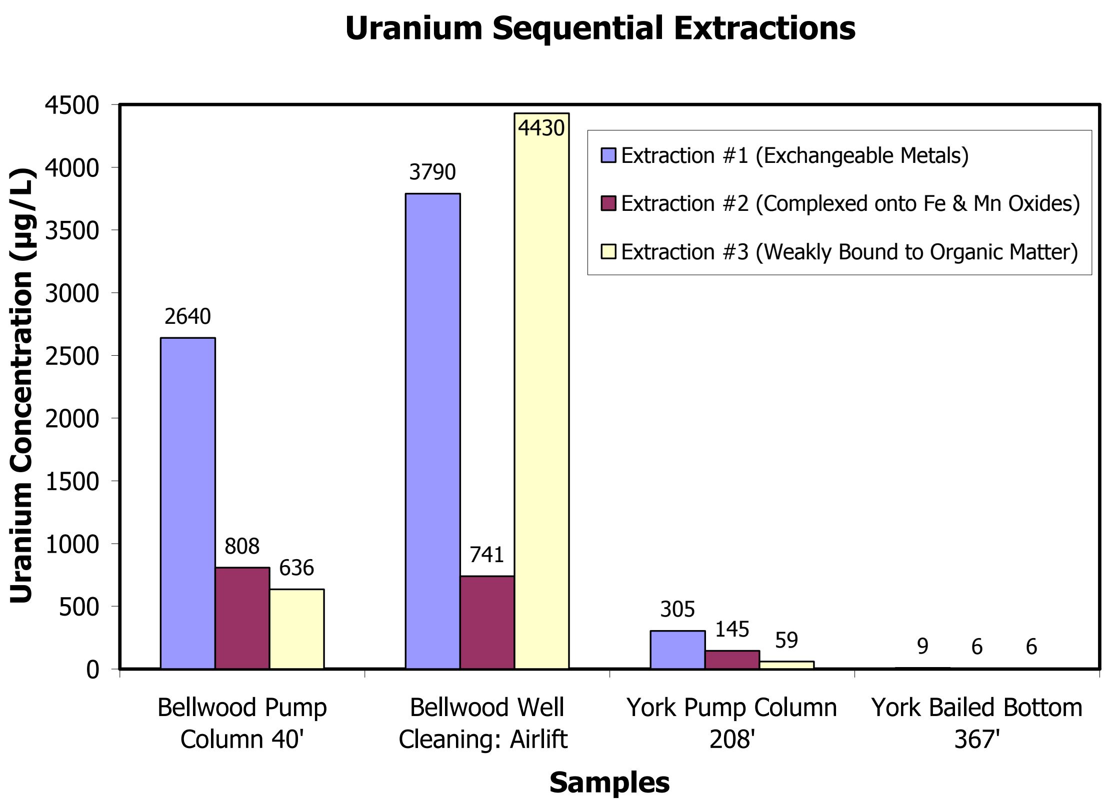


Fig 2b – Sequential sediment extraction of well sediments from the Haigler, Stromsburg, and Wauneta public water supplies. Arsenic concentrations in ppb are indicated at the top of each column.

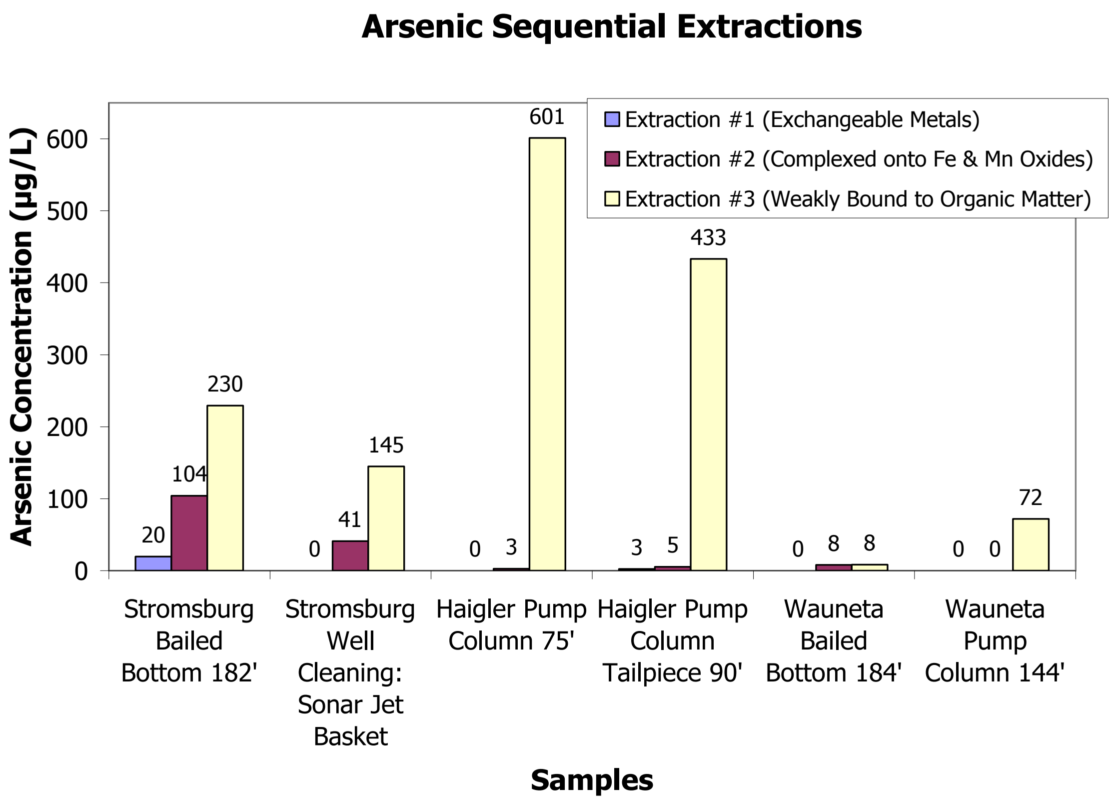


Fig. 3 – Microprobe imagery at 3500x magnification of hexagonal iron oxide structures sampled from the Clarks 2005-2 public water supply well.

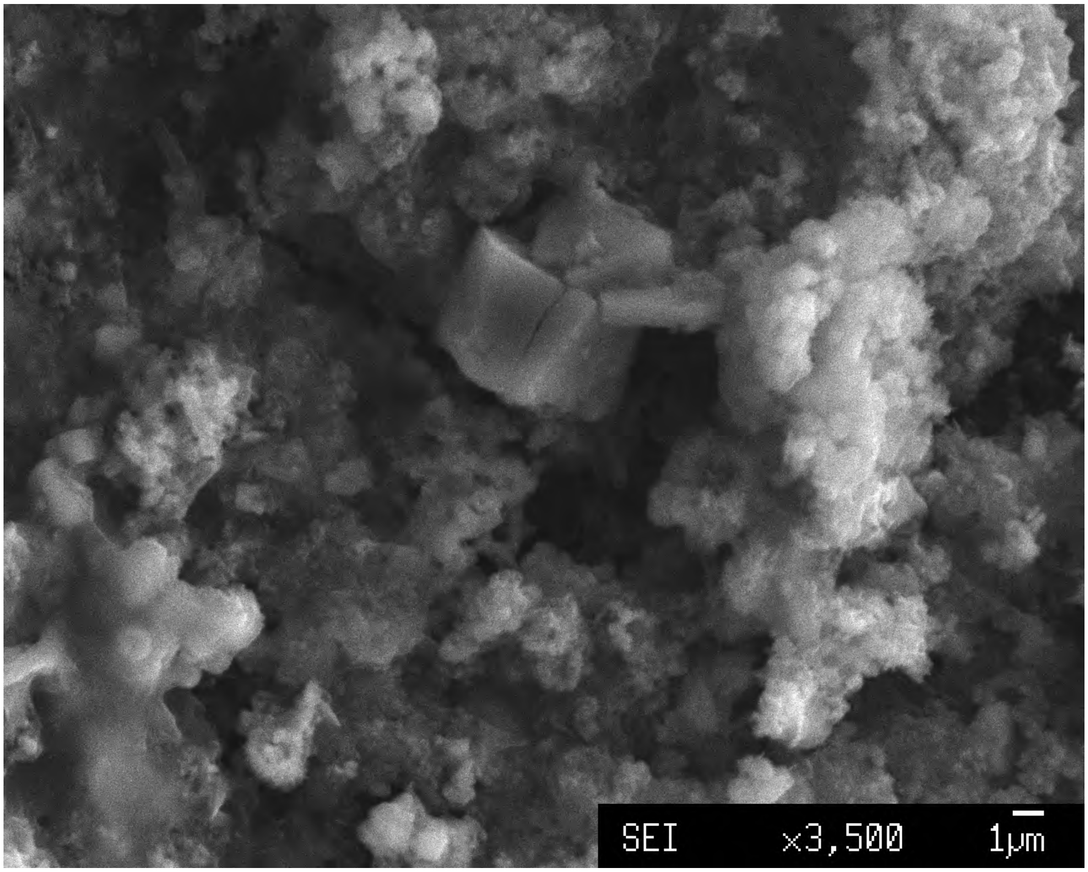


Fig. 4 – Microprobe imagery at 8500x magnification of pyritohedral iron sulfide structures sampled from the Clarks 2005-2 public water supply well.

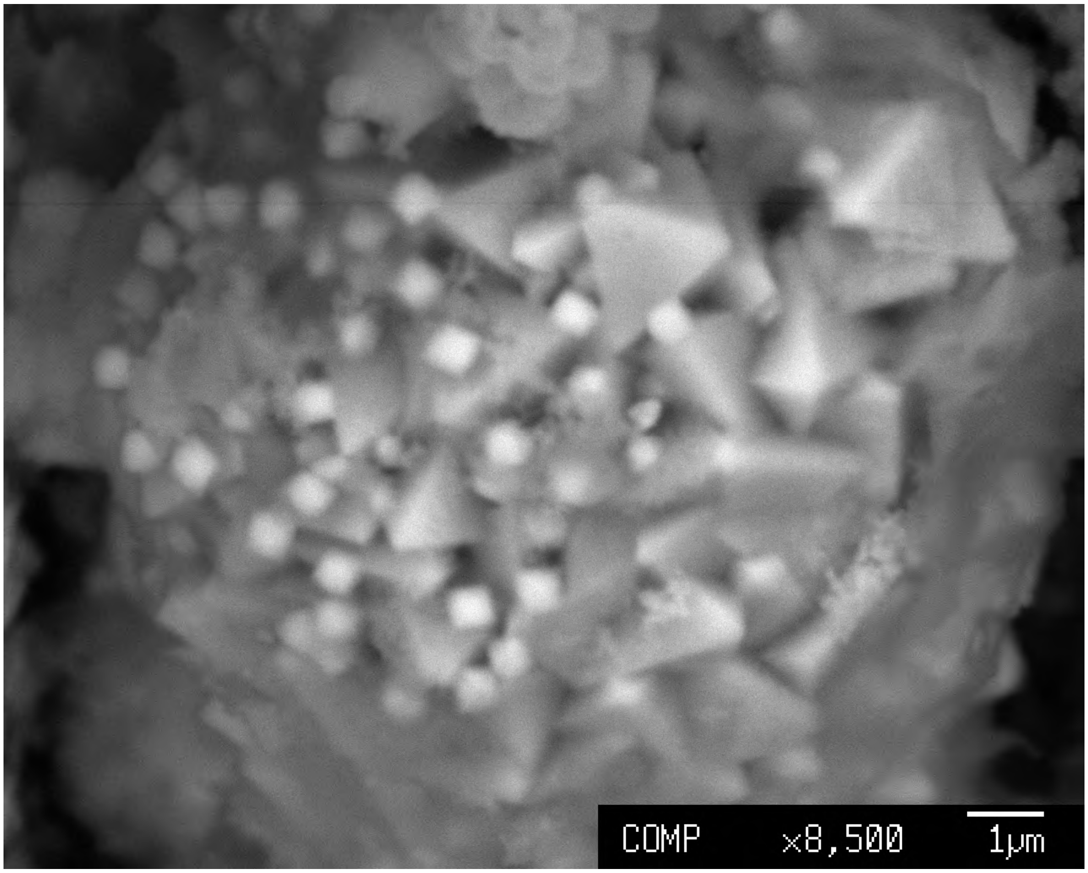


Fig. 5 – Microprobe imagery at 2000x magnification of globular/amorphous Fe-oxides on filaments from the York 73-1 public water supply system.

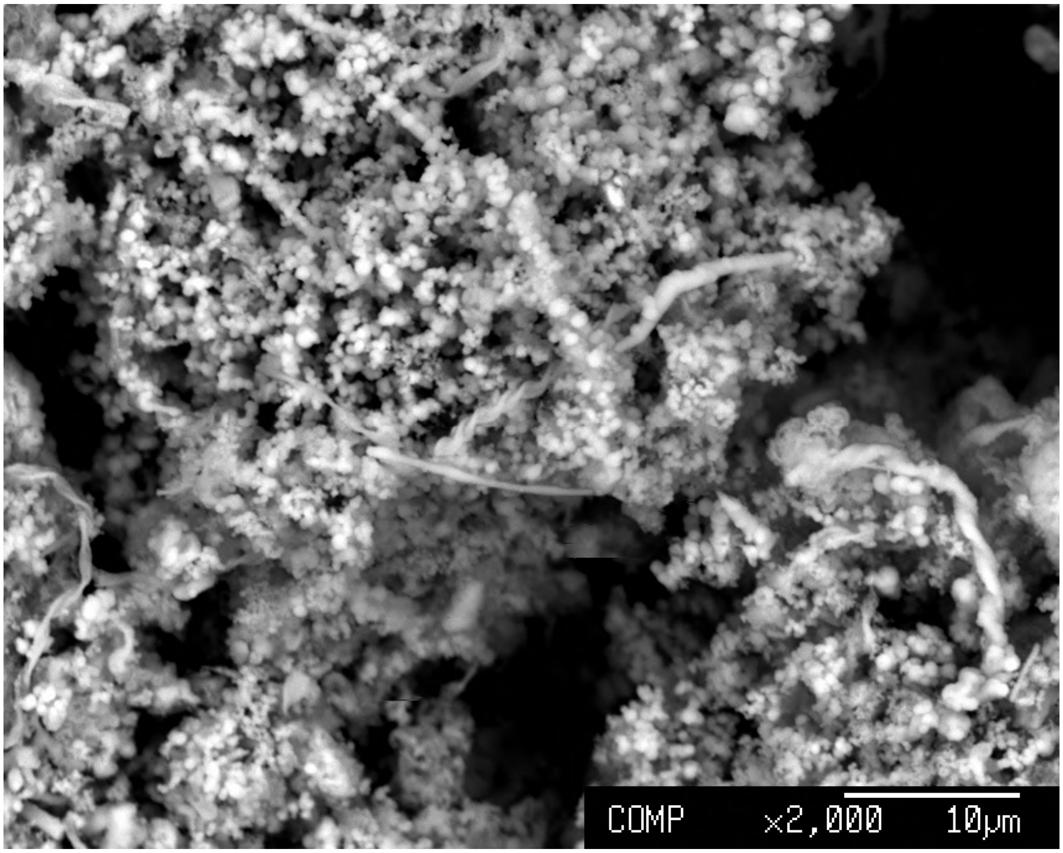


Fig. 6 – EDS scan results of Stromsburg 3 PWS well Fe-oxide globular/amorphous structures.

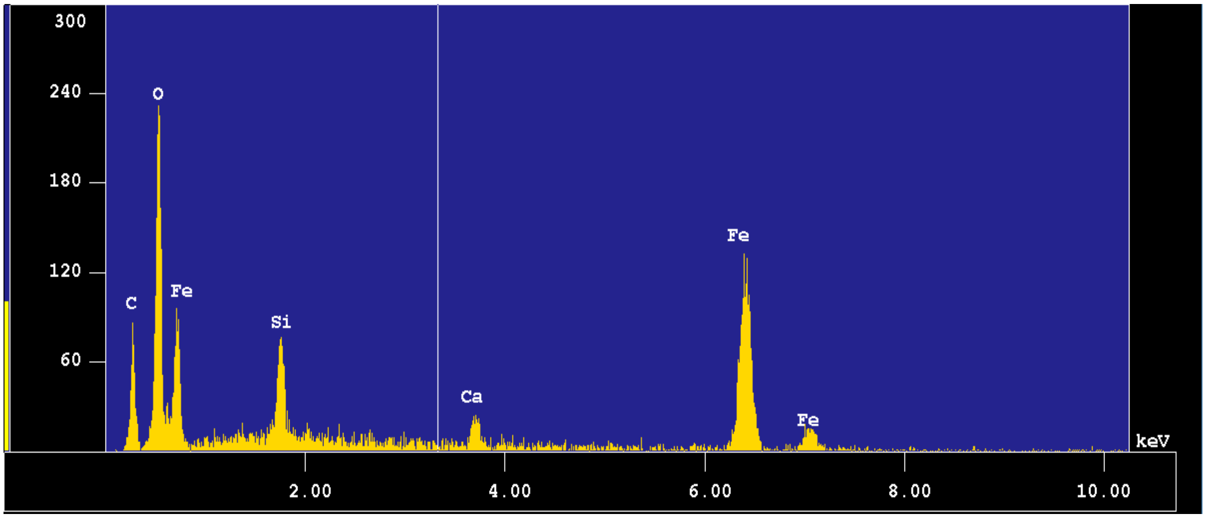


Fig. 7 - Rhombohedral, flat hematite crystals viewed at 8000x magnification sampled from the Stromsburg 3 public water supply well.

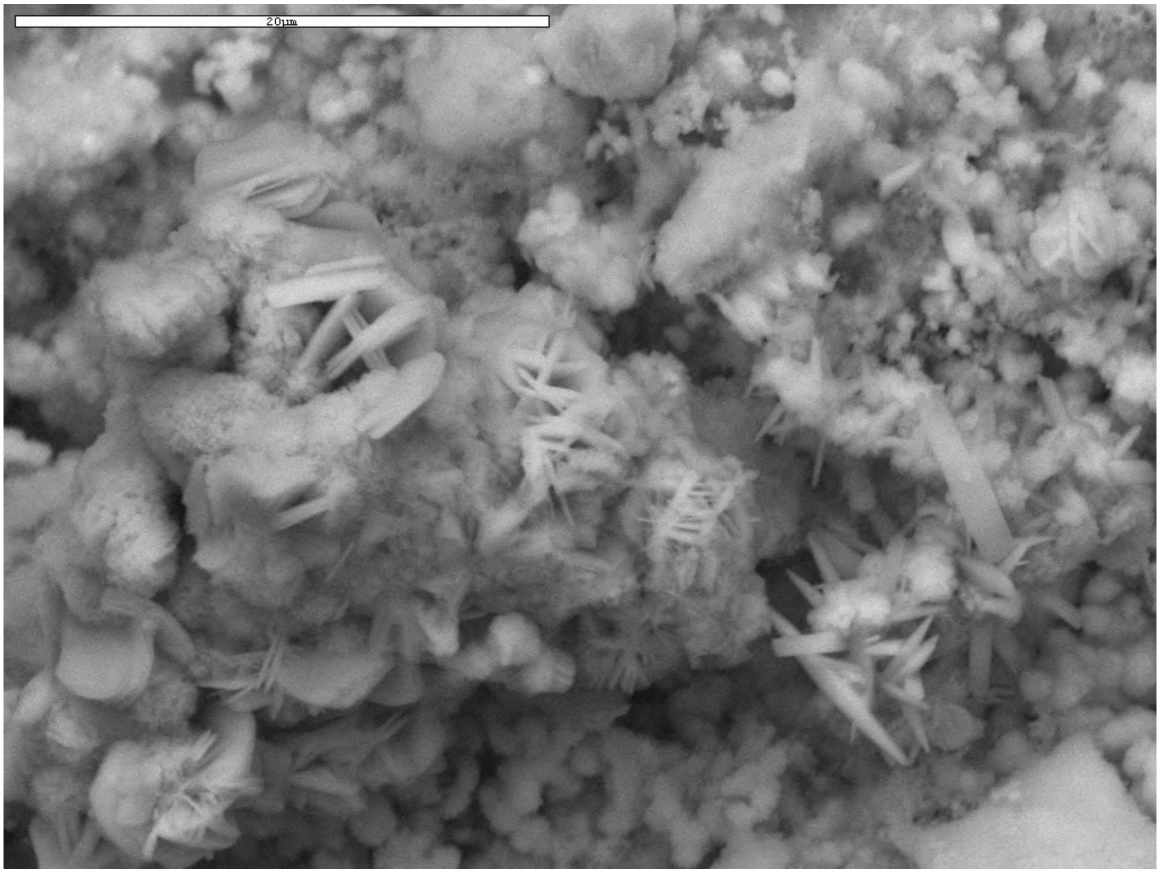


Fig. 8 – SEM imagery at 250x magnification of goethite fibers from the Bellwood 76-1 public water supply well.

Fig. 9 – Microprobe imagery at 8000x magnification of Fe–oxide coated filaments and possible *Gallionella ferruginea* from samples at the Stromsburg 3 public water supply well.

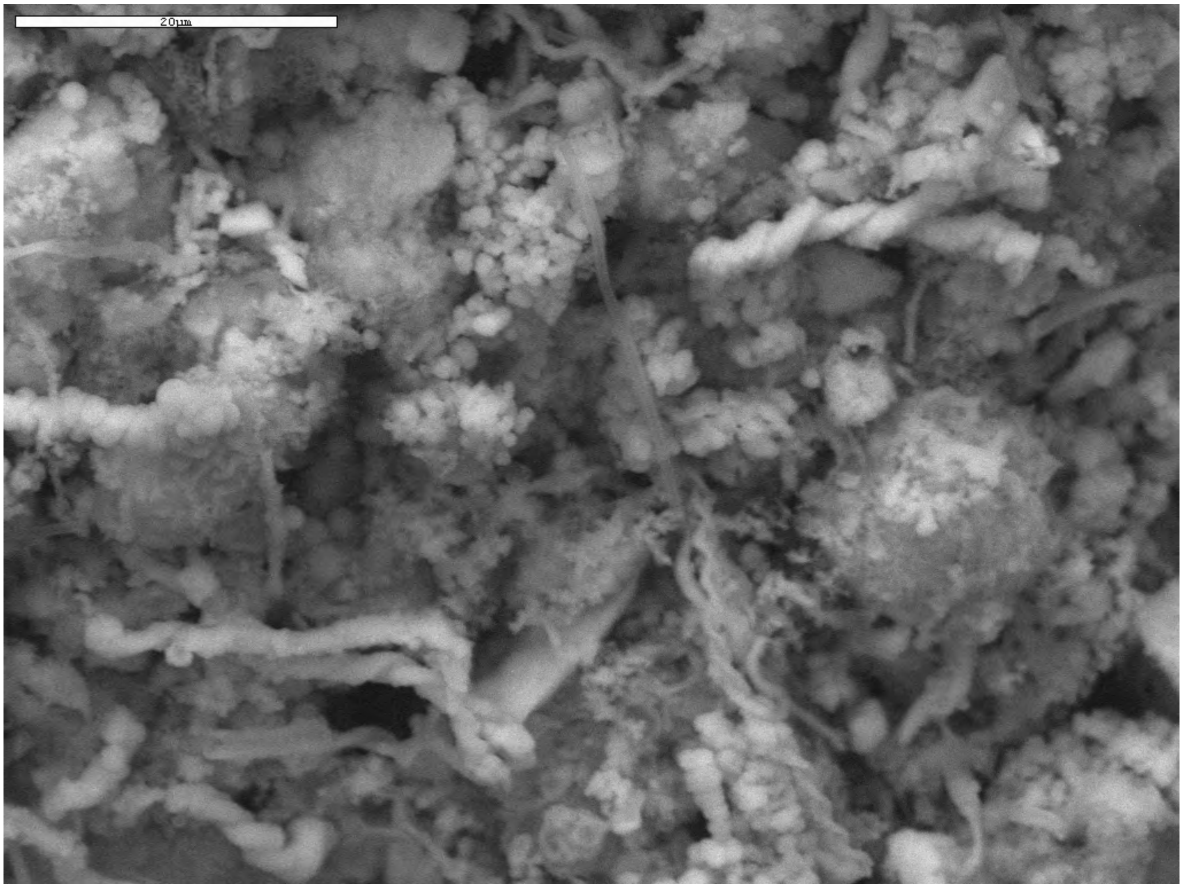


Fig. 10 – Downhole video of biofilms encrusting screened intervals at 178.3' from the Stromsburg 3 public water supply well. Videotaping was performed by NHHS personnel.

IV. Microbial Community Analyses of Nebraska Public Water Supplies Affected by High Arsenic and Uranium Concentrations

Introduction

Microbial mediation of reactions controlling mobility of the arsenic and uranium in aquatic environments has been the subject of extensive research (Islam et al., 2005, Lovley, 2000, 1997) in attempt to better understand controls on mobilization of these metals. Uranium (VI) is mobile in oxidized groundwater, and may be complexed with various dissolved carbonates in solution. In contrast, uranium (IV) is relatively immobile and precipitates in the form of uraninite under reduced conditions. Arsenic, under reducing conditions as arsenite (III), is more mobile and toxic than it is under oxidizing conditions where it primarily exists as arsenate (V) and has a tendency to adsorb to the surface of iron-bearing mineral accumulations.

Biogeochemical conditions and microbially mediated chemical reactions influence oxidation state of both arsenic and uranium in groundwater systems (McVey, Chapter 3, Unpublished Data). Iron (III) reducing organisms have been found to be primarily responsible for U(VI) reduction (Finneran et al., 2002), as U(VI) and Fe(III) reduction occurs concurrently. In these environments, Fe(III)-reducing bacteria are likely to outcompete sulfate-reducing bacteria because Fe(III) is a much more abundant electron acceptor than sulfate in subsurface sediments (Lovley, 2000, Lovley and Anderson, 2000). Mechanisms of arsenic mobilization remain to be characterized in detail, however respiration of sorbed As(V) by arsenate-reducing prokaryotes (including *Shewanella*, *Bacillus*, *Citrobacter*, and *Sulfospirillum*) among other groups may play a role (Oremland and Stolz, 2005). Islam et al. (2005) suggested direct enzymatic reduction of As(V) by Fe(III)-reducing bacteria such as *Geobacter sp.* or indirect mechanisms associated with

the microbial reduction of Fe-oxides and oxyhydroxides could be important mechanisms of arsenic release.

The operational nature of a public water supply (PWS) well disturbs the natural environment found in the aquifer. The hydrologic and geochemical inconsistencies created by periodic pumping of these PWS wells disturb these otherwise reducing conditions, bringing outside carbon sources, dissolved oxygen, and sediment to the well pump location. These conditions create artificial environments foreign to an aquifer, encouraging growth of aerotolerant and facultative aerobes such as *Gallionella ferruginea* or *Leptothrix sp.* The formation of biofilms noted in previous studies has been shown to disturb well operation, but also may serve as potential sinks for heavy metals (Houben, 2003, McVey and Gosselin, Unpublished Data). Biofilm accumulation may allow diverse microbial communities to flourish in these environments. This has potential and multiple implications for arsenic and uranium behavior. Microbial diversity created by the existence of these PWS systems and potential effects on arsenic and uranium mobilization has not been examined closely thus far.

The purpose of this study is to examine the combined results from field and laboratory investigations of several PWS wells in Nebraska. This study will (1) sample and document members of planktonic and benthic microbial communities in PWS systems, and (2) determine how these communities coupled with PWS well operation may affect well biogeochemical environments with respect to arsenic and uranium mobilization. This investigation was a cooperative effort between Nebraska Health and Human Services and several villages with historical arsenic and uranium issues across

Nebraska. The predominant groundwater contaminants at these sites were dissolved arsenic and uranium.

Methods

Sample Collection and Preparation

Water samples were collected from the Bellwood 76-1, Clarks 2005-2 and North Test Well (NTW), Cambridge 53-1, McCook 4, Stromsburg 3, and York 73-1 PWS wells, as well as biofilm samples from Stromsburg 3 and Clarks NTW for microbial analyses (Fig. 1). The Bellwood, Clarks, and York locations have historically high dissolved uranium concentrations, while Stromsburg has historically high dissolved arsenic concentrations. The Cambridge and McCook locations have arsenic concentrations below the 10 ppb MCL, and were sampled as background.

Water samples were collected at ~2-3 gallon per minute pumping rates from well sampling ports or using a Grundfos submersible pump (Grundfos, USA) and sealed in sterile polypropylene bottles, and stored at ~4°C. As part of the process to collect water samples, data for standard field parameters (field alkalinity, dissolved oxygen, electrical conductivity, pH, and temperature) was acquired. Inoculation of selective/enrichment cultures was performed at each well location. Aerobic media were kept under aerobic conditions while anaerobic media were kept anoxic using a portable nitrogen environment. Biofilm materials were sampled from well casing and screened intervals using a sterilized scraping tool, sealed with well water in polypropylene bottles, and stored at ~4°C. Biofilm encrusted materials and sediment collected from well screens used for electron microscopy were collected during sonication and bailing events at the

Bellwood, Stromsburg, and York well locations. Solids and well water were collected in polypropylene bottles and stored at ~4°C.

Culturing

Water samples from each well location were subjected to selective and/or enrichment culture techniques for the purpose of detecting culturable representatives of common redox bacteria found in subsurface waters. Media specific to sulfur oxidizing and sulfate reducing bacteria included Sulfur Oxidizing Medium and Postgate's Medium for Sulfate Reducers (Atlas, 1964). Media specific to iron reducing and oxidizing bacteria included *Geobacter* Medium, *Thiobacillus ferroxidans* Medium (ATCC 64) at pH 2 and 5, *Leptospirillum ferroxidans* Medium at pH 2 and 5, *Leptospira* Medium EMJH, Iron Oxidizer Medium, (Atlas, 1964). Media tubes and plates were inoculated using aseptic technique and incubated at temperatures specific to each media for 24 to 48 hours. Incubation periods ranged from 72 hours to 120 hours per medium at 37°C until growth was evident.

Amplification of 16S rDNA Genes and Construction of Clone Libraries

For construction of 16S rRNA gene clone libraries, water samples (500 to 600 ml) were taken from 1L sample storage bottles. Preliminary PCR amplification of 16S rRNA genes using primers targeting specific genera of iron and sulfur redox bacteria was performed prior to cloning (Table 1). Reaction mixtures contained 0.5 µl of each primer (stock concentration, 15 µM), 5 µl of template, and 15 µl of Easy-Taq bead DNA polymerase mixture (GE Inc., USA) (stock concentration, 5 U μl^{-1}) and were adjusted to a final volume of 50 µl with nuclease-free water. The PCR was performed on a Mastercycler (Eppendorf, Germany) with the following cycling conditions: 1 initial

denaturation cycle at 94°C for 3 min followed by 25 cycles consisting of: denaturation at 94°C for 30 s, primer-specific annealing temperatures for 30 s, elongation at 72°C for 2 min, and final extension at 72°C for 5 min. Amplification was verified by gel electrophoresis. Primer verification was performed using available pure cultures of target organisms.

For the amplification of 16S rRNA genes by PCR for cloning, 5 µl of 10x PCR buffer, 2 µl of the deoxynucleoside triphosphates (stock concentration, 2.5 mM), 10 µl of template, 0.5 µl of the universal bacterial primers 8F and 1492R (stock concentration, 15 µM), and 0.25 µl of TaKaRa-***Ta****q* DNA polymerase (TaKaRa BIO Inc., Japan) (stock concentration, 5 U μl^{-1}) were adjusted to a final volume of 50 µl with nuclease-free water. The PCR was performed on a Mastercycler (Eppendorf, Germany) with the following cycling conditions: 1 initial denaturation cycle at 94°C for 3 min followed by 25 cycles consisting of: denaturation at 94°C for 30 s, primer-specific annealing temperatures for 30 s, elongation at 72°C for 2 min, and final extension at 72°C for 5 min. Amplification was verified by gel electrophoresis. The amplified 16S rRNA gene fragments were purified with a QIAquick PCR purification kit (QIAGEN, Germany), inserted into the TOPO vector **(**TOPO TA cloning kit, Invitrogen, Germany), and cloned into TOP10 chemically competent cells of *Escherichia coli* as described by Invitrogen. The transformed cells were plated on agar containing 50 µg of kanamycin ml^{-1} and incubated overnight at 37°C. Plasmids were purified using a QIAprep Spin Miniprep kit (QIAGEN). Plasmid DNA concentrations were verified using a NanoDrop Spectrophotometer (Thermo Scientific, USA). Samples containing plasmid DNA concentrations below 70 ng/µl were not submitted for sequencing. The plasmid DNAs

were sequenced with the primers M13F (5'-GTA AAA CGA CGG CCA G-3') and M13R (5'-CAG GAA ACA GCT ATG AC-3'), located on the vector pCR4-TOPO by Eurofins MWG Operon, USA. Sequences were compared against available databases with the BLAST network service on the NCBI website. Phylogenetic trees were constructed using the neighbor-joining method in MEGA4 (Tamura et al., 2007)

DGGE

Denaturing gradient gel electrophoresis (DGGE) was performed on all water samples as described by Walter et al. (2000) using a DCode universal mutation detection system (Bio-Rad, Hercules, USA). PCR product was prepared using previously described protocols modified with 1 µl BSA, primer PRBA338F (5’-ACT CCT ACG GGA GGC AGC AG-3’ with GC-clamp at the 5’ end and PRUN518r (5’-ATT ACC GCG GCT GCT GG-3’) (Ovreas et al., 1997). Eight percent polyacrylamide gels were prepared and run with 1× TAE buffer diluted from 50× TAE buffer (2 M Tris base, 1 M glacial acetic acid, and 50 mM EDTA). The denaturing gradient gel was made from 8% acrylamide (acrylamide-bis, 37.5:1) (Bio-Rad, Hercules, USA) and contained a 30 to 50% gradient of urea and formamide increasing in the direction of electrophoresis. A 100% denaturing solution contained 40% (vol/vol) formamide and 7.0 M urea. The electrophoresis was conducted with a constant voltage of 130 V at 60°C for 4 hours and 30 minutes. The run was stopped when a xylene cyanol dye marker reached the bottom of the gel.

DNA bands on DGGE gels were visualized by staining with standard ethidium bromide and photographed using an InGenius gel documentation system (Syngene, Frederick, USA). Images were analyzed using BioNumerics software Version 5.0

(Applied Maths, Kortrijk, Belgium). Bands were manually assigned, and the normalized banding patterns were used to generate dendrograms of representative species by calculating the Pearson product moment correlation coefficient and by UPGMA (unweighted pair group method with arithmetic averages) clustering. This approach compares profiles in a pair-wise manner based on the entire densitometric curve, therefore accounting for both band position and intensity.

SEM and Microscopic Analyses

In addition to bulk analytical techniques, samples were examined on a JEOL 5800 scanning electron microscope (SEM) equipped with an Oxford (Link) Isis Energy Dispersive X-ray Analyzer (EDX) for qualitative elemental analysis. Wet sediment/biofilm encrustation samples were mounted directly on an SEM sample stub. After mounting, the samples were examined using secondary and backscattered electron imaging.

Samples of liquid cultures were examined using brightfield microscopy at 400X. Liquid cultures were treated with 0.1% acridine orange dye on slides and observed under fluorescent illumination using an inverted Leica microscope (Leica Microsystems, USA).

Statistical Analyses

Correlation of chemical parameters from sampled wells and microbial phylogenetic orders were conducted using SAS 9.1 Statistical Software (SAS, USA). The first dataset included chemical parameters for each well including standard cation, anion, iron, arsenic, and uranium concentrations in mg/L collected during prior sampling events. Bacteria were grouped and quantified by family at each well location in the second dataset. A cluster analysis was used for each dataset to calculate statistical

distance between the chemical parameters and phylogenetic makeup of wells. This distance matrix used a single linkage method (McQuitty, 1957 and Sneath, 1957).

$$\mathbf{D_{KL} = \min_{i \varepsilon C_K} \min_{j \varepsilon C_L}} \, d(x_i, x_j)$$

In a single linkage matrix, distance between two clusters is the minimum distance between an observation in one cluster and an observation in the other cluster.

Results

Geochemical and Physical Conditions

The geochemical conditions present in PWS well environments are variable. The pump intake location in the PWS systems is located at the bottom of the wellbore, well below the respective anoxic/oxic interface. Aquifer water may have less than 0.1 mg/L dissolved oxygen (reducing conditions for sulfates, sulfides, iron, and nitrates) ~20-30 ft below the water table during periods of well inactivity. However, dissolved oxygen probe detection limits (0.1 mg/L) and lack of an Eh probe in this study limited the ability to precisely measure redox states at these depths. The pH values of these PWS systems are circumneutral (pH 6-8). Typical total organic carbon levels in these wells vary, however inorganic carbon is also available from CO_2 and dissolution of carbonaceous sediment. Geochemical modeling indicated saturation of carbonate complexes in all wells sampled (McVey Chapters 1 and 2, Unpublished Data, Appendix D). Saturation of groundwater with various iron-oxide minerals such as magnetite and ferrihydrite in wells was also estimated based on water chemistry and observed via SEM (McVey, Chapter 3, Unpublished Data, Appendix D).

Selective and/or Enrichment Cultures

Culture experiments revealed limited growth in iron-reducing liquid and sulfate-reducing agar media. Sparse colony growth was observed on Postgate's sulfate-reducing agar plates after 72 hours of anaerobic incubation at room temperature. Sulfur-oxidizing and sulfate-reducing liquid media demonstrated no evidence of growth following extended incubation periods under anaerobic conditions at 37°C. No growth was evident in iron oxidizing liquid media following incubation under aerobic conditions at 37°C. Iron-reducing liquid media however showed evidence of biotic activity in all wells. The most microbial activity (from visual observation of turbidity in the innoculated medium) was observed in the York and Stromsburg inoculations. Brightfield and fluorescent microscopy of samples in iron reducing media from Clarks 2005-2, Clarks NTW, Cambridge, McCook, Stromsburg, and York revealed rod-shaped bacteria attached to surfaces of, or motile near, iron oxide/hydroxide precipitate clusters (Figs. 2a and 2b).

Microbial Community Structure

Community DNA was extracted from water and biofilm samples and probed for the presence of specific prokaryotic groups. Gel analysis of the PCR product confirmed the presence of members of the Geobacteracea family and other unidentifiable prokaryotes. Figures 3a-c show bands in well samples for the 8F/1492R universal eubacterial, 8F/519R and 8F/Geo825R *Geobacter* primer pairs. Weak bands may be attributed to low initial DNA template concentrations, a consequence of low bacterial loads characteristic of aquifer water. Primers targeting *Gallionella sp*. produced no detectable bands, although SEM indicated its presence.

DGGE of water and biofilm samples displayed diverse communities among wells. DGGE analysis of DNA extracted from water and biofilm samples is presented in Fig. 4. As expected, biofilm communities have different organisms than planktonic samples (see Stromsburg 3 and Clarks NTW data), although common bands indicate that some organisms are participants of both communities. Several species appear to be ubiquitous in both planktonic and benthic samples from all wells (Fig. 5a-c).

Phylogenetic relationships between indigenous well water bacteria were assessed utilizing 71 clones obtained from sequences obtained using PCR amplification of 16S rDNA genes. Distance trees including all aligned sequences created in Mega 4 can be seen in Figures 5a, 5b, and 5c. Clusters of uncultured *Flavobacterium sp.*, Alpha and Gamma-Proteobacterium, Pseudomonadaceae, and *Burkholderia sp.*, and *Rhizobium sp.* were differentiated from a larger cluster containing all other species of bacteria, both cultured and uncultured. Within this larger cluster, the *Escherichia coli* control and Pseudomonadaceae were most genetically distant from other species. The phylogenies of the Cambridge and McCook wells, both lower in arsenic concentrations than other wells, were dominated by uncultured Bacteroidetes, *Caulobacter sp.*, and Pseudomonadacae. Locations with historically higher arsenic and uranium concentrations, such as the Stromsburg 3 and Clarks 2005-2 wells, respectively, were populated by iron-oxidizing and -reducing phyla including *Rhodoferax sp.*, *Gallionella ferrugine,* and *Geobacter sp.*

Biofilm samples taken from the Stromsburg 3 and Clarks NTW wells were populated with *Leptospira sp.*, uncultured *Leptothrix sp.*, *Saprospiracae sp.*, and *Pseudomonas sp.*

Scanning Electron Microscopy

Scanning electron microscopy of selected samples of biofilm encrustations and well sediments displayed a conglomerate of iron oxyhydroxides and sulfides mixed with organic materials in the Bellwood 76-1, Stromsburg 3, and York 73-1 samples. Mineralogical evidence of hematite, pyrrhotite, ferrihydrite, magnetite, and goethite was observed intermixed with globular iron formations and organics (Fig. 6a). EDX scans indicated peaks of iron oxides and iron sulfides from selected mineral formations. Filamentous and helical organic structures were observed coated with globular iron oxyhydroxides. Probable remnants of the iron oxidizing bacteria *Gallionella ferruginea* coated with globular iron were common in all three well samples, (Fig. 6b). Other potential biotas present were not distinguishable from surrounding organics and minerals.

Statistical Analyses

Clustering of chemical and biological data from wells indicated similarities between well locations. Chemical clustering of the Bellwood, Cambridge, Stromsburg, and York were least statistically distant, with dissimilarity increasing with the Clarks 2005-2 and NTW wells, followed by the McCook well (Fig. 7a). Biological population clustering displayed Bellwood, Clarks 2005-2, Stromsburg, and York water samples least statistically distant (Fig. 7b). This is followed by the McCook water and both the Clarks NTW and Stromsburg biofilm samples, with the Clarks NTW water sample most statistically distant from other wells.

Discussion

Geochemical and Hydraulic Factors Affecting Arsenic and Uranium

Both arsenic and uranium respond differently to the geochemical conditions that constantly fluctuate in the PWS well environment. Arsenic exists as a less toxic, sorbed ion as the oxidized arsenate (V) and in a more toxic, dissolved state as the reduced arsenite (III). The uranium ion is dissolved in the oxidized (VI) state and precipitates in the reduced (IV) state. Geochemical modeling indicates various iron mineral phases including goethite, ferrihydrite, and magnetite are saturated with respect to groundwater in sampled wells (Appendix D). The highest concentrations of uranium are present in dissolved uranyl-carbonate phases in the groundwater surrounding sampled wells (Appendix D). Arsenic concentrations are present in both precipitated, oxidized phases and reduced, dissolved phases (Appendix D). Resident aquifer water within and surrounding the well casing facilitates reducing conditions, affecting complexation of these trace metals with iron and other metals. Arsenic is adsorbed during oxygenation to immobile ferric iron and potentially to sulfate ions, and although reducing conditions may not be sufficient to mobilize arsenic, they may provide more sorption sites for mobile ferrous iron (Islam et al., 2005). McVey (Chapter 2, Unpublished Data) observed increases in dissolved arsenic concentrations at the town of Wauneta during extended periods of well downtime, which may be facilitated by these reduced conditions. Hexavalent uranium, however, may be reduced concurrently with ferric iron, precipitating out of the water supply (Petrie et al., 2003). Decreases in dissolved uranium were observed at the Beemer and York PWS wells due to decreased pumping frequency over time, which may be linked to reduction of iron minerals and sorbed uranium

(McVey, Chapter 1, Unpublished Data). Arsenic and uranium may become trapped and concentrated within layers of a biofilm matrix, and may be potentially released into solution as pumping regimens and geochemical conditions change within different well systems.

Correlation of historical chemical data from PWS wells in this study indicated weak relation to geographic location among PWS systems, irrespective of differences in arsenic and uranium concentrations. Clustering of the Bellwood, Stromsburg, and York wells are located within close proximity to one another within the Platte River Valley, with Stromsburg just upland of the valley. This indicates weak similarities in geochemistry based on location. The village of Clarks, located within the Platte River Valley in eastern Nebraska, did not cluster with these three communities, and indicates regional variability in alluvial materials in this river system . The village of Cambridge, located within the Republican River Valley in southwestern Nebraska, clustered with Stromsburg, Bellwood, and York, and may share geochemically similar alluvial materials with these three locations. Well logs indicate these four wells contain similar geologic profiles, including beds of coarse sand, gravel, and interbedded blue clay units (Appendix A). The village of McCook, also within the Republican River Valley, was most statistically different from all other locations, representing distinctive geochemistry. The PWS wells sampled each have distinctive geochemical environments, which are a function of both the regional geology and the operational histories of the water supplies. These distinctive environments affect the availability of carbon sources, metals, dissolved oxygen, and diversity of microbial communities found at these well locations.

Biofilm Existence, Formation, and Microbial Communities

Aquifer conditions are favorable for bacterial growth, and depending on availability of electron acceptors, can support both aerobic and/or anaerobic growth. Hydraulic gradients may carry in additional carbon substrates as well as iron and sulfate complexes to the bacterial communities for use as electron acceptors. Available energy sources in an aquifer may include organic (humic) materials, hydrogen, and reduced metals such as ferrous iron, however this a relatively nutrient-poor environment. Bacteria may utilize carbon from dissolved CO_2 via autotrophy, or from organic sources via heterotrophy in this environment. Active redox cycling provides a means for the interaction of both metal reducing and oxidizing microbial communities in the aquifer. Iron and sulfur oxidizing bacteria in the vicinity of an anoxic/oxic boundary may readily oxidize available reduced metals. Weber (2006) and Straub et al. (2001) suggest that nitrate reduction may facilitate the oxidation of reduced metals, such as iron, under anaerobic conditions. These oxidized metals are then utilized as electron acceptors by iron and sulfate reducing bacteria present such as *Rhodoferax ferrireducens* (Figs. 5a-c)

Planktonic bacteria may attach to a solid surface and aggregate to form complex multi-species communities known as biofilms. A biofilm is a three-dimensional complex of microbial populations embedded in a slime-like extracellular polysaccharide (EPS) matrix, providing opportunity for interaction among various microbial populations (Cullimore, 2000) (Fig. 8). These complex communities of bacteria are highly successful due to spatial compartmentalization in the three-dimensional matrix, producing specialized niches and separation of metabolic activities (Caldwell et al., 1997). These EPS layers, sections of which were observed via SEM imagery, act as selective barriers to prevent toxic materials from reaching microcolonies, provide are as for nutrient

exchange, and encourage metabolic cooperation between phylogenetically diverse groups (Davey and OToole, 2000) (Figs. 6a-b). EPS is integral to biofilm attachment to the stainless steel screens and casing of wells. Within a PWS well environment, groundwater flow affects the structural development of these biofilms. The natural flow of the aquifer creates biofilms with patchy cell clusters separated by interstitial voids; however turbulent conditions during pumping creates elongated “streamers”, which oscillate in the bulk groundwater (Davey and OToole, 2000) (Fig. 8). Theoretically, these interstitial voids, or channels, are the lifeline of the biofilms, allowing nutrients and metabolic products to circulate with the bulk fluid layer within a well (Costerton, 1995). These channels are a vital part of the biofilm structure, and serve as pathways for interaction between diverse microbial populations.

These biofilm encrustations were observed at multiple PWS well systems including the villages of Stromsburg, York, and Bellwood during downhole videotaping (McVey, Chapter 3, Unpublished Data). Within the vertical profile of wells, biofilm encrustations have been known to start at the top of the filter screens, as increased amounts of oxygenated water are introduced at these depths (Houben, 2003). Steep redox gradients driven by pumping disturbing otherwise reducing conditions enhance EPS attachment to well casings and screens. Mechanisms of delivering oxygenated water other than pumping include the drip mechanism used to lubricate well pumps when offline in addition to oxygenated water returning down through the well pump following well shutoff. This oxygenated water is introduced into the well casing, creating an environment conducive to iron oxidation and facultatively aerobic or microaerophilic biofilm-forming bacteria such as *Leptospira sp.*, *Leptothrix sp.*, *Caulobacter sp.*, or

Pseudomonas aeruginosa observed in multiple well samples in this study (Figs. 5a-c). Walter (1997) suggests the presence of *Gallionella ferruginea* is indicative of a mature biofilm in organic-rich well environments; however this species was only observed in the Bellwood, Stromsburg, and York wells by SEM and phylogenetic analyses. These biofilms may form layers of EPS, with the outermost colonies of bacteria the most aerotolerant.

A biofilm community, like other aggregated bacterial communities, is subject to shifts in diversity dependent upon environmental conditions and availability of energy sources. The structural nature of biofilms found in sampled PWS wells explains the diversity of microbial communities observed among these wells. Between EPS layers, environmental conditions may also change as biofilms grow thicker. As conditions within the layers of EPS become more reducing, there are changes in the dominant bacteria in those niches (De Beer and Stoodley, 2006). The acetogenic bacteria *Geobacter metallireducens* or *Rhodoferax ferrireducens* found in well samples may find these niches favorable for propagation, and can live between the EPS layers with synergistic metabolic effects with other genera (Figs. 5a-c). In such environments, metal reducing bacteria such as these may break down iron and other metal oxide minerals trapped within biofilm EPS layers. In these reducing conditions, fermentative bacteria, including several *Pseudomonas sp.* found in various well samples, degrade complex organic materials and supply acids for these iron reducers. Methanogens observed in these environments, including potential *Methylotenera mobila* and other species, convert hydrogen and carbon dioxide to methane (Figs. 5a-c). These diverse communities indicate that an efficient interdependence has evolved in these PWS biofilms.

Notable differences were observed in community makeup of microbes between the Clarks PWS well and monitoring well (Figs. 5a-c, 7b). Given the same regional geology, we can assume the statisically diverse groups are the result of differences in aquifer chemistry. As the pumping well is exposed to a higher redox gradient due to pumping, this environment may be more favorable for biofilm accumulation and diversification (Houben, 2003, Caldwell et al., 1997). The phylogenetically diverse populations observed have developed within biofilms of the Clarks pumping well due to these conditions compared to the monitoring well. The monitoring well does not influence geochemical changes like those observed in water sampled from the PWS well, and microbial population detected may be more representative of microbial diversity in undisturbed aquifer conditions.

Microbial and Mineralogical Effects on Arsenic and Uranium

SEM analysis with EDX and selective culturing experiments were correlated in an effort to develop a rough indicator of the relationship between iron complex abundance and microbial metabolism. Large amounts of iron oxide and hydroxide were present in samples of the Bellwood, Stromsburg, and York well encrustations. Mineralogical examination indicated ferrihydrite, hematite, goethite, and magnetite iron complexes, with abundant poorly-ordered globular iron oxides attached to remnants of *Gallionella ferruginea,* among other biofilm-forming organisms. Iron sulfide presence in the form of pyrrhotite was relatively small compared to the amounts of iron oxyhydroxides present in these samples. Selective culturing and fluorescent microscopy of well samples indicated microbial reduction of ferric iron. Evidence of abundant sulfate reducing microorganisms was not observed during culturing or phylogenetic analyses, which may

indicate stronger links to iron metabolism in the sampled PWS well environments. Because Fe(III) is an electrochemically more dominant electron acceptor compared to sulfate, iron-reducing bacteria are able to out-compete sulfate reducers metabolically as electron donors (North et al., 2004). When the supply of ferric iron for use as an electron acceptor is exhausted, the niche for iron reducing bacteria gives way to a sulfate reducing niche. The mineralogy of the geologic samples indicate that substantial sources of iron are present in the alluvium surrounding the wells, so it is not likely to be limiting.

PWS well environments coupled with availability of these biofilm-aggregated mineral phases serve as in-situ sinks for uranium and/or arsenic concentration. The fluctuating oxidation and reduction periods created by the inconsistencies of well pumping create biogeochemical conditions conducive to trace metal concentration. The presence of large amounts of ferrihydrite crystals and globular iron observed in the Bellwood, Stromsburg, and York well biofilm encrustations indicates plentiful sorption sites for available arsenic and uranium along the well casing and screened intervals. Iron oxides contain sorptive capacities for uranium and/or arsenic due to high surface areas, and commonly occur as grain coatings (Waite et al., 1994, 1992). Iron oxide-coated grains are indicated by the association of iron oxides and oxyhydroxides with silicates observed in EDX scans of samples (McVey, Chapter 3, Unpublished Data). The cyclic nature of PWS well operation facilitates this sorption. Relative reducing conditions exist in PWS wells during extended periods of pump downtime due to a lack of aqueous mixing. Potential evidence for metal dissolution and mobilization during extended pump shutoff were observed at the village of Wauneta, as dissolved arsenic concentrations increased several parts per billion due to the extended residence time of well water

between pumping events (McVey, Chapter 2, Unpublished Data). Bose and Sharma (2002) suggest arsenic can be reduced as a result of dissolution of arsenic-contaminated iron oxyhydroxides due to the onset of reducing conditions in the subsurface, which is detrimental to controlling dissolved arsenic concentrations. This can be directly linked to the various metal-reducing microbial populations observed in this study. As geochemistry within a PWS well and surrounding aquifer is affected, the opportunity for specific bacteria to increase or decrease their metabolic rate changes. This can adversely affect PWS systems, depending upon the contaminant of concern. Mobile ferrous iron, potentially derived from pyrite and other such minerals, has been suggested to complex mobile U(VI) by adsorption to available surface sites (Liger et al., 1999) under reducing conditions, thereby removing it from solution. However, this allows for the concentration of uranium in biofilms under reducing conditions as iron reducing bacteria affect the surface charge of mineral phases found in these wells such as hematite and goethite (McVey, Chapter 3, Unpublished Data). Oxygenated waters introduced to the biofilms through well activity mobilize sorbed uranium, which is suggested to occur under natural conditions favoring oxidation of ferrous to ferric iron (Duff et al., 1997). Iron oxidizing bacteria cloned from multiple wells including *Leptothrix sp. And Gallionella ferruginea*, catalyze these reactions on the surfaces of iron minerals trapped within biofilms, freeing sorbed uranium. In contrast, these conditions serve to sorb mobile arsenic. Bang et al. (2005), however, found removal rates of As^{3+} and As^{5+} were much higher under oxidized conditions than anoxic conditions, as arsenic is sorbed in these conditions and desorbed due to reductive dissolution of Fe-oxides. The metabolic activity of various bacteria detected influence minerals and metals trapped within PWS

and monitoring wells in addition to surrounding aquifer sediments, which affect the mobility of arsenic and/or uranium under different geochemical conditions.

Conclusions

Microbial communities were examined in six public water supply systems in Nebraska, and provided a glimpse of the bacterial influence affecting redox states of metals concentrated in PWS and monitoring wells. Cycling oxidation and reduction periods during well pumping create biogeochemical conditions conducive to enhanced microbial diversity. Links to iron metabolism was observed in the sampled PWS well environments due to the availability of iron minerals and oxides found in previous studies, as well as from selective culturing experiments. Phylogenetic techniques indicated unique microbial communities at each well sampled. Several species of iron reducing and iron oxidizing bacteria were present in multiple well systems. Statistical correlation of microbial family structure indicated a monitoring well from the town of Clarks, NE contained the most statistically distant microbial populations from other wells. This reflects populations that were exposed to the range of conditions seen in active pumping wells differ from those populations seen in monitoring wells, which are more reflective of natural aquifer conditions. The bacterial communities in the Clarks monitoring well are the most representative microbial diversity in the undisturbed aquifer at this location. Previous mineralogical analyses indicated plentiful metal oxides concentrated in biofilms. The redox states of these metal phases are influenced by the complex microbial populations present within these biofilms. Biofilms flourish in the well environment partly due to steep redox gradients created by cycles of well operation.

Within these biofilms, diverse groups of metal oxidizing and reducing bacteria are present in multiple wells, affecting redox states of mineral surfaces in these biofilms. This directly influences the sorption and concentration of toxic trace metals such as arsenic and uranium. To obtain a better understanding of microbial influences on the sorption and concentration of toxic trace metals in these biofilms, further experimentation with pumping regimes reflective of the operational history, microbial community structure, and local geology of each individual well is required.

Tables

Table 1 – List of 16S rRNA PCR primer sequences from 5'-3' ends. Target bacteria and set number are indicated in addition to primer labels.

Target Bacteria	Primer	Sequence 5' - 3'
Eubacteria (Set 1)	8F	AGA GTT TGA TCC TGG CTC AG
	1492R	CGG CTA CCT TGT TAC GAC TT
Geobacter sp. (Sets 2 and 3)	8F	AGA GTT TGA TCC TGG CTC AG
	519R	GWA TTA CCG CGG CKG CTG
	8F	AGA GTT TGA TCC TGG CTC AG
	Geo825R	TAC CCG CRA CAC CTA GT
Gallionella sp. (Set 4)	Eub787F	TTA GAT ACC CTG GTA
	Nso1225R	CGC CAT TGT ATT ACG TGT GA
Desulfovibrio sp. (Set 5)	DSV682F	GGT GTA GGA GTG AAA TCC G
	DSV+1402R	CTT TCG TGG TGT GAC GGG
Desulfotomaculum sp. (Set 6)	DFM140F	TAG MCY GGG ATA ACR SYK
	DFM842R	ATA CCC SCW WCW CCT AGC
Desulfobacter sp. (Set 7)	DSB+57F	GCA AGT CGA ACG AGA AAG GGA
	DSB1243R	AGT CGC TGC CCT TTG TAC CTA
Leptospirillum sp. (Sets 8 and 9)	LEPTO176F	CGA ATA GTA TCC GGT TCC G
	LEPTO679R	AAA TTC CGC TTC CCT CTC C
	EUB27F	GAG TTT GAT CCT GGC TCA G
	LEPTO679R	AAA TTC CGC TTC CCT CTC C
Thiobacillus sp. (Set 10)	FERRO458F	GGG TTC TAA TAC AAT CTG CT
	FERRO1473R	TAC CGT GGT AAC CGC CCT

Figures

Fig. 1 – Map of sampling sites in Nebraska and ranges of historical high and current arsenic and uranium concentrations.

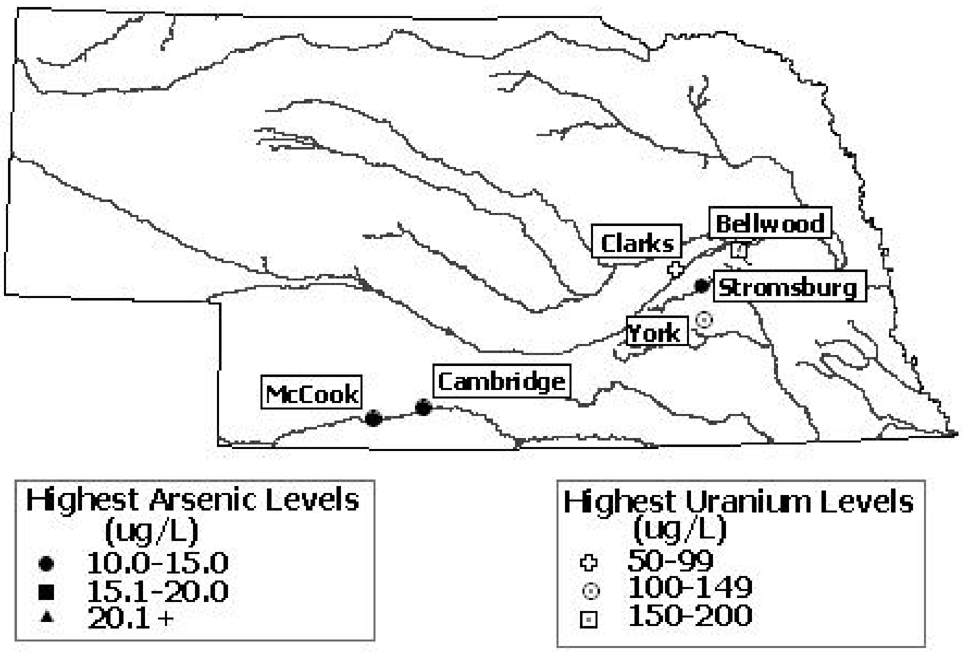


Fig 2a – Fluorescent imagery at 1000x magnification of Fe-reducing media with York 73-1 well inoculants taken from water samples.

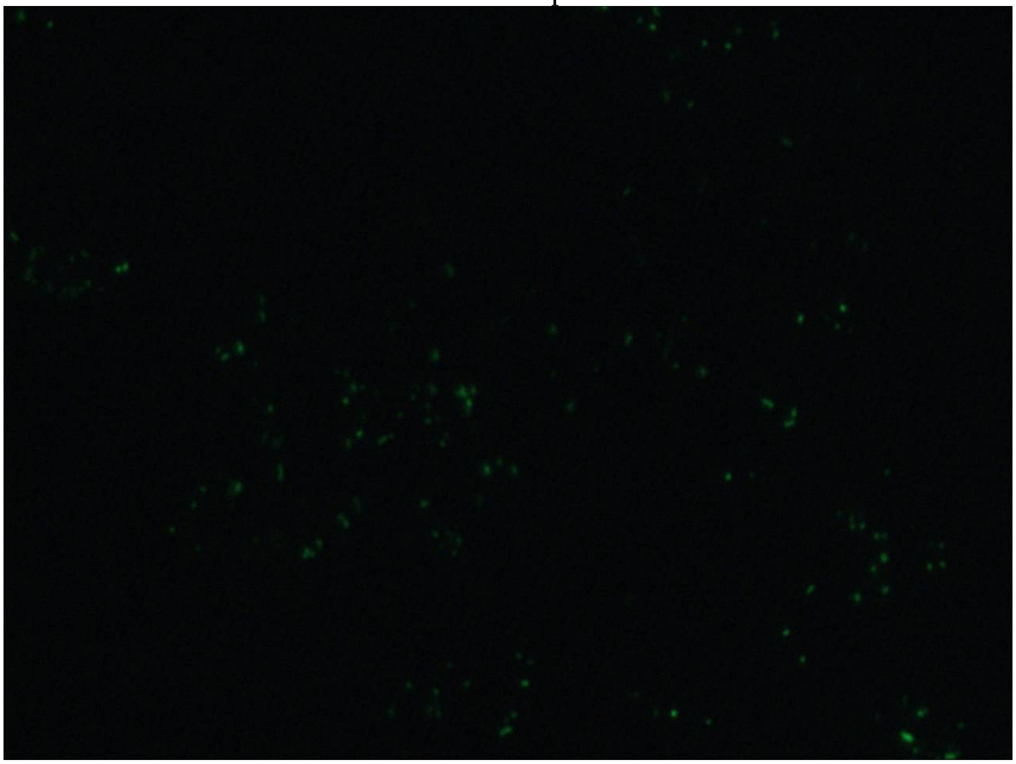


Fig. 2b - Brightfield imagery at 1000x of Fe-reducing media with York 73-1 well inoculants taken from water samples.

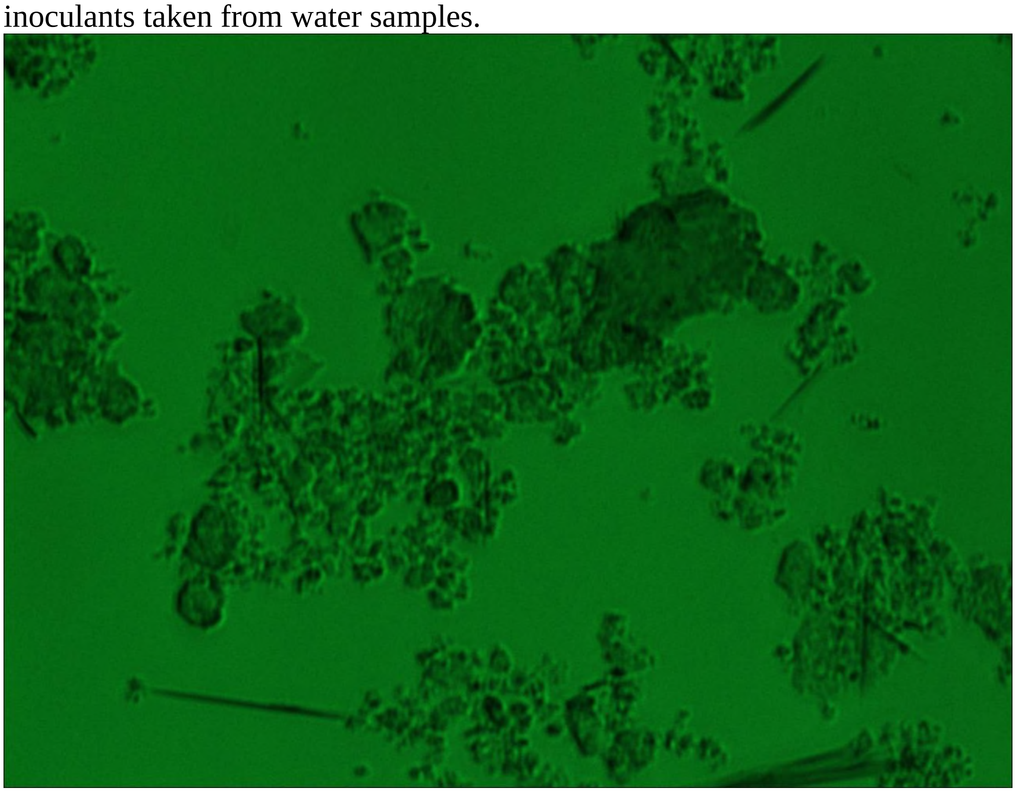


Fig. 3a – PCR results from primer sets 1 and 2. Bands indicate molecular weight of PCR products. Size in base pairs of the PCR bands are displayed on the left column.

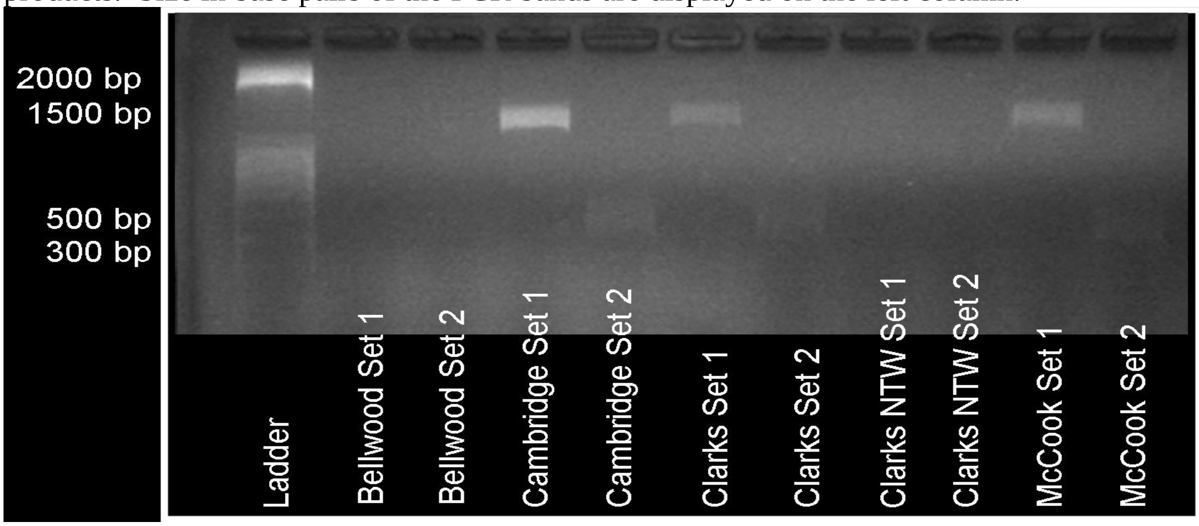


Fig. 3b – PCR results from primer sets 1, 2, and 3. Bands indicate molecular weight of PCR products. Size in base pairs of the PCR bands are displayed on the left column.

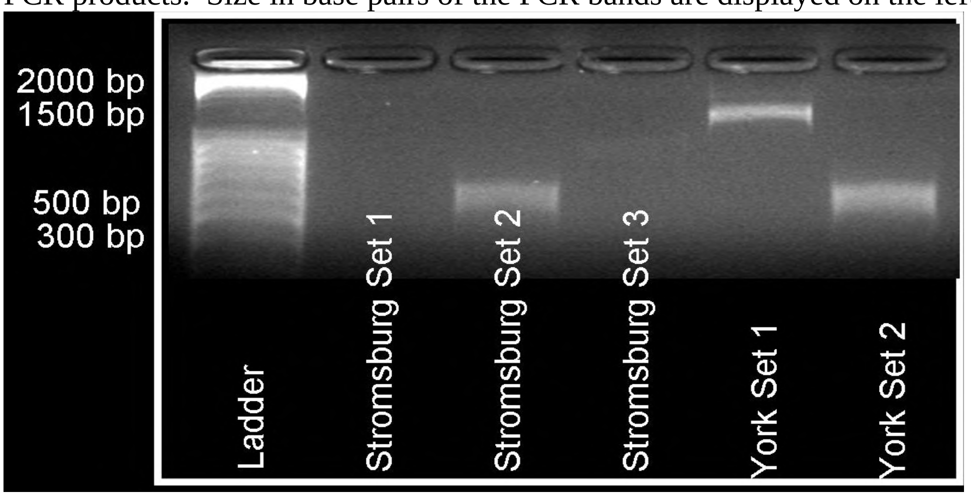


Fig 3c – PCR results from primer sets 2 and 3, with set 4 used in biofilm samples. Bands indicate molecular weight of PCR products. Size in base pairs of the PCR bands are displayed on the left column.

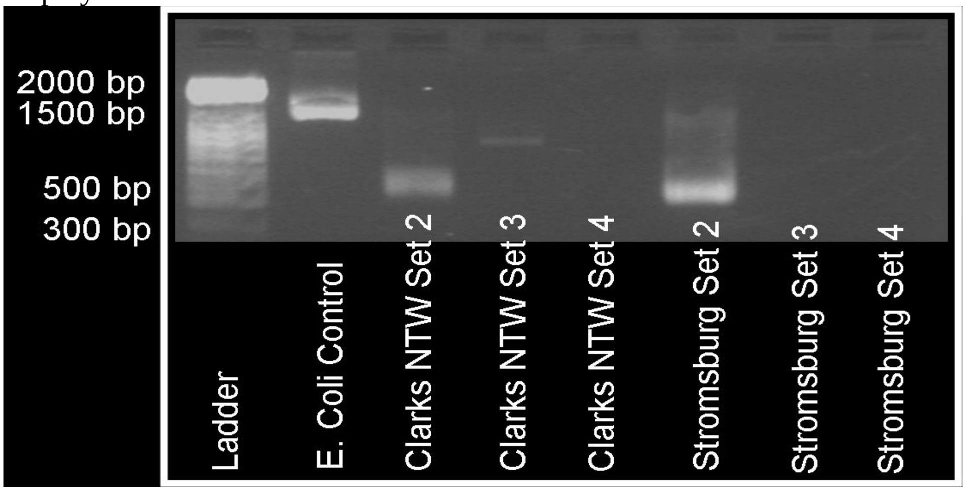


Fig. 4 –DGGE results from selected well locations. Graph on left indicates statistical distance between DGGE bands. Red markers indicate arsenic contaminated wells and green indicate uranium contaminated wells.

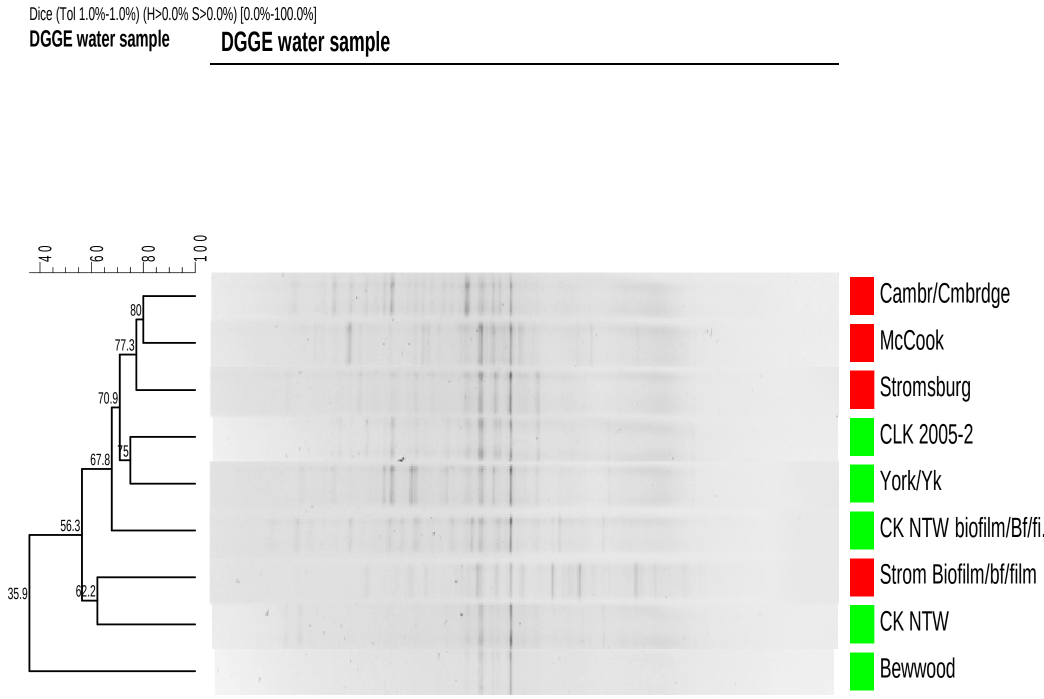


Fig. 5a – Phylogenetic distance tree of clone library produced from MEGA-4.0 software. Genetic distances are shown on scale.

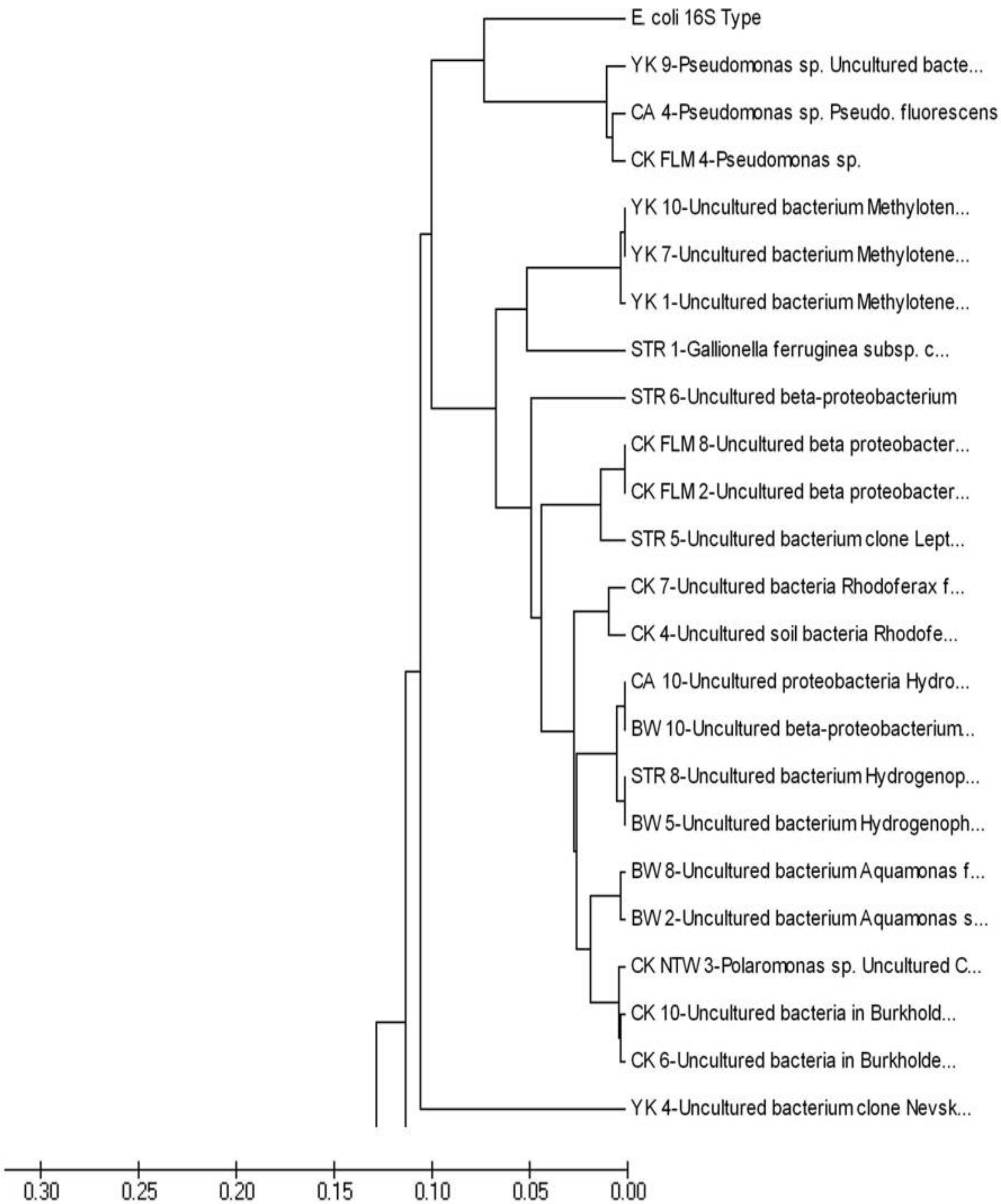


Fig. 5b – Phylogenetic distance tree of clone library produced from MEGA-4.0 software. Genetic distances are shown on scale.

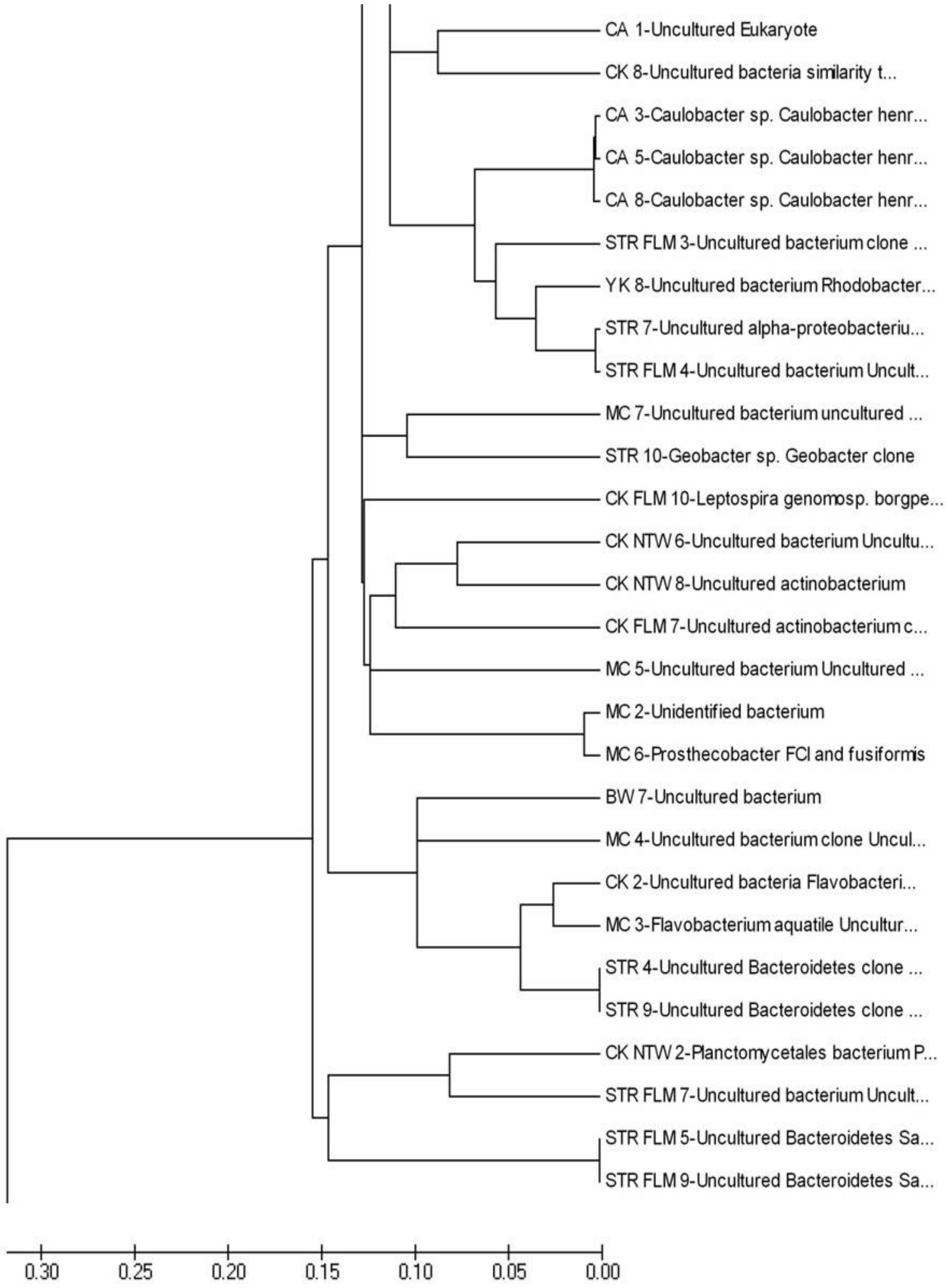


Fig. 5c – Phylogenetic distance tree of clone library produced from MEGA-4.0 software. Genetic distances are shown on scale.

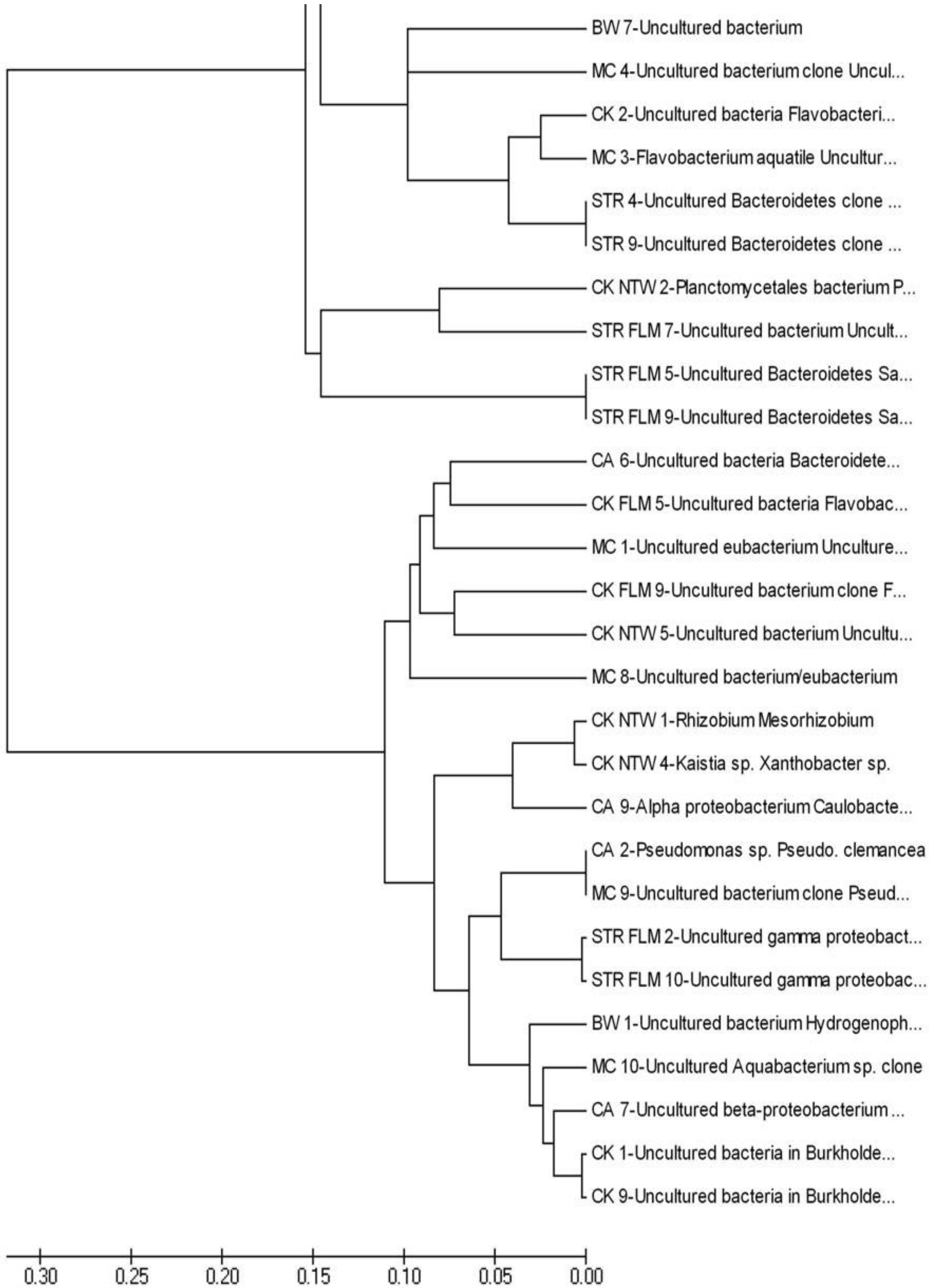


Fig. 6a – SEM at 250x magnification of Fe-oxyhydroxides (goethite and ferrihydrite) in biofilm accumulations observed in the Bellwood 76-1 public water supply well.

Fig. 6b – SEM at 8000x magnification of helical shaped bacteria most likely *Gallionella ferruginea* observed in the Stromsburg 3 public water supply well.

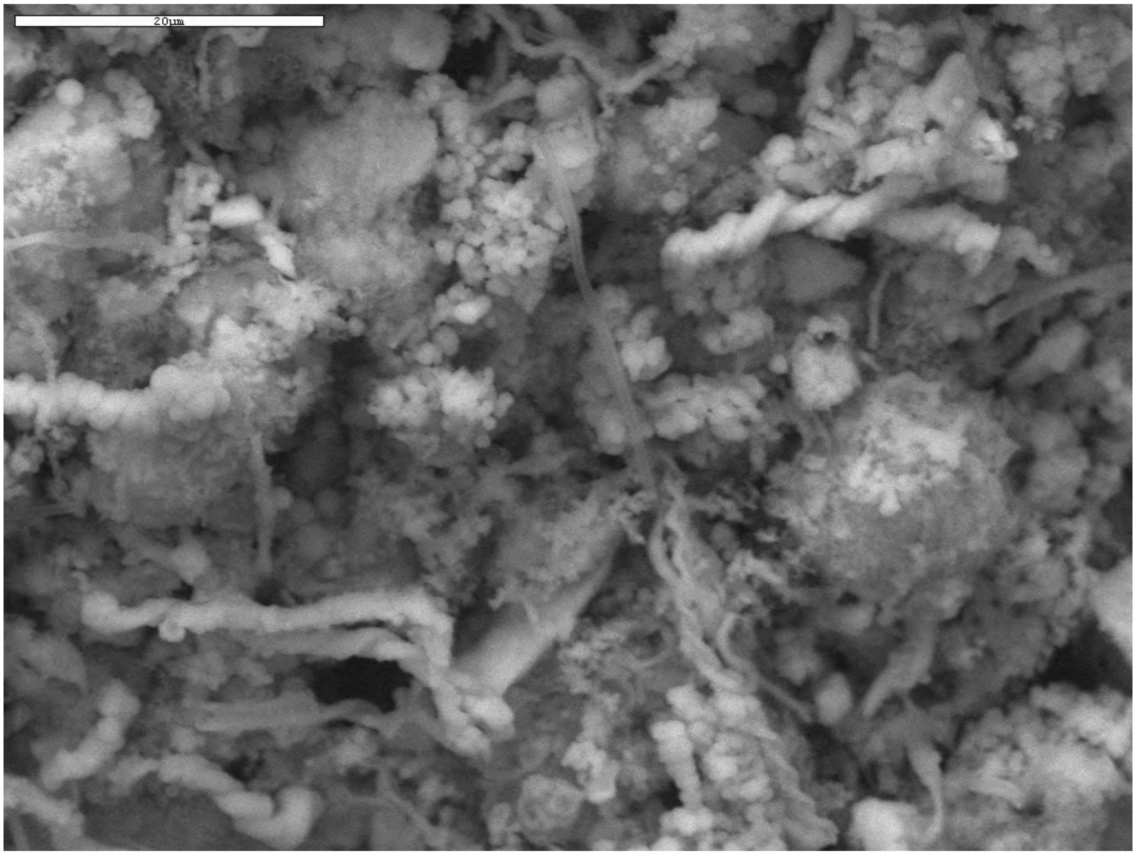


Fig. 7a – Statistical clustering of chemical datasets from sampled PWS wells. Statistical distances are displayed on the left column.

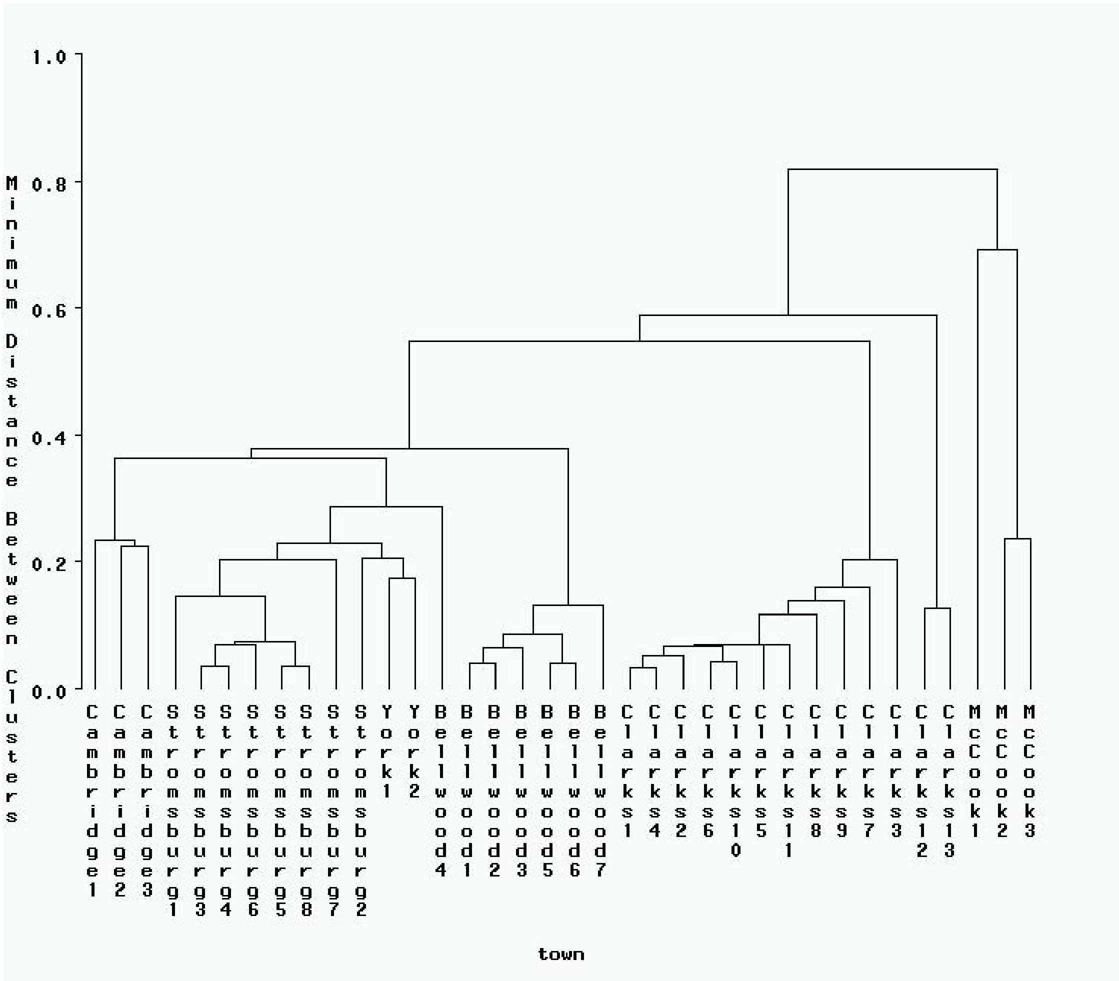


Fig. 7b – Statistical clustering by taxonomic order (family level) of clone library for community similarities in sampled PWS wells. Statistical distances are displayed on the left column.

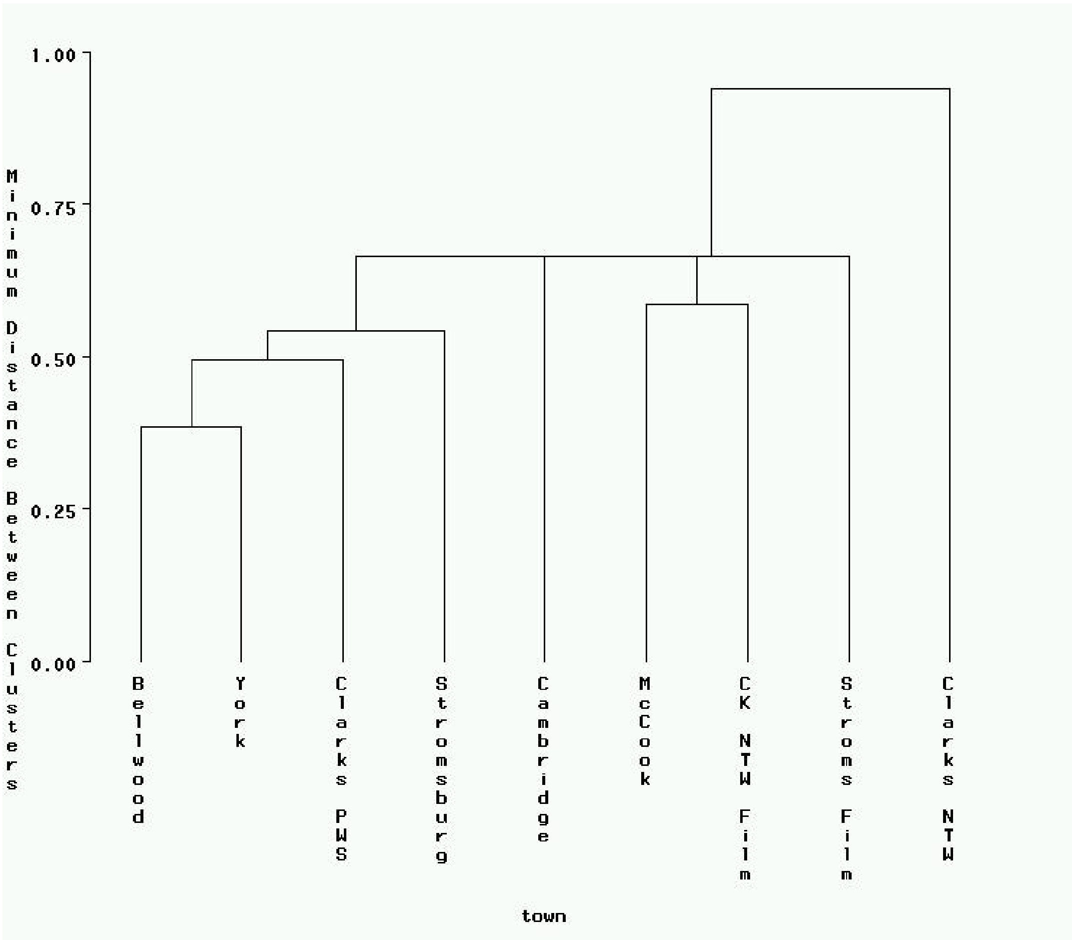
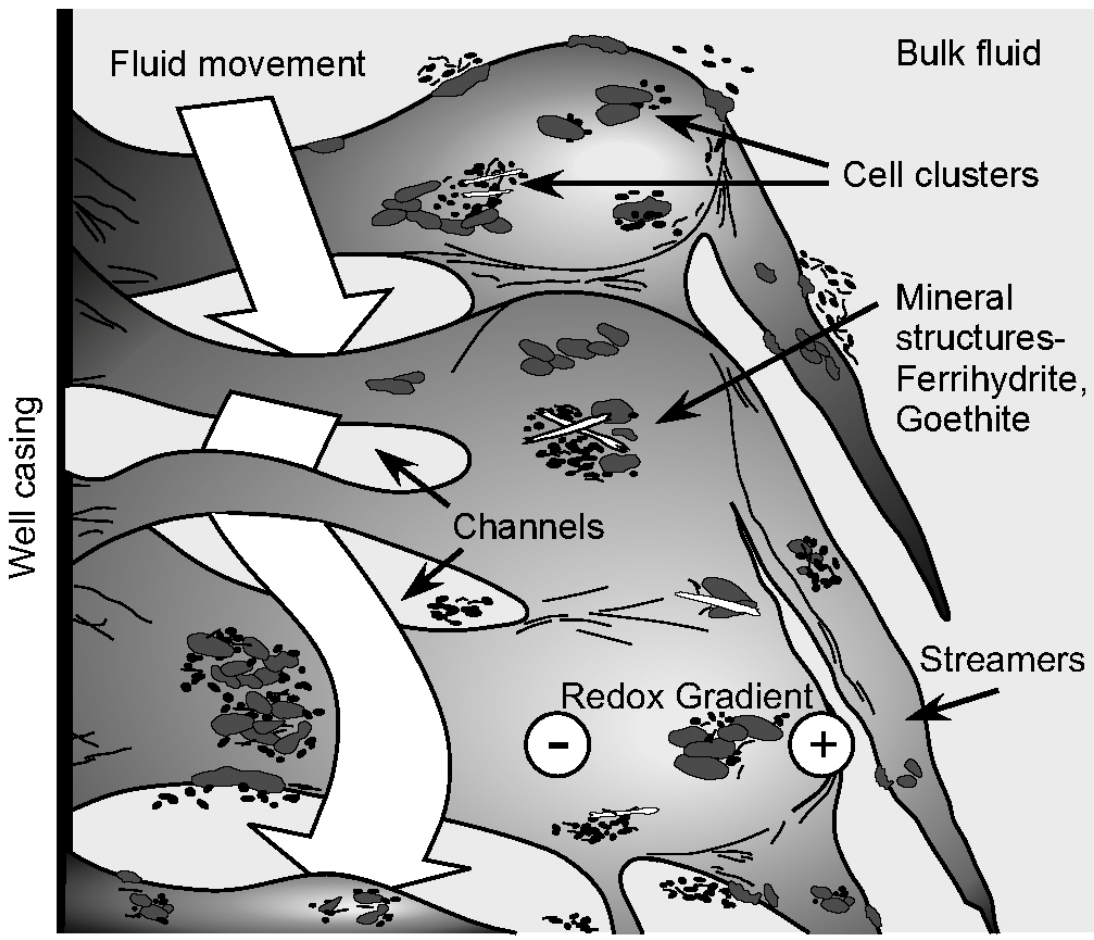


Fig. 8 – Conceptual model of a cross section of biofilm structures attached to PWS well casing and screens.



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Appendix A

Driller's Logs

Registration No. G-28137 County of Custer Date Filed October 4, 1967

STATE OF NEBRASKA

MUNICIPAL OR INDUSTRIAL WELL REGISTRATION

I, Ernest H. Spanel (Name of person signing registration) of Anselmo (Postoffice Address)

County of Custer State of Nebraska, being first duly sworn upon my oath say:

1st. That the name of the owner of the municipal (or) industrial well registered herein is Village of Anselmo whose postoffice address is Anselmo, Nebr. 68813

2nd. That the well is located on the ~~SW~~ NW Quarter of the ~~NW~~ SW Quarter of Section 16, Township 19, Range 22 of the Sixth P. M., Custer County, and it is 210 feet from the west line and 550 feet from the North line of said tract, as accurately shown on the plat on page 2 hereof.

3rd. That the well was installed for the following purpose or purposes: Municipal water supply

4th. That the capacity of said well under normal operating conditions is 150 gallons per minute.

5th. That the depth of the well is 166 feet, measured from the surface of the ground.

6th. That the inside diameter of the casing is 8" inches.

7th. That the static water level in the well is ~~46~~ 40 feet below ground surface.

8th. That the depth to water under normal pumping condition is ~~60~~ 50 (Pumping Level) feet below ground surface.

9th. That the diameter of the pump column is 4 inches. That the diameter of the 8 (Give Number of bowls) bowl or bowls is 8" inches.

10th. That the type and size of impeller is as follows: 8" DKLC

11th. That the well was completed on or about the 7th day of July, 1964

VILLAGE OF ANSELMO

NW SW, Sec. 16, T. 19N., R. 22W., Custer Co.

vol= 43.9 ft³ = 329 gal

~~vol = 40.5 ft³ = 303 gal~~

12th. That attached hereto are three copies of the log of the well certified to by the driller of the well.

13th. That the well was drilled by LAYNE-WESTERN COMPANY whose address is 4430 Commercial Avenue - Omaha, Nebraska

14th. That the relation which the subscriber to this affidavit bears to said registrant is that of Agent (Owner or Agent) and that he is authorized to make this affidavit in behalf of the interest affected.

Ernest H. Spaniel

STATE OF Nebraska

Custer County

I hereby certify that the foregoing was signed in my presence and sworn to before me this 2nd day of October, 1967

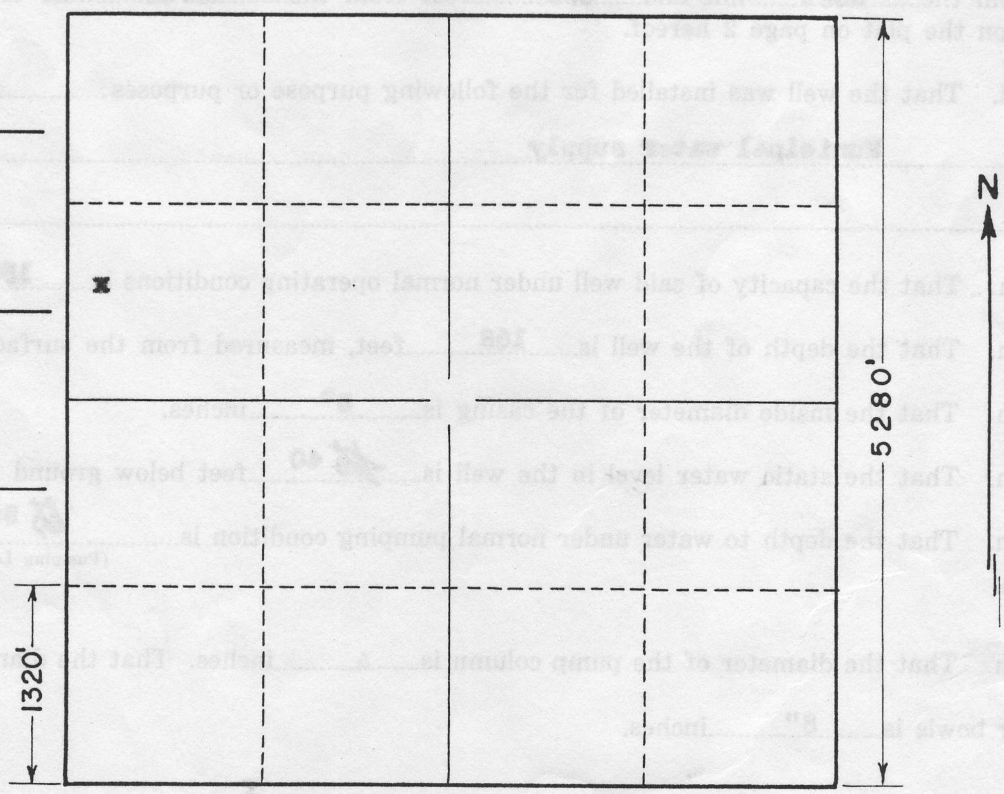
[signature]
Notary Public

This drawing represents one Section

Section No. 16

Township 19

Range 22



Each small subdivision is a 40 acre tract.

State of Nebraska

Department of Water Resources

This instrument was filed for record at 8:30 o'clock A.M. on the 4th day of October, 1967

Dan S. Jones, Jr.
Director of Water Resources

Clev 2604

3

Revised April 1, 1966
Irr. 57-3

Registration No. G-28137 County of Custer Date Filed October 4, 1967

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

I, LAYNE-WESTERN COMPANY (Name of Driller) of 4430 Commercial Ave. - Omaha (Postoffice Address)

County of Douglas State of Nebraska, do hereby certify that:

1. I am the driller of a well located on the NW Quarter, Section No. 16 Township 19 North, Range 22, owned by village of Anselmo whose postoffice address is Anselmo State of Nebraska

2. That the drilling was begun on the ...... day of ......, 19...., and completed on the 7th day of July, 1964

3. That the well is cased and screened in the following manner: 30' of 8", 6 ga. Armco Layne screen from 166' to 136'; 138' of 8" std. T & C steel casing from 136' to 2' above ground (Give kind of casing, lengths and position of plain and screen casing, weight of metallic casing, etc.)

4. That the diameter of drilled hole is 30 inches.

5. That reverse rotary hydraulic type of drilling machinery was used.

6. That the drilled hole is/is not sealed, as follows: 3/16 steel plate

7. That the following is an accurate log of the depth, thickness and character of the different strata penetrated, and the location of water-bearing strata:

DEPTH IN FEET FROM	TO	MATERIAL DRILLED
0	16	Sand
16	19	Clay
19	62	Fine sand
62	80	Sand and trace of blue clay
80	91	Coarse sand and trace of blue clay
91	121	Fine and coarse sand, some gravel, fine clay streaks
121	166	Gravel, fine and coarse sand
166	173	Sandstone

Date Signed 9/14/67

[signature]
Driller R. L. Heckman
LAYNE-WESTERN COMPANY

(If more space is required please use reverse side of this page.)

Layne-Western Company, Inc. Well Information
Omaha, Nebraska

1. Contract Bellwoo , Ne. Date 4-29-76 #1
2. City and State Bellwood, Ne. Driller Bing Herber
3. Well No. 76-1 at test hole No. 76-1 Well location (attach map) north of main street by city building Registration# SD2021
4. Work completed .... No of man hours as charged to job on time sheet ....
5. MATERIAL:

	LENGTH	DIA.	GAUGE OR WALL THICKNESS	MATERIAL	TYPE	NO. OF OPENINGS
6. Screen	20'	12"	7 ga.	S S	Layne	#5
7. Inner Casing	105'	12"	3/8	steel	welded	
8. Outer Casing						

9. 37 tons of gravel used in the well. Size road gravel
10. Test of well. Did you use test or permanent pump? test 12 (Size of Bowl) 3 (Stages)
11. Size of orifice 6 inch by 5 inch. Orifice tube reading 16.5 inches.
12. Pumping test — measurements from ground level:

TIME	G.P.M.	STATIC	DRAWDOWN	PUMPING LEVEL
4 hrs.	500	12'	15'	27'

13. Recovery in 5 minutes complete, in 30 minutes ....
14. Did you seal bottom of well? yes Thickness ¼ inches, material SS
15. Well underreamed? .... From .... feet to .... feet, ... feet to .... feet.
16. If all screen was not placed at bottom, state how it was spaced.
From .... feet to .... feet; from .... feet to .... feet; from .... feet to .... feet.
17. Depth of well from ground level to top of plug 122' Size of drilled hole 32"
18. Was cement placed around or between any of the casings? lost 10'
19. If so, state where, how much and method used. ....

Layne-Western Co...pany, ...rmation

Omaha, Nebraska

CONTRACT Bellwood, Nebraska Well No. 76-1

#1

Log of well from ground level:

Feet		Feet	Formation
0	to	2	black soil
2	to	8	sandy clay
8	to	80	sand and gravel
80	to	98	clay
98	to	122	sand and gravel
	to		
	to		
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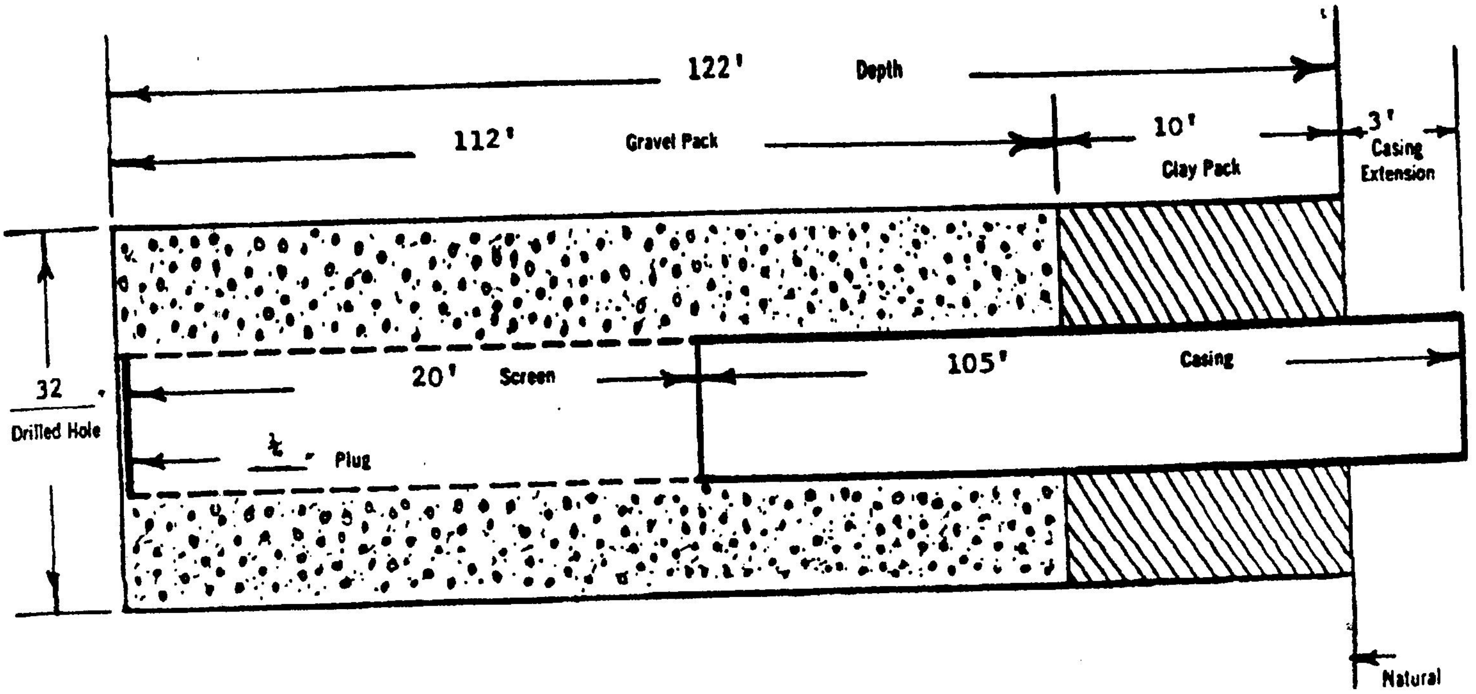


Revised April 1, 1966
Irr. 57-3

Registration No. G-39907 County of Dundy Date Filed June 7, 1973

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

I, Midwest Pump & Drilling (Name of Driller) of Box 126 Brule, (Postoffice Address)

County of Keith State of Nebraska, do hereby certify that:

1. I am the driller of a well located on the ______ Quarter, Section No. 19

Township 1? North, Range 37W. D.P., owned by ______

whose postoffice address is ______ State of ______

2. That the drilling was begun on the 15 day of April, 1972 and completed on the 15 day of April, 1972

3. That the well is cased and screened in the following manner: 0-23 16" OD. .219 well plain casing 23-43 16 " OD Johnson well screen . (Give kind of casing, lengths and position of plain and screen casing, weight of metallic casing, etc.)

4. That the diameter of drilled hole is 28 inches.

5. That straight rotary type of drilling machinery was used.

6. That the drilled hole is/is not sealed, as follows: Medium gravel pack 43-23 23-0 clay packed

7. That the following is an accurate log of the depth, thickness and character of the different strata penetrated, and the location of water-bearing strata:

DEPTH IN FEET FROM TO	MATERIAL DRILLED	
		E 2975
0-12	Top soil	2953 SWL
12-21	Fine sand	
21-24	Fine sand & gravel	To-Ab
24-40	Gravel-clay layers	
40-43	Shale	2935 Kp

Date Signed July 19,1972

[signature] Driller

(If more space is required please use reverse side of this page.)

Report No. .... **NEBRASKA WATER SURVEY—FIELD LOG** Original Altitude 5665

Well Number MO-1-05 T.D. 140 Date 6/9/05

County Morrill Loc.: SW NW SE NW Sec. 33, T. 20 N., R. 50 W

Loc. in section: (circle and cross out) 2050 ft. S of N quarter, half or section line.

1560 ft. E of W quarter, half or section line.

Located in (circle): Upland, side slope, terrace, bottomland, ravine, sand dunes.

Local Description: 10th & Q St Bridgeport, Nebraska

Recorder: Sibray

Drilling Crew: Rider

WATER LEVEL MEASUREMENTS

Date ....
Time ....
Tape Held ....
Water Cut ....
Depth to water ....
Hole open to .... ft. *
*C = caved; P = plugged.

SYMBOLS

CALC. CONTENT	HYD. PRESS.	DRILLING ACTION	
N: Non-calc.	Blank: None	E: Even, smooth	r: Slightly rough
S: Slightly	L: Low	C: Crunchy	R: Mod. rough
M: Moderately	M: Medium	I: Intermittently rough	R: Very rough
V: Very	F: Full		

Drilling Time Record Depth From	To	Time From	To	min.	Depth From	To	Hydraulic Pressure	Drilling Action	FIELD LOG Description and Driller's Notes: (Material, color, texture, hardness, and other notes)	Color	Calc. Cont.
0	2							E	dark brown soil		
3	20							"	f to m sand, minor gravel		
20	35							"	f to m. sand		
35	50							"	f to m sand, minor c. sand		
50	65							"	Ditto		
65	80							"	M to C. sand, very minor fine gravel		
80	95							"	m to c sand, a few rounded pebbles of brown sltst.		
95	110							"	f to m sand, a few clasts of large rounded brown sltst.		
110	115								Ditto		
115	124								Sand, mostly c, some f to m. minor gravel.		
124	140								sltst, brown to gray, & clay.		

city of Bridgeport.

Registration No. G-51717 County of Morrill Date Filed 8-31-76

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

I, Shaul Drilling (Name of Driller) of Harrisburg Box 36 Rt 2 (Postoffice Address)

County of Banner State of Nebraska 69345, do hereby certify that: lot 18

1. I am the driller of a well located on the NE 1/4 Quarter, Section 32 [redacted]
Block 6 Original Town Township 20 North, Range 50, owned by City of Bridgeport
whose postoffice address is Bridgeport State of Nebraska

2. That the drilling was begun on the 24 day of June, 1976, and completed on the 24 day of June, 1976.

3. That the well is cased and screened in the following manner: 92' plain casing top (Give kind of casing, lengths and position of plain and screen casing, weight of metallic casing, etc.) 40' perforated casing in bottom (casing 16" - 6 gage)

4. That the diameter of drilled hole is 24" inches.

5. That Reverse Rotary with air type of drilling machinery was used.

6. That the drilled hole is/is not sealed, as follows: 12' surface casing cemented in. Then gravel packed to bottom, (top sealed)

7. That the following is an accurate log of the depth, thickness and character of the different strata penetrated, and the location of water-bearing strata:

DEPTH IN FEET FROM	TO	MATERIAL DRILLED
0	3'	Top soil
3'	25'	gravel (small to med.)
25'	47'	coarse sand, very little gravel.
47'	51'	coarse sand - gravel - very firm sandy clay.
51'	82'	coarse sand to small gravel.
82'	93'	coarse sand to small gravel.
93'	96'	gravel.
96'	101'	coarse sand small gravel
101'	120'	Gravel small to med.
120'	125'	Broken clay some gravel 125' to 132' clay.

Date Signed June 24 Ken Cushing Driller

(If more space is required please use reverse side of this page.)

— Elev 3582 Sumner Well #751 As = 13ug/L & 14ug/L 3

Registration No. G-50272 County of XXXXXX Morrill Date Filed 6-21-76

STATE OF NEBRASKA

57776

MUNICIPAL OR INDUSTRIAL WELL REGISTRATION

I, Village of Broadwater (Name of person signing registration) of Box 245 Broadwater (Postoffice Address)

County of Morrill State of Nebraska, being first duly sworn upon my oath say

1st. That the name of the owner of the municipal (or) industrial well registered herein is Village of Broadwater whose postoffice address is Broadwater, Nebraska 69125

2nd. That the well is located on the N.E. Quarter of the N.E. Quarter of Section 28 Township 19 N, Range 48 of the Sixth P. M., Morrill County, and it is 780 feet from the North line and 195 feet from the East line of said tract, as accurately shown on the plat on page 2 hereof.

3rd. That the well was installed for the following purpose or purposes: Village supply

4th. That the capacity of said well under normal operating conditions is 1542 gallons per minute

5th. That the depth of the well is 80 feet, measured from the surface of the ground.

6th. That the inside diameter of the casing is 16" inches.

7th. That the static water level in the well is 7'6" feet below ground surface.

8th. That the depth to water under normal pumping condition is 49 (Pumping Level) feet below ground surface.

9th. That the diameter of the pump column is 6 inches. That the diameter of the 4 (Give Number of bowls) bowl or bowls is 12 inches.

10th. That the type and size of impeller is as follows:

4 Stage 12L-54 Bowl Assembly Worthington Turbine Pump

11th. That the well was completed on or about the 22 day of September, 1975

vol = 101.2 ft³

= 757 gal

12th. That attached hereto are three copies of the log of the well certified to by the driller of the well.

13th. That the well was drilled by Haggard Drilling, Inc, whose address is Ogallala, Nebr.

14th. That the relation which the subscriber to this affidavit bears to said registrant is that of Chairman of the Board (Owner or Agent) and that he is authorized to make this affidavit in behalf of the interest affected.

STATE OF Nebraska

Morrill County

I hereby certify that the foregoing was signed in my presence and sworn to before me this 17th day of June, 1976.

Sue O. Nussbaum
Notary Public

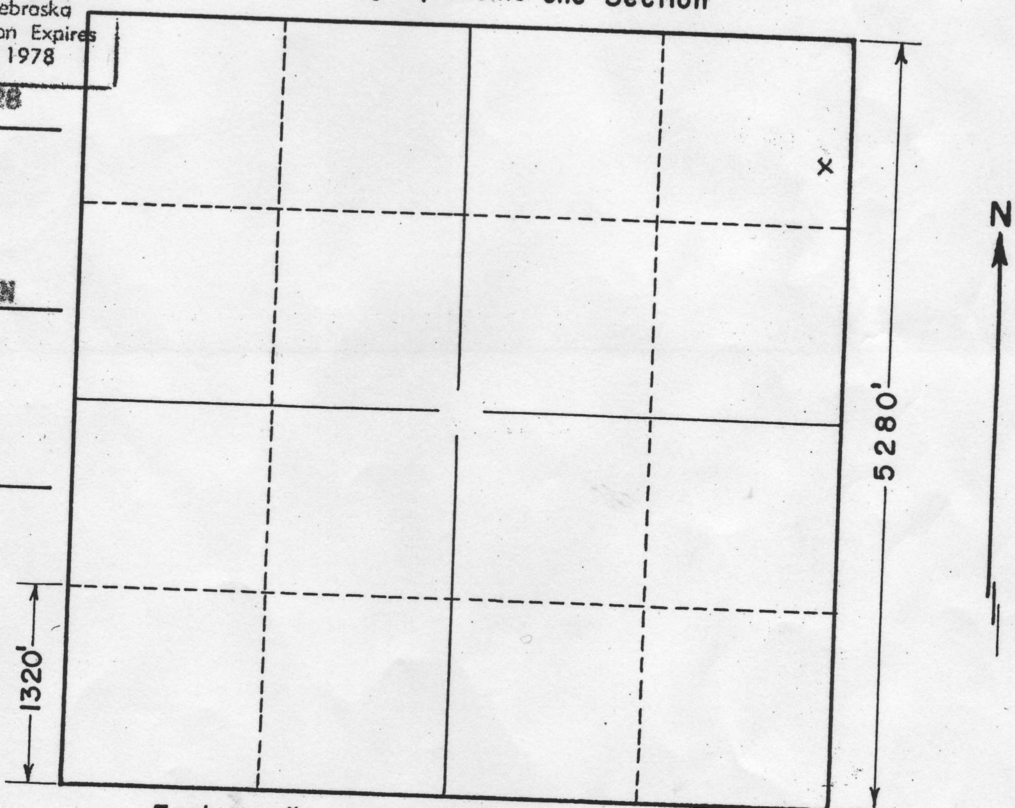
SUE O. NUSSBAUM
GENERAL NOTARY
State of Nebraska
My Commission Expires
Feb. 22, 1978

This drawing represents one Section

Section No. 28

Township 19 N

Range 48



Each small subdivision is a 40 acre tract.

State of Nebraska

Department of Water Resources

This instrument was filed for record at 10 o'clock A M. on the KX 21 day of June, 1976

M.E. Ball
Director of Water Resources

Revised April 1, 1966
Irr. 57-3

Registration No. G-50272 **County of** ~~XXXXXXX~~ Morrill **Date Filed** 6-21-76

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

I, Haggard Drilling, Inc. (Name of Driller) of Ogallala, Nebraska (Postoffice Address)

County of Keith State of Nebraska, do hereby certify that:

1. I am the driller of a well located on the N. E Quarter, Section No. 28 Township 19 N North, Range 46, owned by Village of Broadwater whose postoffice address is Broadwater State of Nebraska.

2. That the drilling was begun on the 14 day of March, 19 75, and completed on the 14 day of March, 19 75.

3. That the well is cased and screened in the following manner: Steel Casing, 40' Plain, 20' screen, 20' perf, 16" casing (Give kind of casing, lengths and position of plain and screen casing, weight of metallic casing, etc.)

4. That the diameter of drilled hole is 30" inches.

5. That Rotary Reverse type of drilling machinery was used.

6. That the drilled hole is/~~XXX~~ is not sealed, as follows: Metal plate welded on the bottom of the well and gravel pack all the way to the top

7. That the following is an accurate log of the depth, thickness and character of the different strata penetrated, and the location of water-bearing strata:

DEPTH IN FEET FROM	TO	MATERIAL DRILLED
0	10	Top Soil clay
10	32	Sand & gravel Med. to fine some coarse
32	65	Sand & gravel Med. to fine
65	85	Brule clay (Broken sts. Brule St. 47±59

Date Signed November 26, 1975

Haggard Drilling, Inc.
Driller

(If more space is required please use reverse side of this page.)

Revised April 1967
M&I - 1

Well # 531

3

Registration No. G-38566 County of Furnas Date Filed March 15, 1973

45751

STATE OF NEBRASKA

MUNICIPAL OR INDUSTRIAL WELL REGISTRATION

I, Ivan E. Wilmot (Name of person signing registration) of 714 Nasby Street (Postoffice Address)

County of Furnas State of Nebraska, do hereby certify:

CITY OF CAMBRIDGE

1st. That the name of the owner of the municipal (or) industrial well registered herein is The City of Cambridge, Nebr. whose postoffice address is 321 Nelson, Cambridge, Nebraska

2nd. That the well is located on the NW Quarter of the NE Quarter of Section 32, Township 4N, Range 25W of the Sixth P. M., Furnas County, and it is 672.8 feet from the North line and 226.7 feet from the East line of said tract, as accurately shown on the plat on page 2 hereof.

3rd. That the well was installed for the following purpose or purposes: Supplying potable water for municipal use and consumption.

Sec. 32, T. 4N., R. 25W., Furnas Co.

4th. That the capacity of said well under normal operating conditions is 400 gallons per minute.

5th. That the depth of the well is 62 feet, measured from the surface of the ground.

6th. That the inside diameter of the casing is 18 inches.

7th. That the static water level in the well is 6'11" feet below ground surface.

8th. That the depth to water under normal pumping condition is 21'5" (Pumping Level) feet below ground surface.

9th. That the diameter of the pump column is 8 inches. That the diameter of the 4 (Give Number of bowls) bowl or bowls is 10 inches.

10th. That the type and size of impeller is as follows: Layne-Western Company Fig. 8KLC, 1750 RPM, Size 10", 4 stages 5"X13 impeller.

11th. That the well was completed on or about the 9th day of November, 1973

vol = 97.3 ft³
= 728 gal

12th. That attached hereto are three copies of the log of the well certified to by the driller of the well.

13th. That the well was drilled by Kerst Brothers, whose address is (was) Bartley, Nebraska (Driller's certificate not available)

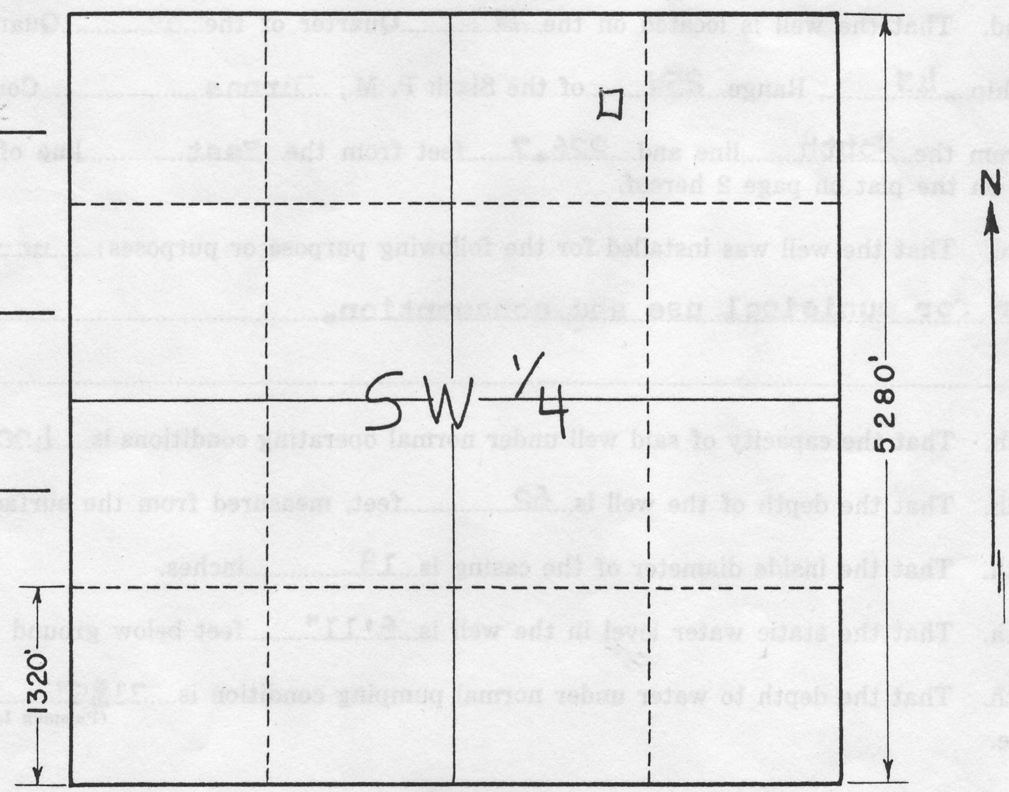
14th. That the relation which the subscriber to this affidavit bears to said registrant is that of Superintendent of Utilities Cambridge, nb and that he is authorized to make this affidavit in
(Owner or Agent)
behalf of the interest affected.

This drawing represents one Section

Section No. ______

Township ______

Range ______



Each small subdivision is a 40 acre tract.

State of Nebraska

Department of Water Resources

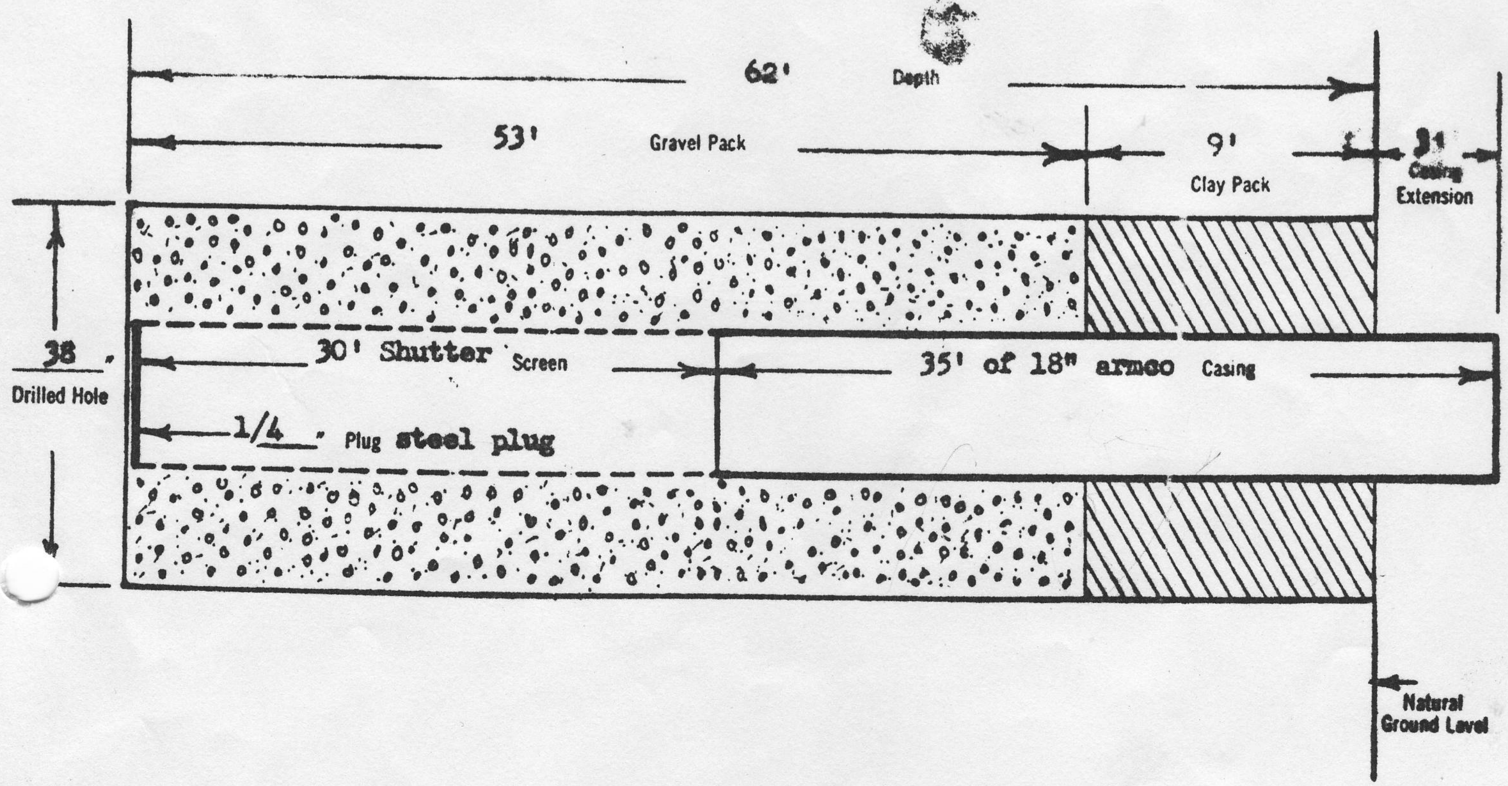
This instrument was filed for record at 10 o'clock A. M. on the 15th day of March, 19 73.

Director of Water Resources

CONTRACT Town of Cambridge Well No. 5

Log of well from ground level: elev 2258

Feet		Feet	Formation
0	to	9	Sandy top soil
9	to	12	Fine sand
12	to	22	Fine and coarse sand, clayballs and trace of gravel
22	to	34	Fine sand with clay and clayballs, soft limerock
34	to	40	Very fine sand with clay, shale, and trace of coarse sand
	to		and gravel
40	to	42	Coarse sand, shale and lime rocks
42	to	51	Fine sand with clay and trace of coarse sand and gravel
51	to	53	Fine sand small gravel 1/16" to 1/8"
53	to	55	Fine to coarse sand trace of gravel
55	to	56	Coarse sand and gravel, clean
56	to	62	Fine to coarse sand and gravel
62	to	Soft shale	
	to		
	to		
	to		



Revised December, 1978 | Well #831 | DWR Form 602

DO NOT WRITE IN THIS SPACE

3

(MUNICIPAL)

Registration No. G-38567B County Furnas Date Filed 2/4/83

WUSE 31-1

STATE OF NEBRASKA
DEPARTMENT OF WATER RESOURCES
WELL REGISTRATION

45753

Type of well to be registered: (Check One)
- [ ] IRRIGATION
- [X] MUNICIPAL
- [ ] INDUSTRIAL
- [ ] Other

1. General information:
   A. Connected well
   Is this well connected to another well? [X] Yes [ ] No G38657, 58 &59
   If yes, give registration number of previously registered well G38566 &67 & G60650
   (If new installation consists of a series of wells with one outlet, complete registration forms and driller's certificates for each and submit $7.50)
   B. Replacement well
   Is this well to replace a permanently abandoned well? [ ] Yes [X] No
   If yes, give registration number of abandoned well ______
   C. Permit No. ______ (required only in a Ground Water Control Area)

2. Name & address of well owner: City of Cambridge
   Box 297
   Cambridge, Nebraska
   Zip Code 69022 Phone (308) 697-3711

3. Name & address of well driller: Layne-Western Company, Inc.
   4430 Commercial Avenue
   Omaha, Nebraska
   Zip Code 68110 Phone: (402) 451.2388

4. Location & purpose of the well:
   A. 23 Lower Republican Natural Resources District (Identify)
   B. SW ¼ of the SE ¼ of Section 29, Township 4N, Range 25 [ ] E [X] W, (check one)
   Furnas County.
   C. The well is 1200 feet from the nearest municipal, irrigation, or industrial well. The nearest well is owned by [X] you [ ] someone other than you. (check one)
   D. The well is intended to irrigate — acres of land, and it is intended to irrigate all or parts of the following land: ______
   OR
   E. The well shall be used for purposes of: Potable water supply

FURNAS CO. Sec. 29, T. 4N, R. 25W

5. Well and pump specifications:
   A. Pumping rate under normal conditions: 450 gallons per minute.
   B. Total well depth: 63 feet.
   C. Inside diameter of the casing: 12 inches.
   D. Static (non-pumping) water level in the well: 7 feet below ground surface.
   E. Depth of water under normal pumping conditions: 16½ feet below ground surface.
   F. Pump column: Diameter 6" inches. Length 55 feet.
   G. The well was completed on or about January 14, 1983.

vol = 43.9 ft³
= 329 gal

MORE ON BACK | MORE ON BACK

ril, 1976

(MUNICIPAL)

Registration No. G-38567B County Furnas Date Filed 2/4/83

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

Permit No. .... (required only in a control area)

Name & Address of well driller: Layne-Western Company, Inc.
4430 Commercial Avenue
Omaha, Nebraska 68110

Well Location:

23 Lower Republican .... Natural Resources District

SW Quarter of the SE Quarter of Section 29, Township 4N, Range 25W,

Furnas County, and owned by City of Cambridge, Nebraska

Drilling & construction specifications:

1. Date construction was begun: January 10 1983
2. Date construction was completed: January 14, 1983
3. Diameter of the drilled hole: 30" inches.
4. Was the hole electronically logged? ☐ Yes ☒ No.
5. How is drilled hole sealed (not sealed)? 20' of cement grout from ground level to 20' below ground level.
6. Well casing & screen: 18' of 12" stainless steel wire wound screen with 0.125" slot from 45' to 63' and 50' of 12" x .375" wall steel casing.
(Give type of casing, lengths and vertical position of plain and slotted segments, slot or perforation size.)
7. Is the well artifically gravel stabilized? ☒ Yes ☐ No

Pumping test information:

1. Pumping rate: 390 gallons per minute.
2. Depth to water before pumping: 7 feet.
3. Depth to water 22' feet after pumping 1410 minutes.

DRILLING LOG ON BACK

DRILLING LOG ON BACK

DRILLING LOG

elev 2255 est

DEPTH IN FEET FROM	TO	MATERIAL DRILLED
0'	1'	Silty clay
1'	28'	Coarse-fine sand, blue color
28'	34'	Coarse-fine sand, blue color
34'	34'-6"	Yellow clay
34'-6"	40'	Coarse-fine sand, buff color
40'	63'	Coarse sand, gravel
63'	65'	Gray shale

Richard S. Hunter
Well Driller's Signature Richard S. Hunter

January 24 1983
Date

Egeland Water Systems
2828 18th Rd
Clarks, NE 68628
Phone #: 308-548-2829

Well Log

Customer: Village Clarks
Project # NE3112101

Date:
Type of Well: 4" test
Driller: Dan

Well Location

Legal Description/Directions: North Well (TW 20042)

Well Depth: 112
Static Water Level: 8
Screen Length: 30
Drawdown: 2'
Slot Size: 16
Grout Placement: 0-110 full length

Depth In Feet:

From	To	Description	From	To	Description
0	10	Topsoil			
10	20	Sand			
20	30	Sand Clay Strips			
30	76	Coarse Sand			
76	79	Clay			
79	96	Sand + Gravel			
96	100	Clay			
100	112	Sand Coarse			
112		Clay			

Egeland Water Systems
2828 18th Rd
Clarks, NE 68628
Phone #: 308-548-2829

Well Log

Customer: Village Clarks
Project # NE 3112101

Date: 2-
Type of Well: 4"
Driller: Dan

Well Location

Legal Description/Directions:
South hole (TW 26041)

Well Depth: 116
Static Water Level: 8'
Screen Length: 30
Drawdown: 2'
Slot Size: #16
Grout Placement: 0 - 114 full length

Depth In Feet:

From	To	Description
0	10	Topsoil
10	20	Sand Med Gravel
20	22	Clay layer
22	40	Sand Many Clay Strips
40	116	Sharp Sand
116	140	Blue Clay

Depth In Feet:

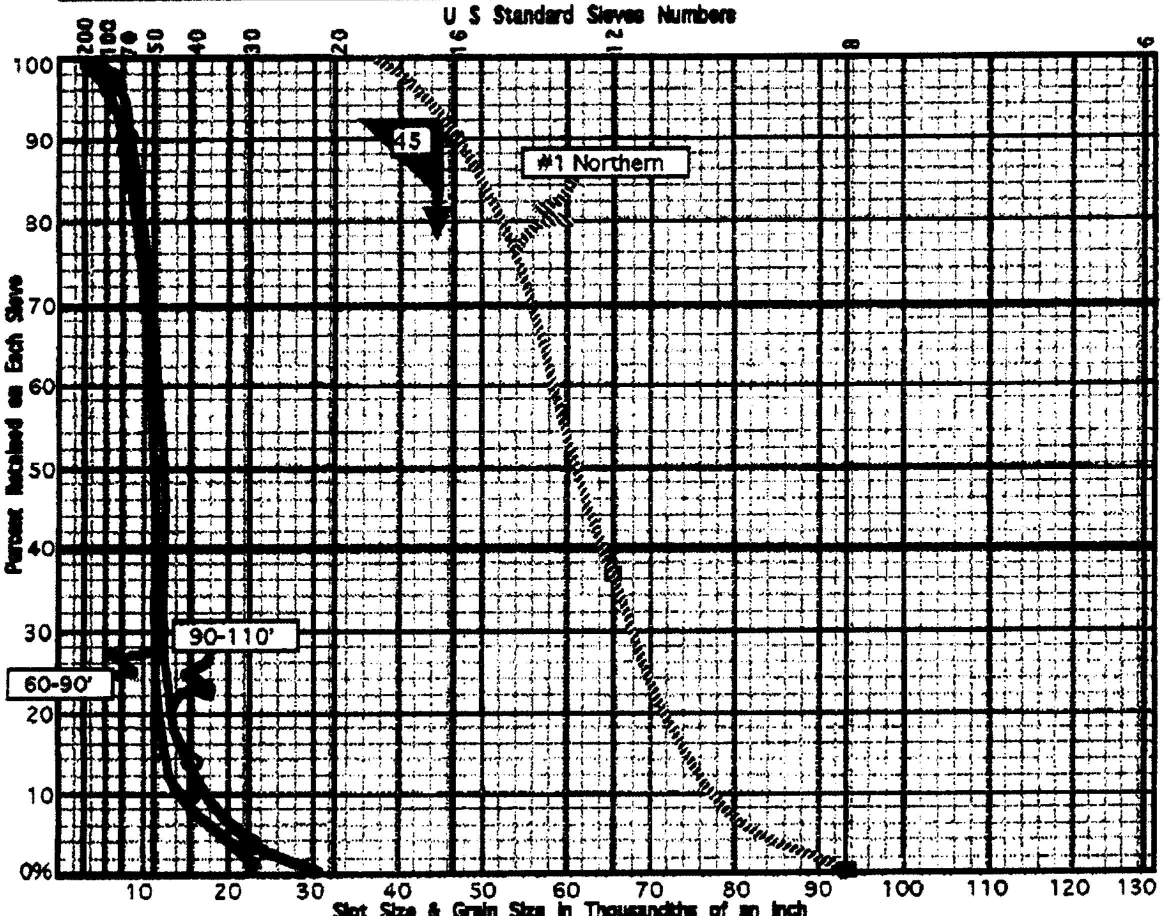
From	To	Description

Check out Alloy's web site @ www.alloyscreen.com

DESIGN WATER TECHNOLOGIES **Fine Sieve Graph**

Job Name Clarks, NE TH20041 Proj #NE3112101 **Date:** Feb 5, 2005
Contractor Egeland Water Systems, Clarks, NE **Engineer** Tagge Engineering
Comments 8' SWL Water Table Aquifer Design **Analysis by** David T. Hanson, Design Water Technologies

Graph Code for Formation Samples
● 60-70', 70-90' ○ 90-110' ■ #1 Northern □



Screen Recommendations **Alloy Const:** 90 x 165 wire	**Slot**	**Length**	**Setting**
Diameter: 12" PS **Open Area:** 170 sq. in./ft or 35.7%. **Transmitting Capacity:** 52.7 GPM/ft @ .1'/sec	45 (.045") slot	35'	80-115'

Comments/Recommendations: The recommended filter pack should be similar to the #1 Northern available from Northern Gravel in Muscatine, IA

Our recommendations are based upon collected samples. We assume no responsibility for the successful, sand free operation of a well

5920 Covington Rd., Shorewood, MN 55331 Toll Free 888.437.6426 or (888 4 den h2o)
Phone 952.474.4657 • Fax 952.470.6637 • E-mail designh2o@aol.com

Check our web site @ www.designwater.com

DESIGN WATER TECHNOLOGIES

Sieve Analysis Work Sheet

Customer: Egeland Water Systems
Project: Clarke WE TH 2004-1
Engineer: Tagaca/[illegible] **Date:** [illegible]

Design Comments: 8' sw

Sample Footages	60-70/70-90'		90-110'					
US Sieve	Retention-Grams/%		Retention-Grams/%		Retention-Grams/%		Retention-Grams/%	
#6								
#8				out				
#12				↑				
#16			4 gr. →					
#20	trace		2 gr.	~~[illegible]~~				
#30	5 gr	2%	11	2.6%				
#40	25	10	58	14				
#50	126	50	218	52.7				
#70	225	89	372	90				
#100	244	96.5	404	97.8%				
#200								
Pan Total	253 gr	100%	413 gr	100%				
Physical Comments/ "P" est.	- fine med - round[illegible] - high silica - good "P" [illegible] 250-300	- fine - med sand - very clean - high silica % - good "P" [illegible] 300 - some shale removed >sieve #16						

5920 Covington Rd, Shorewood, MN 55331 * 952-474-4657 * Fax 952-470-6637

Design Considerations
There is some clay present in the drillers log but I don't believe is significant to present an aquatard for an Artesian Aquifer. The lower portion of the formation is in all likelihood hydraulically connected and therefore will probably react to pumping as a Water Table Aquifer. The recommended screen length (35') represents screening 33% of the saturated thickness (115' total depth - 8' static) which is standard design for optimum capacity while allowing as much available drawdown (pumping level - static level) without pumping into the screen area.

A screen set to a depth of 115' should have a minimum calculated collapse of 23 psi. The recommended screen as manufactured by Alloy Screen of Houston Texas has a calculated collapse strength of 34.07 psi.

Estimates of Well Yield
Visual estimates of Permeability may range between 225 to as high as 400 gallons per day/foot squared. This would calculate to an estimated Transmissivity between 22,500 to 40,000 gallons per day. Estimated field Specific Capacity would be estimated between 7 to 12 GPM/foot of drawdown assuming a field well efficiency of 70% which should be obtainable. Estimated pumping level at a 400 GPM pumping rate would be approximately 42 to 65'.

Please use these only as estimates as all calculations are based upon visual estimates of similar size sand and gravel which may not be truly representative of the actual formation, or any layering effects. It also can not account for any boundary or recharge conditions within the aquifer.

If you have any questions, please call. Thank you.

Sincerely,

Design Water Technologies

David T. Hanson, President
Alloy Screen Technical Representative

Check out our new web site @ www.designwater.com

Enclosed: 2 copies

STATE OF NEBRASKA
DEPARTMENT OF NATURAL RESOURCES
WATER WELL REGISTRATION

Fee Paid $110.00 DNR Cash Fund $18.50
HHSS Fee $70.00 HHSS-DNR Cash Fun $0.00
Get Billing 11323

FOR DEPARTMENT USE ONLY

NOL ID	11223257374058	NOL Status	Accepted	Well Status	A	Registration Code	G-134902
Owner ID	5394	NOL Date	07/27/2005	Call Up Code		Registration Date	07/27/2005
Seq Num	165853			Call Up Date			

Add

07272005 - 165853 -WWRF

1a Owner's Name
b Company Name: Village of Clarks
c Correspondent Name: Attention Name:
Address: PO box 132
City: Clarks State NE Zip Code 68628 - Phone 308 - 548-2412

2a HHSS Contractor Lic ID: 16593903 Contractor's Name: Loren C.Taylor
Contractor's License No: 3919403 Contractor's Email Address:
b Drilling Firm Name: Charles Sargent Irrigation Inc - Geneva
Address: P.O. Box 367
City: Geneva State NE Zip Code 68361 Phone 402 - 759-3902
Drilling Firms Email Address: sargentdrilling@alltel.net

3a Well Location SWSE of Section 30 Township 15 North, Range 4 W (E/W), Merrick County
b Natural Resource District: Central Platte
c The well is 463 feet from the S (N/S) section line and 2103 feet from the E (E/W) section line
GPS: or Latitude: 41 14' 09.90" Longitude: -097 49' 03.30"
d Street address or block, lot and subdivision, if applicable: Block No Lot
e Location of water use, if applicable (give legal descriptions): Village of Clarks
f If for irrigation, the land to be irrigated is Acres
g Well Reference letter(s), if applicable: 05-1 North should be 05-J

Doug will change (Per D.Peterson, Tagge Eng & Doug Yantze, Sargent Drilling 3/12/07)

4 Permits

Permits	Permits Number	Date	Permits	Permits Number	Date
Management Area Permit	CPMI6104057	12/17/2004	Transfer Out-Of-State		
Surface Water			Well Spacing		
Geothermal			Conduct Water		
Industrial			Municipal		
Industrial Transfer Notice			Other		

5 Purpose of Well: Public Water Supplier with Spacing Prote Other:
Notes:

6 Wells in a Series
a Is this well a part of a series? ☐
b If one or more of the wells in the series is currently registered, give the well registration number
c How many wells in the series are you registering at this time?

7 Replacement and abandoned well information Replacement Number
a Is this well a replacement well? ☐
b Registration number of abandoned well
If not registered, date abandoned well was constructed
c Replacement well is feet from abandoned well.
d Abandoned well last operated

e Original well pump column size: [ ] inches. f Completion of original well abandonment on [ ]

g Location of water use of abandoned well [ ]

8 Pump Information

a Is pump installed at this time? ☑

Is pump installed by well owner in section 1? ☐ Is pump installed by contractor in section 2? ☑

Else installed by pump installer.

b HHSS Installer's License ID. 16593903

Pump Installer's License No. 3919403 Pump Installer's Name Loren C.Taylor

Pump Installer's Email Address

Pump Installer's Firm Name Charles Sargent Irrigation Inc - Geneva

Pump Installer's Firm Address P.O. Box 367

City: Geneva State NE Zip Code 68361-0000 Phone 402 - 759-3902

Pump Installer's Firm Email Address Sargentdrilling@alltel.net

c Pumping Rate 300 gallons per minute M measured or estimated

d Drop pipe diameter 4 inches e Length of drop pipe 86 .5 feet.

f Pumping equipment installed 07 / 11 / 2005 g Pump Brand Grundfos

h This well will be used to pump less than 50 gpm ☐

9 Well Construction Information

a Total well depth 115 . feet. b Static Water Level 12 .5 feet.

c Pumping Water Level 35 . feet. d Well construction began: 05 / 09 / 2005

e Well construction completed: 05 / 09 / 2005 f Bore hole diameter in inches. Top 24 . Bottom 24 .

g Casing and Screen Joints Welded Other

10 Well Construction (Casing and Screen)

Ft Depth	To Depth	Case Scrn	In Diam	Out Diam	Thickness	Scrn Slot Size	Material	Trade name	NOLID
-4	79.5	casing	12.00	12.75	.375		Steel		112232573740
79.5	115	screen	12.00	12.75	.375	.030	Stainless	Stainless stee	112232573740

11 Well Construction (Grout and Gravel)

NOL ID	From Depth	To Depth	GroutGravel	Material
11223257374058	0	15	grout	Contrete
11223257374058	15	64	grout	Bentonite
11223257374058	64	115	gravel	Chlorinated Gravel Pack

12 Geolog Material Logged

NOL ID	From Depth	To Depth	Description
11223257374058	0	2	Clay
11223257374058	2	5	Fine sand
11223257374058	5	7	Clay
11223257374058	7	13	Coarse sand and fine gravel
11223257374058	13	20	Medium to fine sand and coarse sand
11223257374058	20	40	Fine to medium sand with trace fine gravel
11223257374058	40	53	Fine to medium sand , fine gravel
11223257374058	53	55	Blue clay
11223257374058	55	59	Fine to medium blue gravel
11223257374058	59	60	Clay
11223257374058	60	62	Blue clay
11223257374058	62	80	Fine blue sand with blue clay streaks

NOL ID	From Depth	To Depth	Description
11223257374058	80	100	Fine to medium blue sand with trace blue clay streaks
11223257374058	100	114	Fine to medium sand with trace blue clay streaks
11223257374058	114	116	Hard
11223257374058	116	120	Shale

Village of Clarks, NE

Given to me 11/2006
(Best Info per Dan Peterson from Tagge Engineering)

Type	Production Well	Test Hole Log	Production Well	Test Hole Log
HHS Designation	2005-2	2005-2	2005-1	2005-1
DNR Registration	G-134902	-	G-134901	-
Physical Designation	North	North	South	South
GPS Location	41° 14' 10.0"	41° 14' 09.8"	41° 14' 06.5"	41° 14' 06.2"
	97° 49' 03.3"	97° 49' 03.0"	97° 49' 08.5"	97° 49' 07.4"
Section Line Distance				
From South Line, ft	463	453	121	92
From East Line, ft	2103	2080	2497	2415
Well Depth, ft	115	120	116	120
Screen, ft	79.5 to 115		80.5 to 116.0	

Modified as per UNL

Install Packer, ft	97.5 to 101.5
Cement Bottom, ft	2
Screen, ft	101.5 to 116
Screen Length, ft	14.5
Blockage, %	0
Flowrate, gpm	220
Veloctiy, ft/s	0.05
	OK

elev. 2680 (2nd was abandoned)

Series of 2 wells

Revised December, 1978 DWR Form 602

DO NOT WRITE IN THIS SPACE

3

Registration No. G-62786A County Gosper Date Filed 12/7/79

10661

STATE OF NEBRASKA
DEPARTMENT OF WATER RESOURCES
WELL REGISTRATION

Type of well to be registered: (Check One)

- [ ] IRRIGATION
- [X] MUNICIPAL
- [ ] INDUSTRIAL
- [ ] Other ______

VILLAGE OF ELWOOD

1. General information:
   A. Connected well
      Is this well connected to another well? [X] Yes [ ] No
      If yes, give registration number of previously registered well ______
      (If new installation consists of a series of wells with one outlet, complete registration forms and driller's certificates for each and submit $7.50)
   B. Replacement well
      Is this well to replace a permanently abandoned well? [ ] Yes [X] No
      If yes, give registration number of abandoned well ______
   C. Permit No. ______ (required only in a Ground Water Control Area)

2. Name & address of well owner: Village of Elwood
   Elwood, Nebraska

   Zip Code 68937 Phone (308) 785-2480

3. Name & address of well driller: Olson & Anderson
   Oakland, Nebraska

   Zip Code ______ Phone: ( )

GOSPER

NE SW, 7N, 22W, Sec. 7

4. Location & purpose of the well:
   A. Tri-Basin 24 Natural Resources District (Identify)
   B. NE ¼ of the SW ¼ of Section 7, Township 7, Range 22 [ ] E [X] W, (check one)
      Gosper County.
   C. The well is 2,350 feet from the nearest municipal, irrigation, or industrial well. The nearest well is owned by [X] you [ ] someone other than you. (check one)
   D. The well is intended to irrigate —— acres of land, and it is intended to irrigate all or parts of the following land: ______
      OR
   E. The well shall be used for purposes of: municipal water supply - Elwood, Nebraska.

5. Well and pump specifications:
   A. Pumping rate under normal conditions: 600 gallons per minute.
   B. Total well depth: 338 feet.
   C. Inside diameter of the casing: 10 inches.
   D. Static (non-pumping) water level in the well: 295 feet below ground surface.
   E. Depth of water under normal pumping conditions: unknown feet below ground surface.
   F. Pump column: Diameter 6 inches. Length 320 feet.
   G. The well was completed on or about ______, 19 03.

vol = 23.5 ft³ = 175 gal

MORE ON BACK MORE ON BACK

Revised April, 1976

Series of 2 wells

Registration No. G-62796 County Gosper Date Filed 12/7/79

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

Permit No. .... (required only in a control area)

Name & Address of well driller: Olson & Anderson
Oakland, Nebraska

Well Location:

Tri-Basin Natural Resources District

NE Quarter of the SW Quarter of Section 7, Township 7N, Range 22W,

Gosper County, and owned by Village of Elwood

Drilling & construction specifications:

1. Date construction was begun: ...., 19 ....
2. Date construction was completed: ...., 1903.
3. Diameter of the drilled hole: 10 inches.
4. Was the hole electronically logged? ☐ Yes ☒ No.
5. How is drilled hole sealed (not sealed)? 2 foot cement cap
6. Well casing & screen: 322' of 10" special drive pipe (35.75 lbs. lft) & 16' of 60 slot cook strainer
(Give type of casing, lengths and vertical position of plain and slotted segments, slot or perforation size.)
7. Is the well artifically gravel stabilized? ☐ Yes ☒ No

Pumping test information:

1. Pumping rate: .... gallons per minute.
2. Depth to water before pumping: .... feet.
3. Depth to water .... feet after pumping .... minutes.

DRILLING LOG ON BACK DRILLING LOG ON BACK

MORE ON BACK

DRILLING LOG

DEPTH IN FEET FROM	TO	MATERIAL DRILLED
0	292'	Clay
292	295'	Dry Sand
295	338'	Water Bearing Gravel

Village of Elwood
Well Driller's Signature

12-6-79
Date

Winona Robb - Village Clerk

Revised April 1967
M&I - 1

Dundy

3

Registration No. G-30112 County of undy Date Filed Aug. 13, 1968

36961

STATE OF NEBRASKA

MUNICIPAL OR INDUSTRIAL WELL REGISTRATION

I, Village of Haigler (Name of person signing registration) of Haigler (Postoffice Address)

County of Dundy State of Nebraska, do hereby certify:

1st. That the name of the owner of the municipal (or) ~~industrial~~ well registered herein is Village of Haigler whose postoffice address is Haigler Nebr.

2nd. That the well is located on the ... Quarter of the ... Quarter of Section 23, Township 1, Range 41 of the Sixth P. M., undy County, and it is 18 feet from the North line and 400 feet from the West line of said tract, as accurately shown on the plat on page 2 hereof.

3rd. That the well was installed for the following purpose or purposes: Supply the Village with Water.

4th. That the capacity of said well under normal operating conditions is 275 gallons per minute.
275

5th. That the depth of the well is 98' 9" feet, measured from the surface of the ground.
98' 9"

6th. That the inside diameter of the casing is 16 inches.

7th. That the static water level in the well is 54' 4" feet below ground surface.

8th. That the depth to water under normal pumping condition is 59 (Pumping Level) feet below ground surface.
59

9th. That the diameter of the pump column is 5 inches. That the diameter of the 10 (Give Number of bowls) bowl or bowls is 10 inches.

10th. That the type and size of impeller is as follows: Peerless Pump

10 Stage 10LA ... with ...-84391 Bronze Impellers ... -1103

10 Stage 10LA Boyles with - 84391 Bronze Impellers

Capacity of the pump 275 ... a head of 320 feet

Capacity of the pump 275 GPM with a head of 320 feet

11th. That the well was completed on or about the 30th day of arch, 1965

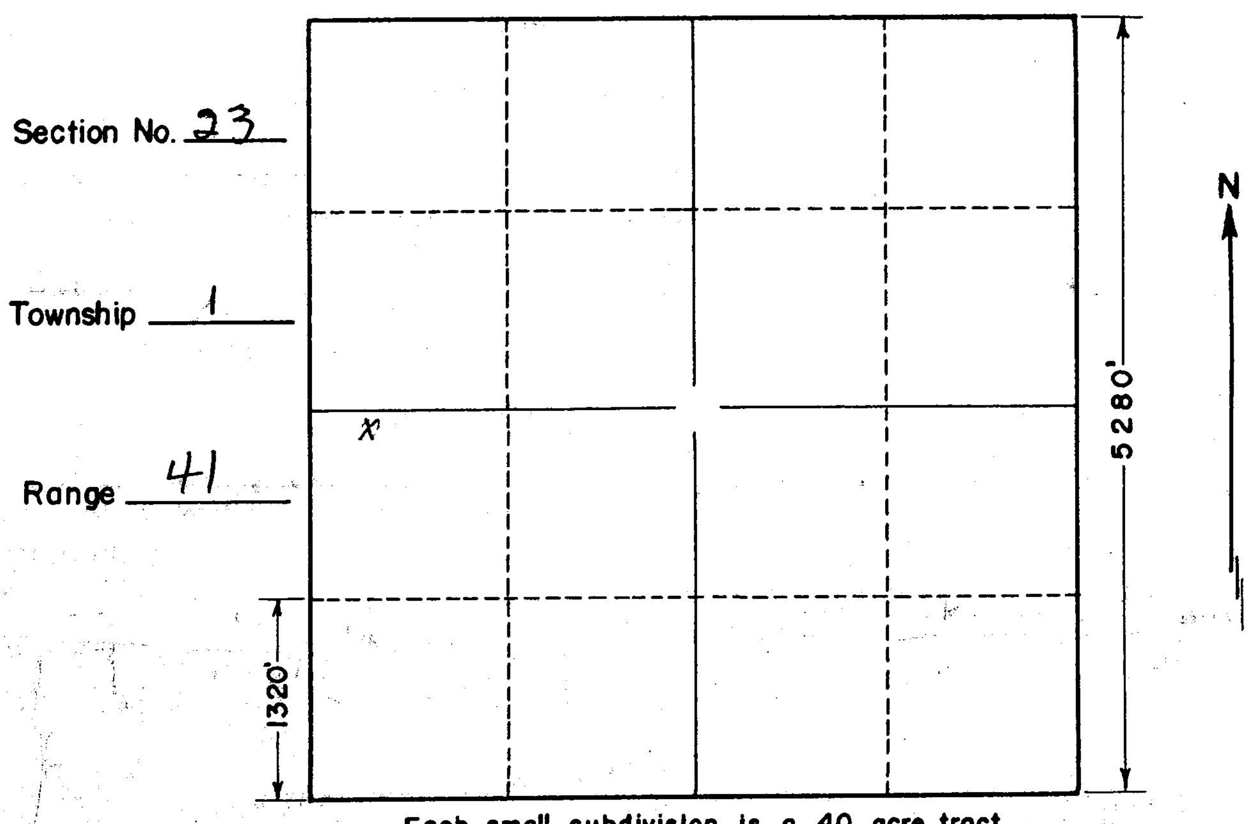
30 March 1965

12th. That attached hereto are three copies of the log of the well certified to by the driller of the well.

13th. That the well was drilled by James Putman whose address is Ogallala Nebr.

14th. That the relation which the subscriber to this affidavit bears to said registrant is that of Village of Haigler (Owner or Agent) and that he is authorized to make this affidavit in behalf of the interest affected.

Keith M. Day



State of Nebraska

Department of Water Resources

This instrument was filed for record at 8:30 o'clock A. M. on the 13th day of August, 1968.

Dan S. Jones Jr.
Director of Water Resources

Revised April 1, 1966
Irr. 57-3

Registration No. G-30112 County of Dundy Dundy Date Filed August 13, 1968

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

I, James B. Putman (Name of Driller) of Ogallala (Postoffice Address)

County of Keith State of Nebraska, do hereby certify that:

1. I am the driller of a well located on the NW ¼ of the NW Quarter, Section No. 23

Township 1 North, Range 41, owned by Village of Haigler

whose postoffice address is Haigler State of Nebraska

2. That the drilling was begun on the 30th day of March, 19 65 and completed on the 30th day of March, 19 65.

3. That the well is cased and screened in the following manner: 2½' above ground 77' 3" Plain casing 16" 0.203" steel pipe; 77' 3" to 98' 9" 16" x 3/16" Perforated Armco Iron with 0.100 Slot (Give kind of casing, lengths and position of plain and screen casing, weight of metallic casing, etc.)

4. That the diameter of drilled hole is 36 inches.

5. That Rotary Reverse Hydraulic type of drilling machinery was used

6. That the drilled hole is/~~is not~~ sealed, as follows: 0 - 10' Clay, 10 - 50 Earth fill, 50 - 98' Gravel Pack. The casing is closed on the bottom with a steel plate.

7. That the following is an accurate log of the depth, thickness and character of the different strata penetrated, and the location of water-bearing strata:

DEPTH IN FEET FROM	TO	MATERIAL DRILLED	
0	5	Top Soil	
5	33	Soft Sandstone	
33	44	Fine sand to fine gravel	
44	48	Fine sand to medium gravel	
48	52	Clay	
52	66	Fine sand to medium gravel	Static Water Level 54' 4"
66	76	Clay	
76	85	Fine sand to medium gravel	Results of Pumping
85	90	Clay and gravel	
90	99	Sand to coarse gravel	1,110 G. P. M Lift 71' 8"
99		Pierre Shale	Draw Down 17' 4"
			Specific Yield 64.5 gallons per foot

Date Signed August 2 1967

James B Putman
James B. Putman Driller

(If more space is required please use reverse side of this page.)

well ID# 757

elev 3833

Revised April 1967
Irr. 57-1

3

Registration No. G-47215 County of Cheyenne Date Filed ~~9-19-75~~ 10/17/75

STATE OF NEBRASKA

MUNICIPAL ~~IRRIGATION~~ WELL REGISTRATION

Lloyd R. Dykman, Utilities Supt.

I, Village of Lodgepole (Name of Person registering well) of Lodgepole, Nebraska (Postoffice Address)

County of Cheyenne State of Nebraska, do hereby certify:

1st. That the name of the owner of the land upon which the ~~irrigation~~ Lodgepole well is located is Village of Lodgepole, of .... Street, Village (City or Village) County of Cheyenne State of Nebraska.

2nd. That the irrigation well is located on the NW Quarter of the .... Quarter of Section 32 Township 14 N, Range 46 W of the Sixth P. M., Cheyenne County, and is 748 feet from the West line and 942 feet from the North line of said tract.

3rd. That the well was installed with the intention of irrigating all or parts of the following described land: This well is to be used as a source of water supply for the Village of Lodgepole. (Give Quarter, Section, Township and Range)

amounting in all to approximately .... acres.

(If installation consists of a battery of wells with one outlet, give details on a sheet to be attached hereto.)

4th. That the capacity of said well under normal operating conditions is ~~399~~ 600 gallons per minute.

5th. That the depth of the well is 200 feet, measured from the surface of the ground.

6th. That the inside diameter of the casing is 36 inches.

7th. That the static water level in the well is 17 feet below ground surface.

8th. That the depth to water under normal pumping conditions is 80 (Pumping Level) feet below ground surface.

9th. That the diameter of the pump column is 6 5/8 inches. That the diameter of the 6 stage (Give number of bowls) bowl or bowls is 10 inches.

10th. That the type and size of impeller is as follows:

Western Landroller Water Loop Turbine Pump 6 Stage 10 CH

6 stage 10 C.H. Western Landroller Water Loop Turbine Pump

11th. That the well was completed on or about the 19th day of September, 19 75.

vol = 1293.6 ft3
= 9676 gal

VILLAGE OF LODGEPOLE

Sec. 32, T. 14N., R. 46W., Cheyenne Co.

Revised April 1967
Irr. 57-2

3

12th. That attached hereto are three copies of the log of the well certified to by the driller of the well.

13th. That the driller of this well is Haggard Drilling, Inc., whose address is Ogallala, Nebraska 69153

14th. That the name of the tenant or operator, if other than the owner, is ______________________, whose address is ______________________

15th. That the relation which the subscriber to this instrument bears to said registrant is that of ______________________
(State whether owner, tenant or agent for land on which well is located)
and that he is authorized to sign this instrument in behalf of the interest affected.

Signed: Lloyd R. Mylsman

Dated: 9-19-75

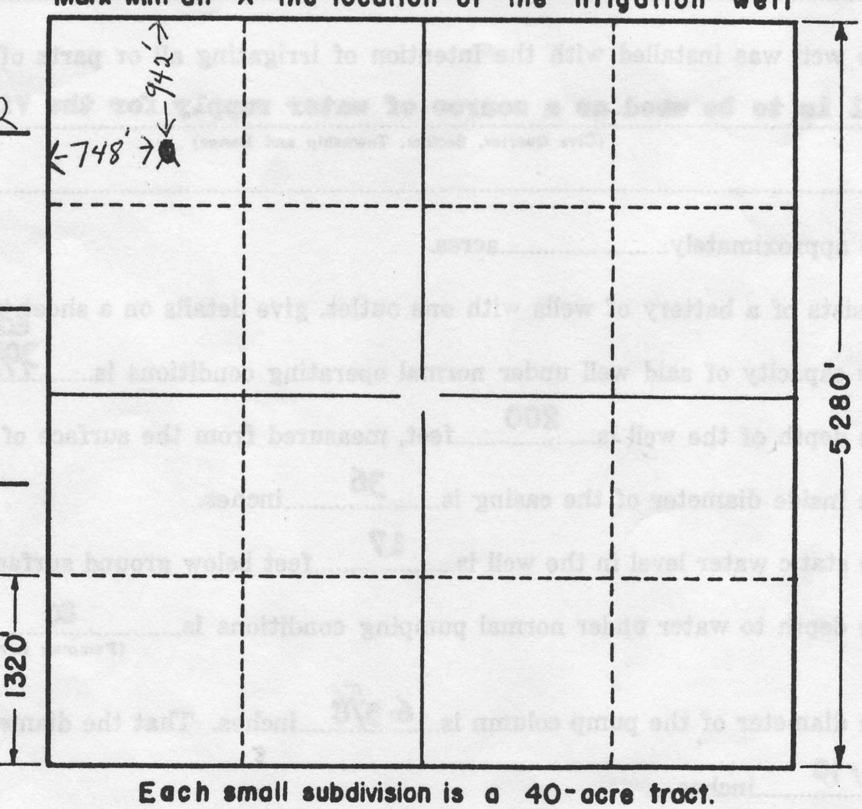
This drawing represents one Section

Mark with an "X" the location of the irrigation well

Section No. 32

Township 14

Range 46



Each small subdivision is a 40-acre tract.

State of Nebraska
Department of Water Resources } ss.

This instrument was filed for record at 10 o'clock A M., on the 17th day of October 19 75

M. E. Ball
Director of Water Resources

Revised April 1, 1966
Irr. [illegible]

Registration No. G-47215 County of Cheyenne Date Filed Oct. 17, 1975

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

I, Haggard Drilling (Name of Driller) of Ogalalla, Ne. (Postoffice Address)

County of Keith State of Nebraska, do hereby certify that:

1. I am the driller of a well located on the Northwest Quarter, Section No. 32 Township 14 North, Range 46, owned by Village of Lodgepole whose postoffice address is Box 266 State of Nebraska.

2. That the drilling was begun on the 26 day of February, 1975, and completed on the 26 day of February, 1975.

3. That the well is cased and screened in the following manner: Originally a 200' well with 22' culvert casing-recased September 20, 1975 with 60' plain and 140' perf. steel casing. (Give kind of casing, lengths and position of plain and screen casing, weight of metallic casing, etc.)

4. That the diameter of drilled hole is 42-28 inches.

5. That rotary-reverse type of drilling machinery was used.

6. That the drilled hole is/~~is not~~ sealed, as follows: Metal plate welded on the bottom of the well and gravel pack all the way to the top.

7. That the following is an accurate log of the depth, thickness and character of the different strata penetrated, and the location of water-bearing strata:

DEPTH IN FEET FROM	TO	MATERIAL DRILLED
0	21	Top soil w/gravel-clay w/gravel
21	122	Bruel clay-broken
122	152	Brule-broken
152	200	Brule clay-hard

2nd copy sent to city

Date Signed October 15, 1975

~~Haggard Drilling, Inc.~~
by Kathy Jessen
Driller

(If more space is required please use reverse side of this page.)

Revised April 1967
M&I - 1

Registration No. G-30430 County of Red Willow Date Filed Sept. 24, 1968

37306

STATE OF NEBRASKA

MUNICIPAL OR INDUSTRIAL WELL REGISTRATION

I, A. J. Ray of McCook
(Name of person signing registration) (Postoffice Address)

County of Red Willow State of Nebr. do hereby certify:

1st. That the name of the owner of the municipal (or) industrial well registered herein is City of McCook whose postoffice address is McCook, Nebr.

2nd. That the well is located on the SW Quarter of the NW Quarter of Section 5, Township 2, Range 29 of the Sixth P. M., Red Willow County, and it is 462 feet from the West line and 623 feet from the South line of said tract, as accurately shown on the plat on page 2 hereof.

3rd. That the well was installed for the following purpose or purposes:

Municipal Water Supply

4th. That the capacity of said well under normal operating conditions is 900 gallons per minute.

5th. That the depth of the well is 83 feet, measured from the surface of the ground.

6th. That the inside diameter of the casing is 26 inches.

7th. That the static water level in the well is 22 feet below ground surface.

8th. That the depth to water under normal pumping condition is 48 (Pumping Level) feet below ground surface.

9th. That the diameter of the pump column is 10 inches. That the diameter of the 3 (Give Number of bowls) bowl or bowls is 24 inches.

10th. That the type and size of impeller is as follows:

24" PELC

11th. That the well was completed on or about the 26th. day of July, 1936

CITY OF MCCOOK

Sec. 5, T. 2N., R. 29W., Redwillow Co.

elev
2486

Revised April 1, 1966
Irr. 57-3

3

Registration No. G-30430 County of Red Willow Date Filed September 24, 1968

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

I, LAYNE-WESTERN COMPANY, INC. (Name of Driller) of 4430 Commercial Ave. - Omaha (Postoffice Address)

County of Douglas State of Nebraska, do hereby certify that:

1. I am the driller of a well located on the North-West Quarter, Section No. 5 Township 2 North, Range 29, owned by City of McCook whose postoffice address is McCook State of Nebraska

2. That the drilling was begun on the .... day of ...., 19...., and completed on the 6th day of July, 19 36

3. That the well is cased and screened in the following manner: 25' of 26" shutter screen; 55' of 26" inside casing; 20' of 38" outside casing (Give kind of casing, lengths and position of plain and screen casing, weight of metallic casing, etc.)

4. That the diameter of drilled hole is --- inches.

5. That ~~rotary~~ blind Casing type of drilling machinery was used.

6. That the drilled hole is/is ~~not~~ sealed, as follows: 12" plug

7. That the following is an accurate log of the depth, thickness and character of the different strata penetrated, and the location of water-bearing strata:

E 2486

DEPTH IN FEET FROM	TO	MATERIAL DRILLED
0	4	Soil
4	14	Sandy clay
14	18	Fine sand
18	35	Coarse sand and gravel
35	45	Medium fine sand
45	84	Coarse sand and gravel
84'		shale

2464 swl

2402 Kp

Date Signed August 27, 1968

George H. Beard
Driller G. H. BEARD
LAYNE-WESTERN CO., INC.

(If more space is required please use reverse side of this page.)

Revised April 1967
M&I - 1

3

Registration No. G-30429 County of Red Willow Date Filed Sept. 24, 1968

37305 #4

9150 44-1

STATE OF NEBRASKA

MUNICIPAL OR INDUSTRIAL WELL REGISTRATION

I, A. J. Ray (Name of person signing registration) of McCook (Postoffice Address)

County of Red Willow State of Nebr., do hereby certify:

1st. That the name of the owner of the municipal (or) industrial well registered herein is City of McCook whose postoffice address is McCook, Nebr.

2nd. That the well is located on the SW Quarter of the NW Quarter of Section 5, Township 2, Range 29 of the Sixth P. M., Red Willow County, and it is 41 feet from the West line and 85 feet from the South line of said tract, as accurately shown on the plat on page 2 hereof.

3rd. That the well was installed for the following purpose or purposes: Municipal Water Supply

4th. That the capacity of said well under normal operating conditions is 1400 gallons per minute.

5th. That the depth of the well is 81 feet, measured from the surface of the ground.

6th. That the inside diameter of the casing is 30 inches.

7th. That the static water level in the well is 22 feet below ground surface.

8th. That the depth to water under normal pumping condition is 44 (Pumping Level) feet below ground surface.

9th. That the diameter of the pump column is 10 inches. That the diameter of the 3 (Give Number of bowls) bowl or bowls is 24 inches.

10th. That the type and size of impeller is as follows: 24" PEMC

11th. That the well was completed on or about the 2nd day of Feb., 19 44

vol = 289.6 ft^3
= 2166.5 gal

CITY OF MCCOOK

Sec. 5, T. 2N., R. 29W., Redwillow Co.

elev 2488

Revised April 1, 1966
Irr. 57-3

3

Registration No. G-30429 **County of** Red Willow **Date Filed** Sept. 24, 1968

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

I, LAYNE-WESTERN COMPANY, INC. (Name of Driller) of 4430 Commercial Ave. - Omaha (Postoffice Address)

County of Douglas State of Nebraska, do hereby certify that:

1. I am the driller of a well located on the North- West Quarter, Section No. 5 Township 2 North, Range 29, owned by City of McCook whose postoffice address is McCook State of Nebraska

2. That the drilling was begun on the 8th day of January, 19 44, and completed on the 2nd day of February, 19 44

3. That the well is cased and screened in the following manner: 25' of 30" shutter screen; 55' of 30" inside casing; 20' of 38" outside casing (Give kind of casing, lengths and position of plain and screen casing, weight of metallic casing, etc.)

4. That the diameter of drilled hole is --- inches.

5. That ~~rotary~~ blind casing type of drilling machinery was used.

6. That the drilled hole is/is ~~not~~ xxxx sealed, as follows: 24" concrete plug

7. That the following is an accurate log of the depth, thickness and character of the different strata penetrated, and the location of water-bearing strata:

DEPTH IN FEET FROM	TO	MATERIAL DRILLED
0	2	Top soil
2	20	Sandy clay
20	25	Fine dirty sand
25	34	Medium to coarse sand
34	37	Fine sand
37	43	Coarse sand and gravel
43	57	Medium fine sand, some gravel
57	65	Fine sand and gravel
65	83	Medium to coarse sand and gravel
83		Shale

E 2488

2466 SWL

2405 Kp

Date Signed August 27, 1968

George H. Beard
Driller G. H. BEARD
LAYNE-WESTERN CO., INC

(If more space is required please use reverse side of this page.)

DNR
PO Box 94676
Lincoln, NE 68509-4676
Phone (402)471-2363

STATE OF NEBRASKA
DEPARTMENT OF NATURAL RESOURCES
WATER WELL REGISTRATION

October DNR Form

water tower Well
Well #1451

FOR DEPARTMENT USE ONLY

Registration Date 2-28-03 Sequence No. 147967 Registration No. G-120260
Owner Code No. 24769 Receipt No. R126625 North Platte NRD

1. a. Well Owner's First Name City of Last Name Oshkosh
 b. Company Name City of Oshkosh
 c. Correspondent Name Bill Campbell Attention
 Address P.O. Box-166 305 West 1st
 City Oshkosh State Ne. Zip 69154 Telephone 308-772-3686

2. a. Contractor's License No NA Contractor's Name H.C. Minnick (1944)
 Contractor's Email Address Alliance, Nebraska
 b. Drilling Firm Name E.F. Waltman
 Address
 City Oshkosh State Ne. Zip 69154 Telephone Deceased
 Drilling Firm's Email Address

3. a. Well location NW ¼ of the NW ¼ of Section 36, Township 17 North, Range 44 East/(West) Garden County.
 b. Natural Resources District North Platte
 c. The well is 1031 feet from the (North)/ South) section line and 966 feet from the (East/(West)) section line (circle one) (circle one)
 or Latitude Degree ____ Minute ____ Second ____
 Longitude Degree ____ Minute ____ Second ____ Differential Correction ___ Yes ___ No
 d. Street address and subdivision, if applicable 100 East Avenue E
 Block One Lot Seven Original town divisi[on]
 e. Location of water use, if applicable (give legal descriptions) MUNICIPAL
 f. If for irrigation, the land to be irrigated is NONE acres.
 g. Well reference letter(s), if applicable Nebraska Dept. of Health (R.M. Babcock) / C.A. Shelby M.D.

4. Permits
 Management Area Permit Number ____
 Geothermal Permit Number ____
 Municipal Permit Number #35901451 ?
 Well Spacing Permit Number ____
 Surface Water Permit Number ____
 Industrial Permit Number ____
 Transfer Out-Of-State Permit Number ____
 Conduct Permit Number ____
 Other Permit Number ____

5. Purpose of well (indicate one) ___Aquaculture ___Commercial/Industrial ___Dewatering (over 90 days)
 ___Domestic ___Ground Heat Exchanger ___Groundwater Source Heat Pump ___Irrigation ___Injection
 ___Livestock ___Monitoring ___Observation ___Public Water Supply (with spacing (46-638))
 X Public Water Supply (without spacing) ___Recovery ___Other ____ (indicate use)

6. Wells in a Series.
 a. Is this well a part of a series? X Yes go to part b of this section ___No go to part 7 of this application
 b. If one or more of the wells in the series is currently registered, give the well registration number well #3 - G-25446
 c. How many wells in the series are you registering at this time? 2 well #4 - G-43401

7. Replacement and abandoned well information.
 a. Is this well a replacement well? ___Yes X No
 b. Registration number of abandoned well ____ If not registered, date abandoned well was constructed (m)___/(d)___/(y)___
 c. Replacement well is ____ feet from abandoned well. d. Abandoned well last operated (m)___/(d)___/(y)___
 e. Original well pump column size ____ inches. f. Completion of original well abandonment on (m)___/(d)___/(y)___
 g. Location of water use of abandoned well ____

Water Tower Well. UT-12A

8. Pump Information.

a. Is pump installed at this time X Yes ____ No
Is pump installed by well owner in section 1? ____ Yes X No Is pump installed by contractor in section 2? X Yes ____ No
If pump installed by pump installer, please fill out license number below

b. Pump Installer's License No. ____________ Pump Installer's Name E.F. Waltman
Pump Installer's Email Address NONE
Pump Installer's Firm Name E.F. Waltman Drilling
Pump Installer's Firm Address ____________
City Oshkosh State Ne. Zip 69154 Telephone N.A.
Pump Installer's Firm Email Address NONE

c. Pumping rate 150 gallons per minute X Measured ____ Estimated
d. Drop pipe diameter 4 inches
e. Length of drop pipe 50' feet
f. Pumping equipment installed (m) 9 /(d) ____ /(y) 45
g. Pump Brand GRUNDFOS
h. This well will be used to pump less than 50 gpm ____ Yes X No

9. Well Construction Information.

a. Total well depth 70 feet.
b. Static water level 20 feet.
c. Pumping water level 27 feet
d. Well Construction began (month) 8 /(day) ____ /(year) 44
e. Well Construction completed (month) 9 /(day) ____ /(year) 45
f. Bore hole diameter in inches Top 32 Bottom 32
g. Casing and Screen Joints are Welded X Glued ____ Threaded ____ Other ____

10. Well Construction (Casing & Screen)- c, d, e, & g measurements should be in inches to three decimal places

a		b	c	d	e	f	g	h
Placement Depth in Feet		Casing or Screen	Inside Diameter	Outside Diameter	Wall Thickness	Type of Material	Screen Slot Size	Trade Name
From	To							
0	26	CASING	16"		12 guage	steel		THOMPSON
26	69	SCREEN	16"				1/4"	THOMPSON

11. Grout and Gravel Pack

Placement Depth in Feet		Grout or Gravel Pack	Material Description
From	To		

12. Geologic Materials Logged

Depth in Feet From	To	Description	Depth in Feet From	To	Description

(Additional sheets may be submitted)

13. I am familiar with the information submitted on this registration, and to the best of my knowledge it is true.

Bill Campbell
Water Well Contractor's Signature
WATER OPERATOR

2-26-03
Date

STATE OF NEBRASKA
DEPARTMENT OF HEALTH
LINCOLN, NEBRASKA

water tower, well

E-98

APPLICATION FOR PERMIT TO CONSTRUCT WELL

City Oshkosh Nebr Date August 7 1944

Attach to this application a map of the existing waterworks clearly showing all streets, roads, and alleys; all water mains now in existence or proposed for construction, marked in such a way as to designate the kind and sizes of pipes and where the various kinds and sizes begin and end; the location of all wells and pumping stations; reservoirs, elevated tanks, fire hydrants, valves, blow-offs, and other appurtenances.

WELL SITE

1. Indicate on the map the location of the proposed well, and clearly designate the distance from the proposed well to centerlines of streets or alleys, property lines, or section lines in at least two directions.
2. Record the following if within 300 feet of well site:

Distance to nearest privy	feet.	Direction	
Distance to nearest sewer	51 feet.	Direction	east
Distance to nearest septic tank	feet.	Direction	
Distance to nearest barnyard	feet.	Direction	
Distance to nearest stream	feet.	Direction	
Distance to nearest well	12 feet.	Direction	north

3. When was the proposed site last flooded? does not flood
4. Maximum depth of water over well site during flood

WELL CASING

1. Diameter of casing 16''
2. Casing material black
3. Weight or thickness 10 guage
4. Seams closed by welding
5. Method of making joints bolts
6. Height casing will extend above natural ground 18''
7. Approximate depth of well 130
8. On the attached blue print show dimensions in the white spaces. In case any space does not apply, mark such space with a "X".

SCREEN

1. Length 115 9 ft 6 in
2. Material Black perforated
3. Trade name or other description Thompson steel pipe

PUMP

1. Type pump peerless
2. Capacity 500 G.P.M.
3. How will upper end of casing be sealed? concrete
4. Size of pipe that will connect pump to main 7 inch
5. Class or working pressure of pipe
6. Method of making joints

(Over)

water Tower well

PUMP HOUSE AND PUMP

1. Floor material cement
2. Concrete mixture
3. Water-cement ratio 4 to 1
4. Size of reinforcing bars
5. Spacing of bars
6. Foundation material cement
7. Pump house construction tile
8. Size of pump house 10 X 12
9. Pump house floor drain leads to outside over hill if permissable

MISCELLANEOUS

1. If test wells were drilled, include log. 65 ft course sand
2. Method that will be used to disinfect equipment 65 ft bruel

To whom should future correspondence be addressed? Village Clerk

(Signed) OKStedry

Village Clerk
(Official Title)

STATE OF NEBRASKA
COUNTY OF Garden, SS

Sworn to and subscribed before me, a notary public in and for said county and state, this 9th day of Aug, 1944.

SEAL

(Notary Public)

My commission expires Sept 18-1946

Mail to
DNR
PO Box 94676
Lincoln, NE 68509-4676
Phone (402)471-2363

North well #1741
Attn: Lynn

STATE OF NEBRASKA
DEPARTMENT OF NATURAL RESOURCES
WATER WELL REGISTRATION

FOR DEPARTMENT USE ONLY

Registration Date 2-28-2003 Sequence No. 147968 Registration No. G-120261
Owner Code No. 24769 Receipt No. R126625 North Platte N

1. a. Well Owner's First Name City of Last Name Oshkosh
b. Company Name City of Oshkosh
c. Correspondent Name Bill Campbell Attention
Address P.O. Box - 166 305 West 1st
City Oshkosh State Ne. Zip 69154 Telephone 308-772-3686

2. a. Contractor's License No NA Contractor's Name
Contractor's Email Address
b. Drilling Firm Name E.F. Waltman
Address
City Oshkosh State Ne Zip 69154 Telephone Deceased
Drilling Firm's Email Address NONE

3. a. Well location SW ¼ of the SW ¼ of Section 25, Township 17 North, Range 44 East/(West) GARDEN County
b. Natural Resources District North Platte
c. The well is 900 feet from the (North/(South)) section line and 40 feet from the (East/(West)) section line
(circle one) (circle one)
or Latitude Degree ____ Minute ____ Second ____
Longitude Degree ____ Minute ____ Second ____ Differential Correction ___ Yes ___ No
d. Street address and subdivision, if applicable AVENUE V & WEST 2nd
Block FOUR Lots NINETEEN & TWENTY BOTT HART ADDITION
e. Location of water use, if applicable (give legal descriptions) MUNICIPAL
f. If for irrigation, the land to be irrigated is NONE acres.
g. Well reference letter(s), if applicable DEPT of Health (RM BABCOCK) T.A. Pilipi

4. Permits
Management Area Permit Number
Geothermal Permit Number
Municipal Permit Number # 35901741
Well Spacing Permit Number
Surface Water Permit Number
Industrial Permit Number
Transfer Out-Of-State Permit Number
Conduct Permit Number
Other Permit Number

5. Purpose of well (indicate one) ___ Aquaculture ___ Commercial/Industrial ___ Dewatering (over 90 days)
___ Domestic ___ Ground Heat Exchanger ___ Groundwater Source Heat Pump ___ Irrigation ___ Injection
___ Livestock ___ Monitoring ___ Observation ___ Public Water Supply (with spacing (46-638))
X Public Water Supply (without spacing) ___ Recovery ___ Other ____ (indicate use)

6. Wells in a Series.
a. Is this well a part of a series? X Yes go to part b of this section ___ No go to part 7 of this application
b. If one or more of the wells in the series is currently registered, give the well registration number WELL #3 - G-25446
c. How many wells in the series are you registering at this time? 2 WELL #4 - G-43401

7. Replacement and abandoned well information.
a. Is this well a replacement well? ___ Yes X No
b. Registration number of abandoned well ____ If not registered, date abandoned well was constructed (m) ___/(d) ___/(y) ___
c. Replacement well is ____ feet from abandoned well.
d. Abandoned well last operated (m) ___/(d) ___/(y) ___
e. Original well pump column size ____ inches.
f. Completion of original well abandonment on (m) ___/(d) ___/(y) ___
g. Location of water use of abandoned well

North well

8. Pump Information.

a. Is pump installed at this time X Yes ___ No

Is pump installed by well owner in section 1? ___ Yes X No Is pump installed by contractor in section 2? X Yes ___

If pump installed by pump installer, please fill out license number below

b. Pump Installer's License No. NA Pump Installer's Name EF Waltman

Pump Installer's Email Address NONE

Pump Installer's Firm Name E.F. Waltman Drilling

Pump Installer's Firm Address ___

City OSHKOSH State NE Zip 69154 Telephone DECEASED

Pump Installer's Firm Email Address NONE

c. Pumping rate 450 gallons per minute X Measured ___ Estimated

d. Drop pipe diameter 6 inches e. Length of drop pipe ___ feet

f. Pumping equipment installed (m) 7 /(d) ___ /(y) 47 g. Pump Brand PEERLESS

h. This well will be used to pump less than 50 gpm ___ Yes X No

9. Well Construction Information.

a. Total well depth 90 feet. b. Static water level 29 feet.

c. Pumping water level 38 feet d. Well Construction began (month) 7 /(day) ___ /(year) 46

e. Well Construction completed (month) 7 /(day) ___ /(year) 47 f. Bore hole diameter in inches Top 34" Bottom 34"

g. Casing and Screen Joints are Welded X Glued ___ Threaded ___ Other ___

10. Well Construction (Casing & Screen)- c, d, e, & g measurements should be in inches to three decimal places

a		b	c	d	e	f	g	h
Placement Depth in Feet		Casing or Screen	Inside Diameter	Outside Diameter	Wall Thickness	Type of Material	Screen Slot Size	Trade Nam
From	To							
0	45	CASING	16"		12guage	STEEL		THOMPSON
45	90	SCREEN	16"		12guage	STEEL	1/4"	THOMPSON

11. Grout and Gravel Pack

Placement Depth in Feet		Grout or Gravel Pack	Material Description
From	To		

12. Geologic Materials Logged

Depth in Feet From	To	Description	Depth in Feet From	To	Description

(Additional sheets may be submitted)

13. I am familiar with the information submitted on this registration, and to the best of my knowledge it is true.

Bill Campbell ___ 2-26-03

Water Well Contractor's Signature Date

WATER OPERATOR

STATE OF NEBRASKA
DEPARTMENT OF HEALTH
LINCOLN, NEBRASKA

E-98

North well

APPLICATION FOR PERMIT TO CONSTRUCT WELL

City Oshkosh Date September 14 1945

Attach to this application a map of the existing waterworks clearly showing all streets, roads, and alleys; all water mains now in existence or proposed for construction, marked in such a way as to designate the kind and sizes of pipes and where the various kinds and sizes begin and end; the location of all wells and pumping stations; reservoirs, elevated tanks, fire hydrants, valves, blow-offs, and other appurtenances.

WELL SITE

1. Indicate on the map the location of the proposed well, and clearly designate the distance from the proposed well to centerlines of streets or alleys, property lines, or section lines in at least two directions.
2. Record the following if within 300 feet of well site:

Distance to nearest privy	129 feet.	Direction	N.E.
Distance to nearest sewer	250 feet.	Direction	South
Distance to nearest septic tank	X feet.	Direction	X
Distance to nearest barnyard	225 feet.	Direction	South lcow
Distance to nearest stream	155 feet.	Direction	North Irr. ditch
Distance to nearest well	96 feet.	Direction	East

3. When was the proposed site last flooded? Does not flood.

4. Maximum depth of water over well site during flood X

WELL CASING

1. Diameter of casing 16 inch
2. Casing material steel
3. Weight or thickness 12 guage
4. Seams closed by welding
5. Method of making joints welded
6. Height casing will extend above natural ground 2 1/2 ft. to 3 ft
7. Approximate depth of well 75 to 85 ft.
8. On the attached blue print show dimensions in the white spaces. In case any space does not apply, mark such space with a "X".

SCREEN

1. Length approximately 45 ft.
2. Material Steel
3. Trade name or other description Thompson

PUMP

1. Type Peerless or its equal
2. Capacity 350 G.P.M.
3. How will upper end of casing be sealed? Clay, grout and cement.
4. Size of pipe that will connect pump to main 6 inch
5. Class or working pressure of pipe
6. Method of making joints welded

(Over)

North well

E-98-2

PUMP HOUSE AND PUMP

1. Floor material Cement
2. Concrete mixture 4 to 1
3. Water-cement ratio 4 to 1
4. Size of reinforcing bars 1/2 inch
5. Spacing of bars
6. Foundation material cement
7. Pump house construction Frame
8. Size of pump house about 10X)10
9. Pump house floor drain leads to outside ground.

MISCELLANEOUS

1. If test wells were drilled, include log.
2. Method that will be used to disinfect equipment
H.T.H.

To whom should future correspondence be addressed?
O.K.Stedry Village Clerk

(Signed) O K Stedry
Village Clerk
(Official Title)

STATE OF NEBRASKA
COUNTY OF Garden, SS

Sworn to and subscribed before me, a notary public in and for said county and state, this 15th day of Sept, 1945.

SEAL

(Notary Public)

My commission expires Sept 18th 1946.

Revised April 1967
Irr. 57-1

3

Registration No. G-30077 County of Buffalo Date Filed Aug. 12, 1968

STATE OF NEBRASKA
~~IRRIGATION~~ WELL REGISTRATION
MUNICIPAL

I, Village of Shelton, Nebraska of Shelton
(Name of Person registering well) (Postoffice Address)

County of Buffalo State of Nebraska, do hereby certify:

1st. That the name of the owner of the land upon which the irrigation well is located is Village of Shelton, Nebraska, of .... Street, ... County of ....
(City or Village)

State of ....

2nd. That the irrigation well is located on the .... Quarter of the .... Quarter of Section 1 Township 9, Range 13 of the Sixth P. M., Buffalo County, and is Intersection Phelps & Fourth Street Village of Shelton, Nebraska feet from the .... line and .... feet from the .... line of said tract.

3rd. That the well was installed with the intention of irrigating all or parts of the following described land: Municipal Service for the Village of Shelton, Nebraska
(Give Quarter, Section, Township and Range)

amounting in all to approximately .... acres.

(If installation consists of a battery of wells with one outlet, give details on a sheet to be attached hereto.)

4th. That the capacity of said well under normal operating conditions is 250 gallons per minute.

5th. That the depth of the well is 59 feet, measured from the surface of the ground.

6th. That the inside diameter of the casing is 34 inches.

7th. That the static water level in the well is 26 feet below ground surface.

8th. That the depth to water under normal pumping conditions is 28 feet below ground surface.
(Pumping Level)

9th. That the diameter of the pump column is 6 inches. That the diameter of the 4 bowl or bowls is 10 inches.
(Give number of bowls)

10th. That the type and size of impeller is as follows:
Layne Bowler pump impeller unknown

11th. That the well was completed on or about the .... day of ...., 1954.

VILLAGE OF SHELTON

Sec. 1, T. 9N., R. 13W., Buffalo Co.

Revised April 1, 1966
Irr. 57-3

Registration No. G-30077 County of Buffalo Date Filed Aug. 12, 1968

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

I, Woodman Farm Service (Name of Driller) of Shelton (Postoffice Address)

County of Buffalo State of Nebraska, do hereby certify that:

1. I am the driller of a well located on the .... Quarter, Section No. .... Intersection Phelps & Fourth Street Village of Shelton, Nebraska
Township .... North, Range ...., owned by ....

whose postoffice address is Shelton State of Nebraska

2. That the drilling was begun on the 8th day of Nov, 19 54, and completed on the 8th day of Nov, 19 54.

3. That the well is cased and screened in the following manner: cement - 24' perf 36' plain cement
(Give kind of casing, lengths and position of plain and screen casing, weight of metallic casing, etc.)

4. That the diameter of drilled hole is 34 inches.

5. That reverse hydraulic type of drilling machinery was used.

6. That the drilled hole is/~~is not~~ sealed, as follows: 12" cement in first section for bottom

7. That the following is an accurate log of the depth, thickness and character of the different strata penetrated, and the location of water-bearing strata:

DEPTH IN FEET FROM	TO	MATERIAL DRILLED
0	9	top soil
9	25	sand
25	35	sand & gravel
35	59	good green gravel
59	62	clay

Date Signed ....

[signature]
Driller

(If more space is required please use reverse side of this page.)

Well #3 (#721)

Revised December, 1978 DWR Form 602

DO NOT WRITE IN THIS SPACE

Registration No. G-030339 County Polk Date Filed 3/14/00 **3**

37209

STATE OF NEBRASKA
DEPARTMENT OF WATER RESOURCES
WELL REGISTRATION

IS A REPLACEMENT WELL ORIGINALLY FILED 9/11/68

1. General information:
   A. Connected well
      Is this well connected to another well? [X] Yes [X] No (originally yes)
      If yes, give registration number of previously registered well ~~G-30338~~ ~~G-30337~~ 30338 30337
      (If new installation consists of a series of wells with one outlet, complete registration forms and driller's certificates for each and submit $7.50)
   B. Replacement well
      Is this well to replace a permanently abandoned well? [X] Yes [X] No (originally yes)
      If yes, give registration number of abandoned well 30339
   C. Permit No. M462 ? (required only in a Ground Water Control Area)

Type of well to be registered: (Check One)
- [ ] IRRIGATION
- [X] MUNICIPAL
- [ ] INDUSTRIAL
- [ ] Other

2. Name & address of well owner:

   City of Stromsburg
   Stromsburg, Ne.
   Box 407

   Zip Code 68666 Phone (402) 764-2561

3. Name & address of well driller:

   Layne - Western Company, Inc.
   4430 Commercial Avenue
   Omaha, Nebraska

   Zip Code 68110 Phone: (402) 451-2388

4. Location & purpose of the well:
   A. Upper Big Blue 01 Natural Resources District (Identify)
   B. NW ¼ of the SW ¼ of Section 7, Township 13 N, Range 2 W [ ] E [X] W. (check one)
      Polk County.
   C. The well is 500 feet from the nearest municipal, irrigation, or industrial well. The nearest well is owned by [X] you [ ] someone other than you. (check one)
   D. The well is intended to irrigate ___ acres of land, and it is intended to irrigate all or parts of the following land:
      OR
   E. The well shall be used for purposes of: Municipal use.

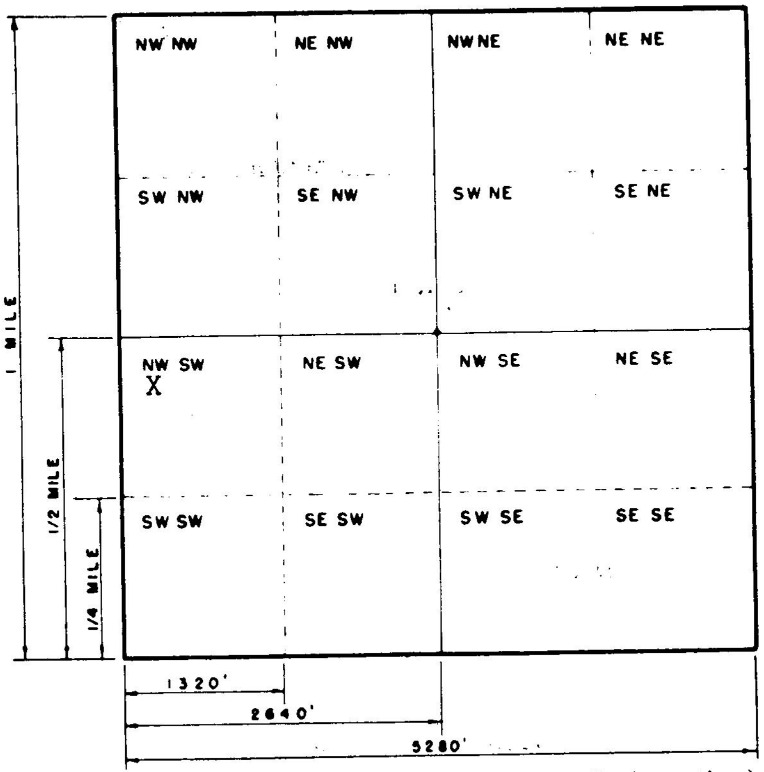
POLK

13N, 2W, Sec. 7

5. Well and pump specifications:
   A. Pumping rate under normal conditions: 400-500 gallons per minute.
   B. Total well depth: 182 feet. PWL 38
   C. Inside diameter of the casing: 16 inches.
   D. Static (non-pumping) water level in the well: 40 feet below ground surface.
   E. Depth of water under normal pumping conditions: 62 feet below ground surface.
   F. Pump column: Diameter 6 inches. Length 150 feet.
   G. The well was completed on or about June, 1972.

MORE ON BACK MORE ON BACK

(With an "X" mark the location of the well)



This drawing represents one square mile (a section).
Each small subdivision is a 40-acre tract.

I certify that I am familiar with the information contained on this registration, and that to the best of my knowledge and belief such information is true, concise and accurate.

Owner City of Stromsburg
By: Tim R. Gulbrandson, Water Comm.

Well Owner's Signature Date

Both a Well Registration and Driller's Certificate must be completed in triplicate and in full. An incomplete or defective form will be returned. A non-refundable $7.50 fee (payable to the Director of Water Resources) must accompany your submittal. No fee is required to register: (1) a permitted well within a Ground Water Control Area; (2) a well constructed to replace a previously registered well; or (3) a well connected in a series with another well previously registered. Forward to:

State of Nebraska
Department of Water Resources
301 Centennial Mall-South
P.O. Box 94676
Lincoln, Nebraska 68509

Revised April, 1976 Stromsburg #3 3

Registration No. G 3?33? | County Pol? | Date Filed ?/1?/?

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

THIS IS A ... ORIGINALLY FILED ?/11/??

Permit No. .... (required only in a control area)

Name & Address of well driller: Layne-Western Company, Inc.
4430 Commercial Ave.
Omaha, NE 68110

Well Location:

Upper Big Blue 01 .... Natural Resources District

NW Quarter of the SW Quarter of Section 7, Township 13N, Range 2W,

Polk County, and owned by City of Stromsburg

Drilling & construction specifications:

1. Date construction was begun: Summer of, 1972.
2. Date construction was completed: Summer of, 1972.
3. Diameter of the drilled hole: 36 inches.
4. Was the hole electronically logged? ☒ Yes ☐ No.
5. How is drilled hole sealed (not sealed)? With Stainless steel plate 3/16" thick.
6. Well casing & screen: Casing is steel Inside diameter 16" thickness 3/8" Length 149'--screen is 35' in length, made of eleven gauge Layne stainless steel.
(Give type of casing, lengths and vertical position of plain and slotted segments, slot or perforation size.)
7. Is the well artifically gravel stabilized? ☒ Yes ☐ No

Pumping test information:

1. Pumping rate: 712 gallons per minute.
2. Depth to water before pumping: 43 feet.
3. Depth to water 75 feet after pumping 8 ~~minutes~~ hours.

DRILLING LOG ON BACK

DRILLING LOG ON BACK

DRILLING LOG

DEPTH IN FEET FROM	TO	MATERIAL DRILLED
0	28	Brown Clay
28	42	Coarse Sand & Gravel
42	80	Brown Clay & Sand
80	125	Blue Clay
125	140	Coarse, Sand, Gravel, and Fine Sand
140	159	Blue Clay
159	182	Gravel, Coarse Sand, and Fine Sand

SWL → 60'

starts @ 149' →

35'

Richard S. Hunter 2-22-80

Well Driller's Signature Date

Richard S. Hunter, P. E. 2-22-80

94-2

NHHSS Well Drinking INFO Site → Well # ~~9~~ 3
Town → Well # 4

DWR Fo

STATE OF NEBRASKA
DEPARTMENT OF WATER RESOURCES
WATER WELL REGISTRATION

INSTRUCTIONS | **For Department Use Only**

To register a ground water well, forward the following to the **Department of Water Resources, P.O. Box 94676, Lincoln, Nebraska 68509-4676.** Telephone number: 402/471-2363:

1. Water Well Registration form (DWR Form 131).
2. The most recent United States Department of Agriculture aerial photograph(s), available at the county Agricultural Stabilization and Conservation Service, marked to show the following:
   a) The location of the well to be registered.
   b) The location of wells owned by you in the same section. Each well should be labeled to show the use of water and the registration number. Abandoned wells should be shown, also.
   c) If the well is for irrigation, the land to be irrigated should be shown by a crosshatch pattern and the number of acres irrigated from the well should be indicated.
3. Fees: ° For monitoring and observation wells --- $60.
   ° For wells which pump less than 50 gallons per minute --- $60.*
   ° For wells which pump 50 gallons per minute or more --- $100.*

* For wells permitted pursuant to the Industrial Ground Water Regulatory Act, a separate registration fee is required for each of the first ten we registered under the permit. For each additional group of ten or fewer wells registered under the permit only one registration fee is required.

Registration Number: G-88470
Registration Date: 7-1-96
Receipt Number: 87018
21 - Upper Republican NRD
(35351) 1004
100480

1. Name of well owner Village of Wauneta Telephone Number (308) 394-5390
   Address P.O. Box 95
   City Wauneta State NE Zip Code 69045

2. Drilling Firm Charles Sargent Irrigation, Inc. Telephone Number (308) 872-6451
   Address P.O. Box 627 Contractor's License No. 39194 Pump Installer License No. 39194
   City Broken Bow State NE Zip Code 68822
   Well Logger (Name) Daniel Jacobson Well Driller (Name) Jonn Deaver

3. Permit Number(s) ____

4. This well will be for (indicate one): ___Irrigation ___Industrial Use X Public Water Supply ___Domestic ___Live:
   ___Recovery ___Injection ___Observation (Ground Water Levels) ___Monitoring (Ground Water Q
   ___Dewatering (over 90 days) ___Other ____ (Indicate use)

5. Replacement and abandoned well information (Notice of abandonment procedure is required for all abandoned, registered wel
   A. Is this well a replacement well? ___Yes X No X B. Registration number of abandoned well: ____
   C. Replacement well is ____ feet from abandoned well. D. Abandoned well last operated ____, 19____
   E. Original well pump column size: ____ inches. F. Abandoned well plugged ____, 19____

6. A. Well location: SE ¼ SW ¼ of Section 11, Township 5 North, Range 36 ~~East~~/West, Chase C
   B. The well is 550 feet from the ~~North~~/South section line and 1520 feet from the ~~East~~/West sectio
   (If possible, measurements should be from nearest section line.)
   C. Street address or block, lot and subdivision, if applicable: ____
   D. Location of use (give legal description): Village of Wauneta
   E. If for irrigation, the land to be irrigated is ____ acres.

printed on recycled pa

7. Pump Information. If a timed pump test was conducted, submit complete pumping and drawdown data including dept observation wells, if any, on separate page.

A. Pumping rate: 600 gallons per minute. Measured ☒ or Estimated ☐

B. Pump: Column diameter: 8 inches. C. Depth to pump: 140

D. Pumping equipment installed: August 6, 1994. E. Brand/Type: Sargent

8. Well Information.

A. Total well depth: 180 feet. B. Static water level: 57 feet. C. Pumping water level 87

D. Construction began: July 14, 1994. E. Construction completed: September 30., 199

F. Bore hole diameter 28 inches.

G. Casing: Diameter 15.25 ID 16 OD in.: Type of material: PVC

Wall thickness .375 in. Joints--~~Welded~~/Glued/~~Threaded~~/Other: : Guides at 95-125-16

Length(s) and placement(s) depth from 152 ft. to 171 ft. from 118-125 ft. to 95-+4

H. Screen: 15.25 ID 16 OD in.; Type of material Stainless Steel

Screen openings (slot size): .030 .060 : Trade name: Cook : Guides at

Length(s) and placement(s) depth from 171 ft. to 178 ft. from 125-152 ft. to 95-118

I. Gravel pack interval(s) from 155 ft. to 178 ft. from 119 ft. to 40 ft. Grade size: Luther Ma

J. Grouted/Sealed from 155-119 ft. to 10-Ground Level ft., with Bentonite (type)

from 40 ft. to 10 ft., with Cement (type)

K. Drilling method: Reverse L. Drilling fluid: Water

M. Well development technique (total time and method): Rawhiding 10 hrs

N. Will chemicals or fertilizer be injected into the distribution system? ___ Yes X No

GEOLOGIC MATERIALS LOGGED

DEPTH IN FEET FROM	TO	DESCRIPTION
0	12	Fine Sand
12	34	Fine Sand w/trace of Clay
~~34~~	~~40~~	~~Sandy Clay & Mag LAyers~~
40	43	Clay & Mag LAyers
43	64	SAndstone & Limestone Layers
~~64~~	~~73~~	~~Coarse Sand & Fine GRavel~~
73	84	Sandstone
84	89	Coarse Coarse Sand & Sandstone
~~89~~	~~104~~	~~Coarse Sand & Fine Gravel~~
104	119	Med Coarse Sand
119	125	Clay
~~125~~	~~140~~	~~Coarse Sand & Sandstone w/trace of Clay~~
140	145	Coarse SAnd & Sandstone
145	152	Sandstone
152	160	Sandstone & Limestone Layers w/trace of Clay
160	169	Sandstone & Limestone Laye
169	178	Fine Gravel
~~178~~	~~180~~	~~Ochre~~

(Additional sheets may be submitted)

I am familiar with the information submitted on this registration, and to the best of my knowledge it is true.

[signature] 9/30/94 x [signature] 6/7/

Water Well Contractor's Signature — Date — Water Well Owner's Signature — Date

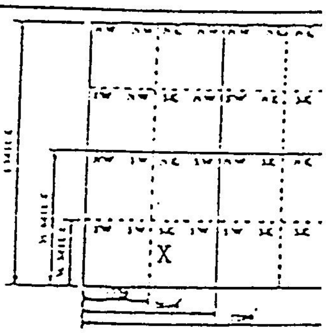
APPLICATION FOR A PERMIT TO CONSTRUCT A WATER WELL WITHIN THE UPPER REPUBLICAN NATURAL RESOURCES DISTRICT GROUND WATER CONTROL AREA

1. NAME OF APPLICANT Village of Wauneta
ADDRESS P.O. Box 95 Wauneta Ne
ZIP CODE 69045 8 TELEPHONE (308) 394-5390

NRD USE ONLY
PERMIT NO. UR 1464
REG. NO. G-88470

2. INDICATE THE PROPOSED USE:
( ) IRRIGATION (X) MUNICIPAL ( ) INDUSTRIAL ( ) DOMESTIC
If the well is for more than one purpose or for a purpose other than indicated above, explain below.

3. IDENTIFY THE LOCATION OF THE PROPOSED WELL:
Chase County, Township 5 North
Range 36 East/West, Section 11
The box at right represents one square mile (section). Indicate with an "X", the proposed location of the well. If the well is to be used for irrigation, indicate the location of lands to be irrigated.



How many acres will be irrigated? N/A
Legal description of land to be irrigated: Cir.______ Sec.______ T______ R______

4. SPECIFICATIONS OF INTENDED WELL AND PUMP:
Pump column diameter 8 inches. Estimated total well depth 172 feet.
Estimated pumping capacity 600 gallons per minute.
Well casing diameter 16 inches.
Expected well log, if known. (Provide a copy of test drilling report, if available)
Type of present use: Farmland______ Range X
Prairie dog town located on proposed location? Yes______ No X

5. I certify that I am familiar with the information contained in this application, and that to the best of my knowledge and belief such information is true, complete and accurate.

DATE JUNE 27, 1994

Signature of Applicant
Greg A. Wolford, Project Engineer

NATURAL RESOURCES DISTRICT COMMENTS:

Date Approved 7-5-1994

Signature of NRD Representative

This form must be completed in full and be accompanied by a non-refundable $17.50 filing fee (payable to the Upper Republican Natural Resources District). Forward this application and filing fee to:

Upper Republican Natural Resources District
135 West 5th Street
Imperial, Nebraska 69033
(308) 882-5173

An incomplete or defective application will be returned by the District within 60 days being allowed for resubmission. All permits shall be issued by the District with conditions attached, or denied not later than 30 days after receipt of a complete and properly prepared application.

UPPER REPUBLICAN
NATURAL RESOURCES DISTRICT
PERMIT TO CONSTRUCT A WELL WITHIN
THE GROUND WATER CONTROL AREA

Name and address of permitee:

Village of Wauneta
P.O. Box 95
Wauneta, NE 69045

Permit Number CA-1464

Location of proposed well:

Upper Republican NRD

Chase County

Township 5 Range 36

Section 11 Quarter ______

Conditions and Restrictions:
This permit shall remain in force for 120 days following date of approval.

Well constructed by the issuance of this permit shall comply with all of the Rules and Regulations adopted by the Upper Republican Natural Resources District and approved by the Director of the Department of Water Resources and Nebraska State Statutes.

The irrigation well authorized by this permit may not be constructed closer than 1320 feet form any stock or domestic well not belonging to or under the control of the permittee.

This permit authorizes irrigated acres for application purposes on the

_______1/2, ________Sec., _________Township, _________Range, not to

exceed ___________ actual irrigated acres will be set by the Board at a regular board meeting as stated Rules and Regulations for Groundwater Control Order No. 7.

A copy of Rules and Regulations is enclosed.

DATE OF APPROVAL 7-5-94

THIS PERMIT EXPIRES 11-3-94

APPROVED BY: W. Eugene Haarberg

Registration of the well in accordance with 46-602,R.R.S. 1943 (Cum supp) (fee waived) or in accordance with Municipal and Rural Groundwater Transfer Permit Act must be accomplished upon completion of the well.
Well registration must be sent to the Department of Water Resources. A fee of $20.00 must be sent with registration form.

G-88470

Static 56'8" 94-2
Static 59'1" 94-1

Well #94-2
Wauneta 12 Hr.
Pump Test

Start 054161
End 054627
Meter Reading

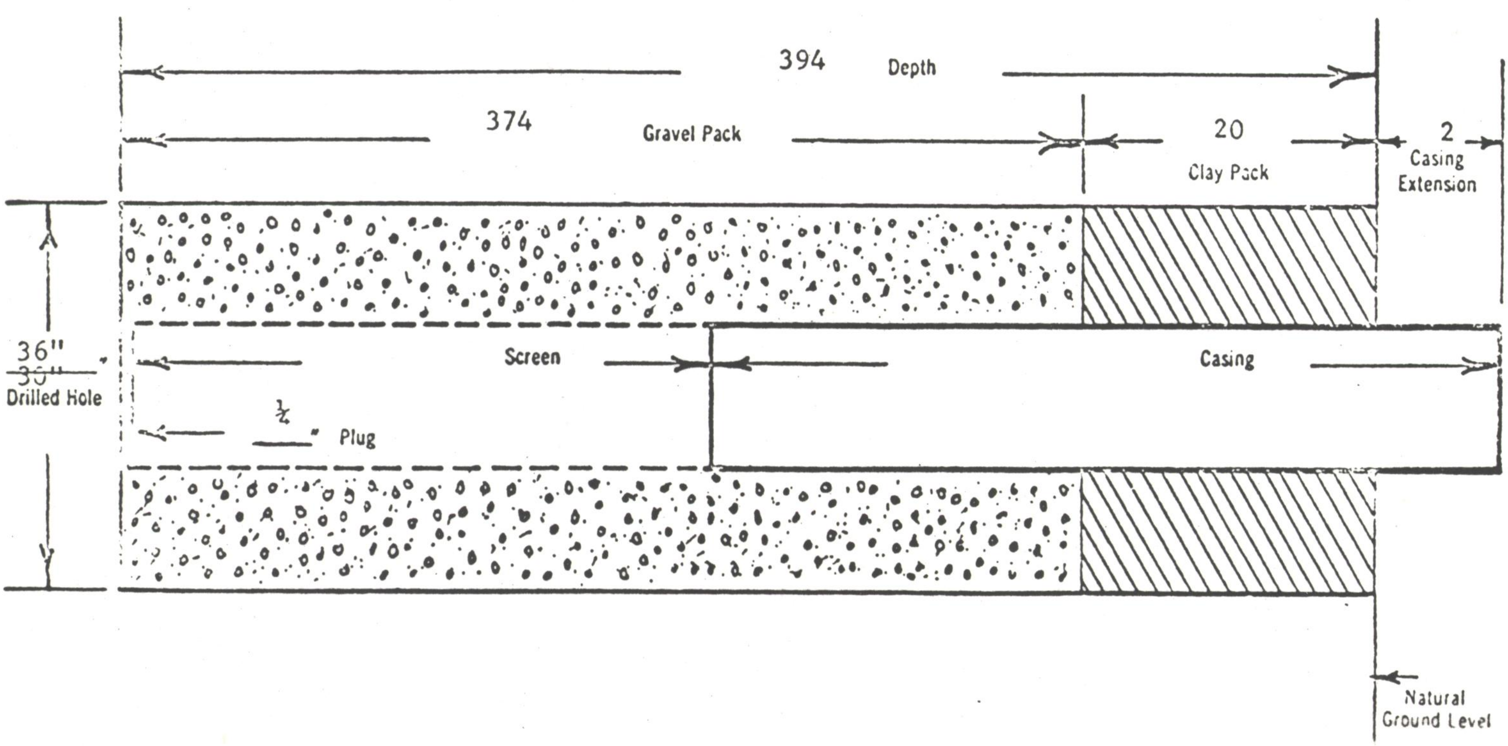
TIME	GPM	PL.	94-1
10:31	800	62'5"	
10:32	800	68'4"	
10:33	800	76'2"	
10:34	800	81'9"	
10:35	800	82'	
10:36	800	98'2"	
10:37	800	82'4"	
10:38	800	82'8"	
10:39	800	83'9"	
10:40	800	84'11"	59'4"
10:45	800	85'7"	59'10"
10:50	800	86'4"	59'10"
10:55	800	86'4"	61'
11:00	800	86'10"	61'3"
11:10	800	87'	61'7"
11:20	800	87'6"	62'2"
11:30	800	87'6"	62'2"
11:40	800	87'6"	62'4"
11:50	800	87'6"	62'5
12:00	800	87'6"	62'5"
12:15	800	87'7"	62'5"
12:30	800	87'7"	62'6"
1:00	800	87'8"	62'6"
1:30	800	87'8"	62'7"
2:30	800	87'9"	62'7"
3:30	800	87'9"	62'7"
4:30	800	87'9"	62'7"
5:30	800	87'8"	62'7"
6:30	800	87'9"	62'7"
7:30	800	87'9"	62'7"
8:30	800	87'9"	62'7"
9:30	800	87'9"	62'7"
10:30	800	87'9"	62'7"

RECOVERY TIME	P.L.	94-1
10:30	61'3"	
10:31	61'	62'6"
10:32	60'7"	
10:33	60'2"	
10:34	60'	
10:35	59'9"	
10:36	59'2"	61'8"
10:37	59'	
10:38	58'10"	
10:39	58'8"	
10:40	59'	59'9"
10:45	58'11"	59'5"
10:50	58'9"	59'4"
10:55	58'6"	59'4"
11:00	58'1"	59'2"
11:15	57'6"	59'2"
11:30	57'	59'2"
12:00	56'8"	59'2"
12:30		
1:30		
2:30		
3:30		
4:30		

CONTRACT City of York, Nebraska Well No.

Log of well from ground level:

Feet		Feet	Formation
0	to	3	top soil
3		35	brown clay
35	to	45	red clay
45		70	sand and gravel
70	to	80	clay
80		90	sand and gravel
90	to	95	clay
95		110	coarse sand
110	to	160	clay
160		220	fine sand
220	to	265	clay
265		285	fine sand
285	to	295	clay
295		310	fine sand
310	to	315	clay
315		325	fine sand
325	to	330	clay
330		335	sand
335	to	340	clay
340		345	sand
345	to	350	clay
350		380	sand
380	to	390	clay
390		394	sand
394	to	395	clay
	to		
	to		
	to		



Appendix B

Public Water Supply Well Sampling Datasets

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Anselmo	641	12-Dec-02	1245		~136	150	P22194-8	12.50						
Anselmo	641	09-Jan-03	1247		~136	170	P22194-7	12.50						
Anselmo	641	30-Jan-03	1314		~136	150	P22462-8	11.60						
Anselmo	641	25-Feb-03	1315		~136	150	P22616-23	11.20						
Anselmo	641	20-Mar-03	1227		~136	150	P22616-7	11.60						
Anselmo	641	29-Apr-03	1117		~136	150	P22714-77	11.60	14.80		11.9			
Anselmo	641	20-May-03	1055		~136	150	P22985-48	12.10	15.80		12.3 / NA			
Anselmo	641	10-Jun-03	1139		~136	150	P23144-25	11.00	15.60	0	13.8			
Anselmo	641	24-Jun-03	1123		~136	150	P23144-18	12.80		0	14.0			
Anselmo	641	31-Jul-03	1145		~136	150	P23372-43	13.10		0				
Anselmo	641	14-Aug-03	1032		~136	150		11.00		0				
Anselmo	641	01-Dec-03	1654		~136	150		11.60						
Anselmo	871	30-Jan-03	1152		60	200	P22462-7	19.80						
Anselmo	871	25-Feb-03	1220	N/A	60	200	P22355-30	18.50						
Anselmo	871	20-Mar-03	1105	N/A	60	200	P22616-2	18.10						
Anselmo	871	29-Apr-03	1245	N/A	60	200	P22714-70	18.30	23.80		19.1			
Anselmo	871	20-May-03	1144	N/A	60	200	P22985-40	19.30	23.60		22.0 / NA			
Anselmo	871	10-Jun-03	1049	N/A	60	200	P23144-19	17.50	24.50	0	20.8			
Anselmo	871	24-Jun-03	1048	N/A	60	200	P23144-28	20.50		0	22.2			
Anselmo	871	31-Jul-03	1103	N/A	60	200	P23372-34	20.70		0				
Anselmo	871	14-Aug-03	1002	N/A	60	200		18.50		0				
Anselmo	871	01-Dec-03	1634	N/A	60	200		18.40						
Anselmo	Distribution	20-Mar-03	1203	N/A	N/A	N/A	P22616-8	18.50	23.10					
Anselmo	Distribution	29-Apr-03	1215	N/A	N/A	N/A	P22714-73	18.60						
Anselmo	Distribution	10-Jun-03	1119	N/A	N/A	N/A	P23144-35	17.30						
Anselmo	Distribution	14-Aug-03	923	N/A	N/A	N/A		16.60						
Beemer	2002-1	19-Oct-05	1132	30	80	550	P28350-43	6.11				199.00		
Beemer	2002-1	19-Oct-05	1102	0	80	550	P27621-74	7.17				290.00		
Beemer	2002-1	19-Oct-05	1120	18	80	550	P27621-75	6.14				194.00		
Beemer	2002-1	19-Oct-05	1155	53	80	550	P27621-76	6.42				213.00		
Beemer	2002-1	20-Jan-06	1301	0	80	250	L29438-06					177.00		
Beemer	2002-1	20-Jan-06	1052	0	80	100	L29438-01					271.00		
Beemer	2002-1	20-Jan-06	1152	60	80	100	L29438-05		7.00			185.00	199.60	
Beemer	2002-1	20-Jan-06	1122	30	80	100	L29438-04					198.00		
Beemer	2002-1	20-Jan-06	1424	0	80	500	L29438-11					158.00		
Beemer	2002-1	20-Jan-06	1331	30	80	250	L29438-09					171.00		
Beemer	2002-1	20-Jan-06	1401	60	80	250	L29438-10		6.00			167.00	183.40	
Beemer	2002-1	20-Jan-06	1545	80	80	500	L29438-15					148.00		
Beemer	2002-1	20-Jan-06	1525	60	80	500	L29438-14		6.00			156.00	167.20	
Beemer	2002-1	20-Jan-06	1455	30	80	500	L29438-13					151.00		
Beemer	2002-1	20-Jan-06	1116	24	80	100	L29438-02					217.00		
Beemer	2002-1	5-Apr-06				500	G-124739					124.00		
Beemer	2002-1	5-Jul-06				500	G-124739					72.00		
Beemer	2002-1	2-Oct-06				500	G-124739					65.00		
Beemer	2002-1	17-Jan-07				500	G-124739					52.00		
Beemer	2002-1	2-Apr-07				500	G-124739					45.00		
Beemer	2002-1	30-Jul-07	1030			500	G-124739					31.00		
Bellwood	761	19-Jun-06	1050	180	55	275						155.00	157.00	
Bellwood	761	19-Jun-06	750	0	55	275						14.60	16.00	
Bellwood	761	19-Jun-06	820	30	55	275						175.00	174.00	
Bellwood	761	19-Jun-06	950	120	55	275						162.00	159.00	
Bellwood	761	19-Jun-06	1150	240	55	275						147.00	152.00	
Bellwood	761	19-Jun-06	850	60	55	275						167.00	166.00	
Bellwood	761	21-Jun-06	1448	30	106.5	3						182.00	170.00	
Bellwood	761	21-Jun-06	1433	15	106.5	3						212.00	186.00	
Bellwood	761	21-Jun-06	1037	0	106.5	3						143.00	178.00	
Bellwood	761	21-Jun-06	1052	15	106.5	3						172.00	176.00	
Bellwood	761	21-Jun-06	1107	30	106.5	3						178.00	179.00	
Bellwood	761	21-Jun-06	1312	0	111.5	3						196.00	180.00	
Bellwood	761	21-Jun-06	1327	15	111.5	3						174.00	161.00	
Bellwood	761	21-Jun-06	1342	30	111.5	3						175.00	165.00	

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Anselmo	641	12-Dec-02	6.35	190	1	14.1	149	181						
Anselmo	641	09-Jan-03	7.60	271	6.2	12.0	160	195						
Anselmo	641	30-Jan-03	7.60	210	0.5	12.0	158	193						
Anselmo	641	25-Feb-03	8.00	143	9.8	11.1	154	187						
Anselmo	641	20-Mar-03	7.40	173	2.6	11.8	140	171						
Anselmo	641	29-Apr-03	7.50	244	3.2	12.8	162	198						
Anselmo	641	20-May-03	7.50	217	5.4	12.5								
Anselmo	641	10-Jun-03	7.50	278	2.8	12.5	170	207						
Anselmo	641	24-Jun-03	7.60	345	2.9	12.7	145	177						
Anselmo	641	31-Jul-03	7.40	350	3	13.3	162	198						
Anselmo	641	14-Aug-03	7.40	288	3.4	13.1	151	184	51.45	9.836	5.9	12.46	n.d.	0.18
Anselmo	641	01-Dec-03	7.50	189	3.2	12.0	166	202	53.4	15.7	6.6	14.7	n.d.	0.19
Anselmo	871	30-Jan-03	7.60	175	2.1	12.5	128	156						
Anselmo	871	25-Feb-03	7.80	144	3.8	11.5	139	169						
Anselmo	871	20-Mar-03	7.50	176	2.8	11.8	117	143						
Anselmo	871	29-Apr-03	7.40	217	2.4	13.8	124	151						
Anselmo	871	20-May-03	7.60	197	1	12.1								
Anselmo	871	10-Jun-03	7.40	256	1.2	13.0	148	180						
Anselmo	871	24-Jun-03	7.50	285	1.2	13.4	149	182						
Anselmo	871	31-Jul-03	7.30	275	1.2	13.0	145	177						
Anselmo	871	14-Aug-03	7.40	236	1.5	14.0	140	171	43.9	12.6	5.3	10.2	n.d.	0.12
Anselmo	871	01-Dec-03	7.50	166	1	12.0	139	169	44.2	13.3	5.8	17.2	n.d.	0.12
Anselmo	Distribution	20-Mar-03	7.40	159	2.4	7.5	146	178						
Anselmo	Distribution	29-Apr-03	7.50	290	7.2	11.5	138	168						
Anselmo	Distribution	10-Jun-03	7.60	245	3.4	13.0	101	123						
Anselmo	Distribution	14-Aug-03	7.50	269	2.7	16.0	130	158						
Beemer	2002-1	19-Oct-05	7.10	456	0.3	9.5	262	319						
Beemer	2002-1	19-Oct-05												
Beemer	2002-1	19-Oct-05	7.00	473	0.3	9.5	264	322						
Beemer	2002-1	19-Oct-05	7.20	448	0.1	9.5								
Beemer	2002-1	20-Jan-06	7.30	417	0.8	9.0	246	300						
Beemer	2002-1	20-Jan-06	7.10	570	4.4	8.9	259	318						
Beemer	2002-1	20-Jan-06	7.20	420	0.2	9.0	230	280	83.1	23.4	17.3	5.2	0.41	0.14
Beemer	2002-1	20-Jan-06	6.70	423	0.2	9.0	256	312						
Beemer	2002-1	20-Jan-06	7.40	400	0.5	9.0	241	294						
Beemer	2002-1	20-Jan-06	7.30	401	0.2	9.0	226	276						
Beemer	2002-1	20-Jan-06	7.30	398	0.2	9.0	255	311	82.1	23.1	17.0	5.3	0.37	0.14
Beemer	2002-1	20-Jan-06	7.20	395	0.1	9.0	235	287						
Beemer	2002-1	20-Jan-06	7.20	396	0.2	9.0	264	322	82.5	23.5	17.2	5.4	0.31	0.14
Beemer	2002-1	20-Jan-06	7.40	396	0.2	9.0	239	291						
Beemer	2002-1	20-Jan-06	7.20	425	0.2	9.0	259	318						
Beemer	2002-1	5-Apr-06												
Beemer	2002-1	5-Jul-06												
Beemer	2002-1	2-Oct-06												
Beemer	2002-1	17-Jan-07												
Beemer	2002-1	2-Apr-07												
Beemer	2002-1	30-Jul-07												
Bellwood	761	19-Jun-06	7.50	517	0.2	11.5	244	298						
Bellwood	761	19-Jun-06	7.80	494	4.0	11.0	243	296						
Bellwood	761	19-Jun-06	6.70	530	0.2	11.0	245	298						
Bellwood	761	19-Jun-06	7.00	519	0.1	11.0	244	298						
Bellwood	761	19-Jun-06	7.40	516	0.1	12.0	246	299						
Bellwood	761	19-Jun-06	6.40	524	0.1	11.5	245	298	99.8	23.7	16.1	10.0	0.38	0.37
Bellwood	761	21-Jun-06	7.60	648	0.1	13.0	296	361	95	22.5	15.4	10.1	0.58	0.35
Bellwood	761	21-Jun-06	7.50	650	0.2	14.0	284	346						
Bellwood	761	21-Jun-06	7.00	592	7.0	20.9	243	296						
Bellwood	761	21-Jun-06	7.50	663	0.3	12.0	258	315						
Bellwood	761	21-Jun-06	7.30	655	0.2	12.0	242	295	95.7	22.8	15.6	9.8	0.75	0.35
Bellwood	761	21-Jun-06	7.80	626	3.4	22.0	248	302						
Bellwood	761	21-Jun-06	7.80	652	0.3	13.0	274	334						
Bellwood	761	21-Jun-06	7.70	649	0.1	12.5	250	305	94.7	22.5	15.4	9.4	1.71	0.35

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Anselmo	641	12-Dec-02												
Anselmo	641	09-Jan-03												
Anselmo	641	30-Jan-03												
Anselmo	641	25-Feb-03												
Anselmo	641	20-Mar-03												
Anselmo	641	29-Apr-03									280.1			
Anselmo	641	20-May-03									333			
Anselmo	641	10-Jun-03									280.1			
Anselmo	641	24-Jun-03									319.8			
Anselmo	641	31-Jul-03									326.1			
Anselmo	641	14-Aug-03	6.22	2.21	9.14	0.03	0	0.03	< 0.1		231.5	6.11		
Anselmo	641	01-Dec-03	0	2.3	8.9	0.03	0	0.03	< 0.1		-69.4	9.1		
Anselmo	871	30-Jan-03												
Anselmo	871	25-Feb-03												
Anselmo	871	20-Mar-03												
Anselmo	871	29-Apr-03									305.6			
Anselmo	871	20-May-03									251			
Anselmo	871	10-Jun-03									237.8			
Anselmo	871	24-Jun-03									290.8			
Anselmo	871	31-Jul-03									356.1			
Anselmo	871	14-Aug-03				0.03	0	0.03	0.2		242.4			
Anselmo	871	01-Dec-03		1.5		0.04	0	0.04	0.1		-79.6			
Anselmo	Distribution	20-Mar-03												
Anselmo	Distribution	29-Apr-03									310.2			
Anselmo	Distribution	10-Jun-03									259.9			
Anselmo	Distribution	14-Aug-03				0.02	0	0.02			227.8			
Beemer	2002-1	19-Oct-05								1.57	-200			
Beemer	2002-1	19-Oct-05												
Beemer	2002-1	19-Oct-05									-215			
Beemer	2002-1	19-Oct-05									-213.5			
Beemer	2002-1	20-Jan-06												
Beemer	2002-1	20-Jan-06												
Beemer	2002-1	20-Jan-06	n.d.	8	33	0.43	0.40	0.03	0.3			10.12		
Beemer	2002-1	20-Jan-06				0.46	0.43	0.03						
Beemer	2002-1	20-Jan-06												
Beemer	2002-1	20-Jan-06												
Beemer	2002-1	20-Jan-06	n.d.	8	34	0.38	0.35	0.03	0.3			4.92		
Beemer	2002-1	20-Jan-06												
Beemer	2002-1	20-Jan-06	n.d.	8	35	0.34	0.30	0.04	0.3			3.68		
Beemer	2002-1	20-Jan-06												
Beemer	2002-1	20-Jan-06				0.51	0.42	0.09						
Beemer	2002-1	5-Apr-06												
Beemer	2002-1	5-Jul-06												
Beemer	2002-1	2-Oct-06												
Beemer	2002-1	17-Jan-07												
Beemer	2002-1	2-Apr-07												
Beemer	2002-1	30-Jul-07												
Bellwood	761	19-Jun-06				0.43	0.43	n.d						
Bellwood	761	19-Jun-06				0.46	0.42	0.04						
Bellwood	761	19-Jun-06				0.41	0.38	0.03						
Bellwood	761	19-Jun-06				0.43	0.40	0.03						
Bellwood	761	19-Jun-06				0.45	0.44	0.01						
Bellwood	761	19-Jun-06	n.d.	12	125	0.43	0.41	0.02	0.1	5.27		-6.31		
Bellwood	761	21-Jun-06	n.d.	10	124	0.80	0.80	n.d	n.d.	4.26		-9.35		
Bellwood	761	21-Jun-06				1.12	1.07	0.04						
Bellwood	761	21-Jun-06												
Bellwood	761	21-Jun-06												
Bellwood	761	21-Jun-06	n.d.	11	123	0.87	0.76	0.11	n.d.	1.61		-2.43		
Bellwood	761	21-Jun-06				1.83	1.79	0.04						
Bellwood	761	21-Jun-06				2.60	1.44	1.16						
Bellwood	761	21-Jun-06	n.d.	10	123	1.70	0.97	0.73	0.1	4.65		-3.67		

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Bellwood	761	21-Jun-06	1418	0	106.5	3						208.00	185.00	
Bellwood	761	23-Jun-06	1925	15	116.5	3						101.00	102.00	
Bellwood	761	23-Jun-06	1630	15	121.5	3						193.00	193.00	
Bellwood	761	23-Jun-06	1940	30	116.5	3						101.00	106.00	
Bellwood	761	23-Jun-06	1615	0	121.5	3						143.00	145.00	
Bellwood	761	23-Jun-06	1645	30	121.5	3						191.00	200.00	
Bellwood	761	23-Jun-06	1910	0	116.5	3						218.00	252.00	
Bellwood	761	16-Jul-06	720	720	55	275			7.90				121.40	
Bellwood	761	16-Jul-06	120	120	55	275							146.90	
Bellwood	761	16-Jul-06	180	180	55	275							145.80	
Bellwood	761	16-Jul-06	480	480	55	275							123.20	
Bellwood	761	16-Jul-06	60	60	55	275							147.10	
Bellwood	761	16-Jul-06	240	240	55	275							141.90	
Bellwood	761	20-Oct-06	1310	240	55	200						174.00		
Bellwood	761	20-Oct-06	2110	720	55	200						163.00		
Bellwood	761	20-Oct-06	1110	120	55	200						184.00		
Bellwood	761	20-Oct-06	1010	60	55	200						188.00		
Bellwood	761	20-Oct-06	910	0	55	350						200.00		
Bellwood	761	20-Oct-06	1210	180	55	200						181.00		
Bellwood	761	20-Oct-06	1710	480	55	200						166.00		
Bellwood	761	10-Feb-07	825	0	55	275						230.00		
Bellwood	761	10-Feb-07	840	15	55	275						236.00		
Bellwood	761	10-Feb-07	1430	480	55	275						199.00		
Bellwood	761	10-Feb-07	1230	240	55	275						186.00		
Bellwood	761	10-Feb-07	855	30	55	275						232.00		
Bellwood	761	10-Feb-07	925	60	55	275						203.00		
Bellwood	761	10-Feb-07	1025	120	55	275						198.00		
Bellwood	761	10-Feb-07	1125	180	55	275						204.00		
Bellwood	761	06-Mar-07	900	0	55	275	L31736-1	6.10				212.00		
Bellwood	761	06-Mar-07	915	15	55	275								
Bellwood	761	06-Mar-07	930	30	55	275	L31736-2	6.20				202.00		
Benkelman	721	06-Jun-05	1045	0	~23	400			19.30				7.6	
Benkelman	721	06-Jun-05	1115	30	~23	400			12.70				7.7	
Benkelman	721	06-Jun-05	1145	60	~23	400			10.90				8.2	
Benkelman	721	06-Jun-05	1245	120	~23	400			11.30				7.5	
Benkelman	721	06-Jun-05	1345	180	~23	400			10.50				8	
Benkelman	721	06-Jun-05	1445	240	~23	400			13.00				8.1	
Benkelman	721	12-Jul-05	1301	0	~23	400		21.10	22.00			6.36		
Benkelman	721	12-Jul-05	1316	15	~23	400								
Benkelman	721	12-Jul-05	1331	30	~23	400		12.30	14.10			7.78		
Benkelman	721	12-Jul-05	1401	60	~23	400		12.20	14.50			7.76		
Benkelman	721	12-Jul-05	1501	120	~23	400		12.90	14.70	n.d.		8.22		
Benkelman	721	12-Jul-05	1601	180	~23	400		12.80	15.00			8.25		
Benkelman	721	12-Jul-05	1704	240	~23	400		13.00	14.90			8.34		
Benkelman	721	14-Jul-05	940	N/A	15.65	400		12.10				7.52		
Benkelman	721	14-Jul-05	955	N/A	30.65	400		4.16				8.65		
Benkelman	721	14-Jul-05	1153	0	35.8	400 Filtered		4.08				8.18		
Benkelman	721	14-Jul-05	1153	0	35.8	400		8.20	9.50			7.74		
Benkelman	721	14-Jul-05	1200	7	35.8	400								
Benkelman	721	14-Jul-05	1203	10	35.8	400								
Benkelman	721	14-Jul-05	1208	15	35.8	400 Filtered		4.34				8.42		
Benkelman	721	14-Jul-05	1208	15	35.8	400		8.72	9.70			7.88		
Benkelman	721	14-Jul-05	1217	24	35.8	400								
Benkelman	721	14-Jul-05	1223	30	35.8	400 Filtered		4.67		n.d.		8.05		
Benkelman	721	14-Jul-05	1223	30	35.8	400		8.16	9.60			7.88		
Benkelman	721	14-Jul-05	1228	25	35.8	400								
Benkelman	721	14-Jul-05	1540	0	2 (Int)	400		8.64	9.80			7.73		
Benkelman	721	14-Jul-05	1540	0	2 (Int)	400 Filtered		4.35				8.18		
Benkelman	721	14-Jul-05	1546	6	2 (Int)	400								
Benkelman	721	14-Jul-05	1555	15	2 (Int)	400		8.91	9.60			7.77		
Benkelman	721	14-Jul-05	1555	15	2 (Int)	400 Filtered		4.71				8.22		

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Bellwood	761	21-Jun-06	7.60	630	5.6	18.0	292	356						
Bellwood	761	23-Jun-06	7.50	235	0.6	13.0	247	301						
Bellwood	761	23-Jun-06	7.40	245	0.8	14.0	236	288						
Bellwood	761	23-Jun-06	7.50	240	0.2	14.0	250	305	100	22.9	15.9	8.2	1.04	0.45
Bellwood	761	23-Jun-06	6.80	418	6.2	16.0	233	284						
Bellwood	761	23-Jun-06	7.50	242	0.4	12.0	252	308	103	24.8	17.1	10.8	0.49	0.38
Bellwood	761	23-Jun-06	7.50	239	1.7	17.0	217	264						
Bellwood	761	16-Jul-06												
Bellwood	761	16-Jul-06												
Bellwood	761	16-Jul-06												
Bellwood	761	16-Jul-06												
Bellwood	761	16-Jul-06												
Bellwood	761	16-Jul-06												
Bellwood	761	20-Oct-06	7.50	520		12.0								
Bellwood	761	20-Oct-06	7.50	580		12.0								
Bellwood	761	20-Oct-06	7.60	510		12.0								
Bellwood	761	20-Oct-06	7.60	590		12.0								
Bellwood	761	20-Oct-06	7.60	600		12.0								
Bellwood	761	20-Oct-06	7.50	490		12.0								
Bellwood	761	20-Oct-06	7.50	600		12.0								
Bellwood	761	10-Feb-07	7.80	670	6.4	12.0	254	310						
Bellwood	761	10-Feb-07	7.60	700	0.5	12.0	237	289						
Bellwood	761	10-Feb-07												
Bellwood	761	10-Feb-07	7.40	680		14.0								
Bellwood	761	10-Feb-07	7.60	720	0.2	12.0	242	295	105	24.9	17.1	11.0	0.18	0.38
Bellwood	761	10-Feb-07	7.60	710	0.2	12.0	244	298						
Bellwood	761	10-Feb-07	7.60	690	0.1	12.0	241	294						
Bellwood	761	10-Feb-07	7.40	690	0.1	12.0	236	288						
Bellwood	761	06-Mar-07	7.60	710		12.0	240	293	71.8	23.1	17.6	9.6	2.84	0.28
Bellwood	761	06-Mar-07	7.60	740		11.5	234	285						
Bellwood	761	06-Mar-07	7.60	740		11.5	238	290	105	24.9	17.1	10.7	0.19	0.37
Benkelman	721	06-Jun-05		N/A	N/A									
Benkelman	721	06-Jun-05		N/A	N/A									
Benkelman	721	06-Jun-05		N/A	N/A									
Benkelman	721	06-Jun-05		N/A	N/A									
Benkelman	721	06-Jun-05		N/A	N/A									
Benkelman	721	06-Jun-05		N/A	N/A									
Benkelman	721	12-Jul-05	7.43	1356	4.4	13.5	274	334					.06	
Benkelman	721	12-Jul-05	7.02	1334	7	12.0	274	334						
Benkelman	721	12-Jul-05	7.11	1330	7.3	11.8	281	343						
Benkelman	721	12-Jul-05	7.58	1311	7.8	11.8	268	327						
Benkelman	721	12-Jul-05		1317	8	11.8	287	350	113	96.9	38.1	29.3		.17
Benkelman	721	12-Jul-05	7.16	1317	6.6	12.0	292	356						
Benkelman	721	12-Jul-05	6.97	1327	7.1	12.0	286	349						
Benkelman	721	14-Jul-05	7.53	957	4.1	16.0								
Benkelman	721	14-Jul-05	7.29	976	3.2	15.0								
Benkelman	721	14-Jul-05			N/A								n.d.	
Benkelman	721	14-Jul-05	7.31	1243	6.2	14.0	292	356						
Benkelman	721	14-Jul-05	7.37	1212	4.2	16.3								
Benkelman	721	14-Jul-05	7.38	1204	3.2	16.0								
Benkelman	721	14-Jul-05			N/A				110	104	38.8	29.5		.73
Benkelman	721	14-Jul-05	7.39	1194	2.1	14.0	278	339						
Benkelman	721	14-Jul-05	7.39	1215	1.6	14.8								
Benkelman	721	14-Jul-05			N/A									
Benkelman	721	14-Jul-05	7.14	1205	1.2	14.2	285	347						
Benkelman	721	14-Jul-05	7.23	1210	1									
Benkelman	721	14-Jul-05	7.02	1050	3	16.2	283	345					n.d.	
Benkelman	721	14-Jul-05			N/A									
Benkelman	721	14-Jul-05	7.34	1166	2.1	15.0								
Benkelman	721	14-Jul-05	7.38	1160	1.6	14.7	291	355						
Benkelman	721	14-Jul-05			N/A				107	98.8	37.2	29		.66

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Bellwood	761	21-Jun-06				2.13	2.01	0.12						
Bellwood	761	23-Jun-06				1.24	0.73	0.51						
Bellwood	761	23-Jun-06				0.55	0.45	0.10						
Bellwood	761	23-Jun-06	n.d.	8	112	0.79	0.72	0.05	0.1	3.18		0.01		
Bellwood	761	23-Jun-06				0.39	0.37	0.02						
Bellwood	761	23-Jun-06	n.d.	10	112	0.48	0.42	0.06	n.d.	4.04		1.74		
Bellwood	761	23-Jun-06				2.19	0.77	1.42						
Bellwood	761	16-Jul-06												
Bellwood	761	16-Jul-06												
Bellwood	761	16-Jul-06												
Bellwood	761	16-Jul-06												
Bellwood	761	16-Jul-06												
Bellwood	761	16-Jul-06												
Bellwood	761	20-Oct-06												
Bellwood	761	20-Oct-06												
Bellwood	761	20-Oct-06												
Bellwood	761	20-Oct-06												
Bellwood	761	20-Oct-06												
Bellwood	761	20-Oct-06												
Bellwood	761	20-Oct-06												
Bellwood	761	10-Feb-07												
Bellwood	761	10-Feb-07				0.91	0.18	0.73						
Bellwood	761	10-Feb-07												
Bellwood	761	10-Feb-07												
Bellwood	761	10-Feb-07	n.d.	13	143	0.24	0.20	0.04	0.1	3.03		-0.91		
Bellwood	761	10-Feb-07				0.22	0.19	0.03						
Bellwood	761	10-Feb-07				0.23	0.21	0.02						
Bellwood	761	10-Feb-07				0.23	0.20	0.03						
Bellwood	761	06-Mar-07	n.d.	13	95				n.d.	1.52		-5.6		
Bellwood	761	06-Mar-07												
Bellwood	761	06-Mar-07	n.d.	13	141				n.d.	2.17		-0.2		
Benkelman	721	06-Jun-05	0.3											
Benkelman	721	06-Jun-05	0.4											
Benkelman	721	06-Jun-05	0.4											
Benkelman	721	06-Jun-05	0.5											
Benkelman	721	06-Jun-05	0.6											
Benkelman	721	06-Jun-05	0.8											
Benkelman	721	12-Jul-05									786.9			
Benkelman	721	12-Jul-05									846.8			
Benkelman	721	12-Jul-05									935.3			
Benkelman	721	12-Jul-05								8.5	878.1			
Benkelman	721	12-Jul-05	1.2	99	211				.1			3.01		
Benkelman	721	12-Jul-05									837.4			
Benkelman	721	12-Jul-05									859.4			
Benkelman	721	14-Jul-05									732.7			
Benkelman	721	14-Jul-05									860.5			
Benkelman	721	14-Jul-05												
Benkelman	721	14-Jul-05									754.5			
Benkelman	721	14-Jul-05									927.3			
Benkelman	721	14-Jul-05									989.8			
Benkelman	721	14-Jul-05	1.2	127	205				.1					
Benkelman	721	14-Jul-05								5.36	1066.4			
Benkelman	721	14-Jul-05									1130.4			
Benkelman	721	14-Jul-05												
Benkelman	721	14-Jul-05									1167.5			
Benkelman	721	14-Jul-05									1198.8			
Benkelman	721	14-Jul-05									782.7			
Benkelman	721	14-Jul-05												
Benkelman	721	14-Jul-05									1044.8			
Benkelman	721	14-Jul-05								5.53	1246.5			
Benkelman	721	14-Jul-05	1.1	98	205				.1			2.26		

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Benkelman	721	14-Jul-05	1604	24	2 (Int)	400								
Benkelman	721	14-Jul-05	1610	30	2 (Int)	400		8.59	10.00			7.68		
Benkelman	721	14-Jul-05	1610	30	2 (Int)	400 Filtered		4.82		1.0		8.18		
Benkelman	721	14-Jul-05	1701	0	25.75	400 Filtered		4.54				7.93		
Benkelman	721	14-Jul-05	1701	0	25.75	400		8.23	10.10			7.73		
Benkelman	721	14-Jul-05	1707	6	25.75	400								
Benkelman	721	14-Jul-05	1716	15	25.75	400		8.33	10.00			7.86		
Benkelman	721	14-Jul-05	1716	15	25.75	400 Filtered		4.53				7.89		
Benkelman	721	14-Jul-05	1731	30	25.75	400 Filtered		4.71		n.d.		7.91		
Benkelman	721	14-Jul-05	1731	30	25.75	400		8.12	10.00			7.59		
Benkelman	721	14-Jul-05	1746	0	4 (Int)	400		7.80	9.90			7.97		
Benkelman	721	14-Jul-05	1746	0	4 (Int)	400 Filtered		4.47				7.95		
Benkelman	721	14-Jul-05	1759	13	4 (Int)	400								
Benkelman	721	14-Jul-05	1802	15	4 (Int)	400		7.91	9.80			7.88		
Benkelman	721	14-Jul-05	1817	30	4 (Int)	400 Filtered		4.81		n.d.		7.89		
Benkelman	721	14-Jul-05	1817	30	4 (Int)	400		8.35	9.90			7.82		
Benkelman	96-1	27-Nov-02	1305	N/A	36	400	P22194-6	12.00						
Benkelman	96-1	06-Jan-03	1624	N/A	36	450	P22355-3	11.50						
Benkelman	96-1	31-Jan-03	1437	N/A	36	400	P22462-20	11.30						
Benkelman	96-1	10-Feb-03	816	N/A	36	400	P22355-23	11.00						
Benkelman	96-1	28-Feb-03	1452	N/A	36	400	P22616-14	9.73						
Benkelman	96-1	21-Mar-03	1527	N/A	36	400	P22653-45	10.80						
Benkelman	96-1	25-Apr-03	1505	N/A	36	400	P22714-71	10.90	12.50		10.5 / NA			
Benkelman	96-1	13-May-03	835	N/A	36	400	P22985-29	10.70	12.90		10.9		36.3	
Benkelman	96-1	04-Jun-03	848	N/A	36	400	P23144-49	9.32	12.60	0	11.0			
Benkelman	96-1	16-Jun-03	1340	N/A	36	400	P23144-14	9.37		0	11.1			
Benkelman	96-1	16-Jul-03	848	N/A	36	400	P23372-37	11.70		0			41.4	
Benkelman	96-1	13-Aug-03	820	N/A	36	400		10.22		0			41.3	
Benkelman	96-1	02-Dec-03	1551	N/A	36	400		9.99					43.2	
Benkelman	96-2	27-Nov-02	1115	N/A	42	350	P22194-5	10.60						
Benkelman	96-2	06-Jan-03	1600	N/A	42	350	P22355-4	9.55						
Benkelman	96-2	31-Jan-03	1408	N/A	42	350	P22462-19	9.68						
Benkelman	96-2	10-Feb-03	753	N/A	42	350	P22566-6	9.57						
Benkelman	96-2	28-Feb-03	1432	N/A	42	350	P22616-12	9.32						
Benkelman	96-2	21-Mar-03	1457	N/A	42	350	P22653-43	9.24						
Benkelman	96-2	25-Apr-03	1452	N/A	42	350	P22714-80	9.89	10.30		4.2 /NA			
Benkelman	96-2	13-May-03	800	N/A	42	350	P22985-34	9.88	10.60		NA / 3.7		47.4	
Benkelman	96-2	04-Jun-03	825	N/A	42	350	P23144-26	8.94	10.80	3.8	6.0			
Benkelman	96-2	16-Jun-03	1325	N/A	42	350	P23144-33	10.20		4.7	4.1			
Benkelman	96-2	16-Jul-03	830	N/A	42	350	P23372-32	11.10		3.7			39.3	
Benkelman	96-2	13-Aug-03	755	N/A	42	350		9.87		4.0			47.8	
Benkelman	96-2	02-Dec-03	1519	N/A	42	350		9.13					47.9	
Benkelman	Distribution	21-Mar-03	1447	N/A	N/A	N/A	P22653-60	9.91						
Benkelman	Distribution	25-Apr-03	1409	N/A	N/A	N/A	P22714-81	10.30	10.00					
Benkelman	Distribution	13-May-03	710	N/A	N/A	N/A	P22985-44	10.50	12.50					
Benkelman	Distribution	04-Jun-03	759	N/A	N/A	N/A	P23144-30	9.64						
Benkelman	Distribution	16-Jul-03	758	N/A	N/A	N/A	P23372-22	9.62						
Benkelman	Distribution	13-Aug-03	725	N/A	N/A	N/A		9.37						
Benkelman	Distribution	02-Dec-03	1449	N/A	N/A	N/A		9.20						
Bridgeport	27H	09-Jun-05	802	N/A	102	1		5.02					26.9	
Bridgeport	27H	09-Jun-05	858	N/A	96	1		3.49					32.3	
Bridgeport	27H	09-Jun-05	956	N/A	20	1								
Bridgeport	641	21-Sep-05	801	0		550	P28733-40	2.74				41.5		
Bridgeport	641	21-Sep-05	816	15		550	P28733-41	2.98				44.3		
Bridgeport	641	21-Sep-05	831	30		550	P28733-42	3.30				44.4		
Bridgeport	641	21-Sep-05	901	60		550	P28733-43	3.21				44.1		
Bridgeport	641	21-Sep-05	1001	120		550	P28733-44	3.29				44.7		
Bridgeport	641	21-Sep-05	1101	180		500	P28733-45	3.42				45.1		
Bridgeport	641	21-Sep-05	1201	240		500	P28733-46	3.50				45.5		
Bridgeport	691	08-Jun-05	1256	0		1200		2.09	1.50			75.1	72.8	
Bridgeport	691	08-Jun-05	1325	30		1200		2.72	2.60			66.7	61.4	

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Benkelman	721	14-Jul-05	7.39	1159	1.4	15.1								
Benkelman	721	14-Jul-05	7.39	1181	1.3	15.0	286	349						
Benkelman	721	14-Jul-05			N/A									
Benkelman	721	14-Jul-05			N/A								n.d.	
Benkelman	721	14-Jul-05	7.40	1147	4	15.5	289	352						
Benkelman	721	14-Jul-05	7.40	1196	3.3	15.5								
Benkelman	721	14-Jul-05	7.40	1195	2.1	15.0	286	349						
Benkelman	721	14-Jul-05			N/A				107	99.4	37.3	28.8		.67
Benkelman	721	14-Jul-05			N/A									
Benkelman	721	14-Jul-05	7.40	1172	1.3	15.5	282	344					n.d.	
Benkelman	721	14-Jul-05	7.38	1183	4.2	14.3	291	355						
Benkelman	721	14-Jul-05	7.38	1183	4.2	14.3	291	355						
Benkelman	721	14-Jul-05	7.39	1202	2.3	15.0								
Benkelman	721	14-Jul-05	7.39	1197	1.8	14.3	287	350	107	101	37.8	29.8		.66
Benkelman	721	14-Jul-05			N/A									
Benkelman	721	14-Jul-05		1195	1.2	14.7	287	350						
Benkelman	96-1	27-Nov-02	8.16	710	5.4	13.2	281	343						
Benkelman	96-1	06-Jan-03	7.60	854	8	13.0	298	363						
Benkelman	96-1	31-Jan-03	7.60	760	2.6	13.9	308	376						
Benkelman	96-1	10-Feb-03	7.60	305	0.6	13.0	282	344						
Benkelman	96-1	28-Feb-03	7.50	679	0.4	13.5	262	319						
Benkelman	96-1	21-Mar-03	7.50	858	0.4	13.5	288	351						
Benkelman	96-1	25-Apr-03	7.40	803	0.6	13.0	300	366						
Benkelman	96-1	13-May-03	7.30	788	0.6	13.0	295	360					n.d.	
Benkelman	96-1	04-Jun-03	7.40	863	0.7	13.0							n.d.	
Benkelman	96-1	16-Jun-03	7.50	1154	1.6	13.0	304	371						
Benkelman	96-1	16-Jul-03	7.50	1094	1.2	13.0	313	382						
Benkelman	96-1	13-Aug-03	7.40	890	1	12.8	287	350	95.4	153	30.9	14.8		n.d.
Benkelman	96-1	02-Dec-03	7.40	727	1.4	13.0	301	367	110	152	33.6	22.4		n.d.
Benkelman	96-2	27-Nov-02	7.59	1169	3.8	13.1	276	337						
Benkelman	96-2	06-Jan-03	7.30	1300	6.2	13.0	262	319						
Benkelman	96-2	31-Jan-03	7.50	1198	1.8	13.9	280	341						
Benkelman	96-2	10-Feb-03	7.50	896	0.6	13.0	253	308						
Benkelman	96-2	28-Feb-03	7.40	1083	0.6	13.0	255	311						
Benkelman	96-2	21-Mar-03	7.40	1375	0.5	13.1	267	326						
Benkelman	96-2	25-Apr-03	7.30	1395	0.6	13.5	269	328						
Benkelman	96-2	13-May-03	7.20	1266	0.6	13.0	260	317					n.d.	
Benkelman	96-2	04-Jun-03	7.30	1422	0.8	13.1							n.d.	
Benkelman	96-2	16-Jun-03	7.40	1976	1.2	13.5	269	328						
Benkelman	96-2	16-Jul-03	7.40	1720	1.2	13.1	274	334						
Benkelman	96-2	13-Aug-03	7.30	1469	0.8	13.0	263	321	204	248	60.3	21.4		0.03
Benkelman	96-2	02-Dec-03	7.30	1139	1.6	13.0	275	335	203	230	61.1	25.6		0.03
Benkelman	Distribution	21-Mar-03	7.40	1271	2.9	12.5	273	333						
Benkelman	Distribution	25-Apr-03	7.50	1226	3.1	12.0	276	336						
Benkelman	Distribution	13-May-03	7.20	1011	5.8	11.0	290	354						
Benkelman	Distribution	04-Jun-03	7.20	1142	13.8	14.0								
Benkelman	Distribution	16-Jul-03	7.30	1347	4.5	15.0	310	378						
Benkelman	Distribution	13-Aug-03	7.50	1089	3.8	14.0	281	343						
Benkelman	Distribution	02-Dec-03	7.40	1110	2.9	12.0	281	343						
Bridgeport	27H	09-Jun-05	7.42	676	0.8	10.0								
Bridgeport	27H	09-Jun-05	6.91	708	3.2	11.0								
Bridgeport	27H	09-Jun-05	7.05	309	5.4	16.0								
Bridgeport	641	21-Sep-05	7.80	1410	N/A	13.0								
Bridgeport	641	21-Sep-05	7.40	1310	N/A	12.0								
Bridgeport	641	21-Sep-05	7.50	1290	N/A	12.0								
Bridgeport	641	21-Sep-05	7.40	1590	N/A	12.2							n.d.	
Bridgeport	641	21-Sep-05	7.40	1430	N/A	12.7							n.d.	
Bridgeport	641	21-Sep-05	7.30	1460	N/A	13.0							n.d.	
Bridgeport	641	21-Sep-05	7.40	1490	N/A	13.4							n.d.	
Bridgeport	691	08-Jun-05	7.46	1323	0.8	12.0	345	421	132	190	26.9	9.9	n.d.	.05
Bridgeport	691	08-Jun-05	6.95	1350	0.6	10.5	340	415	129	190	27.2	11.3	n.d.	.06

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Benkelman	721	14-Jul-05									1319.7			
Benkelman	721	14-Jul-05									1347.2			
Benkelman	721	14-Jul-05												
Benkelman	721	14-Jul-05												
Benkelman	721	14-Jul-05									984.5			
Benkelman	721	14-Jul-05									1108.1			
Benkelman	721	14-Jul-05								5	1256.3			
Benkelman	721	14-Jul-05	1.1	97	208				.1			2.62		
Benkelman	721	14-Jul-05												
Benkelman	721	14-Jul-05									1363.7			
Benkelman	721	14-Jul-05									1392.5			
Benkelman	721	14-Jul-05									1392.5			
Benkelman	721	14-Jul-05									1398.7			
Benkelman	721	14-Jul-05	1.1	97	206				.1	6.62	1398.2	3.21		
Benkelman	721	14-Jul-05												
Benkelman	721	14-Jul-05									1397.2			
Benkelman	96-1	27-Nov-02												
Benkelman	96-1	06-Jan-03												
Benkelman	96-1	31-Jan-03												
Benkelman	96-1	10-Feb-03												
Benkelman	96-1	28-Feb-03												
Benkelman	96-1	21-Mar-03									228.1			
Benkelman	96-1	25-Apr-03									290.1			
Benkelman	96-1	13-May-03									266.4			
Benkelman	96-1	04-Jun-03												
Benkelman	96-1	16-Jun-03									248.3			
Benkelman	96-1	16-Jul-03									214			
Benkelman	96-1	13-Aug-03	7.06	53.45	221	0.05	0.01	0.04	< 0.1		217.5	9.04		
Benkelman	96-1	02-Dec-03	2.1	51.2	245	0.02	0	0.02	< 0.1		-157.2	10.15		
Benkelman	96-2	27-Nov-02												
Benkelman	96-2	06-Jan-03												
Benkelman	96-2	31-Jan-03												
Benkelman	96-2	10-Feb-03												
Benkelman	96-2	28-Feb-03												
Benkelman	96-2	21-Mar-03									253.4			
Benkelman	96-2	25-Apr-03									281.2			
Benkelman	96-2	13-May-03									195.8			
Benkelman	96-2	04-Jun-03												
Benkelman	96-2	16-Jun-03									242.4			
Benkelman	96-2	16-Jul-03									206.7			
Benkelman	96-2	13-Aug-03				0.04	0	0.04	< 0.1		233.6			
Benkelman	96-2	02-Dec-03		100.3		0.02	0	0.02	0.1		-170.5			
Benkelman	Distribution	21-Mar-03									239.8			
Benkelman	Distribution	25-Apr-03									249.2			
Benkelman	Distribution	13-May-03									288.5			
Benkelman	Distribution	04-Jun-03												
Benkelman	Distribution	16-Jul-03									209.5			
Benkelman	Distribution	13-Aug-03				0.02	0	0.02			253			
Benkelman	Distribution	02-Dec-03				0.04	0	0.04			-155.9			
Bridgeport	27H	09-Jun-05									898.3			
Bridgeport	27H	09-Jun-05									713			
Bridgeport	27H	09-Jun-05									1516.2			
Bridgeport	641	21-Sep-05												
Bridgeport	641	21-Sep-05												
Bridgeport	641	21-Sep-05												
Bridgeport	641	21-Sep-05												
Bridgeport	641	21-Sep-05												
Bridgeport	641	21-Sep-05												
Bridgeport	641	21-Sep-05												
Bridgeport	691	08-Jun-05	8.5	44	360				n.d.		898	4.65		
Bridgeport	691	08-Jun-05	8.3	44	359				n.d.		909.9	4.78		

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL
Bridgeport	691	08-Jun-05	1355	60		1200		3.34	2.30			60.8	61.6
Bridgeport	691	08-Jun-05	1455	120		1200		3.20	2.20			67.1	60.8
Bridgeport	691	08-Jun-05	1555	180		1200		2.92	2.50			68.9	61.8
Bridgeport	691	08-Jun-05	1655	240		1200		2.65	2.30			70.1	61.9
Bridgeport	691	08-Jun-05	1700	245		1200							
Bridgeport	691-MW	28-Jun-05		N/A	28-bailer			3.85				67.3	
Bridgeport	691-MW	28-Jun-05		N/A	7.8-bailer			3.65				67.4	
Bridgeport	691-MW	28-Jun-05		N/A	11-bailer			3.78				68.6	
Bridgeport	691-MW	28-Jun-05	1106	0	122	7		0.00	0.00			0	
Bridgeport	691-MW	28-Jun-05	1112	6	122	0.87							
Bridgeport	691-MW	28-Jun-05	1114	8	122	0.87		4.48				63	
Bridgeport	691-MW	28-Jun-05	1118	12	122	0.87		4.56				61.9	
Bridgeport	691-MW	28-Jun-05	1121	15	122	0.87		4.37	5.10			64.7	
Bridgeport	691-MW	28-Jun-05	1136	30	122	0.87		4.19	4.70			63.2	64.5
Bridgeport	691-MW	28-Jun-05	1248	0	99	0.84		4.28	4.70			63	
Bridgeport	691-MW	28-Jun-05	1253	5	99	0.85		4.53				64.1	
Bridgeport	691-MW	28-Jun-05	1255	7	99	0.85							
Bridgeport	691-MW	28-Jun-05	1257	9	99	0.85		4.32				63	
Bridgeport	691-MW	28-Jun-05	1260	12	99	0.85							
Bridgeport	691-MW	28-Jun-05	1304	15	99	0.85		4.13	4.80			62.4	
Bridgeport	691-MW	28-Jun-05	1315	26	99	0.85							
Bridgeport	691-MW	28-Jun-05	1319	30	99	0.84		4.34	4.70			62.7	
Bridgeport	691-MW	28-Jun-05	1340	0	76	1.1 @119 hz		4.50	5.20			64.1	
Bridgeport	691-MW	28-Jun-05	1346	6	76	1.1		4.84				63.7	
Bridgeport	691-MW	28-Jun-05	1349	9	76	1.1							
Bridgeport	691-MW	28-Jun-05	1352	12	76	1.1							
Bridgeport	691-MW	28-Jun-05	1355	15	76	1.1 @ 119 hz		4.44	4.90			64.8	62.1
Bridgeport	691-MW	28-Jun-05	1401	21	76	1.1							
Bridgeport	691-MW	28-Jun-05	1410	30	76	1.1		4.22	5.00			65.5	
Bridgeport	691-MW	28-Jun-05	1432	0	53	0.85		4.29	5.10			69.5	
Bridgeport	691-MW	28-Jun-05	1435	3	53	0.85		4.81				65.7	
Bridgeport	691-MW	28-Jun-05	1439	7	53	0.85		4.58				67.6	
Bridgeport	691-MW	28-Jun-05	1442	10	53	0.85							
Bridgeport	691-MW	28-Jun-05	1447	15	53	0.85		4.24	5.10			69.9	
Bridgeport	691-MW	28-Jun-05	1454	22	53	0.85		4.50				66	
Bridgeport	691-MW	28-Jun-05	1501	30	53	0.85		4.15	5.20			71.9	
Bridgeport	691-MW	28-Jun-05	1525	0	30	0.92 @ 95 hz		4.54	5.10			67.1	
Bridgeport	691-MW	28-Jun-05	1528	3	30	0.92		4.94				67	
Bridgeport	691-MW	28-Jun-05	1532	7	30	0.92		4.76				65.5	
Bridgeport	691-MW	28-Jun-05	1535	10	30	0.92							
Bridgeport	691-MW	28-Jun-05	1539	14	30	0.92		4.75				65	
Bridgeport	691-MW	28-Jun-05	1540	15	30	0.92 @ 95 hz		4.33	5.10			70	65.5
Bridgeport	691-MW	28-Jun-05	1555	30	30	0.92		4.19	5.00			67.1	
Bridgeport	691-MW	15-Aug-05	823	0	122	1-2		5.48	5.70			56.8	
Bridgeport	691-MW	15-Aug-05	832	9	122	4		5.36				56.3	
Bridgeport	691-MW	15-Aug-05	838	15	122	4		5.09	5.40			57.8	
Bridgeport	691-MW	15-Aug-05	853	30	122	4							
Bridgeport	691-MW	15-Aug-05	853	30	122	4		5.50	5.40			59.7	
Bridgeport	691-MW	15-Aug-05	916	0	99	4		5.70	5.70			64.3	
Bridgeport	691-MW	15-Aug-05	925	9	99	4		5.39				59.5	
Bridgeport	691-MW	15-Aug-05	931	15	99	4		5.43	5.50			59.7	
Bridgeport	691-MW	15-Aug-05	946	30	99	4				0.0051			
Bridgeport	691-MW	15-Aug-05	946	30	99	4		5.57	5.50			62	
Bridgeport	691-MW	15-Aug-05	1008	0	53	4		5.94	5.70			68.9	
Bridgeport	691-MW	15-Aug-05	1013	5	53	4		5.75				68.2	
Bridgeport	691-MW	15-Aug-05	1023	15	53	4		5.72	5.50			63.5	
Bridgeport	691-MW	15-Aug-05	1038	30	53	4							
Bridgeport	691-MW	15-Aug-05	1038	30	53	4		5.64	5.50			65.5	
Bridgeport	691-MW	23-Aug-05		30	53	4				nd			
Bridgeport	691-MW	23-Aug-05		30	99	4				nd			
Bridgeport	691-MW	23-Aug-05		30	122	4				nd			

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Bridgeport	691	08-Jun-05	6.41	1361	1.2	11.0	352	429	128	187	27	12.3		.06
Bridgeport	691	08-Jun-05	6.87	1375	0.2	11.0	352	429	129	188	27.2	11.5		.06
Bridgeport	691	08-Jun-05	6.49	1387	0.2	11.0	341	416	131	189	27.5	11.9		.07
Bridgeport	691	08-Jun-05	6.88	1390	0.3	10.5	341	416	128	187	27.2	11.9		.07
Bridgeport	691	08-Jun-05	7.19		0.2	11.0								
Bridgeport	691-MW	28-Jun-05			N/A									
Bridgeport	691-MW	28-Jun-05			N/A									
Bridgeport	691-MW	28-Jun-05			N/A									
Bridgeport	691-MW	28-Jun-05	6.43	280	7	19.0	341	416					n.d.	
Bridgeport	691-MW	28-Jun-05	7.17	977	5.8	13.0								
Bridgeport	691-MW	28-Jun-05	7.21	1113	4.8	12.0								
Bridgeport	691-MW	28-Jun-05	7.25	1168	3.4	12.0								
Bridgeport	691-MW	28-Jun-05	7.26	1200	3.2	12.0	361	440	117	208	33.9	24.3		n.d.
Bridgeport	691-MW	28-Jun-05	7.10	1240	1.9	12.0	350	427						
Bridgeport	691-MW	28-Jun-05	7.38	535	2.2	13.6	346	422						
Bridgeport	691-MW	28-Jun-05	7.39	1250	1.3	13.0							n.d.	
Bridgeport	691-MW	28-Jun-05	7.39	1255	N/A	12.5								
Bridgeport	691-MW	28-Jun-05	7.39	1258	0.8	12.0								
Bridgeport	691-MW	28-Jun-05	7.39	1262	0.8	12.0								
Bridgeport	691-MW	28-Jun-05	7.40	1263	0.6	11.8	330	402	121	210	34	22.1		.01
Bridgeport	691-MW	28-Jun-05	7.25	1272	0.4	11.8								
Bridgeport	691-MW	28-Jun-05	7.35	1276	0.3	11.8	363	443						
Bridgeport	691-MW	28-Jun-05	7.20	1250	3.5	11.6	348	424					n.d.	
Bridgeport	691-MW	28-Jun-05	7.25	1279	2.1	11.9								
Bridgeport	691-MW	28-Jun-05	7.29	1285	1.2	11.8								
Bridgeport	691-MW	28-Jun-05	7.31	1286	0.8	11.8								
Bridgeport	691-MW	28-Jun-05	7.32	1288	0.6	11.8	357	435	120	215	34.7	24.4		.01
Bridgeport	691-MW	28-Jun-05	7.35	1288	0.4	11.9								
Bridgeport	691-MW	28-Jun-05	7.36	1290	0.2	11.6	359	438						
Bridgeport	691-MW	28-Jun-05	6.97	1267	1.8	13.0	390	475					n.d.	
Bridgeport	691-MW	28-Jun-05	7.13	1292	1.1	12.7								
Bridgeport	691-MW	28-Jun-05	7.23	1296	0.7	12.4								
Bridgeport	691-MW	28-Jun-05	7.27	1299	0.4	12.2								
Bridgeport	691-MW	28-Jun-05	7.31	1289	0.3	12.2	363	443	120	222	35.3	25.5		.01
Bridgeport	691-MW	28-Jun-05	7.33	1297	0.2	12.3								
Bridgeport	691-MW	28-Jun-05	7.35	1293	0.2	12.0	368	449						
Bridgeport	691-MW	28-Jun-05	7.11	1192	2.7	13.8	371	452						
Bridgeport	691-MW	28-Jun-05	7.21	1278	2.2	13.0							n.d.	
Bridgeport	691-MW	28-Jun-05	7.27	1296	1.6	12.5								
Bridgeport	691-MW	28-Jun-05	7.30	1300	1.4	12.5								
Bridgeport	691-MW	28-Jun-05	7.32	1301	1.1	12.5								
Bridgeport	691-MW	28-Jun-05	7.32	1303	1	12.4	369	450	117	215	34.4	25.2		.01
Bridgeport	691-MW	28-Jun-05	7.04	1290	0.5	12.2	350	427						
Bridgeport	691-MW	15-Aug-05	6.49	1663	2.4	12.4	347	423					n.d.	
Bridgeport	691-MW	15-Aug-05	6.99	1652	1.5	12.4	305	372						
Bridgeport	691-MW	15-Aug-05	7.13	1651	0.4	12.6	349	426						
Bridgeport	691-MW	15-Aug-05			N/A									
Bridgeport	691-MW	15-Aug-05	7.23	1645	0.2	12.0	359	438	128	213	33	16.9		.02
Bridgeport	691-MW	15-Aug-05	7.28	1676	3	13.0	387	472					n.d.	
Bridgeport	691-MW	15-Aug-05	7.28	1673	0.6	12.7	380	463						
Bridgeport	691-MW	15-Aug-05	7.28	1675	0.4	13.4	359	438						
Bridgeport	691-MW	15-Aug-05			N/A									
Bridgeport	691-MW	15-Aug-05	7.28	1679	0.2	12.0	371	452	129	222	34	19		.02
Bridgeport	691-MW	15-Aug-05	7.25	1700	2.8	13.0	375	457					n.d.	
Bridgeport	691-MW	15-Aug-05	7.25	1706	0.3	13.0	382	466						
Bridgeport	691-MW	15-Aug-05	7.27	NA	0.4	12.5	293	357						
Bridgeport	691-MW	15-Aug-05			N/A									
Bridgeport	691-MW	15-Aug-05	7.27	1694	0.7	12.4	362	441	129	225	34.6	19.7		.02
Bridgeport	691-MW	23-Aug-05			N/A									
Bridgeport	691-MW	23-Aug-05			N/A									
Bridgeport	691-MW	23-Aug-05			N/A									

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Bridgeport	691	08-Jun-05	8.4	43	356				n.d.		834.7	3.84		
Bridgeport	691	08-Jun-05	8.3	42	355				n.d.		836.9	4.25		
Bridgeport	691	08-Jun-05	8.4	43	352				n.d.		819	5.58		
Bridgeport	691	08-Jun-05	8.4	43	352				n.d.		872.2	4.83		
Bridgeport	691	08-Jun-05									895.5			
Bridgeport	691-MW	28-Jun-05												
Bridgeport	691-MW	28-Jun-05												
Bridgeport	691-MW	28-Jun-05												
Bridgeport	691-MW	28-Jun-05									800.9			
Bridgeport	691-MW	28-Jun-05									812.3			
Bridgeport	691-MW	28-Jun-05									835.7			
Bridgeport	691-MW	28-Jun-05									852.4			
Bridgeport	691-MW	28-Jun-05	11.9	47	421				n.d.	5.63	878.4	2.24		
Bridgeport	691-MW	28-Jun-05									825.9			
Bridgeport	691-MW	28-Jun-05									837.3			
Bridgeport	691-MW	28-Jun-05									854.1			
Bridgeport	691-MW	28-Jun-05									865.4			
Bridgeport	691-MW	28-Jun-05									872.7			
Bridgeport	691-MW	28-Jun-05									877.8			
Bridgeport	691-MW	28-Jun-05	12.1	47	380				n.d.	8.16	888.7	7.28		
Bridgeport	691-MW	28-Jun-05									922.3			
Bridgeport	691-MW	28-Jun-05									920.5			
Bridgeport	691-MW	28-Jun-05									866.4			
Bridgeport	691-MW	28-Jun-05									876.9			
Bridgeport	691-MW	28-Jun-05									896.1			
Bridgeport	691-MW	28-Jun-05									942.1			
Bridgeport	691-MW	28-Jun-05	12	48	379				n.d.	7.9	941.1	6.36		
Bridgeport	691-MW	28-Jun-05									954.4			
Bridgeport	691-MW	28-Jun-05									987.9			
Bridgeport	691-MW	28-Jun-05									839.7			
Bridgeport	691-MW	28-Jun-05									874.2			
Bridgeport	691-MW	28-Jun-05									917.3			
Bridgeport	691-MW	28-Jun-05									1318.4			
Bridgeport	691-MW	28-Jun-05	11.7	48	383				n.d.	7.87	1289	6.74		
Bridgeport	691-MW	28-Jun-05									1135.7			
Bridgeport	691-MW	28-Jun-05									1293			
Bridgeport	691-MW	28-Jun-05									644.8			
Bridgeport	691-MW	28-Jun-05									728.1			
Bridgeport	691-MW	28-Jun-05									919.4			
Bridgeport	691-MW	28-Jun-05									954.9			
Bridgeport	691-MW	28-Jun-05									1013.5			
Bridgeport	691-MW	28-Jun-05	11.6	48	381				n.d.	5.1	1029.2	5.11		
Bridgeport	691-MW	28-Jun-05									982.1			
Bridgeport	691-MW	15-Aug-05												
Bridgeport	691-MW	15-Aug-05												
Bridgeport	691-MW	15-Aug-05												
Bridgeport	691-MW	15-Aug-05												
Bridgeport	691-MW	15-Aug-05	14.2	50	397				.1	5.68		4.79		
Bridgeport	691-MW	15-Aug-05												
Bridgeport	691-MW	15-Aug-05												
Bridgeport	691-MW	15-Aug-05												
Bridgeport	691-MW	15-Aug-05												
Bridgeport	691-MW	15-Aug-05	13.9	51	407				.1	6.11		4.97		
Bridgeport	691-MW	15-Aug-05												
Bridgeport	691-MW	15-Aug-05												
Bridgeport	691-MW	15-Aug-05												
Bridgeport	691-MW	15-Aug-05												
Bridgeport	691-MW	15-Aug-05	13.6	53	407				.1	6.07		5.37		
Bridgeport	691-MW	23-Aug-05												
Bridgeport	691-MW	23-Aug-05												
Bridgeport	691-MW	23-Aug-05												

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Bridgeport	Distribution-1	28-Jun-05	1645	N/A	N/A	N/A		2.66				98.3		
Bridgeport	Distribution-2	28-Jun-05	1701	N/A	N/A	N/A		2.60				48		
Bridgeport	Domestic	15-Aug-05	1053	N/A	N/A	N/A		6.19				30.2		
Bridgeport	Domestic	15-Aug-05	1056	N/A	N/A	N/A		5.81				28.3		
Bridgeport	Domestic	15-Aug-05	1059	N/A	N/A	N/A		5.10				22.5		
Bridgeport	Domestic	15-Aug-05	1102	N/A	N/A	N/A		7.33				14.3		
Bridgeport	Domestic	15-Aug-05	1105	N/A	N/A	N/A		4.61				28.7		
Broadwater	551	17-Dec-02	1115	N/A		220	P22233-5	16.00						
Broadwater	551	07-Jan-03	1031	N/A		220	P22355-17	15.90						
Broadwater	551	27-Jan-03	1025	N/A		220	P22462-1	16.70						
Broadwater	551	09-Feb-03	1250	N/A		220	P22194-12	15.60						
Broadwater	551	14-Mar-03	1758	N/A		220	P22495-15	17.50						
Broadwater	551	02-May-03	1558	N/A		220	P22495-20	17.90					27.1	
Broadwater	551	03-Jun-03	1523	N/A		220	P22985-30	13.40	17.80	0	15.6			
Broadwater	551	30-Jun-03	1705	N/A		220	P22495-26	14.00					27.4	
Broadwater	551	15-Jul-03	1432	N/A		220	P23144-21	14.30		0			26.4	
Broadwater	551	03-Dec-03	1545	N/A		220		13.90					28.9	
Broadwater	751	17-Dec-02	1200	N/A	~40	550	P22233-6	13.50						
Broadwater	751	07-Jan-03	1120	N/A	~40	550	P22355-18	13.50						
Broadwater	751	27-Jan-03	1110	N/A	~40	550	P22462-2	12.00						
Broadwater	751	09-Feb-03	1345	N/A	~40	550	P22355-26	11.30						
Broadwater	751	14-Mar-03	1819	N/A	~40	550	P22495-14	11.60						
Broadwater	751	02-May-03	1630	N/A	~40	550	P22495-21	12.30					25.1	
Broadwater	751	12-May-03	1444	N/A	~40	550	P22985-49	11.70	14.50		12.2		25	
Broadwater	751	03-Jun-03	1401	N/A	~40	550	P23144-37	11.80	15.60	0	12.9			
Broadwater	751	30-Jun-03	1621	N/A	~40	550	P22495-27	13.60					25.3	
Broadwater	751	15-Jul-03	1312	N/A	~40	550	P23144-13	13.20		0			25.2	
Broadwater	751	12-Aug-03	1350	N/A	~40	550		13.49		0			26.8	
Broadwater	751	03-Dec-03	1605	N/A	~40	550		11.50					26.7	
Broadwater	Distribution	03-Jun-03	1440	N/A	N/A	N/A	P22985-25	12.00						
Broadwater	Distribution	15-Jul-03	1420	N/A	N/A	N/A	P23372-25	13.40						
Broadwater	Distribution	12-Aug-03	1345	N/A	N/A	N/A		13.60						
Broadwater	Distribution	03-Dec-03	1620	N/A	N/A	N/A		13.10						
Cairo	951	21-Feb-05	1658	N/A	90	450	P27307-18	9.18		0	10.9			
Cairo	951	25-Apr-05	1630	N/A	90	450	P27621-28	9.83						
Cairo	952	16-Aug-05	2007	N/A	90	500		9.67		nd				
Cairo	952	18-Oct-05	1643	N/A	90	500	P28350-40	9.62						
Cambridge	531	27-Nov-02	1800	N/A	~32	430	P22194-2	14.00						
Cambridge	531	06-Jan-03	1310	N/A	~32	430	P22355-19	13.80						
Cambridge	531	31-Jan-03	1202	N/A	~32	430	P22462-16	13.40						
Cambridge	531	10-Feb-03	1215	N/A	~32	430	P22566-7	12.60						
Cambridge	531	28-Feb-03	1155	N/A	~32	430	P22616-15	12.30						
Cambridge	531	21-Mar-03	1145	N/A	~32	430	P22653-46	12.30						
Cambridge	531	25-Apr-03	1220	N/A	~32	430	P22714-72	12.20	12.60		11.1 / NA			
Cambridge	531	13-May-03	1313	N/A	~32	430	P22985-19	13.10	14.00		10.4		14.2	
Cambridge	531	04-Jun-03	1326	N/A	~32	430	P23144-2	11.80	13.60	2.5	12.0			
Cambridge	531	16-Jun-03	1149	N/A	~32	430	P23144-20	11.30		2.8	11.7			
Cambridge	531	09-Jul-03	1424	N/A	~32	430	P23144-32	13.40		2.5			14.3	
Cambridge	531	13-Aug-03	1540	N/A	~32	430		12.65		1.9			15.7	
Cambridge	531	02-Dec-03	911	N/A	~32	430		12.80					15.7	
Cambridge	531	13-Mar-07	1151	0		51	L31736-10	14.40				15.7		
Cambridge	531	13-Mar-07	1206	15		51								
Cambridge	531	13-Mar-07	1221	30		51	L31736-11	15.40				15.8		
Cambridge	831	27-Nov-02	1730	N/A	55	525	P22194-1	10.60						
Cambridge	831	06-Jan-03	1230	N/A	55	525	P22355-20	8.74						
Cambridge	831	31-Jan-03	1137	N/A	55	525	P22462-15	9.81						
Cambridge	831	10-Feb-03	1157	N/A	55	525	P22566-6	8.73						
Cambridge	831	28-Feb-03	1134	N/A	55	525	P22161-16	8.83						
Cambridge	831	21-Mar-03	1120	N/A	55	525	P22653-56	9.76						
Cambridge	831	25-Apr-03	1155	N/A	55	525	P22714-84	9.51	10.80		9.4 / NA			
Cambridge	831	13-May-03	1247	N/A	55	525	P22985-50	9.51	11.10		9.7 / 9.8		46.3	

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Bridgeport	Distribution-1	28-Jun-05	7.46	1170	1.6	23.0	339	413						
Bridgeport	Distribution-2	28-Jun-05	7.42	1254	2.2	23.0								
Bridgeport	Domestic	15-Aug-05	7.48	768	6.8	19.0	172	210						
Bridgeport	Domestic	15-Aug-05	7.34	917	7	17.0	206	251						
Bridgeport	Domestic	15-Aug-05	7.41	759	6.3	15.0	214	261						
Bridgeport	Domestic	15-Aug-05	7.58	586	6.9	19.0	153	187						
Bridgeport	Domestic	15-Aug-05	7.46	801	6.1	16.0	205	250						
Broadwater	551	17-Dec-02	6.80	1120	N/A	14.4	305	372						
Broadwater	551	07-Jan-03	7.60	785	3.2	13.1	283	345						
Broadwater	551	27-Jan-03	7.30	1120	N/A	13.5	301	367						
Broadwater	551	09-Feb-03	7.40	738	1.5	13.8	305	372						
Broadwater	551	14-Mar-03	7.30	970	N/A	14.0	281	343						
Broadwater	551	02-May-03	7.20	870	N/A	14.0	289	344					n.d.	
Broadwater	551	03-Jun-03	7.30	899	2	13.1								
Broadwater	551	30-Jun-03	7.30	1070	N/A	14.0	270	329						
Broadwater	551	15-Jul-03	7.20	1055	2	14.0	286	349						
Broadwater	551	03-Dec-03	7.20	751	7.2	13.5	292	356	121.4	117	25.2	22.1		n.d.
Broadwater	751	17-Dec-02	7.63	1090	N/A	15.0	283	345						
Broadwater	751	07-Jan-03	7.50	749	1.5	14.2	267	326						
Broadwater	751	27-Jan-03	7.20	1020	N/A	14.5	280	341						
Broadwater	751	09-Feb-03	7.30	675	1.6	15.0	280	341						
Broadwater	751	14-Mar-03	7.40	1000	N/A	14.0	260	317						
Broadwater	751	02-May-03	7.30	840	N/A	14.5	268	327						
Broadwater	751	12-May-03	7.20	871	2	15.0	275	335					n.d.	
Broadwater	751	03-Jun-03	7.20	891	1.5	15.9							0.02	
Broadwater	751	30-Jun-03	6.90	1040	N/A	14.5	258	315						
Broadwater	751	15-Jul-03	7.20	1082	1.5	14.2	277	338						
Broadwater	751	12-Aug-03	7.20	1074	1.6	15.0	296	361	117	108	25	15.8		n.d.
Broadwater	751	03-Dec-03	7.30	740	4	13.8	275	335	111	112	24.9	21.3		n.d.
Broadwater	Distribution	03-Jun-03	7.20	896	3.3	19.0							n.d.	
Broadwater	Distribution	15-Jul-03	7.10	1014	3.6	19.8	285	347						
Broadwater	Distribution	12-Aug-03	7.20	1070	3.6	27.0	300	366					n.d.	
Broadwater	Distribution	03-Dec-03	7.30	742	3.4	12.0	291	355						
Cairo	951	21-Feb-05	7.40	168.4	1.6	11.2	91	111	32.3	5.04	4.2	7.5		n.d.
Cairo	951	25-Apr-05	6.70	184	2	11.5	74	90						
Cairo	952	16-Aug-05	7.30	240	2	12.0	99	121	33.2	5.21	4.42	7.4		n.d.
Cairo	952	18-Oct-05	7.20	201	1.6	11.0	88	107						
Cambridge	531	27-Nov-02	7.17	480	0.4	13.5	251	306						
Cambridge	531	06-Jan-03	7.20	617	0.2	13.9	276	336						
Cambridge	531	31-Jan-03	7.40	508	0.2	13.8	285	347						
Cambridge	531	10-Feb-03	7.60	519	0.3	13.5	241	294						
Cambridge	531	28-Feb-03	7.60	545	0.4	13.5	241	294						
Cambridge	531	21-Mar-03	7.50	598	0.2	13.5	244	297						
Cambridge	531	25-Apr-03	7.30	534	0.2	13.7	244	297						
Cambridge	531	13-May-03	7.40	640	0.2	14.0	254	310					0.13	
Cambridge	531	04-Jun-03	7.40	649	0.3	13.2							0.25	
Cambridge	531	16-Jun-03	7.50	782	0.3	13.5	263	321					0.18	
Cambridge	531	09-Jul-03	7.50	817	0.4	13.7	254	310						
Cambridge	531	13-Aug-03	7.40	810	3.2	13.2	264	322	82.6	81.7	24.6	18.9	0.11	0.33
Cambridge	531	02-Dec-03	7.60	583	4.5	13.0	292	356	76.3	89.8	24.6	26.8		0.35
Cambridge	531	13-Mar-07	7.60	570	5.6	13	296	361	80.3	62.8	24.4	17.5		0.34
Cambridge	531	13-Mar-07	7.50	870	0.4	13	301	367						
Cambridge	531	13-Mar-07	7.40	880	0.4	13	285	347	75.8	59.7	23.5	18.4		0.32
Cambridge	831	27-Nov-02	7.63	689	6.4	13.4	365	445						
Cambridge	831	06-Jan-03	7.00	848	0.2	14.1	396	483						
Cambridge	831	31-Jan-03	7.20	666	0.2	13.8	392	478						
Cambridge	831	10-Feb-03	7.30	702	0.4	14.0	363	443						
Cambridge	831	28-Feb-03	7.30	718	0.4	13.8	366	446						
Cambridge	831	21-Mar-03	7.20	823	0.2	13.8	379	462						
Cambridge	831	25-Apr-03	7.10	694	0.2	13.5	378	461						
Cambridge	831	13-May-03	7.20	864	0.4	14.0	382	466					n.d.	

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Bridgeport	Distribution-1	28-Jun-05									771.8			
Bridgeport	Distribution-2	28-Jun-05									857.2			
Bridgeport	Domestic	15-Aug-05												
Bridgeport	Domestic	15-Aug-05												
Bridgeport	Domestic	15-Aug-05												
Bridgeport	Domestic	15-Aug-05												
Bridgeport	Domestic	15-Aug-05												
Broadwater	551	17-Dec-02												
Broadwater	551	07-Jan-03												
Broadwater	551	27-Jan-03												
Broadwater	551	09-Feb-03												
Broadwater	551	14-Mar-03												
Broadwater	551	02-May-03												
Broadwater	551	03-Jun-03									281.8			
Broadwater	551	30-Jun-03												
Broadwater	551	15-Jul-03									219.4			
Broadwater	551	03-Dec-03		25		0.03	0	0.03	< 0.1		-106.1			
Broadwater	751	17-Dec-02												
Broadwater	751	07-Jan-03												
Broadwater	751	27-Jan-03												
Broadwater	751	09-Feb-03												
Broadwater	751	14-Mar-03												
Broadwater	751	02-May-03												
Broadwater	751	12-May-03									271.1			
Broadwater	751	03-Jun-03									324.1			
Broadwater	751	30-Jun-03												
Broadwater	751	15-Jul-03									222.5			
Broadwater	751	12-Aug-03	17.68	27.2	231	0.02	0	0.02	< 0.1		223.8	4.92		
Broadwater	751	03-Dec-03	14.7	27.1	263	0.02	0	0.02	< 0.1		-92	5.09		
Broadwater	Distribution	03-Jun-03												
Broadwater	Distribution	15-Jul-03									229.8			
Broadwater	Distribution	12-Aug-03				0.01	0	0.01			229			
Broadwater	Distribution	03-Dec-03				0.03	0	0.03			-84.5			
Cairo	951	21-Feb-05	0.9	3	14	0	0	0	.6		-190.7	3.46		
Cairo	951	25-Apr-05									-1000			
Cairo	952	16-Aug-05	1.3	2	14	0.02			.5			1.76		
Cairo	952	18-Oct-05									-190.3			
Cambridge	531	27-Nov-02												
Cambridge	531	06-Jan-03												
Cambridge	531	31-Jan-03												
Cambridge	531	10-Feb-03												
Cambridge	531	28-Feb-03												
Cambridge	531	21-Mar-03									65.8			
Cambridge	531	25-Apr-03									53.9			
Cambridge	531	13-May-03									69.4			
Cambridge	531	04-Jun-03												
Cambridge	531	16-Jun-03									129.3			
Cambridge	531	09-Jul-03									190			
Cambridge	531	13-Aug-03	3.98	33.9	116.8	0.14	0.08	0.06	0.1		189.1	7.89		
Cambridge	531	02-Dec-03	1.9	34.4	121	0.28	0.21	0.07	0.1		-93.3	5.4		
Cambridge	531	13-Mar-07	0.3	36	119					3.08		-1.08		
Cambridge	531	13-Mar-07												
Cambridge	531	13-Mar-07	0.3	36	117	0.15	0.14	0.01		3.9		-1.92		
Cambridge	831	27-Nov-02												
Cambridge	831	06-Jan-03												
Cambridge	831	31-Jan-03												
Cambridge	831	10-Feb-03												
Cambridge	831	28-Feb-03												
Cambridge	831	21-Mar-03									272.3			
Cambridge	831	25-Apr-03									221.1			
Cambridge	831	13-May-03									319			

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Cambridge	831	04-Jun-03	1308	N/A	55	525	P23144-1	9.98	11.60	0	10.4			
Cambridge	831	16-Jun-03	1133	N/A	55	525	P23144-42	8.75		0	10.4			
Cambridge	831	09-Jul-03	1448	N/A	55	525	P23144-4	9.07		0			46	
Cambridge	831	13-Aug-03	1630	N/A	55	525		9.77		0			45.7	
Cambridge	831	02-Dec-03	736	N/A	55	525		8.55					49.6	
Cambridge	Distribution	21-Mar-03	1128	N/A	N/A	N/A	P22616-1	9.65						
Cambridge	Distribution	25-Apr-03	1150	N/A	N/A	N/A	P22714-74	9.68	10.90					
Cambridge	Distribution	13-May-03	1304	N/A	N/A	N/A	P22985-31	9.63	12.00					
Cambridge	Distribution	04-Jun-03	1305	N/A	N/A	N/A	P23144-12	8.58						
Cambridge	Distribution	09-Jul-03	1450	N/A	N/A	N/A	P23144-11	9.62						
Cambridge	Distribution	13-Aug-03	1543	N/A	N/A	N/A		9.29						
Cambridge	Distribution	02-Dec-03	740	N/A	N/A	N/A		9.02						
Cedar Bluffs	571	21-Feb-05	945	N/A	~111	300	P24577-22	9.70		0	10.2			
Cedar Bluffs	571	25-Apr-05	944	N/A	~111	300	P27621-26	9.80						
Cedar Bluffs	571	17-Aug-05	1140	N/A	~111	300		10.00		nd				
Cedar Bluffs	571	19-Oct-05	1439	N/A	~111	300	P27621-73	9.70						
Clarks	2005-1	19-Sep-05	909	42	85	400			1.60	n.d.		43.30		
Clarks	2005-1	19-Sep-05	1214	15	85	400		2.98				38.90		
Clarks	2005-1	19-Sep-05	857	30	85	400		2.36				42.30		
Clarks	2005-1	19-Sep-05	1234	25	85	400			1.70	n.d.		40.30		
Clarks	2005-1	21-Oct-05	1205	12960	85	400		2.96				44.10		
Clarks	2005-1	02-Nov-05	1212		85	400	P28852-18	4.55				40.60	46.50	
Clarks	2005-1	25-Jan-06	1525	60	85	400	L29438-24		10.00			62.10	56.50	
Clarks	2005-1	25-Jan-06	1455	30	85	400	L29438-22					61.00		
Clarks	2005-1	25-Jan-06	1425	0	85	400	L29438-20					56.30		
Clarks	2005-1	25-Jan-06	1440	15	85	400	L29438-21					61.20		
Clarks	2005-1	15-Feb-06	1100		85	400	P21797-30					64.10		
Clarks	2005-1	06-Mar-06	1640	30	85	400	L29598-4					68.60		
Clarks	2005-1	18-Aug-06	1800		85	400						57.40		
Clarks	2005-1	30-May-07	1500		85	400	P31882-6					49.10		
Clarks	2005-1	05-Jun-07	1400	60	85	100	L32375-5					57.20		
Clarks	2005-1	05-Jun-07	1410	20	85	100	L32375-1					60.40		
Clarks	2005-1	10-Jun-07	1530	60	85	100	L32375-6					58.60		
Clarks	2005-1	10-Jun-07	1450	20	85	100	L32375-2					58.20		
Clarks	2005-1	15-Jun-07	1450	20	85	100	L32375-3					56.90		
Clarks	2005-1	15-Jun-07	1530	60	85	100	L32375-7					41.80		
Clarks	2005-1	20-Jun-07	750	20	85	100	L32375-4					60.40		
Clarks	2005-1	20-Jun-07	830	60	85	100	L32375-8					56.40		
Clarks	2005-1	25-Jun-07	1020	20	85	100	L32486-1					61.10		
Clarks	2005-1	25-Jun-07	1100	60	85	100	L32486-2					57.30		
Clarks	2005-1	30-Jun-07	1200	60	85	100	L32486-4					58.70		
Clarks	2005-1	30-Jun-07	1120	20	85	100	L32486-3					61.00		
Clarks	2005-1	05-Jul-07	1200	60	85	100	L32486-6					62.20		
Clarks	2005-1	05-Jul-07	1120	20	85	100	L32486-5					63.90		
Clarks	2005-1	10-Jul-07	1120	20	85	100	L32486-7					58.60		
Clarks	2005-1	10-Jul-07	1200	60	85	100	L32486-8					58.30		
Clarks	2005-2	19-Sep-05	1645	0	94.5	400		2.35				40.10		
Clarks	2005-2	19-Sep-05	1715	30	94.5	400		2.60	2.40	n.d.		39.50		
Clarks	2005-2	22-Sep-05	1102	0	100	4						27.80		
Clarks	2005-2	22-Sep-05	1320	0	94.5	400		2.82				39.50		
Clarks	2005-2	22-Sep-05	1212	30	86	4			1.30	n.d.		52.00		
Clarks	2005-2	22-Sep-05	1157	15	86	4						66.80		
Clarks	2005-2	22-Sep-05	1147	5	86	4								
Clarks	2005-2	22-Sep-05	1132	30	100	4			1.10	n.d.		31.70		
Clarks	2005-2	22-Sep-05	1142	0	86	4						57.50		
Clarks	2005-2	22-Sep-05	1112	10	100	4								
Clarks	2005-2	22-Sep-05	1354	30	94.5	400		2.73	2.40	n.d.		39.80		
Clarks	2005-2	22-Sep-05	1022	3	117.2	4								
Clarks	2005-2	22-Sep-05	1433	33	94.5	100								
Clarks	2005-2	22-Sep-05	1019	0	117.2	4						15.90		
Clarks	2005-2	22-Sep-05	1117	15	100	4		2.02				31.30		

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Cambridge	831	04-Jun-03	7.10	865	0.4	13.9							n.d.	
Cambridge	831	16-Jun-03	7.20	1053	0.4	13.9	379	462						
Cambridge	831	09-Jul-03	7.30	1004	0.2	14.0	377	460						
Cambridge	831	13-Aug-03	7.10	1084	0.4	13.8	380	463	112	98.6	33.2	25.7		0.36
Cambridge	831	02-Dec-03	7.10	711	0.4	13.8	362	441	107	110	33.8	32.8		0.36
Cambridge	Distribution	21-Mar-03	7.40	788	2.7	10.0	361	440						
Cambridge	Distribution	25-Apr-03	7.30	702	5	12.0	365	445						
Cambridge	Distribution	13-May-03	7.30	869	3.6	16.0	365	445						
Cambridge	Distribution	04-Jun-03	7.30	884	4.2	17.5							n.d.	
Cambridge	Distribution	09-Jul-03	7.30	1061	2.4	21.8	361	440						
Cambridge	Distribution	13-Aug-03	7.30	1072	3.9	20.0	389	474					n.d.	
Cambridge	Distribution	02-Dec-03	7.30	698	4.2	8.5	361	440						
Cedar Bluffs	571	21-Feb-05	6.70	478	4	11.0	278	339	114	21.6	22.2	13.5	.42	.07
Cedar Bluffs	571	25-Apr-05	6.80	577	5.6	11.0	205	250						
Cedar Bluffs	571	17-Aug-05	6.90	830	4.3		275	335	111	22.5	22.6	13.4	n.d.	.22
Cedar Bluffs	571	19-Oct-05	7.00	538	4.3	11.0	279	340						
Clarks	2005-1	19-Sep-05	6.80	421	0.2	11.0	138	168	57.1	31.3	9.70	5.4	0.63	0.20
Clarks	2005-1	19-Sep-05	7.10	263	0.8	11.0								
Clarks	2005-1	19-Sep-05	6.90	431	0.4	11.5								
Clarks	2005-1	19-Sep-05	7.50	418	0.2	11.0	132	161	57.3	31.5	9.72	5.6	0.65	0.20
Clarks	2005-1	21-Oct-05	7.00	425	0.4	10.3	160	195						
Clarks	2005-1	02-Nov-05	6.93	522	0.4	10.8	156	190	70.1	42.4	11.6	7.3	0.61	0.18
Clarks	2005-1	25-Jan-06	7.40	435	0.1	10.8	172	210	65.5	42.7	10.7	7.6	0.57	0.17
Clarks	2005-1	25-Jan-06	7.30	433	0.1	10.8	173	211						
Clarks	2005-1	25-Jan-06	7.30	431	1.0	11.0	161	196						
Clarks	2005-1	25-Jan-06	7.30	431	0.1	10.5	165	201						
Clarks	2005-1	15-Feb-06												
Clarks	2005-1	06-Mar-06	7.20	473	2.2	10.5	144	176						
Clarks	2005-1	18-Aug-06												
Clarks	2005-1	30-May-07												
Clarks	2005-1	05-Jun-07												
Clarks	2005-1	05-Jun-07												
Clarks	2005-1	10-Jun-07												
Clarks	2005-1	10-Jun-07												
Clarks	2005-1	15-Jun-07												
Clarks	2005-1	15-Jun-07												
Clarks	2005-1	20-Jun-07												
Clarks	2005-1	20-Jun-07												
Clarks	2005-1	25-Jun-07												
Clarks	2005-1	25-Jun-07												
Clarks	2005-1	30-Jun-07												
Clarks	2005-1	30-Jun-07												
Clarks	2005-1	05-Jul-07												
Clarks	2005-1	05-Jul-07												
Clarks	2005-1	10-Jul-07												
Clarks	2005-1	10-Jul-07												
Clarks	2005-2	19-Sep-05	6.90	416	0.8	17.8								
Clarks	2005-2	19-Sep-05	6.90	448	0.1	11.0	98	119	52.8	26.1	8.42	6.7	0.72	0.20
Clarks	2005-2	22-Sep-05	6.85	244	0.2	11.3	114	139						
Clarks	2005-2	22-Sep-05	7.56	186	0.7	11.0								
Clarks	2005-2	22-Sep-05	7.28	249	0.1	11.3	138	168	56.1	27.9	8.93	6.9	0.69	0.41
Clarks	2005-2	22-Sep-05	7.56	258	n.d	11.3	132	161						
Clarks	2005-2	22-Sep-05	7.28	257	n.d	11.3								
Clarks	2005-2	22-Sep-05	7.50	240	n.d	11.3	125	152	53.2	26.0	8.56	6.6	1.02	0.46
Clarks	2005-2	22-Sep-05	6.58	251	0.3	11.4	129	157						
Clarks	2005-2	22-Sep-05	7.32	245	n.d	11.3								
Clarks	2005-2	22-Sep-05	7.16	215	0.2	10.4	114	139	53.5	26.6	8.54	6.5	0.76	0.19
Clarks	2005-2	22-Sep-05	6.75	229	0.2	11.4								
Clarks	2005-2	22-Sep-05												
Clarks	2005-2	22-Sep-05	7.23	244	3.2	11.2	123	150						
Clarks	2005-2	22-Sep-05	7.40	245	n.d	11.3	114	139						

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Cambridge	831	04-Jun-03												
Cambridge	831	16-Jun-03									263.1			
Cambridge	831	09-Jul-03									235.7			
Cambridge	831	13-Aug-03				0.04	0.02	0.02	< 0.1		190			
Cambridge	831	02-Dec-03		42.1		0.06	0	0.06	0.1		-189.1			
Cambridge	Distribution	21-Mar-03									278.7			
Cambridge	Distribution	25-Apr-03									225.3			
Cambridge	Distribution	13-May-03									307.8			
Cambridge	Distribution	04-Jun-03												
Cambridge	Distribution	09-Jul-03									229.5			
Cambridge	Distribution	13-Aug-03				0.04	0	0.04			183.6			
Cambridge	Distribution	02-Dec-03				0.01	0	0.01			-82.2			
Cedar Bluffs	571	21-Feb-05	4.8	8	99	0.03	0.03	0	0.3		696.9	5.28		
Cedar Bluffs	571	25-Apr-05									957.5			
Cedar Bluffs	571	17-Aug-05	4.2	7	100	0.03			0.3			15.05		
Cedar Bluffs	571	19-Oct-05									-193.7			
Clarks	2005-1	19-Sep-05	0.5	12	77	0.65	0.64	0.01	0.2	2.75		4.8		
Clarks	2005-1	19-Sep-05												
Clarks	2005-1	19-Sep-05												
Clarks	2005-1	19-Sep-05	0.5	14	76	0.68	0.62	0.06	0.5	3.45		5.89		
Clarks	2005-1	21-Oct-05				0.63	0.59	0.04			-307.5			
Clarks	2005-1	02-Nov-05	1.5	14	93	0.60	0.56	0.04	n.d.		-223	8.7		
Clarks	2005-1	25-Jan-06	0.5	16	97				0.1			2.52		
Clarks	2005-1	25-Jan-06												
Clarks	2005-1	25-Jan-06												
Clarks	2005-1	25-Jan-06												
Clarks	2005-1	15-Feb-06												
Clarks	2005-1	06-Mar-06												
Clarks	2005-1	18-Aug-06												
Clarks	2005-1	30-May-07												
Clarks	2005-1	05-Jun-07												
Clarks	2005-1	05-Jun-07												
Clarks	2005-1	10-Jun-07												
Clarks	2005-1	10-Jun-07												
Clarks	2005-1	15-Jun-07												
Clarks	2005-1	15-Jun-07												
Clarks	2005-1	20-Jun-07												
Clarks	2005-1	20-Jun-07												
Clarks	2005-1	25-Jun-07												
Clarks	2005-1	25-Jun-07												
Clarks	2005-1	30-Jun-07												
Clarks	2005-1	30-Jun-07												
Clarks	2005-1	05-Jul-07												
Clarks	2005-1	05-Jul-07												
Clarks	2005-1	10-Jul-07												
Clarks	2005-1	10-Jul-07												
Clarks	2005-2	19-Sep-05								4.55				
Clarks	2005-2	19-Sep-05	0.4	10	72	0.75	0.72	0.03	0.2	2.54		11.06		
Clarks	2005-2	22-Sep-05												
Clarks	2005-2	22-Sep-05												
Clarks	2005-2	22-Sep-05	0.4	10	79	0.79	0.72	0.07	0.1	2.70		2.87		
Clarks	2005-2	22-Sep-05												
Clarks	2005-2	22-Sep-05												
Clarks	2005-2	22-Sep-05	n.d.	12	72				n.d.			4.24		
Clarks	2005-2	22-Sep-05												
Clarks	2005-2	22-Sep-05								1.82				
Clarks	2005-2	22-Sep-05	0.4	20	71				0.1	3.17		4.4		
Clarks	2005-2	22-Sep-05												
Clarks	2005-2	22-Sep-05												
Clarks	2005-2	22-Sep-05												
Clarks	2005-2	22-Sep-05												

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Clarks	2005-2	22-Sep-05	1338	15	94.5	400		3.03				39.00		
Clarks	2005-2	22-Sep-05	1035	15	117.2	4						15.40		
Clarks	2005-2	22-Sep-05	1050	30	117.2	4			1.00	n.d.		11.50		
Clarks	2005-2	21-Oct-05	1411	11	94.5	400								
Clarks	2005-2	21-Oct-05	1415	15	94.5	400		3.57				40.00		
Clarks	2005-2	21-Oct-05	1430	30	94.5	400		3.37				38.80		
Clarks	2005-2	21-Oct-05	1400	0	94.5	400		3.10				40.50		
Clarks	2005-2	02-Nov-05	1303	30	94.5	400	P28852-21	4.85				52.40	59.20	
Clarks	2005-2	02-Nov-05	1244	11	94.5	400								
Clarks	2005-2	02-Nov-05	1248	15	94.5	400	P28852-20	5.33				67.00		
Clarks	2005-2	02-Nov-05	1257	24	94.5	400								
Clarks	2005-2	02-Nov-05	1347	74	94.5	400	P28852-22							
Clarks	2005-2	02-Nov-05	1233	0	94.5	400	P28852-19	4.88				39.00		
Clarks	2005-2	25-Jan-06	1655	60	94.5	400	L29438-23		3.00			38.00	35.90	
Clarks	2005-2	25-Jan-06	1625	30	94.5	400	L29438-18					40.20		
Clarks	2005-2	25-Jan-06	1555	0	94.5	400	L29438-16					26.30		
Clarks	2005-2	25-Jan-06	1610	15	94.5	400	L29438-17					38.60		
Clarks	2005-2	15-Feb-06	1100	30???	94.5	400	P21797-29					41.30		
Clarks	2005-2	06-Mar-06	1615	48960???	94.5	400	L29598-1					57.60		
Clarks	2005-2	17-Aug-06	1643	240	94.5	100						39.80	52.70	
Clarks	2005-2	17-Aug-06	1543	180	94.5	100						39.10	51.30	
Clarks	2005-2	17-Aug-06	1343	60	94.5	100						34.40	45.20	
Clarks	2005-2	17-Aug-06	1313	30	94.5	100						32.90	43.20	
Clarks	2005-2	17-Aug-06	1243	0	94.5	100						29.60	40.40	
Clarks	2005-2	17-Aug-06	1443	120	94.5	100						37.80	48.80	
Clarks	2005-2	18-Aug-06	1710	0	88.3?	3						128.00	165.50	
Clarks	2005-2	18-Aug-06	1630	15	101.8?	3						123.00	155.40	
Clarks	2005-2	18-Aug-06	1425	0	117.4?	3						91.40	82.40	
Clarks	2005-2	18-Aug-06	1440	15	117.4?	3						82.90	107.70	
Clarks	2005-2	18-Aug-06	1615	0	101.8?	3						120.00	155.70	
Clarks	2005-2	18-Aug-06	1645	30	101.8?	3						112.00	126.80	
Clarks	2005-2	18-Aug-06	1740	30	88.3?	3						121.00	141.70	
Clarks	2005-2	18-Aug-06	1455	30	117.4?	3						74.70	99.20	
Clarks	2005-2	18-Aug-06	1725	15	88.3?	3						147.00	178.40	
Clarks	2005-2	05-Oct-06	1555	15	102.1	2						16.20		
Clarks	2005-2	05-Oct-06	1319	0	111.9	3.5						9.05	8.90	
Clarks	2005-2	05-Oct-06	1334	15	111.9	3.5						8.16		
Clarks	2005-2	05-Oct-06	1349	30	111.9	3.5						8.29	8.30	
Clarks	2005-2	05-Oct-06	1540	0	102.1	2						17.20	18.30	
Clarks	2005-2	05-Oct-06	1610	30	102.1	2						16.00	16.90	
Clarks	2005-2	05-Oct-06	1640	0	89.5	2.4						24.80	28.00	
Clarks	2005-2	05-Oct-06	1710	30	89.5	2.4						28.50	31.10	
Clarks	2005-2	05-Oct-06	1655	15	89.5	2.4						25.40		
Clarks	2005-2	10-Feb-07	1533	0	104	100								
Clarks	2005-2	10-Feb-07	1633	60	104	100								
Clarks	2005-2	10-Feb-07	1548	15	104	100								
Clarks	2005-2	10-Feb-07	1603	30	104	100								
Clarks	2005-2	12-Feb-07	1400	30	104	50						43.50		
Clarks	2005-2	12-Feb-07	1430	60	104	50						43.40		
Clarks	2005-2	12-Feb-07	1330	0	104	50						41.30		
Clarks	2005-2	20-Feb-07	1120	30	104	50						33.40		
Clarks	2005-2	20-Feb-07	1150	60	104	50						39.10		
Clarks	2005-2	20-Feb-07	1050	0	104	50						42.50		
Clarks	2005-2	02-Mar-07	1120	60	104	50						39.30		
Clarks	2005-2	02-Mar-07	1050	30	104	50						31.20		
Clarks	2005-2	02-Mar-07	1020	0	104	50						40.20		
Clarks	2005-2	06-Mar-07	1430	30	104	50	L31736-6	3.70				37.80		
Clarks	2005-2	06-Mar-07	1415	15	104	50								
Clarks	2005-2	06-Mar-07	1400	0	104	50	L31736-5	3.40				266.00		
Clarks	2005-2	12-Mar-07	1430	0	104	50	L31735-3					27.50		
Clarks	2005-2	12-Mar-07	1530	60	104	50	L31735-1					37.90		

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Clarks	2005-2	22-Sep-05	6.97	210	0.2	10.2	111	135						
Clarks	2005-2	22-Sep-05	7.00	231	0.2	11.4	125	152						
Clarks	2005-2	22-Sep-05	6.00	393	n.d	11.3	127	155	54.8	24.4	8.22	5.2	1.32	0.47
Clarks	2005-2	21-Oct-05	6.90	371	4.8	10.4								
Clarks	2005-2	21-Oct-05	5.60	366	3.4	10.3								
Clarks	2005-2	21-Oct-05	6.40	361	4.2	10.3	126	154						
Clarks	2005-2	21-Oct-05	7.00	367	4.6	16.0	132	161						
Clarks	2005-2	02-Nov-05	7.00	452	0.05	10.5	143	174	61.4	29.7	9.75	7.6	0.76	0.21
Clarks	2005-2	02-Nov-05	7.20	495	0.05	10.5	130	158						
Clarks	2005-2	02-Nov-05	7.10	482	0.05	10.5	148	180						
Clarks	2005-2	02-Nov-05	7.00	461	0.05	10.5	138	168						
Clarks	2005-2	02-Nov-05	7.10	385	4.8	15.4								
Clarks	2005-2	02-Nov-05	7.40	478	0.4	14.5	134	163						
Clarks	2005-2	25-Jan-06	7.20	357	n.d	10.3	91	111	51.3	25.5	8.21	6.9	0.72	0.20
Clarks	2005-2	25-Jan-06	7.20	358	n.d	10.5	111	135						
Clarks	2005-2	25-Jan-06	7.70	231	0.2	7.6	116	141						
Clarks	2005-2	25-Jan-06	7.20	360	n.d	10.2	122	149						
Clarks	2005-2	15-Feb-06												
Clarks	2005-2	06-Mar-06	6.80	444	1.5	10.3	146	178						
Clarks	2005-2	17-Aug-06	7.21	470	n.d	13.0	136	166						
Clarks	2005-2	17-Aug-06	7.21	469	n.d	12.0	138	169						
Clarks	2005-2	17-Aug-06	6.98	463	0.1	13.0	142	173						
Clarks	2005-2	17-Aug-06	7.25	460	0.1	13.0	128	156	49.9	26.8	8.60	6.5	0.56	0.27
Clarks	2005-2	17-Aug-06	7.11	448	2.7	18.0	141	172						
Clarks	2005-2	17-Aug-06	7.21	466	0.1	12.0	131	160						
Clarks	2005-2	18-Aug-06	7.02	433	5.4	16.0	156	190						
Clarks	2005-2	18-Aug-06	7.38	441	4.7	13.0	172	210						
Clarks	2005-2	18-Aug-06	6.47	447	8.0	16.0	200	244						
Clarks	2005-2	18-Aug-06	6.95	430	6.2	13.0	179	219						
Clarks	2005-2	18-Aug-06	7.39	418	8.6	14.0	139	170						
Clarks	2005-2	18-Aug-06	7.34	442	4.0	13.7	151	184	57.4	30.0	9.80	6.7	0.09	0.33
Clarks	2005-2	18-Aug-06	7.36	474	2.0	13.5	165	201	54.8	28.9	9.49	6.5	0.08	0.32
Clarks	2005-2	18-Aug-06	7.11	426	6.0	13.3	180	220	53.9	25.9	8.68	6.3	0.15	0.33
Clarks	2005-2	18-Aug-06	7.29	466	3.2	13.7	169	206						
Clarks	2005-2	05-Oct-06	7.87	445	0.1	12.9								
Clarks	2005-2	05-Oct-06	8.71	308	7.5	15.3	171	209						
Clarks	2005-2	05-Oct-06	7.80	75	0.3	12.0								
Clarks	2005-2	05-Oct-06	7.80	445	0.2	12.0	142	173	52.2	24.7	7.70	4.8	0.69	0.39
Clarks	2005-2	05-Oct-06	7.79	442	2.4	13.0	140	171						
Clarks	2005-2	05-Oct-06	7.79	288	0.1	12.9	134	164	49.2	25.4	7.62	5.6	0.68	0.33
Clarks	2005-2	05-Oct-06	7.54	429	2.0	14.6	126	154						
Clarks	2005-2	05-Oct-06	7.98	444	0.1	13.0	136	166	48.8	25.9	7.74	6.2	0.59	0.27
Clarks	2005-2	05-Oct-06	8.05	444	0.1	13.0	126	154						
Clarks	2005-2	10-Feb-07	7.90	460	6.3	7.0	144	176						
Clarks	2005-2	10-Feb-07	7.40	490	2.0	11.0	119	145						
Clarks	2005-2	10-Feb-07	7.90	590	3.9	10.5	131	160						
Clarks	2005-2	10-Feb-07	7.60	460	3.8	11.0	130	159	51	25.9	7.67	6.9	0.36	0.15
Clarks	2005-2	12-Feb-07	7.80	760		1.0								
Clarks	2005-2	12-Feb-07	7.60	440		1.15								
Clarks	2005-2	12-Feb-07	6.90	440		0.8								
Clarks	2005-2	20-Feb-07	7.80	550		1.1								
Clarks	2005-2	20-Feb-07	7.60	560		1.1								
Clarks	2005-2	20-Feb-07	7.30	440		0.7								
Clarks	2005-2	02-Mar-07	7.50	420		11.0								
Clarks	2005-2	02-Mar-07	7.40	440		7.0								
Clarks	2005-2	02-Mar-07	7.20	440		9.0								
Clarks	2005-2	06-Mar-07	7.50	380	0.4		121	148	47.8	24.8	7.78	6.1	0.59	0.23
Clarks	2005-2	06-Mar-07	7.60	380	0.6	10.5	120	146						
Clarks	2005-2	06-Mar-07	7.90	400	6.2	8.2	127	155	43.8	22.5	7.14	5.8	0.63	0.20
Clarks	2005-2	12-Mar-07	7.20	410		7.0								
Clarks	2005-2	12-Mar-07	7.50	400		11.0								

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Clarks	2005-2	22-Sep-05												
Clarks	2005-2	22-Sep-05												
Clarks	2005-2	22-Sep-05	n.d.	29	62				0.1	2.22		7.1		
Clarks	2005-2	21-Oct-05												
Clarks	2005-2	21-Oct-05												
Clarks	2005-2	21-Oct-05				0.74	0.70	0.04						
Clarks	2005-2	21-Oct-05												
Clarks	2005-2	02-Nov-05	n.d.	12	84	0.75	0.71	0.04	0.1		-265.9	4.34		
Clarks	2005-2	02-Nov-05									-232.6			
Clarks	2005-2	02-Nov-05									-236.3			
Clarks	2005-2	02-Nov-05									-254.6			
Clarks	2005-2	02-Nov-05												
Clarks	2005-2	02-Nov-05									-193			
Clarks	2005-2	25-Jan-06	n.d.	10	74				0.1			11.13		
Clarks	2005-2	25-Jan-06												
Clarks	2005-2	25-Jan-06												
Clarks	2005-2	25-Jan-06												
Clarks	2005-2	15-Feb-06												
Clarks	2005-2	06-Mar-06												
Clarks	2005-2	17-Aug-06				0.17	0.10	0.07						
Clarks	2005-2	17-Aug-06				0.14	0.05	0.09						
Clarks	2005-2	17-Aug-06				0.48	0.46	0.02						
Clarks	2005-2	17-Aug-06	n.d.	12	76	0.67	0.25	0.42	0.2	n.d.		0.91		
Clarks	2005-2	17-Aug-06				0.20	0.19	0.01						
Clarks	2005-2	17-Aug-06				0.18	0.12	0.06						
Clarks	2005-2	18-Aug-06												
Clarks	2005-2	18-Aug-06				0.09	0.05	0.04						
Clarks	2005-2	18-Aug-06				0.06	n.d.	0.06						
Clarks	2005-2	18-Aug-06				0.01	0.01	n.d.						
Clarks	2005-2	18-Aug-06				0.04	0.01	0.03						
Clarks	2005-2	18-Aug-06	n.d.	11	71	0.17	0.06	0.11	n.d.	n.d.		3.59		
Clarks	2005-2	18-Aug-06	0.2	12	81	0.06	0.04	0.02	0.1	n.d.		-3.59		
Clarks	2005-2	18-Aug-06	n.d.	11	68	0.06	0.06	n.d.	0.1	n.d.		-6.2		
Clarks	2005-2	18-Aug-06				0.16	0.13	0.03						
Clarks	2005-2	05-Oct-06												
Clarks	2005-2	05-Oct-06												
Clarks	2005-2	05-Oct-06												
Clarks	2005-2	05-Oct-06	n.d.	11	60				n.d.	n.d.		0.9		
Clarks	2005-2	05-Oct-06												
Clarks	2005-2	05-Oct-06	n.d.	12	66				n.d.	n.d.		-0.39		
Clarks	2005-2	05-Oct-06												
Clarks	2005-2	05-Oct-06	n.d.	12	70				n.d.	n.d.		-1.44		
Clarks	2005-2	05-Oct-06												
Clarks	2005-2	10-Feb-07												
Clarks	2005-2	10-Feb-07				0.34	0.04	0.30						
Clarks	2005-2	10-Feb-07				2.10	0.05	2.05						
Clarks	2005-2	10-Feb-07	0.3	16	73	0.33	0.06	0.27	0.1	3.01		-0.93		
Clarks	2005-2	12-Feb-07												
Clarks	2005-2	12-Feb-07												
Clarks	2005-2	12-Feb-07												
Clarks	2005-2	20-Feb-07												
Clarks	2005-2	20-Feb-07												
Clarks	2005-2	20-Feb-07												
Clarks	2005-2	02-Mar-07												
Clarks	2005-2	02-Mar-07												
Clarks	2005-2	02-Mar-07												
Clarks	2005-2	06-Mar-07	n.d.	11	71	0.68	0.66	0.02	0.1	3.13		0.89		
Clarks	2005-2	06-Mar-07												
Clarks	2005-2	06-Mar-07	n.d.	11	68				n.d.	1.76		-4.1		
Clarks	2005-2	12-Mar-07												
Clarks	2005-2	12-Mar-07												

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Clarks	2005-2	12-Mar-07	1500	30	104	50						35.60		
Clarks	2005-2	14-May-07	1500		104	50	P30090-44					47.40		
Clarks	2005-2	21-May-07	1500		104	50	P30090-45					47.90		
Clarks	2005-2	05-Jun-07	1410	20	104	100	L32375-9					43.90		
Clarks	2005-2	05-Jun-07	1500	60	104	100	L32375-9					43.40		
Clarks	2005-2	10-Jun-07	1530	60	104	100	L32375-14					42.80		
Clarks	2005-2	10-Jun-07	1450	20	104	100	L32375-10					41.90		
Clarks	2005-2	15-Jun-07	1530	60	104	100	L32375-15					41.70		
Clarks	2005-2	15-Jun-07	1450	20	104	100	L32375-11					44.20		
Clarks	2005-2	20-Jun-07	830	60	104	100	L32375-16					40.40		
Clarks	2005-2	20-Jun-07	750	20	104	100	L32375-12					41.90		
Clarks	2005-2	25-Jun-07	1020	20	104	100	L32486-9					43.60		
Clarks	2005-2	25-Jun-07	1100	60	104	100	L32486-10					41.70		
Clarks	2005-2	30-Jun-07	1200	60	104	100	L32486-12					43.40		
Clarks	2005-2	30-Jun-07	1120	20	104	100	L32486-11					42.60		
Clarks	2005-2	05-Jul-07	1120	20	104	100	L32486-13					42.50		
Clarks	2005-2	05-Jul-07	1200	60	104	100	L32486-14					43.50		
Clarks	2005-2	10-Jul-07	1200	60	104	100	L32486-16					43.80		
Clarks	2005-2	10-Jul-07	1120	20	104	100	L32486-15					42.40		
Clarks	NTW	22-Sep-05	1510		12							12.90		
Clarks	NTW	22-Sep-05	930		12							13.00		
Clarks	NTW	22-Sep-05	1433		12			2.47				40.50		
Clarks	NTW	21-Oct-05	1530		12							11.80		
Clarks	NTW	17-Aug-06	1238	0	86	2						260.00	279.90	
Clarks	NTW	17-Aug-06	1308	30	86	2						228.00	251.80	
Clarks	NTW	17-Aug-06	1338	60	86	2						229.00	251.80	
Clarks	NTW	17-Aug-06	1405	0	100	0.5						216.00	250.40	
Clarks	NTW	17-Aug-06	1605	60	117	0.5						247.00	279.90	
Clarks	NTW	17-Aug-06	1535	30	117	0.5						270.00	296.70	
Clarks	NTW	17-Aug-06	1520	0	117	0.5						226.00	249.00	
Clarks	NTW	17-Aug-06	1505	60	100	0.5						242.00	263.10	
Clarks	NTW	17-Aug-06	1435	30	100	0.5						239.00	260.20	
Clarks	NTW	25-Jan-07	1412	15	80	2						252.00	247.50	
Clarks	NTW	25-Jan-07	1357	0	80	2						215.00	211.40	
Clarks	NTW	25-Jan-07	1427	30	80	2						244.00	242.50	
Clarks	NTW	25-Jan-07	1309	0	100	2						256.00	252.60	
Clarks	NTW	25-Jan-07	1324	15	100	2						244.00	237.30	
Clarks	NTW	25-Jan-07	1339	30	100	2						245.00	237.80	
Clarks	NTW	25-Jan-07	1055	0	117	2						266.00	260.40	
Clarks	NTW	25-Jan-07	1110	15	117	2						254.00	247.90	
Clarks	NTW	25-Jan-07	1125	30	117	2						243.00	239.30	
Clarks	NTW	10-Feb-07	1430	28	113	2.5		2.16				293.00		
Clarks	NTW	06-Mar-07	1300	45	112.5	2		3.40				266.00		
Clarks	NTW	06-Mar-07	1215	0	112.5	2		3.10				254.00		
Clarks	NTW	06-Mar-07	1230	15	112.5	2								
Colon	661	21-Feb-05	817	N/A	40	150	P24577-20	10.50		3.1	6.5			
Colon	661	25-Apr-05	838	N/A	40	150	P27621-25	10.00						
Culbertson	781	22-Feb-05	831	N/A	100	200	P27307-19	6.76		0	6.9			
Culbertson	781	11-Apr-05	1210	N/A	100	200	P27307-40	6.39						
Culbertson	781	16-Aug-05	1158	N/A	100	200		6.59						
Culbertson	781	23-Aug-05		N/A	100	200				nd				
Culbertson	781	18-Oct-05	1244	N/A	100	200	P28350-39	7.34						
Elgin	771	21-Feb-05	1356	N/A	~135	500	P27307-17	12.70		0	13.2			
Elgin	771	25-Apr-05	1338	N/A	~135	500	P27621-29	12.30						
Elgin	771	17-Aug-05	733	N/A	~135	500		12.00		nd				
Elgin	771	19-Oct-05	730	N/A	~135	500	P28350-41	12.60						
Elwood	71	06-Dec-02	936	N/A	250	600	P22194-17	5.13						
Elwood	71	06-Jan-03	1015	N/A	250	600	P22355-10	5.87						
Elwood	71	31-Jan-03	945	N/A	250	600	P22462-13	5.15						
Elwood	71	10-Feb-03	1345	N/A	250	600	P22462-24	5.54						
Elwood	71	28-Feb-03	1000	N/A	250	600	P22616-18	5.13						

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Clarks	2005-2	12-Mar-07	7.50	410		11.0								
Clarks	2005-2	14-May-07												
Clarks	2005-2	21-May-07	7.50	400		11.0								
Clarks	2005-2	05-Jun-07												
Clarks	2005-2	05-Jun-07												
Clarks	2005-2	10-Jun-07												
Clarks	2005-2	10-Jun-07												
Clarks	2005-2	15-Jun-07												
Clarks	2005-2	15-Jun-07												
Clarks	2005-2	20-Jun-07												
Clarks	2005-2	20-Jun-07												
Clarks	2005-2	25-Jun-07												
Clarks	2005-2	25-Jun-07												
Clarks	2005-2	30-Jun-07												
Clarks	2005-2	30-Jun-07												
Clarks	2005-2	05-Jul-07												
Clarks	2005-2	05-Jul-07												
Clarks	2005-2	10-Jul-07												
Clarks	2005-2	10-Jul-07												
Clarks	NTW	22-Sep-05	7.15	192	3.3	16.0								
Clarks	NTW	22-Sep-05	6.50	403	4.3	15.4								
Clarks	NTW	22-Sep-05	7.02	208	0.7	12.0	104	127						
Clarks	NTW	21-Oct-05	7.10	330	5.0	15.2								
Clarks	NTW	17-Aug-06	7.80	760		15.6	332	405						
Clarks	NTW	17-Aug-06	7.60	900		14.4	314	383	108	74.1	18.7	13.7	1.47	0.18
Clarks	NTW	17-Aug-06	7.60	890		14.4	310	378						
Clarks	NTW	17-Aug-06	7.60	840		15.6	305	372						
Clarks	NTW	17-Aug-06	7.60	880		15.6	308	375						
Clarks	NTW	17-Aug-06	7.60	870		15.6	312	380	112	80.2	19.5	14.4	0.88	0.17
Clarks	NTW	17-Aug-06	7.60	880		15.6	318	387						
Clarks	NTW	17-Aug-06	7.60	910		15.6	307	375						
Clarks	NTW	17-Aug-06	7.60	920		15.6	322	392	109	77.4	19.1	13.3	1.08	0.17
Clarks	NTW	25-Jan-07	6.75	471	0.1	11.0	315	384						
Clarks	NTW	25-Jan-07	7.70	472	7.7	10.0	292	356						
Clarks	NTW	25-Jan-07	7.70	467	0.5	11.0	299	365	113	75.7	19.5	13.6	0.68	0.21
Clarks	NTW	25-Jan-07	7.60	482	9.6	10.0	328	400						
Clarks	NTW	25-Jan-07	7.20	466	1.5	10.5	324	395						
Clarks	NTW	25-Jan-07	7.40	429	3.8	11.0	314	383	112	75.9	19.3	13.4	0.70	0.20
Clarks	NTW	25-Jan-07	4.42	446	6.8	9.5	326	398						
Clarks	NTW	25-Jan-07	7.20	493	4.2	10.0	322	393						
Clarks	NTW	25-Jan-07	6.89	489	n.d	10.0	334	408	112	77.0	19.2	15.1	0.66	0.20
Clarks	NTW	10-Feb-07	7.70	1000	6.8	9.0	338	412						
Clarks	NTW	06-Mar-07	7.70	980	0.5	12.0	324	395	115	82.4	19.4	14.0	0.46	0.20
Clarks	NTW	06-Mar-07	8.30	1040	6.4	9.5	338	412	117	87.2	19.7	13.7	0.72	0.23
Clarks	NTW	06-Mar-07	7.80	990		11.0	324	395						
Colon	661	21-Feb-05	7.00	485	3.8	10.5	275	335	106	32	22.9	13.1	n.d.	.23
Colon	661	25-Apr-05	7.10	605	3.2	10.5	236	288						
Culbertson	781	22-Feb-05	7.10	438	7.4	12.0	306	373	95.2	42.7	29.7	16.5		n.d.
Culbertson	781	11-Apr-05	7.00	659	9.2	12.0	303	369					n.d.	
Culbertson	781	16-Aug-05	6.90	920	7.8	13.0	319	389	95.6	42.5	30.2	15.9		n.d.
Culbertson	781	23-Aug-05			N/A								n.d.	
Culbertson	781	18-Oct-05	7.00	613	8.5	12.5	334	408						
Elgin	771	21-Feb-05	6.70	339	2.6	11.0	223	284	76.5	8.63	12.7	11.7		n.d.
Elgin	771	25-Apr-05	6.80	403	3.6	11.0	208	254						
Elgin	771	17-Aug-05	6.80	552	3.4	11.0	223	272	78.4	9.17	13.6	11.2		n.d.
Elgin	771	19-Oct-05	7.20	364	2.6	11.5	216	263						
Elwood	71	06-Dec-02	7.66	673	5.6	14.0	383	467						
Elwood	71	06-Jan-03	7.42	574	6.4	12.0	202	246						
Elwood	71	31-Jan-03	7.50	448	6.1	13.3	215	262						
Elwood	71	10-Feb-03	7.60	468	9.9	11.0	183	223						
Elwood	71	28-Feb-03	7.70	480	8.6	10.0	201	245						

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Clarks	2005-2	12-Mar-07												
Clarks	2005-2	14-May-07												
Clarks	2005-2	21-May-07												
Clarks	2005-2	05-Jun-07												
Clarks	2005-2	05-Jun-07												
Clarks	2005-2	10-Jun-07												
Clarks	2005-2	10-Jun-07												
Clarks	2005-2	15-Jun-07												
Clarks	2005-2	15-Jun-07												
Clarks	2005-2	20-Jun-07												
Clarks	2005-2	20-Jun-07												
Clarks	2005-2	25-Jun-07												
Clarks	2005-2	25-Jun-07												
Clarks	2005-2	30-Jun-07												
Clarks	2005-2	30-Jun-07												
Clarks	2005-2	05-Jul-07												
Clarks	2005-2	05-Jul-07												
Clarks	2005-2	10-Jul-07												
Clarks	2005-2	10-Jul-07												
Clarks	NTW	22-Sep-05												
Clarks	NTW	22-Sep-05												
Clarks	NTW	22-Sep-05												
Clarks	NTW	21-Oct-05												
Clarks	NTW	17-Aug-06												
Clarks	NTW	17-Aug-06	n.d.	18	178	1.45	0.14	1.31	0.2	1.44		0.33		
Clarks	NTW	17-Aug-06				1.39	0.34	1.05						
Clarks	NTW	17-Aug-06				1.62	0.53	1.09						
Clarks	NTW	17-Aug-06				1.07	0.41	0.66						
Clarks	NTW	17-Aug-06	n.d.	19	191	0.90	0.28	0.62	0.1	1.05		1.59		
Clarks	NTW	17-Aug-06				2.40	0.80	1.60						
Clarks	NTW	17-Aug-06				0.42	0.09	0.33						
Clarks	NTW	17-Aug-06	n.d.	18	183	1.22	0.50	0.72	0.1	1.23		0.09		
Clarks	NTW	25-Jan-07				0.66	0.63	0.03						
Clarks	NTW	25-Jan-07				0.34	0.22	0.12						
Clarks	NTW	25-Jan-07	n.d.	19	194	0.74	0.67	0.07	0.1	2.74		4.71		
Clarks	NTW	25-Jan-07				0.62	0.61	0.01						
Clarks	NTW	25-Jan-07				0.89	0.88	0.01						
Clarks	NTW	25-Jan-07	n.d.	20	198	0.74	0.66	0.08	0.1	2.69		2.74		
Clarks	NTW	25-Jan-07												
Clarks	NTW	25-Jan-07				0.70	0.60	0.10						
Clarks	NTW	25-Jan-07	n.d.	20	198	0.67	0.64	0.03	0.1	3.33		1.62		
Clarks	NTW	10-Feb-07				0.23	0.24	0.01						
Clarks	NTW	06-Mar-07	n.d.	19	201				n.d.	3.52		0.47		
Clarks	NTW	06-Mar-07	n.d.	19	198				n.d.	2.77		0.98		
Clarks	NTW	06-Mar-07												
Colon	661	21-Feb-05	12.1	4	104	0.48	0.44	0.04	.3		-10.1	5.69		
Colon	661	25-Apr-05									648.9			
Culbertson	781	22-Feb-05	13.9	11	57	0.02	0	0.02	.1		-148.2	9.47		
Culbertson	781	11-Apr-05									9.32			
Culbertson	781	16-Aug-05	13.6	11	58				n.d.			7.69		
Culbertson	781	23-Aug-05												
Culbertson	781	18-Oct-05									-158.8			
Elgin	771	21-Feb-05	4.7	4	7	0.01	0	0.01	.3		1020.4	5.21		
Elgin	771	25-Apr-05									881.7			
Elgin	771	17-Aug-05	3.3	3	7	0.02			.3			9.32		
Elgin	771	19-Oct-05									-204			
Elwood	71	06-Dec-02												
Elwood	71	06-Jan-03												
Elwood	71	31-Jan-03												
Elwood	71	10-Feb-03												
Elwood	71	28-Feb-03												

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Elwood	71	21-Mar-03	954	N/A	250	600	P22653-57	5.46						
Elwood	71	25-Apr-03	1057	N/A	250	600	P22714-83	5.38	6.40		5.1 / NA			
Elwood	71	13-May-03	1452	N/A	250	600	P22985-47	5.81	7.20		5.8 / 5.9			
Elwood	71	04-Jun-03	1447	N/A	250	600	P23144-36	5.95	6.70	0	5.8			
Elwood	71	16-Jun-03	1010	N/A	250	600	P23144-22	5.51		0	5.7			
Elwood	71	16-Jul-03	1420	N/A	250	600	P23372-39	6.85		0				
Elwood	71	13-Aug-03	1834	N/A	250	600		5.22		0				
Elwood	71	01-Dec-03	1930	N/A	250	600		4.99						
Elwood	881	06-Dec-02	1030	N/A	300	800	P22194-18	6.22						
Elwood	881	06-Jan-03	1055	N/A	300	800	P22355-9	6.37						
Elwood	881	31-Jan-03	1041	N/A	300	800	P22462-14	6.25						
Elwood	881	10-Feb-03	1313	N/A	300	800	P22462-22	5.65						
Elwood	881	28-Feb-03	1038	N/A	300	800	P22616-17	5.90						
Elwood	881	21-Mar-03	1025	N/A	300	800	P22653-52	6.07						
Elwood	881	25-Apr-03	1020	N/A	300	800	P22714-78	6.06	7.30		6.2 / NA			
Elwood	881	13-May-03	1405	N/A	300	800	P22985-37	6.33	7.80		6.1 / 6.4			
Elwood	881	04-Jun-03	1437	N/A	300	800	P23144-50	6.74	7.40	0	6.6			
Elwood	881	16-Jun-03	1037	N/A	300	800	P23144-17	6.39		0	7.3			
Elwood	881	16-Jul-03	1436	N/A	300	800	P23372-38	8.05		0				
Elwood	881	13-Aug-03	1803	N/A	300	800		6.16		0				
Elwood	881	01-Dec-03	2002	N/A	300	800		5.80						
Elwood	Distribution	21-Mar-03	1018	N/A	N/A	N/A	P22653-55	6.05						
Elwood	Distribution	25-Apr-03	1044	N/A	N/A	N/A	P22714-75	6.27	7.30					
Elwood	Distribution	13-May-03	1410	N/A	N/A	N/A	P22985-32	6.16	7.60					
Elwood	Distribution	04-Jun-03	1430	N/A	N/A	N/A	P23144-8	6.65						
Elwood	Distribution	16-Jul-03	1416	N/A	N/A	N/A	P23372-35	7.49						
Elwood	Distribution	13-Aug-03	1752	N/A	N/A	N/A		5.08						
Elwood	Distribution	01-Dec-03	2000	N/A	N/A	N/A		5.93						
Haigler	651	07-Aug-06	833	0	95	330		17.20	21.60					
Haigler	651	07-Aug-06	1233	240	95	330		17.70	21.00					
Haigler	651	07-Aug-06	1133	180	95	330		17.40	21.00					
Haigler	651	07-Aug-06	1033	120	95	330		17.90	20.90					
Haigler	651	07-Aug-06	933	60	95	330		17.60	21.40					
Haigler	651	07-Aug-06	903	30	95	330		17.30	20.80	n.d.	21.3			
Haigler	651	10-Aug-06	1410	30	84.1	3		14.30	35.00	1.7	15.6			
Haigler	651	10-Aug-06	1102	30	92.5	3		14.50	17.50	n.d.	17.7			
Haigler	651	10-Aug-06	1032	0	92.5	3		15.40	19.00					
Haigler	651	10-Aug-06	1227	0	87.5	3		22.70	53.70					
Haigler	651	10-Aug-06	1242	15	87.5	3		4.00	32.70					
Haigler	651	10-Aug-06	1455	15	76.9	3		15.10	28.40					
Haigler	651	10-Aug-06	1510	30	76.9	3		14.40	20.90	6.2	11.5			
Haigler	651	10-Aug-06	1440	0	76.9	3		16.30	44.20					
Haigler	651	10-Aug-06	1257	30	87.5	3		12.80	25.50	n.d.	15.2			
Haigler	651	10-Aug-06	1340	0	84.1	3		5.41	69.80					
Haigler	651	10-Aug-06	1355	15	84.1	3		14.90	44.90					
Haigler	651	10-Aug-06	1047	15	92.5	3		14.90	19.00					
Haigler	651	13-Nov-06	1415	25	95	85			22.00					
Haigler	651	13-Nov-06	1511	3	95	85			22.90					
Haigler	651	13-Nov-06	1538	27	95	85			21.50					
Haigler	651	13-Nov-06	1345	4	95	91.2			49.70					
Haigler	651	14-Nov-06	1200	0	95	105		21.70	20.10					
Haigler	651	14-Nov-06	1230	30	95	102		20.00	20.10					
Haigler	651	14-Nov-06	1300	60	95	101		19.20	22.40					
Haigler	651	16-Nov-06	1139	0	95	100		18.70						
Haigler	651	16-Nov-06	1210	30	95	100		19.00						
Haigler	651	22-Nov-06	1245	0	95	90		19.80						
Haigler	651	22-Nov-06	1316	30	95	90		18.80						
Haigler	651	29-Nov-06	1521	0	95	110		20.60						
Haigler	651	29-Nov-06	1551	30	95	110		20.30						
Haigler	651	06-Dec-06	1420	0	95	110		19.80						
Haigler	651	06-Dec-06	1458	38	95	110		19.50						

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Elwood	71	21-Mar-03	7.70	574	9	12.0	203	247						
Elwood	71	25-Apr-03	7.30	515	7.6	14.0	194	237						
Elwood	71	13-May-03	7.50	589	9.8	15.0	196	239					n.d.	
Elwood	71	04-Jun-03	7.40	642	8	16.0							n.d.	
Elwood	71	16-Jun-03	7.30	538	5.6	15.5	214	261						
Elwood	71	16-Jul-03	7.30	770	5.5	16.0	219	267						
Elwood	71	13-Aug-03	7.30	766	5.2	15.1	210	256	103	49.2	20.3	13.2		n.d.
Elwood	71	01-Dec-03	7.40	413	6.7	13.0	208	254	94.8	40.3	20.3	20.5		n.d.
Elwood	881	06-Dec-02	7.65	610	4.4	14.0	177	216						
Elwood	881	06-Jan-03	7.24	530	3.8	15.0	190	232						
Elwood	881	31-Jan-03	7.40	466	5.7	14.0	182	222						
Elwood	881	10-Feb-03	7.40	461	3.8	15.0	162	198						
Elwood	881	28-Feb-03	7.50	484	4.2	15.0	191	233						
Elwood	881	21-Mar-03	7.40	586	3.8	15.0	186	227						
Elwood	881	25-Apr-03	7.30	525	3.8	15.0	194	237						
Elwood	881	13-May-03	7.20	596	4	15.0	187	228					n.d.	
Elwood	881	04-Jun-03	7.30	664	4.1	15.0							n.d.	
Elwood	881	16-Jun-03	7.30	550	4.4	15.0	185	226						
Elwood	881	16-Jul-03	7.30	794	4	15.5	186	227						
Elwood	881	13-Aug-03	7.40	777	4	15.1	190	232	86.3	59.8	17.5	12.4		n.d.
Elwood	881	01-Dec-03	7.20	409	3.6	14.0	190	232	90.6	58	19.4	19		n.d.
Elwood	Distribution	21-Mar-03	7.50	588	6.8	11.0	189	230						
Elwood	Distribution	25-Apr-03	7.30	522	5.3	13.8	191	233						
Elwood	Distribution	13-May-03	7.50	602	8.4	16.0	188	229						
Elwood	Distribution	04-Jun-03	7.20	647	6.2	16.9							n.d.	
Elwood	Distribution	16-Jul-03	7.20	755	5.4	17.0	189	230						
Elwood	Distribution	13-Aug-03	7.40	819	6.8	19.0	203	247					n.d.	
Elwood	Distribution	01-Dec-03	7.30	409	6.3	12.0	185	226						
Haigler	651	07-Aug-06	7.31	421	7.0	15.4	205	250						
Haigler	651	07-Aug-06	7.30	434	5.2	13.0	201	242						
Haigler	651	07-Aug-06	7.50	433	4.6	13.0	208	244						
Haigler	651	07-Aug-06	7.50	429	5.3	14.5	206	251						
Haigler	651	07-Aug-06	7.60	299	3.5	14.0	203	248						
Haigler	651	07-Aug-06	7.40	422	2.4	14.1	212	258	59.2	16.8	12.2	13.6	n.d.	n.d.
Haigler	651	10-Aug-06	7.45	379	4.0	14.0	217	265	56.1	16.5	11.9	14.6	n.d.	0.02
Haigler	651	10-Aug-06	7.41	386	3.0	14.0	200	244	59.3	16.7	12.1	13.8	0.05	0.03
Haigler	651	10-Aug-06	6.29	363	3.8	18.0	196	239						
Haigler	651	10-Aug-06	7.53	328	6.7	16.0	209	255						
Haigler	651	10-Aug-06	7.51	366	3.7	14.0	216	264						
Haigler	651	10-Aug-06	7.39	379	3.7	14.0	214	261						
Haigler	651	10-Aug-06	6.69	380	3.2	14.0	214	261	56.1	16.5	11.9	15.0	0.04	0.02
Haigler	651	10-Aug-06	6.78	376	6.6	17.0	214	261						
Haigler	651	10-Aug-06	7.50	368	3.5	14.0	213	260	56.7	16.6	12.0	14.1	0.02	0.03
Haigler	651	10-Aug-06	7.17	369	6.0	16.0	211	258						
Haigler	651	10-Aug-06	7.42	378	4.6	14.0	212	259						
Haigler	651	10-Aug-06	7.29	389	3.2	13.0	209	255						
Haigler	651	13-Nov-06	7.80	500	6.6	13.0	189	231						
Haigler	651	13-Nov-06	7.80	470	6.2	13.0	187	228						
Haigler	651	13-Nov-06	7.80	470	6.3	13.0	191	233						
Haigler	651	13-Nov-06	7.80	510	7.9	13.0	198	241						
Haigler	651	14-Nov-06	8.00	440		13.5	189	230						
Haigler	651	14-Nov-06	7.70	440	7.4	14.0	189	231	63.8	18.3	13.1	14.0	0.03	n.d.
Haigler	651	14-Nov-06	7.70	450	7.8	13.5	191	233						
Haigler	651	16-Nov-06	7.70	440		13.5								
Haigler	651	16-Nov-06	7.60	440		13.5								
Haigler	651	22-Nov-06	8.00	430		13.5								
Haigler	651	22-Nov-06	7.70	430		13.5								
Haigler	651	29-Nov-06	7.80	430		13.5								
Haigler	651	29-Nov-06	7.60	440		13.5								
Haigler	651	06-Dec-06	7.70	440		13.5								
Haigler	651	06-Dec-06	7.70	430		13.5								

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Elwood	71	21-Mar-03									273.5			
Elwood	71	25-Apr-03									223.6			
Elwood	71	13-May-03									276.1			
Elwood	71	04-Jun-03												
Elwood	71	16-Jun-03												
Elwood	71	16-Jul-03									235.9			
Elwood	71	13-Aug-03	17.7	16.3	140.7	0	0	0	< 0.1		227.3	8.26		
Elwood	71	01-Dec-03	11.6	17.9	145	0.04	0	0.04	< 0.1		-66.8	4.86		
Elwood	881	06-Dec-02												
Elwood	881	06-Jan-03												
Elwood	881	31-Jan-03												
Elwood	881	10-Feb-03												
Elwood	881	28-Feb-03												
Elwood	881	21-Mar-03									285.4			
Elwood	881	25-Apr-03									208.5			
Elwood	881	13-May-03									270.8			
Elwood	881	04-Jun-03												
Elwood	881	16-Jun-03												
Elwood	881	16-Jul-03									236			
Elwood	881	13-Aug-03				0.04	0	0.04	< 0.1		201.3			
Elwood	881	01-Dec-03		16.2		0.03	0	0.03	< 0.1		-76.1			
Elwood	Distribution	21-Mar-03									284.3			
Elwood	Distribution	25-Apr-03									224.8			
Elwood	Distribution	13-May-03									278.7			
Elwood	Distribution	04-Jun-03												
Elwood	Distribution	16-Jul-03									244			
Elwood	Distribution	13-Aug-03				0.02	0	0.02			204.1			
Elwood	Distribution	01-Dec-03				0.03	0	0.03			-65.1			
Haigler	651	07-Aug-06				n.d	n.d	n.d						
Haigler	651	07-Aug-06				0.02	n.d.	0.02						
Haigler	651	07-Aug-06				0.01	n.d.	0.01						
Haigler	651	07-Aug-06				0.01	n.d.	0.01						
Haigler	651	07-Aug-06				0.01	n.d.	0.01						
Haigler	651	07-Aug-06	2.4	3	13	0.03	0.01	0.02	0.1	n.d.		4.29		
Haigler	651	10-Aug-06	2.4	4	14	0.01	n.d	0.01	0.1	n.d.		0.87		
Haigler	651	10-Aug-06	2.1	3	13	0.03	0.02	0.01	0.1	n.d.		6.88		
Haigler	651	10-Aug-06				0.01	n.d	0.01						
Haigler	651	10-Aug-06				0.03	0.01	0.02						
Haigler	651	10-Aug-06				n.d	n.d	n.d						
Haigler	651	10-Aug-06				0.01	n.d	0.01						
Haigler	651	10-Aug-06	2.3	4	14	n.d	n.d	n.d	0.2	n.d.		1.7		
Haigler	651	10-Aug-06				n.d	n.d	n.d						
Haigler	651	10-Aug-06	2.1	4	14	0.04	0.03	0.01	0.1	n.d.		2.1		
Haigler	651	10-Aug-06				n.d	n.d	n.d						
Haigler	651	10-Aug-06				0.01	0.01	n.d						
Haigler	651	10-Aug-06				0.06	0.04	0.02						
Haigler	651	13-Nov-06				0.03	n.d	0.03						
Haigler	651	13-Nov-06				0.01	n.d	0.01						
Haigler	651	13-Nov-06				0.06	0.01	0.05						
Haigler	651	13-Nov-06												
Haigler	651	14-Nov-06				0.10	0.04	0.06						
Haigler	651	14-Nov-06	2.8	5	14	0.03	n.d	0.03	n.d.	n.d.		-4.46		
Haigler	651	14-Nov-06				0.04	n.d	0.04						
Haigler	651	16-Nov-06												
Haigler	651	16-Nov-06												
Haigler	651	22-Nov-06												
Haigler	651	22-Nov-06												
Haigler	651	29-Nov-06												
Haigler	651	29-Nov-06												
Haigler	651	06-Dec-06												
Haigler	651	06-Dec-06												

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Haigler	651	13-Dec-06	1530	30	95	120		18.10						
Haigler	651	13-Dec-06	1500	0	95	120		19.50						
Haigler	651	26-Dec-06	1500	0	95	125		19.90						
Haigler	651	26-Dec-06	1532	30	95	120		19.30						
Haigler	651	04-Jan-07	1557	0	95	110		19.40						
Haigler	651	04-Jan-07	1630	30	95	110		19.60						
Haigler	651	11-Jan-07	1730	35	95	55		19.00						
Haigler	651	11-Jan-07	1655	0	95	55		18.00						
Haigler	651	18-Jan-07	1519	0	95	47		21.10						
Haigler	651	18-Jan-07	1555	26	95	48		19.30						
Haigler	651	23-Jan-07	1230	0	95	50		13.20						
Haigler	651	23-Jan-07	1320	50	95	50		18.70						
Haigler	651	06-Mar-07	1014	30	95	130	L31734-8	20.20						
Haigler	651	06-Mar-07	948	0	95	130	L31734-7	29.40						
Haigler	651	09-Mar-07	1016	0	95	150	L31734-6	22.20						
Haigler	651	09-Mar-07	1046	30	95	140	L31734-5	19.10						
Haigler	651	22-Mar-07	1446	37	95	30	L32099-1	19.40						
Haigler	651	22-Mar-07	1637	148	95	22	L32099-2	19.10						
Haigler	651	22-Mar-07	1409	0	95	50	L32099-3	24.00						
Humphrey	20011	21-Feb-05	1154	N/A	140	625	P27307-16	11.30		0	10.0			
Humphrey	20011	25-Apr-05	1140	N/A	140	625	P27621-27	9.91						
Humphrey	20011	17-Aug-05	935	N/A	140	625		9.25		nd				
Humphrey	20011	19-Oct-05	915	N/A	140	625	P28350-42	10.50						
Lodgepole	641	17-Dec-02	1445	N/A	~40	375	P22233-4	8.00						
Lodgepole	641	07-Jan-03	810	N/A	~40	375	P22355-13	7.96						
Lodgepole	641	27-Jan-03	838	N/A	~40	375	P22462-4	7.64						
Lodgepole	641	09-Feb-03	1532	N/A	~40	375	P22355-8	6.82						
Lodgepole	641	21-Feb-03	1430	N/A	~40	375	P22495-17	7.08						
Lodgepole	641	14-Mar-03	1340	N/A	~40	375	P22495-23	8.12						
Lodgepole	641	02-May-03	1240	N/A	~40	375	P22495-29	7.24						
Lodgepole	641	12-May-03	1305	N/A	~40	375	P22985-41	7.22	8.60		7.1 / 6.7			
Lodgepole	641	03-Jun-03	1247	N/A	~40	375	P22985-16	7.30	9.10	0	8.2			
Lodgepole	641	30-Jun-03	1337	N/A	~40	375	P22495-38	7.27						
Lodgepole	641	15-Jul-03	1145	N/A	~40	375	P23372-23	6.68		0				
Lodgepole	641	12-Aug-03	1152	N/A	~40	375		7.49		0				
Lodgepole	641	03-Dec-03	1420	N/A	~40	375		6.61						
Lodgepole	751	17-Dec-02	1530	N/A	~60	370	P22233-3	9.59						
Lodgepole	751	07-Jan-03	854	N/A	~60	370	P22355-14	10.40						
Lodgepole	751	27-Jan-03	749	N/A	~60	370	P22462-3	10.20						
Lodgepole	751	09-Feb-03	1555	N/A	~60	370	P22566-2	10.50						
Lodgepole	751	21-Feb-03	1330	N/A	~60	370	P22495-16	9.97						
Lodgepole	751	14-Mar-03	1425	N/A	~60	370	P22495-22	10.10						
Lodgepole	751	02-May-03	1205	N/A	~60	370	P22495-28	10.10						
Lodgepole	751	12-May-03	1214	N/A	~60	370	P22985-43	9.91	12.80		10.4 / 9.8			
Lodgepole	751	03-Jun-03	1310	N/A	~60	370	P3144-46	8.99	12.50	0	10.9			
Lodgepole	751	30-Jun-03	1300	N/A	~60	370	P22495-37	9.96						
Lodgepole	751	15-Jul-03	1123	N/A	~60	370	P23372-19	9.20		0				
Lodgepole	751	12-Aug-03	1127	N/A	~60	370		9.58		0				
Lodgepole	751	03-Dec-03	1335	N/A	~60	370		9.47						
Lodgepole	Distribution	12-May-03	1243	N/A	N/A	N/A	P22985-35	9.60	12.80					
Lodgepole	Distribution	03-Jun-03	1230	N/A	N/A	N/A	P23144-9	9.47						
Lodgepole	Distribution	15-Jul-03	1127	N/A	N/A	N/A	P23372-28	11.90						
Lodgepole	Distribution	12-Aug-03		N/A	N/A	N/A		9.15						
Lodgepole	Distribution	03-Dec-03	1350	N/A	N/A	N/A		8.16						
Lyman	471	23-Feb-05	845	N/A		200	P27307-24	24.10		0	28.3			
Lyman	471	26-Apr-05	935	N/A		200	P27621-32	23.90						
Lyman	471	15-Aug-05	1525	N/A		200		25.60		nd				
Lyman	471	17-Oct-05	1458	N/A		200	P28350-34	24.50						
McCook	4	27-Nov-02	1612	N/A	~30	900	P22194-4	12.60						
McCook	4	07-Jan-03	1530	N/A	~30	900	P22355-21	11.20						
McCook	4	31-Jan-03	1309	N/A	~30	900	P22462-18	11.40						

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Haigler	651	13-Dec-06	7.80	450		13.5								
Haigler	651	13-Dec-06	7.80	450		13.5								
Haigler	651	26-Dec-06	7.40	440		13.5								
Haigler	651	26-Dec-06	7.70	440		13.5								
Haigler	651	04-Jan-07	7.50	460		13.5								
Haigler	651	04-Jan-07	7.90	450		13.5								
Haigler	651	11-Jan-07	7.60	420		13.5								
Haigler	651	11-Jan-07	7.50	420		13.5								
Haigler	651	18-Jan-07	7.60	450		13.5								
Haigler	651	18-Jan-07	7.50	430		13.5								
Haigler	651	23-Jan-07	7.80	420		13.5								
Haigler	651	23-Jan-07	7.70	450		13.5								
Haigler	651	06-Mar-07	7.50	1450		13.5								
Haigler	651	06-Mar-07	7.60	1460		13.5								
Haigler	651	09-Mar-07	7.80	450		13.5								
Haigler	651	09-Mar-07	7.50	450		13.5								
Haigler	651	22-Mar-07	7.70	450		13.5								
Haigler	651	22-Mar-07	7.60	440		13.5								
Haigler	651	22-Mar-07	7.70	450		13.5								
Humphrey	20011	21-Feb-05	6.80	517	5.2	10.0	309	377	114	27.6	21	8.1		n.d.
Humphrey	20011	25-Apr-05	6.90	599	7.1	10.0	279	340						
Humphrey	20011	17-Aug-05	6.40	830	5.6	9.5	316	385	110	27.2	20.7	8.3		n.d.
Humphrey	20011	19-Oct-05	7.00	498	5.9	9.5	307	374						
Lodgepole	641	17-Dec-02	7.65	580	N/A	13.3	197	240						
Lodgepole	641	07-Jan-03	7.50	440	6	12.1	250	305						
Lodgepole	641	27-Jan-03	7.30	387	5.4	12.0	208	254						
Lodgepole	641	09-Feb-03	7.40	415	6.2	12.4	214	261						
Lodgepole	641	21-Feb-03	7.10	610	N/A	12.0	202	246						
Lodgepole	641	14-Mar-03	7.40	520	N/A	12.0	202	246						
Lodgepole	641	02-May-03	7.10	480	N/A	12.5	201	245						
Lodgepole	641	12-May-03	7.30	576	5	12.5	210	256					n.d.	
Lodgepole	641	03-Jun-03	7.40	523	6.8	12.3							n.d.	
Lodgepole	641	30-Jun-03	7.20	570	N/A	12.0	188	229						
Lodgepole	641	15-Jul-03	7.40	608	7	12.5	203	247						
Lodgepole	641	12-Aug-03	7.40	585	6.4	12.5	210	256	65.5	42.6	14.3	10.6		n.d.
Lodgepole	641	03-Dec-03	7.30	436	6.7	13.0	215	262	72.7	36.2	15.7	16.8		n.d.
Lodgepole	751	17-Dec-02	7.67	510	N/A	13.9	182	222						
Lodgepole	751	07-Jan-03	7.70	391	7.3	12.5	196	239						
Lodgepole	751	27-Jan-03	7.40	354	6.9	12.6	177	216						
Lodgepole	751	09-Feb-03	7.50	361	7.5	13.0	162	198						
Lodgepole	751	21-Feb-03	7.50	520	N/A	13.0	178	217						
Lodgepole	751	14-Mar-03	7.50	450	N/A	12.0	184	224						
Lodgepole	751	02-May-03	7.10	390	N/A	12.0	177	216						
Lodgepole	751	12-May-03	7.50	507	7.4	12.9	210	256					n.d.	
Lodgepole	751	03-Jun-03	7.50	461	7.8	12.8							n.d.	
Lodgepole	751	30-Jun-03	7.30	480	N/A	13.0	170	207						
Lodgepole	751	15-Jul-03	7.50	501	8.3	12.9	187	228						
Lodgepole	751	12-Aug-03	7.40	509	7.5	12.5	196	239	70.2	48.3	10.7	9.4		n.d.
Lodgepole	751	03-Dec-03	7.40	386	8.9	13.0	196	239	60.9	44.7	11.3	15.2		n.d.
Lodgepole	Distribution	12-May-03	7.50	476	6.4	14.0	175	213						
Lodgepole	Distribution	03-Jun-03	7.50	457	8.3	15.0							n.d.	
Lodgepole	Distribution	15-Jul-03	7.50	468	8.2	18.0	170	207						
Lodgepole	Distribution	12-Aug-03	7.40	503	7.2	19.0	184	224					n.d.	
Lodgepole	Distribution	03-Dec-03	7.50	425	8.4	13.0	203	247						
Lyman	471	23-Feb-05	7.20	835	0.05	10.2	394	480	77.1	255	22.5	12.5		.09
Lyman	471	26-Apr-05	6.90	1024	1	10.2	387	472						
Lyman	471	15-Aug-05	7.52	1620	0.9	11.0	403	491	74.2	263	22	12		.11
Lyman	471	17-Oct-05	7.50	1330	0.9	10.0	391	477						
McCook	4	27-Nov-02	7.19	817	2.8	13.3	361	440						
McCook	4	07-Jan-03	7.20	1059	3.3	13.0	387	472						
McCook	4	31-Jan-03	7.30	850	3.3	13.2	379	462						

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Haigler	651	13-Dec-06												
Haigler	651	13-Dec-06												
Haigler	651	26-Dec-06												
Haigler	651	26-Dec-06												
Haigler	651	04-Jan-07												
Haigler	651	04-Jan-07												
Haigler	651	11-Jan-07												
Haigler	651	11-Jan-07												
Haigler	651	18-Jan-07												
Haigler	651	18-Jan-07												
Haigler	651	23-Jan-07												
Haigler	651	23-Jan-07												
Haigler	651	06-Mar-07												
Haigler	651	06-Mar-07												
Haigler	651	09-Mar-07												
Haigler	651	09-Mar-07												
Haigler	651	22-Mar-07												
Haigler	651	22-Mar-07												
Haigler	651	22-Mar-07												
Humphrey	20011	21-Feb-05	4.2	5	71	0.01	0	0.01	.4		939.5	5.74		
Humphrey	20011	25-Apr-05									886			
Humphrey	20011	17-Aug-05	3.9	5	67	0.02			.4			8.99		
Humphrey	20011	19-Oct-05									-169.7			
Lodgepole	641	17-Dec-02												
Lodgepole	641	07-Jan-03												
Lodgepole	641	27-Jan-03												
Lodgepole	641	09-Feb-03												
Lodgepole	641	21-Feb-03												
Lodgepole	641	14-Mar-03												
Lodgepole	641	02-May-03												
Lodgepole	641	12-May-03									266.4			
Lodgepole	641	03-Jun-03												
Lodgepole	641	30-Jun-03												
Lodgepole	641	15-Jul-03									231.4			
Lodgepole	641	12-Aug-03	19.7	30.7	34.9	0.03	0	0.03	< 0.1		227.8	3.65		
Lodgepole	641	03-Dec-03	27.6	19.7	37.1	0.02	0	0.02	< 0.1		-51.7	6.62		
Lodgepole	751	17-Dec-02												
Lodgepole	751	07-Jan-03												
Lodgepole	751	27-Jan-03												
Lodgepole	751	09-Feb-03												
Lodgepole	751	21-Feb-03												
Lodgepole	751	14-Mar-03												
Lodgepole	751	02-May-03												
Lodgepole	751	12-May-03									161.6			
Lodgepole	751	03-Jun-03												
Lodgepole	751	30-Jun-03												
Lodgepole	751	15-Jul-03									233.4			
Lodgepole	751	12-Aug-03				0.01	0	0.01	< 0.1		246.2			
Lodgepole	751	03-Dec-03		10		0.01	0	0.01	< 0.1		-65.7			
Lodgepole	Distribution	12-May-03									279.4			
Lodgepole	Distribution	03-Jun-03												
Lodgepole	Distribution	15-Jul-03									227.9			
Lodgepole	Distribution	12-Aug-03				0.22	0	0.22			229.9			
Lodgepole	Distribution	03-Dec-03				0.02	0	0.02			-56.4			
Lyman	471	23-Feb-05	4.5	32	343	0.02	0	0.02	0.2		987.1	3.42		
Lyman	471	26-Apr-05									803			
Lyman	471	15-Aug-05	3.7	34	219	0.03	0	0.03	0.1			11.77		
Lyman	471	17-Oct-05									-186.8			
McCook	4	27-Nov-02												
McCook	4	07-Jan-03												
McCook	4	31-Jan-03												

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
McCook	4	10-Feb-03	1038	N/A	~30	900	P22355-25	11.20						
McCook	4	28-Feb-03	1315	N/A	~30	900	P22616-13	10.00						
McCook	4	21-Mar-03	1357	N/A	~30	900	P22653-47	10.40						
McCook	4	25-Apr-03	1353	N/A	~30	900	P22714-82	11.40	12.00		10.8/ NA			
McCook	4	13-May-03	1137	N/A	~30	900	P22985-20	10.90	12.40		11.1		38.2	
McCook	4	04-Jun-03	1130	N/A	~30	900	P23144-24	9.83	13.30	0	11.5			
McCook	4	16-Jun-03	1303	N/A	~30	900	P23144-45	11.80		0	11.4			
McCook	4	16-Jul-03	1200	N/A	~30	900	P23372-31	11.50		0			39.3	
McCook	4	13-Aug-03	1400	N/A	~30	900		9.43		0			41.4	
McCook	4	02-Dec-03	1158	N/A	~30	900		10.60					40.3	
McCook	4	13-Mar-07	1507	0	30	250	L31736-12	15.10				16.1		
McCook	4	13-Mar-07	1522	15	30	250								
McCook	4	13-Mar-07	1537	30	30	250	L31736-13	14.40				49.1		
McCook	6	27-Nov-02	1545	N/A	~34	1200	P22194-3	12.30						
McCook	6	07-Jan-03	1435	N/A	~34	1200	P22355-22	12.00						
McCook	6	31-Jan-03	1312	N/A	~34	1200	P22462-17	11.80						
McCook	6	10-Feb-03	1038	N/A	~34	1200	P22355-11	11.20						
McCook	6	28-Feb-03	1315	N/A	~34	1200	P22616-11	10.90						
McCook	6	21-Mar-03	1307	N/A	~34	1200	P22653-49	11.30						
McCook	6	25-Apr-03	1338	N/A	~34	1200	P22714-86	11.60	13.60		11.3 / NA			
McCook	6	13-May-03	1118	N/A	~34	1200	P22985-33	11.50	14.50		11.4		21.1	
McCook	6	04-Jun-03	1157	N/A	~34	1200	P23144-16	11.40	13.70	0	12.4			
McCook	6	16-Jun-03	1249	N/A	~34	1200	P23144-48	10.40	13.70	0	12.6			
McCook	6	16-Jul-03	1137	N/A	~34	1200	P23372-36	12.80		0			24.2	
McCook	6	13-Aug-03	1422	N/A	~34	1200		11.19		0			26.2	
McCook	6	02-Dec-03	1110	N/A	~34	1200		11.00					23.3	
McCook	Dist. (East)	21-Mar-03	1325	N/A	N/A	N/A	P22653-58	10.20						
McCook	Dist. (East)	13-May-03	1200	N/A	N/A	N/A	P22985-36	10.50	13.70					
McCook	Dist. (East)	04-Jun-03	1130	N/A	N/A	N/A	P23144-15	10.40						
McCook	Dist. (East)	16-Jul-03	1140	N/A	N/A	N/A	P23372-30	11.90						
McCook	Dist. (East)	02-Dec-03	1150	N/A	N/A	N/A		10.10						
McCook	Dist. (Res)	21-Mar-03	1246	N/A	N/A	N/A	P22653-53	10.20						
McCook	Dist. (Res)	25-Apr-03	1320	N/A	N/A	N/A	P22714-76	9.76	12.10					
McCook	Dist. (Res)	13-May-03	1105	N/A	N/A	N/A	P22985-45	10.90	11.90					
McCook	Dist. (Res)	04-Jun-03	1115	N/A	N/A	N/A	P23144-40	10.70						
McCook	Dist. (Res)	16-Jul-03	1115	N/A	N/A	N/A	P23372-20	9.15						
McCook	Dist. (Res)	13-Aug-03	1335	N/A	N/A	N/A		10.60						
McCook	Dist. (Res)	02-Dec-03	1153	N/A	N/A	N/A		9.71						
McCook	Dist. (West)	21-Mar-03	1315	N/A	N/A	N/A	P22653-51	10.30						
McCook	Dist. (West)	13-May-03	1205	N/A	N/A	N/A	P22985-18	11.00	13.30					
McCook	Dist. (West)	04-Jun-03	1140	N/A	N/A	N/A	P23144-38	10.20						
McCook	Dist. (West)	16-Jul-03	1145	N/A	N/A	N/A	P23372-26	9.90						
McCook	Dist. (West)	02-Dec-03	1155	N/A	N/A	N/A		9.45						
Morril	531	15-Aug-05	1357	N/A	~55	300		25.40						
Morrill	531	23-Feb-05	1033	N/A	~55	300	P27307-25	25.90		0	28.6			
Morrill	531	26-Apr-05	815	N/A	~55	300	P27621-30	24.10						
Morrill	531	17-Oct-05		N/A	~55	300								
Osceola	721	10-Aug-05	1115	N/A		1000		6.96		nd				
Osceola	721	21-Oct-05	1009	N/A		1000	P27621-77	8.92						
Osceola	721-wk1	17-Aug-05	1042	N/A		1000	P27307-35	9.42						
Osceola	721-wk2	25-Aug-05	1100	N/A		1000	P27621-41	9.18						
Osceola	721-wk3	01-Sep-05	1025	N/A		1000	P27621-42	8.12						
Osceola	721-wk4	07-Sep-05	1023	N/A		1000	P27621-43	8.37						
Osceola	721-wk5	22-Sep-05	1321	N/A		1000	P27621-44	7.72						
Osceola	851	15-Feb-05	1145	N/A		400	P24577-17	11.00		0	11.2			
Osceola	851	19-Apr-05	906	N/A		400	P27621-35	10.20						
Osceola	851	10-Aug-05	1015	N/A		400		10.10		nd				
Osceola	851	21-Oct-05	1037	N/A		400	P28852-9	12.10						
Oshkosh	1451	17-Dec-02	820	N/A	50	200	P22233-1	13.50						
Oshkosh	1451	07-Jan-03	1314	N/A	50	200	P22355-2	13.20						
Oshkosh	1451	27-Jan-03	1324	N/A	50	200	P22462-5	12.70						

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
McCook	4	10-Feb-03	7.30	715	3	13.0	348	424						
McCook	4	28-Feb-03	7.30	805	3.1	13.0	388	473						
McCook	4	21-Mar-03	7.40	918	3	15.0	380	463						
McCook	4	25-Apr-03	7.10	869	2.8	13.1	367	447						
McCook	4	13-May-03	7.10	1034	3.3	13.2	400	488					n.d.	
McCook	4	04-Jun-03	7.20	1061	3	13.1							n.d.	
McCook	4	16-Jun-03	7.30	1226	2.8	13.2	371	452					0.04	
McCook	4	16-Jul-03	7.20	1199	2.2	13.2	373	455						
McCook	4	13-Aug-03	7.20	1230	2.4	13.0	388	473	121	147	36.5	30.5	0	n.d.
McCook	4	02-Dec-03	7.00	823	3	12.8	374	456	129.2	137	36.2	50.8		n.d.
McCook	4	13-Mar-07	7.40	1350	5.2	13	411	501	108	118	37.9	40.5		0.01
McCook	4	13-Mar-07	7.30	1370	2.7	13	404	492						
McCook	4	13-Mar-07	7.30	1370	2.8	13	407	496	109	117	39	42.7		0
McCook	6	27-Nov-02	7.50	827	2.5	14.2	333	406						
McCook	6	07-Jan-03	7.10	961	2.6	13.5	346	422						
McCook	6	31-Jan-03	7.20	777	2.6	13.0	350	427						
McCook	6	10-Feb-03	7.20	652	2.6	13.0	330	402						
McCook	6	28-Feb-03	7.20	732	2.7	13.0	317	386						
McCook	6	21-Mar-03	7.20	914	2.5	13.1	344	419						
McCook	6	25-Apr-03	7.10	848	2.4	13.0	349	426						
McCook	6	13-May-03	7.10	995	2.8	13.0	375	457					n.d.	
McCook	6	04-Jun-03	7.10	1000	2.7	13.0							n.d.	
McCook	6	16-Jun-03	7.20	1146	2.9	13.1	360	439						
McCook	6	16-Jul-03	7.20	1147	2.7	13.0	374	456						
McCook	6	13-Aug-03	7.20	1204	3	13.2	372	454	144	123	30.1	24.3		n.d.
McCook	6	02-Dec-03	7.10	794	2.6	13.0	358	436	151	118	31.2	32.7		n.d.
McCook	Dist. (East)	21-Mar-03	7.30	855	4.6	13.0	344	419						
McCook	Dist. (East)	13-May-03	7.10	912	3.6	16.0	349	426						
McCook	Dist. (East)	04-Jun-03	7.10	981	3.6	17.5								
McCook	Dist. (East)	16-Jul-03	7.20	1128	3.8	19.5	369	450						
McCook	Dist. (East)	02-Dec-03	7.30	781	3.1	12.8	353	430						
McCook	Dist. (Res)	21-Mar-03	7.30		4.8	13.0	332	405						
McCook	Dist. (Res)	25-Apr-03	7.20	828	4.2	13.0	356	434						
McCook	Dist. (Res)	13-May-03	7.20	922	4.1	14.0	370	451						
McCook	Dist. (Res)	04-Jun-03	7.20	958	4	13.9								
McCook	Dist. (Res)	16-Jul-03	7.10	1114	4	14.5	374	456						
McCook	Dist. (Res)	13-Aug-03	7.40	1147	5.2	15.5	373	455						
McCook	Dist. (Res)	02-Dec-03	7.30	778	3.2	14.0	348	424						
McCook	Dist. (West)	21-Mar-03	7.40	850	4.4	13.0	349	426						
McCook	Dist. (West)	13-May-03	7.20		3.2	17.0	335	408					n.d.	
McCook	Dist. (West)	04-Jun-03	7.10	1030	4.3	18.8							n.d.	
McCook	Dist. (West)	16-Jul-03	7.00	1114	4.1	19.0	365	445						
McCook	Dist. (West)	02-Dec-03	7.20	772	2.9	12.3	364	444						
Morril	531	15-Aug-05	7.34	1181	1.4	11.0	299	365	99.6	123	31.3	20.2		0.06
Morrill	531	23-Feb-05	7.10	718	0.6	11.0	296	361	95	115	29.3	20.1		.06
Morrill	531	26-Apr-05	7.10	704	2	11.0	274	334						
Morrill	531	17-Oct-05			N/A									
Osceola	721	10-Aug-05	7.00	651	4.2	12.0	314	383						
Osceola	721	21-Oct-05	6.80	552	4	11.0	309	377						
Osceola	721-wk1	17-Aug-05	7.60	790	7.5	13.0								
Osceola	721-wk2	25-Aug-05	7.40	710	6.1	13.0							.07	
Osceola	721-wk3	01-Sep-05	7.40	690	5.6	13.0								
Osceola	721-wk4	07-Sep-05	7.50	690	5.1	13.0							.05	
Osceola	721-wk5	22-Sep-05	7.60	680	7.5	13.0								
Osceola	851	15-Feb-05	6.80	605	1.5	12.0	290	354	107	19.8	16.3	7.1		.15
Osceola	851	19-Apr-05	6.70	605	1.8	12.0	275	335						
Osceola	851	10-Aug-05	7.00	618	1.8	12.0	303	369	111	20.8	17.1	7.6		.15
Osceola	851	21-Oct-05	7.00	512	1.5	11.0	291	355						
Oshkosh	1451	17-Dec-02	7.60	820	N/A	15.0	270	329						
Oshkosh	1451	07-Jan-03	7.00	703	1.3	14.0	262	319						
Oshkosh	1451	27-Jan-03	7.20	728	5.6	14.7	287	350						

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
McCook	4	10-Feb-03												
McCook	4	28-Feb-03												
McCook	4	21-Mar-03									290.3			
McCook	4	25-Apr-03									290.9			
McCook	4	13-May-03									305.9			
McCook	4	04-Jun-03												
McCook	4	16-Jun-03									251.2			
McCook	4	16-Jul-03									217.1			
McCook	4	13-Aug-03				0.02	0	0.02	< 0.1		261.1			
McCook	4	02-Dec-03		37.9		0	0	0	< 0.1		-115.7			
McCook	4	13-Mar-07	11.4	41	225					3.54		1.53		
McCook	4	13-Mar-07												
McCook	4	13-Mar-07	12.4	41	230	0.02	0.032			3.32		1.91		
McCook	6	27-Nov-02												
McCook	6	07-Jan-03												
McCook	6	31-Jan-03												
McCook	6	10-Feb-03												
McCook	6	28-Feb-03												
McCook	6	21-Mar-03									294.4			
McCook	6	25-Apr-03									248.9			
McCook	6	13-May-03									294.9			
McCook	6	04-Jun-03												
McCook	6	16-Jun-03									248.9			
McCook	6	16-Jul-03									221.7			
McCook	6	13-Aug-03	90.1	42.5	199	0.03	0.02	0.01	0.1		271.3	4.68		
McCook	6	02-Dec-03	80.4	42	224	0.01	0	0.01	0.1		-134.6	5.86		
McCook	Dist. (East)	21-Mar-03									285.1			
McCook	Dist. (East)	13-May-03									324.9			
McCook	Dist. (East)	04-Jun-03												
McCook	Dist. (East)	16-Jul-03									221.7			
McCook	Dist. (East)	02-Dec-03				0.01	0	0.01			-71.1			
McCook	Dist. (Res)	21-Mar-03									283.3			
McCook	Dist. (Res)	25-Apr-03									224.1			
McCook	Dist. (Res)	13-May-03									287.6			
McCook	Dist. (Res)	04-Jun-03												
McCook	Dist. (Res)	16-Jul-03									224.3			
McCook	Dist. (Res)	13-Aug-03				0.03	0	0.03			260.6			
McCook	Dist. (Res)	02-Dec-03				0.02	0	0.02			-70.7			
McCook	Dist. (West)	21-Mar-03									285.8			
McCook	Dist. (West)	13-May-03									341.1			
McCook	Dist. (West)	04-Jun-03												
McCook	Dist. (West)	16-Jul-03									226.2			
McCook	Dist. (West)	02-Dec-03				0	0	0			-72.5			
Morril	531	15-Aug-05	3.5	20	285	0.04	0.03	0.01	0.1			3.38		
Morrill	531	23-Feb-05	3.7	21	265	0	0	0	.2		878.1	2.32		
Morrill	531	26-Apr-05									828.3			
Morrill	531	17-Oct-05												
Osceola	721	10-Aug-05				0.04	0	0.04			-182.7			
Osceola	721	21-Oct-05									-233.9			
Osceola	721-wk1	17-Aug-05												
Osceola	721-wk2	25-Aug-05												
Osceola	721-wk3	01-Sep-05												
Osceola	721-wk4	07-Sep-05												
Osceola	721-wk5	22-Sep-05												
Osceola	851	15-Feb-05	8.1	9	57	0.11	0.05	0.06	.2		4.81	2.37		
Osceola	851	19-Apr-05									-144.5			
Osceola	851	10-Aug-05	2.4	9	55	0.1	0.09	0.01	.2		1252	3.65		
Osceola	851	21-Oct-05									-258.7			
Oshkosh	1451	17-Dec-02												
Oshkosh	1451	07-Jan-03												
Oshkosh	1451	27-Jan-03												

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Oshkosh	1451	09-Feb-03	1135	N/A	50	200	P22355-7	12.20						
Oshkosh	1451	21-Feb-03	1550	N/A	50	200	P22495-18	12.40						
Oshkosh	1451	14-Mar-03	1600	N/A	50	200	P22495-24	13.20						
Oshkosh	1451	02-May-03	1403	N/A	50	200	P22495-30	13.30						
Oshkosh	1451	12-May-03	1632	N/A	50	200	P22985-27	12.30	16.00		10.7			
Oshkosh	1451	03-Jun-03	1535	N/A	50	200	P22985-17	13.40	15.80	0	14.0			
Oshkosh	1451	30-Jun-03	1455	N/A	50	200	P22495-39	12.90						
Oshkosh	1451	15-Jul-03	1532	N/A	50	200	P23372-21	13.10		0				
Oshkosh	1451	12-Aug-03	1515	N/A	50	200		11.40		0				
Oshkosh	1451	03-Dec-03	948	N/A	50	200		11.00						
Oshkosh	1741	17-Dec-02	925	N/A	~45	330	P22233-2	10.90						
Oshkosh	1741	07-Jan-03	1320	N/A	~45	330	P22355-1	9.54						
Oshkosh	1741	27-Jan-03	1357	N/A	~45	330	P22462-6	9.18						
Oshkosh	1741	09-Feb-03	1205	N/A	~45	330	P22355-29	8.36						
Oshkosh	1741	21-Feb-03	1645	N/A	~45	330	P22495-19	9.52						
Oshkosh	1741	14-Mar-03	1634	N/A	~45	330	P22495-25	9.60						
Oshkosh	1741	02-May-03	1435	N/A	~45	330	P22495-34	9.45						
Oshkosh	1741	12-May-03	1555	N/A	~45	330	P22985-42	9.36	11.60		13.5 / 9.8			
Oshkosh	1741	03-Jun-03	1604	N/A	~45	330	P22985-26	9.39	12.00	0	10.4			
Oshkosh	1741	30-Jun-03	1515	N/A	~45	330	P22495-40	9.38						
Oshkosh	1741	15-Jul-03	1545	N/A	~45	330	P23144-27	8.86		0				
Oshkosh	1741	23-Jul-03	1319	N/A	~45	330	P23372-42	10.90		0				
Oshkosh	1741	12-Aug-03		N/A	~45	330		9.35						
Oshkosh	1741	03-Dec-03	851	N/A	~45	330		8.39						
Oshkosh	Distribution	03-Jun-03	1548	N/A	N/A	N/A	P22985-15	11.90						
Oshkosh	Distribution	15-Jul-03	1705	N/A	N/A	N/A	P23372-27	12.10						
Oshkosh	Distribution	12-Aug-03	1638	N/A	N/A	N/A		15.60						
Oshkosh	Distribution	03-Dec-03	1025	N/A	N/A	N/A		8.25						
Palisade	361	22-Feb-05	1133	N/A		300	P27307-21	7.45		0	8.6			
Palisade	361	11-Apr-05	1520	N/A		300	P27307-37	7.37						
Palisade	361	16-Aug-05	1044	N/A		300		7.54						
Palisade	361	23-Aug-05		N/A		300				nd				
Palisade	361	18-Oct-05	922	N/A		300	P28350-38	8.95						
Shelby	641	15-Feb-05	1425	N/A	~210	350	P24577-18	11.20		0	18.0			
Shelby	641	19-Apr-05	1038	N/A	~210	350	P27621-36	15.00						
Shelby	641	10-Aug-05	1304	N/A	~210	350		14.20		nd				
Shelton	49	06-Dec-02	1250	N/A	50	350	P22194-19	4.17						
Shelton	49	09-Jan-03	821	N/A	50	350	P22355-27	4.45						
Shelton	49	31-Jan-03	732	N/A	50	350	P22462-11	4.42						
Shelton	49	10-Feb-03	1546	N/A	50	350	P22462-23	4.39						
Shelton	49	28-Feb-03	729	N/A	50	350	P22616-20	3.92						
Shelton	49	21-Mar-03	813	N/A	50	350	P22653-59	4.39						
Shelton	49	25-Apr-03	736	N/A	50	350	P22714-85	3.87	4.50		3.4 / NA			
Shelton	49	13-May-03	1629	N/A	50	350	P22985-28	4.21	5.10		3.6 / 3.7		85	
Shelton	49	03-Jun-03	821	N/A	50	350	P22985-22	4.19	5.00	0	4.0			
Shelton	49	16-Jun-03	815	N/A	50	350	P23144-34	4.83		0	4.1			
Shelton	49	15-Jul-03	750	N/A	50	350	P23144-31	3.96		0			84.5	
Shelton	49	12-Aug-03	750	N/A	50	350		4.12		0			96.5	
Shelton	49	01-Dec-03	1318	N/A	50	350		3.75					85.6	
Shelton	97	06-Dec-02	1350	N/A	45	285	P22194-20	10.50						
Shelton	97	09-Jan-03	920	N/A	45	285	P22355-28	10.50						
Shelton	97	31-Jan-03	824	N/A	45	285	P22462-12	10.70						
Shelton	97	10-Feb-03	1605	N/A	45	285	P22566-3	10.00						
Shelton	97	28-Feb-03	822	N/A	45	285	P22616-19	9.75						
Shelton	97	21-Mar-03	725	N/A	45	285	P22653-54	9.51						
Shelton	97	25-Apr-03	826	N/A	45	285	P22714-69	9.73	11.10		7.7 / NA			
Shelton	97	13-May-03	1702	N/A	45	285	P22985-23	10.50	12.40		8.4 / 8.3		2.93	
Shelton	97	03-Jun-03	840	N/A	45	285	P3144-47	9.37	12.10	3.3	7.7			
Shelton	97	16-Jun-03	842	N/A	45	285	P23144-10	9.26		3.5	8.2			
Shelton	97	15-Jul-03	841	N/A	45	285	P23144-23	9.96		2.9			3.52	
Shelton	97	12-Aug-03	829	N/A	45	285		10.09		3.3			3.83	

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Oshkosh	1451	09-Feb-03	7.30	607	1.6	14.0	289	352						
Oshkosh	1451	21-Feb-03	7.40	830	N/A	14.0	272	332						
Oshkosh	1451	14-Mar-03	7.20	720	N/A	15.0	265	323						
Oshkosh	1451	02-May-03	7.00	600	N/A	14.0	263	321						
Oshkosh	1451	12-May-03	7.10	770	1.6	14.0	255	311					n.d.	
Oshkosh	1451	03-Jun-03	7.20	691	1.4	13.9							n.d.	
Oshkosh	1451	30-Jun-03	7.00	710	N/A	14.0	245	299						
Oshkosh	1451	15-Jul-03	7.20	855	1.6	14.0	275	335						
Oshkosh	1451	12-Aug-03	7.10	832	1.3	14.0	293	245	104	64.9	20.1	22.2		n.d.
Oshkosh	1451	03-Dec-03	6.80	472	1.4	14.0	280	341	110	65.1	21.3	30.2		n.d.
Oshkosh	1741	17-Dec-02	7.40	540	N/A	13.9	187	228						
Oshkosh	1741	07-Jan-03	7.40	562	5	13.0	185	226						
Oshkosh	1741	27-Jan-03	7.30	500	0.8	12.2	180	219						
Oshkosh	1741	09-Feb-03	7.50	431	3.4	12.0	186	227						
Oshkosh	1741	21-Feb-03	7.70	590	N/A	12.0	189	230						
Oshkosh	1741	14-Mar-03	7.45	500	N/A	11.0	180	219						
Oshkosh	1741	02-May-03	7.10	430	N/A	12.0	177	215						
Oshkosh	1741	12-May-03	7.40	568	2.3	12.0	180	219						
Oshkosh	1741	03-Jun-03	7.40	495	2.2	12.5							n.d.	
Oshkosh	1741	30-Jun-03	7.10	510	N/A	13.0	167	204					n.d.	
Oshkosh	1741	15-Jul-03	7.40	546	2.4	13.0	184	224						
Oshkosh	1741	23-Jul-03	7.40	529	2.8	13.0	199	243						
Oshkosh	1741	12-Aug-03	7.30	570	2.8	13.0	201		77.2	30.7	11.8	12.6		n.d.
Oshkosh	1741	03-Dec-03	7.20	310	4.8	12.0	372	454	73.5	25.8	10.3	19.5		n.d.
Oshkosh	Distribution	03-Jun-03	7.40	545	5.3	16.0							n.d.	
Oshkosh	Distribution	15-Jul-03	7.30	843	6.6	18.0	272	332						
Oshkosh	Distribution	12-Aug-03	6.90	918	5	18.9	299	365					n.d.	
Oshkosh	Distribution	03-Dec-03	7.00	470	3	11.0	273	333						
Palisade	361	22-Feb-05	7.30	337	5.8	12.0	213	260	56.8	25.5	16.4	12.7		n.d.
Palisade	361	11-Apr-05	7.10	399	6.3	11.8	198	241					n.d.	
Palisade	361	16-Aug-05	7.30	606	6.4	13.0	223	272	62.6	30.5	18.1	12.9		n.d.
Palisade	361	23-Aug-05			N/A								n.d.	
Palisade	361	18-Oct-05	6.90	393	6.3	12.5	228	278						
Shelby	641	15-Feb-05	6.80	466	1.8	11.0	258	315	89.4	17.5	13.7	8.6		n.d.
Shelby	641	19-Apr-05	6.60	511	1.8	11.8	225	274						
Shelby	641	10-Aug-05	6.80	564	5	12.0	232	283	86.2	20.2	13.3	8.2		.14
Shelton	49	06-Dec-02	7.33	1200	1.2	14.2	290	354						
Shelton	49	09-Jan-03	7.20	1440	1.5	13.0	328	400						
Shelton	49	31-Jan-03	7.10	758	1.3	13.5	314	383						
Shelton	49	10-Feb-03	7.20	907	0.9	14.0	295	360						
Shelton	49	28-Feb-03	6.90	842	1.8	13.2	321	391						
Shelton	49	21-Mar-03	7.10	783	1	13.5	321	391						
Shelton	49	25-Apr-03	7.10	1058	1.4	13.1	315	384						
Shelton	49	13-May-03	7.10	1294	1	14.0	324	395					n.d.	
Shelton	49	03-Jun-03	7.00	1012	2.4	13.1							n.d.	
Shelton	49	16-Jun-03	7.00	1184	1.2	13.0	338	412						
Shelton	49	15-Jul-03	7.00	1887	1.1	13.0	317	386						
Shelton	49	12-Aug-03	7.10	1246	1.1	13.0	331	404	176	128	36.4	29.8		0.05
Shelton	49	01-Dec-03	6.90	872	0.9	12.9	303	369	180	127	37.2	43.5		0.04
Shelton	97	06-Dec-02	7.14	499	0.4	13.1	237	289						
Shelton	97	09-Jan-03	7.50	399	0.1	12.7	274	334						
Shelton	97	31-Jan-03	7.30	340	0.3	12.7	257	313						
Shelton	97	10-Feb-03	7.40	398	0.8	13.0	245	299						
Shelton	97	28-Feb-03	7.30	384	1.2	12.9	260	317						
Shelton	97	21-Mar-03	7.40	377	0.2	13.0	259	316						
Shelton	97	25-Apr-03	7.20	432	0.2	13.0	242	295						
Shelton	97	13-May-03	7.30	428	0.3	13.0	258	315					0.02	
Shelton	97	03-Jun-03	7.20	461	1.1	13.0							0.06	
Shelton	97	16-Jun-03	7.30	440	0.4	13.0	265	323						
Shelton	97	15-Jul-03	7.30	521	0.2	13.1	256	312						
Shelton	97	12-Aug-03	7.30	517	0.3	13.1	266	324	74.9	39.4	14.5	7.8		0.69

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Oshkosh	1451	09-Feb-03												
Oshkosh	1451	21-Feb-03												
Oshkosh	1451	14-Mar-03												
Oshkosh	1451	02-May-03												
Oshkosh	1451	12-May-03									291.8			
Oshkosh	1451	03-Jun-03									288.6			
Oshkosh	1451	30-Jun-03												
Oshkosh	1451	15-Jul-03									227.2			
Oshkosh	1451	12-Aug-03	26.6	9.46		0.02	0	0.02	< 0.1		214.1			
Oshkosh	1451	03-Dec-03	23.4	9.5	141	0.02	0	0.02	< 0.1		-110.1	8.37		
Oshkosh	1741	17-Dec-02												
Oshkosh	1741	07-Jan-03												
Oshkosh	1741	27-Jan-03												
Oshkosh	1741	09-Feb-03												
Oshkosh	1741	21-Feb-03												
Oshkosh	1741	14-Mar-03												
Oshkosh	1741	02-May-03												
Oshkosh	1741	12-May-03									265.1			
Oshkosh	1741	03-Jun-03									335.4			
Oshkosh	1741	30-Jun-03												
Oshkosh	1741	15-Jul-03									225.8			
Oshkosh	1741	23-Jul-03									227.5			
Oshkosh	1741	12-Aug-03				0.02			< 0.1					
Oshkosh	1741	03-Dec-03		5.7		0.02	0	0.02	< 0.1		-100.7			
Oshkosh	Distribution	03-Jun-03									323.9			
Oshkosh	Distribution	15-Jul-03									224			
Oshkosh	Distribution	12-Aug-03				0.03	0	0.03			246			
Oshkosh	Distribution	03-Dec-03									-74.2			
Palisade	361	22-Feb-05	4.3	6	30	0.01	0	0.01	.2		-0.2	4.59		
Palisade	361	11-Apr-05									9.63			
Palisade	361	16-Aug-05	6.2	6	33	0.02	0	0.02	.1			7.32		
Palisade	361	23-Aug-05												
Palisade	361	18-Oct-05									-142.3			
Shelby	641	15-Feb-05	1.7	6	32	0.02	0	0.02	.3		8.27	4.32		
Shelby	641	19-Apr-05									-143.6			
Shelby	641	10-Aug-05	3.9	7	31				.3		-161.2	7.87		
Shelton	49	06-Dec-02												
Shelton	49	09-Jan-03												
Shelton	49	31-Jan-03												
Shelton	49	10-Feb-03												
Shelton	49	28-Feb-03												
Shelton	49	21-Mar-03									200.7			
Shelton	49	25-Apr-03									176.7			
Shelton	49	13-May-03									312.9			
Shelton	49	03-Jun-03												
Shelton	49	16-Jun-03									240.8			
Shelton	49	15-Jul-03									254.9			
Shelton	49	12-Aug-03				0.03	0.01	0.02	0.1		262			
Shelton	49	01-Dec-03	14.3	55.7	417	0.02	0	0.02	0.1		51.6	6.12		
Shelton	97	06-Dec-02												
Shelton	97	09-Jan-03												
Shelton	97	31-Jan-03												
Shelton	97	10-Feb-03												
Shelton	97	28-Feb-03												
Shelton	97	21-Mar-03									451.3			
Shelton	97	25-Apr-03									39.1			
Shelton	97	13-May-03									146.9			
Shelton	97	03-Jun-03												
Shelton	97	16-Jun-03									116.5			
Shelton	97	15-Jul-03									248.3			
Shelton	97	12-Aug-03				0.05	0.01	0.04	< 0.1		241.6			

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Shelton	97	01-Dec-03	1400	N/A	45	285		10.30					3.99	
Shelton	Distribution	21-Mar-03	755	N/A	N/A	N/A	P22653-48	9.95						
Shelton	Distribution	25-Apr-03	845	N/A	N/A	N/A	P22714-87	7.64	7.70					
Shelton	Distribution	03-Jun-03	855	N/A	N/A	N/A	P23144-5	9.20						
Shelton	Distribution	15-Jul-03	823	N/A	N/A	N/A	P23372-18	4.29						
Shelton	Distribution	12-Aug-03	845	N/A	N/A	N/A		9.55						
Shelton	Distribution	01-Dec-03	1332	N/A	N/A	N/A		5.14						
Stratton	752	22-Feb-05	944	N/A	~24	300	P27307-20	16.40		0	15.2			
Stratton	752	11-Apr-05	1050	N/A	~24	300	P27307-29	25.00						
Stratton	752	11-Apr-05	1347	N/A	~24	300	P27307-30	14.70		n.d.				
Stratton	752	14-Apr-05	1050	N/A	~24	300	P27307-31	15.30						
Stratton	752	18-Apr-05	1045	N/A	~24	300	P27307-32	14.70						
Stratton	752	21-Apr-05	1310	N/A	~24	300	P27307-33	15.10						
Stratton	752	25-Apr-05	1010	N/A	~24	300	P27307-34	14.90						
Stratton	752	16-Aug-05	1321	N/A	~24	300		14.90						
Stratton	752	23-Aug-05		N/A	~24	300				nd				
Stratton	752	18-Oct-05	1140	N/A	~24	300	P28350-32	15.10						
Stromsburg	3	06-Dec-02	1622	10	150	490	P22194-15	20.20						
Stromsburg	3	09-Jan-03	1656	10	150	490	P22328-7	21.50						
Stromsburg	3	31-Jan-03	1706	10	150	490	P22462-9	20.80						
Stromsburg	3	13-Feb-03	1618	10	150	490	P22355-16	19.50						
Stromsburg	3	25-Feb-03	1720	10	150	490	P22616-21	18.30						
Stromsburg	3	20-Mar-03	1547	10	150	490	P22616-5	19.20						
Stromsburg	3	29-Apr-03	1630	10	150	490	P22714-88	19.20	23.10	4.2/5.0	18.8			
Stromsburg	3	20-May-03	1610	10	150	490	P22985-39	21.20	24.60	4.7	19.1			
Stromsburg	3	10-Jun-03	1610	10	150	490	P23144-43	18.20	23.60	0.7	20.8			
Stromsburg	3	24-Jun-03	1528	10	150	490	P23144-39	23.20		1.3	20.4			
Stromsburg	3	21-Jul-03	1435	10	150	490	P23372-29	21.10		2.3	22.4			
Stromsburg	3	14-Aug-03	1430	10	150	490		19.00		2.7	21.2			
Stromsburg	3	29-Sep-03	1649	10	150	490		18.10						
Stromsburg	3	30-Sep-03	844	10	150	490		18.80	21.00					
Stromsburg	3	01-Dec-03	1022	10	150	490		16.20						
Stromsburg	3	10-Jul-06	835	30	161	490		21.00	25.00	4.7	20.2			
Stromsburg	3	10-Jul-06	1205	240	161	490		20.80	24.90					
Stromsburg	3	10-Jul-06	1105	180	161	490		20.70	25.10					
Stromsburg	3	10-Jul-06	805	0	161	490		19.00	22.30					
Stromsburg	3	10-Jul-06	905	60	161	490		20.90	25.20					
Stromsburg	3	10-Jul-06	1005	120	161	490		20.30	25.00					
Stromsburg	3	12-Jul-06	935	0	105	2.4		43.50	37.30					
Stromsburg	3	12-Jul-06	1005	30	105	2.4		17.20	18.80	n.d.	13.1			
Stromsburg	3	12-Jul-06	950	15	105	2.4		19.70	21.90					
Stromsburg	3	19-Jul-06	1100	0	178	2.4		22.30	40.20					
Stromsburg	3	19-Jul-06	1115	15	178	2.4		27.40	29.80					
Stromsburg	3	19-Jul-06	1130	30	178	2.4		21.40	25.70	n.d.	20.7			
Stromsburg	3	07-Aug-06	1205	15	175	500			22.20					
Stromsburg	3	07-Aug-06	1619	1	175				3859.00					
Stromsburg	3	07-Aug-06	1445	175	175	500			20.30					
Stromsburg	3	07-Aug-06	1400	130	175	500			20.40					
Stromsburg	3	07-Aug-06	1635	17	175				23.20					
Stromsburg	3	07-Aug-06	1625	7	175				201.80					
Stromsburg	3	07-Aug-06	1154	4	175	500			262.00					
Stromsburg	3	07-Aug-06	1620	2	175				802.30					
Stromsburg	3	07-Aug-06	1152	2	175	500			1023.00					
Stromsburg	3	07-Aug-06	1150	0	175	500			29.70					
Stromsburg	3	07-Aug-06	1245	45	175	500			18.00					
Stromsburg	3	07-Sep-06	1133	15	177.8	1.5		34.10	36.90					
Stromsburg	3	07-Sep-06	1118	0	177.8	1.5		55.10	41.40					
Stromsburg	3	07-Sep-06	1148	30	177.8	1.5		24.80	26.00	n.d.	20.7			
Stromsburg	3	07-Sep-06	1420	0	164.9	3.0		30.10	31.00					
Stromsburg	3	07-Sep-06	1435	15	164.9	3.0		25.70	23.80					
Stromsburg	3	07-Sep-06	1450	30	164.9	3.0		24.50	23.20	n.d.	21.2			

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Shelton	97	01-Dec-03	7.20	440	0.4	13.0	269	328	68.4	32.7	15.1	12		0.65
Shelton	Distribution	21-Mar-03	7.60	394	7	11.2	260	317						
Shelton	Distribution	25-Apr-03	7.30	675	5.6	12.0	267	326						
Shelton	Distribution	03-Jun-03	7.20	461	6.4	13.5							n.d.	
Shelton	Distribution	15-Jul-03	7.10	1184	6.8	15.0	310	378					.32	
Shelton	Distribution	12-Aug-03	7.30	524	6.7	14.0	271	330					.01	
Shelton	Distribution	01-Dec-03	7.20	636	5.8	12.0	284	346					n.d.	
Stratton	752	22-Feb-05	7.30	587	1.6	12.0	342	417	114	94	34.7	21.8	n.d.	n.d.
Stratton	752	11-Apr-05	6.90	1060	3.4	13.0	306	373	115	94.2	34.6	19.8	n.d.	.35
Stratton	752	11-Apr-05	7.20	1100	N/A	13.0	348	424	118	94.7	34.8	20.4	n.d.	.05
Stratton	752	14-Apr-05	7.30	1120	N/A	13.0			115	92.4	33.9	20	n.d.	.05
Stratton	752	18-Apr-05	7.30	1110	N/A	13.0			115	92.2	33.9	20.2		.03
Stratton	752	21-Apr-05	7.40	1110	N/A	13.0			113	91.5	33.4	19.6		.04
Stratton	752	25-Apr-05	7.60	1110	N/A	13.0			115	93.5	34	20.9		.05
Stratton	752	16-Aug-05	7.30	1180	1.1	12.5	339	413	105	87.3	31.8	19.7		.07
Stratton	752	23-Aug-05			N/A									
Stratton	752	18-Oct-05	7.00	795	1	12.5	340	415						
Stromsburg	3	06-Dec-02	7.28	591	0.6	13.0	258	315						
Stromsburg	3	09-Jan-03	7.10	444	0.4	12.3	303	369						
Stromsburg	3	31-Jan-03	7.10	460	0.4	13.0	264	322						
Stromsburg	3	13-Feb-03	7.10	454	0.6	13.1	269	328						
Stromsburg	3	25-Feb-03	7.20	345	0.6	13.0	286	349						
Stromsburg	3	20-Mar-03	7.10	457	0.4	12.4	262	319						
Stromsburg	3	29-Apr-03	7.10	570	0.4	13.0								
Stromsburg	3	20-May-03	7.00	483	0.6	13.0								
Stromsburg	3	10-Jun-03	7.10	648	0.5	13.0	302	368						
Stromsburg	3	24-Jun-03	7.20	670	0.4	13.0	279	279						
Stromsburg	3	21-Jul-03	7.00	608	0.4	13.1	276	336						
Stromsburg	3	14-Aug-03	7.00	679	0.7	14.0	295	360	99.1	37.9	15.3	7.9	0.03	0.14
Stromsburg	3	29-Sep-03	6.80	540	3.4	12.8	270	329						
Stromsburg	3	30-Sep-03	6.90	476	4.0	13.0	290	354					0.16	0.17
Stromsburg	3	01-Dec-03	6.90	559	2.4	12.6	270	329	92.6	31.8	15.8	13.9	0.02	0.11
Stromsburg	3	10-Jul-06	7.10	656	1.0	13.4	303	370	108	23.0	16.4	9.1	0.05	0.14
Stromsburg	3	10-Jul-06	7.10	639	0.8	13.3	288	352						
Stromsburg	3	10-Jul-06	7.10	638	0.8	13.3	288	351						
Stromsburg	3	10-Jul-06	6.80	654	6.1	15.1	292	356						
Stromsburg	3	10-Jul-06	7.10	646	0.8	13.5	298	364						
Stromsburg	3	10-Jul-06	7.00	640	0.8	13.5	301	367						
Stromsburg	3	12-Jul-06	7.80	655	7.2	29.2	301	363						
Stromsburg	3	12-Jul-06	7.20	715	0.9	13.0	305	372	105	23.6	16.2	9.2	0.02	0.09
Stromsburg	3	12-Jul-06	7.20	714	1.1	13.0	296	361						
Stromsburg	3	19-Jul-06	7.30	482	8.0	24.6	298	364						
Stromsburg	3	19-Jul-06	7.20	528	1.2	14.3	290	354						
Stromsburg	3	19-Jul-06	7.10	530	1.2	15.0	312	381	107	24.6	16.8	8.7	0.05	0.17
Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Aug-06												
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Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Sep-06	7.21	761	1.2	13.9	302	369						
Stromsburg	3	07-Sep-06	7.30	692	3.0	15.5	306	373						
Stromsburg	3	07-Sep-06	7.09	763	1.0	13.8	296	361	111	24.3	16.8	7.6	0.44	0.16
Stromsburg	3	07-Sep-06	7.36	742	9.0	15.6	293	357						
Stromsburg	3	07-Sep-06	7.06	759	1.2	13.7	304	371						
Stromsburg	3	07-Sep-06	7.04	761	1.2	13.6	300	366	109	24.1	16.6	8.1	0.42	0.16

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Shelton	97	01-Dec-03		5.3		0.09	0.04	0.05	< 0.1					
Shelton	Distribution	21-Mar-03												
Shelton	Distribution	25-Apr-03									113.5			
Shelton	Distribution	03-Jun-03												
Shelton	Distribution	15-Jul-03									198.1			
Shelton	Distribution	12-Aug-03				0.24	0.08	0.16			194.8			
Shelton	Distribution	01-Dec-03				0.13	0.09	0.04			13.2			
Stratton	752	22-Feb-05	2.3	33	217	0.02	0	0.02	.2		-165.2	3.41		
Stratton	752	11-Apr-05	2.2	36	210				.5		8.01	6.78		
Stratton	752	11-Apr-05	2.1	32	209				.2		10.43	4.52		
Stratton	752	14-Apr-05	1.8	32	208				.2					
Stratton	752	18-Apr-05	1.8	31	210				.2					
Stratton	752	21-Apr-05	1.8	31	205				.2					
Stratton	752	25-Apr-05	2	32	204				.2					
Stratton	752	16-Aug-05	1.4	30	212				.1					
Stratton	752	23-Aug-05												
Stratton	752	18-Oct-05									-223.1			
Stromsburg	3	06-Dec-02												
Stromsburg	3	09-Jan-03												
Stromsburg	3	31-Jan-03												
Stromsburg	3	13-Feb-03												
Stromsburg	3	25-Feb-03												
Stromsburg	3	20-Mar-03												
Stromsburg	3	29-Apr-03									224.8			
Stromsburg	3	20-May-03									175			
Stromsburg	3	10-Jun-03									230.7			
Stromsburg	3	24-Jun-03									262.2			
Stromsburg	3	21-Jul-03									228.3			
Stromsburg	3	14-Aug-03	10.1	8	49	0.07	0.02	0.05	0.3		152.2	4.94		
Stromsburg	3	29-Sep-03									255.2			
Stromsburg	3	30-Sep-03							0.3		292.5			
Stromsburg	3	01-Dec-03	3.4	8	49	0.04	n.d.	0.04	0.3		71.2	6.82		
Stromsburg	3	10-Jul-06	2.1	9	54	0.05	0.05	n.d	0.4	3.10		3.25		
Stromsburg	3	10-Jul-06				0.03	0.03	n.d						
Stromsburg	3	10-Jul-06				0.07	0.05	0.02						
Stromsburg	3	10-Jul-06				0.07	0.03	0.04						
Stromsburg	3	10-Jul-06				0.08	0.05	0.03						
Stromsburg	3	10-Jul-06				0.06	0.04	0.02						
Stromsburg	3	12-Jul-06				0.04	n.d	0.04						
Stromsburg	3	12-Jul-06	2.9	10	51	0.03	0.01	0.02	0.3	3.88		2.28		
Stromsburg	3	12-Jul-06												
Stromsburg	3	19-Jul-06				0.08	n.d.	0.08						
Stromsburg	3	19-Jul-06				0.05	0.04	0.01						
Stromsburg	3	19-Jul-06	3.2	11	56	0.04	0.03	0.01	0.4	2.75		1.58		
Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Aug-06												
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Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Aug-06												
Stromsburg	3	07-Sep-06				1.02	0.97	0.05						
Stromsburg	3	07-Sep-06				0.60	0.48	0.12						
Stromsburg	3	07-Sep-06	2.8	11	56	0.51	0.49	0.02	0.4	4.55		4.51		
Stromsburg	3	07-Sep-06				0.91	0.90	0.01						
Stromsburg	3	07-Sep-06				0.57	0.56	0.01						
Stromsburg	3	07-Sep-06	3.0	9	85	0.41	0.40	0.01	0.4	5.34		0.17		

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Stromsburg	3	07-Sep-06	1518	0	138.4	2.1		25.00	25.20					
Stromsburg	3	07-Sep-06	1533	15	138.4	2.1		23.80	24.00					
Stromsburg	3	07-Sep-06	1548	30	138.4	2.1		23.60	22.60	n.d.	22.4			
Stromsburg	3	04-Dec-06	1153	6	125	650		54.60						
Stromsburg	3	04-Dec-06	1213	26	125	650		25.50						
Stromsburg	3	04-Dec-06	1205	18	125	650		27.80						
Stromsburg	3	04-Dec-06	1147	0	125	650		7.90						
Stromsburg	3	06-Dec-06	1132	15	125	120		25.80						
Stromsburg	3	06-Dec-06	1117	0	125	120		29.40						
Stromsburg	3	06-Dec-06	1147	30	125	120		25.10						
Stromsburg	3	06-Dec-06	1217	60	125	120		25.50						
Stromsburg	3	13-Dec-06	1520	30	125	120		21.30						
Stromsburg	3	13-Dec-06	1450	0	125	120		18.50						
Stromsburg	3	27-Dec-06	1500	30	125	150		23.50						
Stromsburg	3	27-Dec-06	1430	0	125	150		314.00						
Stromsburg	3	29-Dec-06	1430	0	125	120		26.60						
Stromsburg	3	29-Dec-06	1500	30	125	120		15.60						
Stromsburg	3	04-Jan-07	1430	30	125	120		23.70						
Stromsburg	3	04-Jan-07	1400	0	125	120		25.80						
Stromsburg	3	11-Jan-07	1430	30	125	150		22.20						
Stromsburg	3	11-Jan-07	1400	0	125	150		38.20						
Stromsburg	3	23-Jan-07	1415	0	125	150		19.00						
Stromsburg	3	23-Jan-07	1445	30	125	150		21.70						
Stromsburg	3	30-Jan-07	1415	0	125	150		24.90						
Stromsburg	3	30-Jan-07	1445	30	125	150		20.00						
Stromsburg	3	08-Feb-07	1500	30	125	150		22.60				7.29		
Stromsburg	3	08-Feb-07	1430	0	125	150		86.40						
Stromsburg	3	16-Feb-07	1430	30	125	150		19.00						
Stromsburg	3	16-Feb-07	1400	0	125	150		41.50						
Stromsburg	3	20-Feb-07	1500	30	125	150		19.60						
Stromsburg	3	20-Feb-07	1430	0	125	150		17.50						
Stromsburg	3	27-Feb-07	1415	0	125	150	L31734-3	133.00						
Stromsburg	3	27-Feb-07	1455	30	125	150	L31734-4	23.40						
Stromsburg	3	06-Mar-07	1620	15	125	125								
Stromsburg	3	06-Mar-07	1605	0	125	125	L31734-1	35.90						
Stromsburg	3	06-Mar-07	1635	30	125	125	L31734-2	24.50						
Stromsburg	3	14-May-07	1500	30	125	125		24.60						
Wauneta	3	22-Feb-05	1447	10	144	450	P27307-22	10.40		n.d.	11.6			
Wauneta	3	11-Apr-05	1506	10	144	450	P27307-39	9.50						
Wauneta	3	16-Aug-05	733	30	144	450		10.10		n.d.	11.3			
Wauneta	3	18-Oct-05	749	30	144	450	P28350-35	9.31						
Wauneta	3	06-Aug-06	1600	180	144	450		10.30	12.70					
Wauneta	3	06-Aug-06	1330	30	144	450		10.20	13.10	n.d.	11.9			
Wauneta	3	06-Aug-06	1400	60	144	450		10.50	11.80					
Wauneta	3	06-Aug-06	1700	240	144	450		10.30	13.40					
Wauneta	3	06-Aug-06	1300	0	144	450		10.20	12.20					
Wauneta	3	06-Aug-06	1500	120	144	450		10.30	12.70					
Wauneta	3	09-Aug-06	1635	15	115.3	3		10.10	12.10					
Wauneta	3	09-Aug-06	1620	0	115.3	3		10.80	13.40					
Wauneta	3	09-Aug-06	1650	30	115.3	3		9.88	12.50	9.5	3.0			
Wauneta	3	09-Aug-06	1554	30	150.5	3.3		15.60	11.40	4.6	12.4			
Wauneta	3	09-Aug-06	1546	22	150.5	3.3								
Wauneta	3	09-Aug-06	1105	30	144.2	0.6		11.40	13.90	6.6	7.9			
Wauneta	3	09-Aug-06	1745	0	176.7	3.2		11.50	14.10					
Wauneta	3	09-Aug-06	1752	8	176.7	3.1								
Wauneta	3	09-Aug-06	1800	15	176.7	3.2		11.40	13.00					
Wauneta	3	09-Aug-06	1809	24	176.7	3.1								
Wauneta	3	09-Aug-06	1050	15	144.2	0.6		12.70	13.80					
Wauneta	3	09-Aug-06	1530	6	150.5	1.3								
Wauneta	3	09-Aug-06	1100	25	144.2	0.6								
Wauneta	3	09-Aug-06	1628	8	115.3	3.0								

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Stromsburg	3	07-Sep-06	7.19	747	5.0	14.6	297	362						
Stromsburg	3	07-Sep-06	7.02	758	1.0	13.8	316	385						
Stromsburg	3	07-Sep-06	6.99	761	1.0	13.7	312	381	112	24.4	16.9	8.9	0.10	0.18
Stromsburg	3	04-Dec-06	7.20	770		12.0								
Stromsburg	3	04-Dec-06	7.00	750		12.0								
Stromsburg	3	04-Dec-06	7.10	760		12.0								
Stromsburg	3	04-Dec-06	7.50	1220		14.5								
Stromsburg	3	06-Dec-06	7.30	730		12.7	275	336						
Stromsburg	3	06-Dec-06	7.40	860		12.7	284	346						
Stromsburg	3	06-Dec-06	7.20	730		12.7	275	335	108	21.2	14.8	7.4	0.13	0.10
Stromsburg	3	06-Dec-06	7.20	730		12.7	276	337						
Stromsburg	3	13-Dec-06	7.20	710		12.8								
Stromsburg	3	13-Dec-06	7.40	740		12.8								
Stromsburg	3	27-Dec-06	7.30	690		13.0								
Stromsburg	3	27-Dec-06	7.50	720		13.0								
Stromsburg	3	29-Dec-06	7.60	690		13.0								
Stromsburg	3	29-Dec-06	7.70	670		13.0								
Stromsburg	3	04-Jan-07	7.10	690		13.0								
Stromsburg	3	04-Jan-07	7.70	690		13.0								
Stromsburg	3	11-Jan-07	7.20	700		13.1								
Stromsburg	3	11-Jan-07	7.60	720		13.2								
Stromsburg	3	23-Jan-07	7.40	660		13.0								
Stromsburg	3	23-Jan-07	7.60	700		13.0								
Stromsburg	3	30-Jan-07	7.40	720		13.0								
Stromsburg	3	30-Jan-07	7.20	690		13.0								
Stromsburg	3	08-Feb-07	7.20	670		13.0								
Stromsburg	3	08-Feb-07	7.50	680		14.0								
Stromsburg	3	16-Feb-07	7.20	690		13.0								
Stromsburg	3	16-Feb-07	7.50	690		14.0								
Stromsburg	3	20-Feb-07	7.50	680		13.0								
Stromsburg	3	20-Feb-07	7.50	680		14.0								
Stromsburg	3	27-Feb-07	7.50	660		14.0								
Stromsburg	3	27-Feb-07	7.20	660		13.0								
Stromsburg	3	06-Mar-07	7.10	680		12.5	287	350						
Stromsburg	3	06-Mar-07	7.60	660		12.5	303	370	101	22.5	15.4	8.0	2.96	0.24
Stromsburg	3	06-Mar-07	7.10	690		12.5	303	370	105	22.5	15.7	7.1	0.17	0.12
Stromsburg	3	14-May-07												
Wauneta	3	22-Feb-05	7.20	286	6.6	14.0	170	207	44.4	16.4	13.0	11.7	n.d.	n.d.
Wauneta	3	11-Apr-05	7.00	307	7.2	14.0	171	208						
Wauneta	3	16-Aug-05	7.25	410	6.7	14.0	174	212	44.6	17.1	13.1	10.5	n.d.	n.d.
Wauneta	3	18-Oct-05	7.60	308	6.4	14.0	168	205						
Wauneta	3	06-Aug-06	7.60	444	4.4	14.0	174	213						
Wauneta	3	06-Aug-06	7.30	441	6.1	14.0	169	206	44.0	16.9	13.0	12.3	nd	n.d.
Wauneta	3	06-Aug-06	7.60	352	3.0	14.0	179	218						
Wauneta	3	06-Aug-06	7.30	444	6.6	14.0	188	230						
Wauneta	3	06-Aug-06	7.34	440	8.8	15.0	177	216						
Wauneta	3	06-Aug-06	7.50	443	3.9	14.5	178	217						
Wauneta	3	09-Aug-06	7.50	288	3.0	17.0	177	216						
Wauneta	3	09-Aug-06	7.60	368	6.0	18.0	182	222						
Wauneta	3	09-Aug-06	7.48	373	3.1	16.0	164	200	43.2	17.3	12.8	11.6	0.01	n.d.
Wauneta	3	09-Aug-06	7.50	285	4.3	16.0	182	222	43.8	16.6	13.0	11.8	0.04	0.02
Wauneta	3	09-Aug-06	7.50	284	4.1	16.0								
Wauneta	3	09-Aug-06	7.26	269	4.7	19.0	187	228	44.0	15.9	13.0	10.6	0.02	0.02
Wauneta	3	09-Aug-06	7.45	285	7.4	17.0	191	233						
Wauneta	3	09-Aug-06	7.44	288	6.1	16.0								
Wauneta	3	09-Aug-06	6.69	289	5.0	16.0	191	233						
Wauneta	3	09-Aug-06	7.45											
Wauneta	3	09-Aug-06	7.44	366	5.4	18.0	186	227						
Wauneta	3	09-Aug-06	7.53	351	5.9	15.0								
Wauneta	3	09-Aug-06	7.44	366	5.4	18.0								
Wauneta	3	09-Aug-06	7.52	285	2.7	17.0								

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Stromsburg	3	07-Sep-06				0.12	0.10	0.02						
Stromsburg	3	07-Sep-06				0.10	0.08	0.02						
Stromsburg	3	07-Sep-06	2.8	10	55	0.14	0.13	0.01	0.4	6.09		3.51		
Stromsburg	3	04-Dec-06												
Stromsburg	3	04-Dec-06												
Stromsburg	3	04-Dec-06												
Stromsburg	3	04-Dec-06												
Stromsburg	3	06-Dec-06												
Stromsburg	3	06-Dec-06												
Stromsburg	3	06-Dec-06	2.1	13	56				0.4	n.d.		4.53		
Stromsburg	3	06-Dec-06												
Stromsburg	3	13-Dec-06												
Stromsburg	3	13-Dec-06												
Stromsburg	3	27-Dec-06												
Stromsburg	3	27-Dec-06												
Stromsburg	3	29-Dec-06												
Stromsburg	3	29-Dec-06												
Stromsburg	3	04-Jan-07												
Stromsburg	3	04-Jan-07												
Stromsburg	3	11-Jan-07												
Stromsburg	3	11-Jan-07												
Stromsburg	3	23-Jan-07												
Stromsburg	3	23-Jan-07												
Stromsburg	3	30-Jan-07												
Stromsburg	3	30-Jan-07												
Stromsburg	3	08-Feb-07												
Stromsburg	3	08-Feb-07												
Stromsburg	3	16-Feb-07												
Stromsburg	3	16-Feb-07												
Stromsburg	3	20-Feb-07												
Stromsburg	3	20-Feb-07												
Stromsburg	3	27-Feb-07												
Stromsburg	3	27-Feb-07												
Stromsburg	3	06-Mar-07												
Stromsburg	3	06-Mar-07	1.5	9	54				0.3	n.d.		0.92		
Stromsburg	3	06-Mar-07	1.7	9	55				0.4	1.58		1.39		
Stromsburg	3	14-May-07												
Wauneta	3	22-Feb-05	2.1	2	16	n.d.	n.d.	n.d.	0.1		-157.2	5.94		
Wauneta	3	11-Apr-05									9.25			
Wauneta	3	16-Aug-05	2.0	2	17	n.d.	n.d.	n.d.	n.d.			4.84		
Wauneta	3	18-Oct-05									-198.6			
Wauneta	3	06-Aug-06				n.d.	n.d.	n.d.						
Wauneta	3	06-Aug-06	1.9	1	16	0.01	n.d.	0.01	n.d.	n.d.		2.76		
Wauneta	3	06-Aug-06				0.01	n.d.	0.01						
Wauneta	3	06-Aug-06				0.03	n.d.	0.03						
Wauneta	3	06-Aug-06				0.04	n.d.	0.04						
Wauneta	3	06-Aug-06				n.d.	n.d.	n.d.						
Wauneta	3	09-Aug-06				n.d.	n.d.	n.d.						
Wauneta	3	09-Aug-06				0.01	n.d.	0.01						
Wauneta	3	09-Aug-06	2.0	1	17	0.02	0.02	n.d.	n.d.	n.d.		7.12		
Wauneta	3	09-Aug-06	1.9	1	17	0.01	n.d.	0.01	0.2	n.d.		2.76		
Wauneta	3	09-Aug-06												
Wauneta	3	09-Aug-06	2.0	1	17	0.01	n.d.	0.01	n.d.	n.d.		0.93		
Wauneta	3	09-Aug-06				0.01	n.d.	0.01						
Wauneta	3	09-Aug-06												
Wauneta	3	09-Aug-06				0.01	n.d.	0.01						
Wauneta	3	09-Aug-06												
Wauneta	3	09-Aug-06				0.02	n.d.	0.02						
Wauneta	3	09-Aug-06												
Wauneta	3	09-Aug-06												
Wauneta	3	09-Aug-06												

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Wauneta	3	09-Aug-06	1635	20	115.3	3.0								
Wauneta	3	09-Aug-06	1815	30	176.7	3.2		10.40	11.10	?				
Wauneta	3	09-Aug-06	1524	0	150.5	1.3		12.60	13.20					
Wauneta	3	09-Aug-06	1539	15	150.5	3.3		12.40	13.60					
Wauneta	3	09-Aug-06	1035	0	144.2	0.6		11.60	14.90					
Wauneta	3	11-Nov-06	748	105	174	220			12.60					
Wauneta	3	11-Nov-06	933	15	174	210			12.20					
Wauneta	3	11-Nov-06	1148	23	174	210			11.80					
Wauneta	3	11-Nov-06	915	0	174	210			16.70					
Wauneta	3	12-Nov-06	1445	45	174	160								
Wauneta	3	12-Nov-06	1400	0	174	160								
Wauneta	3	12-Nov-06	846	0	174	230		10.40	11.20					
Wauneta	3	12-Nov-06	915	30	174	155		10.90	11.90					
Wauneta	3	12-Nov-06	948	60	174	155		11.00	11.70					
Wauneta	3	15-Nov-06	1045	30	174	155		10.80						
Wauneta	3	15-Nov-06	1000	0	174	155		11.80						
Wauneta	3	23-Nov-06	1035	0	174	160		12.70						
Wauneta	3	23-Nov-06	1105	30	174	160		10.70						
Wauneta	3	29-Nov-06	1445	45	174	160		10.50						
Wauneta	3	29-Nov-06	1400	0	174	160		12.40						
Wauneta	3	06-Dec-06	1200	0	174	160		12.70						
Wauneta	3	06-Dec-06	1230	38	174	160		10.60						
Wauneta	3	12-Dec-06	1050	0	174	160		15.00						
Wauneta	3	12-Dec-06	1125	35	174	160		10.50						
Wauneta	3	22-Dec-06	1415	0	174	160		11.60						
Wauneta	3	22-Dec-06	1450	30	174	160		10.80						
Wauneta	3	28-Dec-06	1520	30	174	160		10.70						
Wauneta	3	28-Dec-06	1445	0	174	160		11.00						
Wauneta	3	04-Jan-07	1120	0	174	160		9.97						
Wauneta	3	04-Jan-07	1150	30	174	160		10.80						
Wauneta	3	11-Jan-07	1450	30	174	160		11.30						
Wauneta	3	11-Jan-07	1415	0	174	160		10.30						
Wauneta	3	18-Jan-07	830	0	174	160		8.74						
Wauneta	3	18-Jan-07	900	30	174	160		10.90						
Wauneta	3	25-Jan-07	855	0	174	160		7.98						
Wauneta	3	25-Jan-07	925	30	174	160		10.80						
Wauneta	3	02-Feb-07	1100	30	174	160		10.30						
Wauneta	3	02-Feb-07	1025	0	174	160		7.42						
Wauneta	3	09-Feb-07	1550	30	174	160		9.05						
Wauneta	3	09-Feb-07	1515	0	174	160		8.81						
Wauneta	3	16-Feb-07	815	30	174	160		9.00						
Wauneta	3	16-Feb-07	740	0	174	160		9.98						
Wauneta	3	22-Feb-07	850	30	174	160		8.85						
Wauneta	3	22-Feb-07	820	0	174	160		6.50						
Wauneta	3	02-Mar-07	945	30	174	160		8.69						
Wauneta	3	02-Mar-07	905	0	174	160		8.00						
Wauneta	3	19-Mar-07	1100	0	174	160	L31781-1	8.20						
Wauneta	3	19-Mar-07	1135	30	174	160	L31781-2	11.70						
Wauneta	3	30-Mar-07	1450	30	174	160	L32099-4	11.20						
Wauneta	3	06-Apr-07	1115	30	174	160	L32099-5	11.10						
Wauneta	3	21-May-07	1200	30	174		P32107-1	11.60						
Wauneta	3	19-Jun-07	1015	30	174	250	P32217-1	9.50						
Wauneta	3	03-Jul-07	1105	90	174	225	P32278-42	9.40						
Wauneta	3 & 4 (POE11)	19-Jun-07	1045	30	#3:174; #4:150	#3: 220; #4:185	P32217-2	9.40				9.40		
Wauneta	3 & 4 (POE11)	26-Jun-07	1445	30	#3:174; #4:150	#3: 220; #4:185	P32217-3	9.76						
Wauneta	3 & 4 (POE11)	03-Jul-07	1130	30	#3:174; #4:150	#3: 225; #4:185	P32217-4							
Wauneta	3 & 4 (POE11)	18-Jul-07	1130	30	#3:174; #4:150	#3: 220; #4:185	P32217-5							
Wauneta	3 & 4 (POE11)	31-Jul-07	1455	30	#3:174; #4:150	#3: 225; #4:180	P32217-8							
Wauneta	3 & 4 (POE11)	07-Aug-07	1305	30	#3:174; #4:150	#3: 225; #4:185	P32217-6							
Wauneta	3 & 4 (POE11)	17-Aug-07	800	60	#3:174; #4:150	#3: 220; #4:185	P32217-7							
Wauneta	3 & 4 (POE11)	02-Oct-07	0	30	#3:174; #4:150	#3: 225; #4:180	P33004-40	9.32						

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Wauneta	3	09-Aug-06	7.49	288	3.1	17.0								
Wauneta	3	09-Aug-06	7.29	291	6.4	16.0	183	223	44.6	17.9	13.0	11.1	0.03	n.d.
Wauneta	3	09-Aug-06	7.54	363	7.5	19.0	189	230						
Wauneta	3	09-Aug-06	7.48	283	4.2	16.0	189	231						
Wauneta	3	09-Aug-06	6.85	249	5.1	17.0	200	244						
Wauneta	3	11-Nov-06	7.90	710	7.9	12.5	160	195						
Wauneta	3	11-Nov-06	7.90	390	9.4	14.0	163	199						
Wauneta	3	11-Nov-06	7.60	390	10.4	14.5	157	192						
Wauneta	3	11-Nov-06	7.90	480	9.4	13.0								
Wauneta	3	12-Nov-06	7.80	420		15.0								
Wauneta	3	12-Nov-06	7.90	400		15.0								
Wauneta	3	12-Nov-06	7.90	400	7.8	15.0	163	199						
Wauneta	3	12-Nov-06	7.80	400	7.8	15.2	161	196	44.7	17.1	12.8	11.8	0.07	n.d.
Wauneta	3	12-Nov-06	7.80	410	8.0	15.0	164	200						
Wauneta	3	15-Nov-06	7.90	380		15.0								
Wauneta	3	15-Nov-06	7.80	360		15.0								
Wauneta	3	23-Nov-06	7.80	350		5.0								
Wauneta	3	23-Nov-06	7.70	380		5.0								
Wauneta	3	29-Nov-06	8.00	350		15.0								
Wauneta	3	29-Nov-06	7.80	420		15.0								
Wauneta	3	06-Dec-06	8.00	350		5.0								
Wauneta	3	06-Dec-06	7.60	400		5.0								
Wauneta	3	12-Dec-06	7.80	360		5.0								
Wauneta	3	12-Dec-06	7.20	400		5.0								
Wauneta	3	22-Dec-06	8.30	350		13.0								
Wauneta	3	22-Dec-06	7.90	420		5.0								
Wauneta	3	28-Dec-06	7.80	370										
Wauneta	3	28-Dec-06	8.40	360		5.0								
Wauneta	3	04-Jan-07	8.50	370		5.0								
Wauneta	3	04-Jan-07	7.80	400		5.0								
Wauneta	3	11-Jan-07	7.80	400		15.0								
Wauneta	3	11-Jan-07	8.80	380		15.0								
Wauneta	3	18-Jan-07	8.40	340		5.0								
Wauneta	3	18-Jan-07	7.60	390		5.0								
Wauneta	3	25-Jan-07	8.00	350		5.0								
Wauneta	3	25-Jan-07	7.50	380		5.0								
Wauneta	3	02-Feb-07	7.30	390		15.0								
Wauneta	3	02-Feb-07	8.00	370		14.0								
Wauneta	3	09-Feb-07	7.80	420		15.0								
Wauneta	3	09-Feb-07	8.20	370		15.0								
Wauneta	3	16-Feb-07	8.00	390		15.0								
Wauneta	3	16-Feb-07	8.30	400		15.0								
Wauneta	3	22-Feb-07	7.70	390		15.0								
Wauneta	3	22-Feb-07	7.70	390		15.0								
Wauneta	3	02-Mar-07	7.70	400		15.0								
Wauneta	3	02-Mar-07	8.30	320		15.0								
Wauneta	3	19-Mar-07	8.30	370		15.0								
Wauneta	3	19-Mar-07	8.00	410		15.0								
Wauneta	3	30-Mar-07	8.10	410		15.0								
Wauneta	3	06-Apr-07	8.40	400		15.0								
Wauneta	3	21-May-07												
Wauneta	3	19-Jun-07	8.20	400										
Wauneta	3	03-Jul-07												
Wauneta	3 & 4 (POE11)	19-Jun-07	8.00	390		11.0								
Wauneta	3 & 4 (POE11)	26-Jun-07	8.00	380		15.0								
Wauneta	3 & 4 (POE11)	03-Jul-07	8.40	390		12.0								
Wauneta	3 & 4 (POE11)	18-Jul-07				15.0								
Wauneta	3 & 4 (POE11)	31-Jul-07	8.20	380		8.0								
Wauneta	3 & 4 (POE11)	07-Aug-07	8.00	400		8.0								
Wauneta	3 & 4 (POE11)	17-Aug-07	8.50	410		7.0								
Wauneta	3 & 4 (POE11)	02-Oct-07												

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Wauneta	3	09-Aug-06												
Wauneta	3	09-Aug-06	1.8	1	16				0.1	n.d.		3.73		
Wauneta	3	09-Aug-06				0.03	n.d.	0.03						
Wauneta	3	09-Aug-06				0.01	n.d.	0.01						
Wauneta	3	09-Aug-06				0.07	n.d.	0.07						
Wauneta	3	11-Nov-06												
Wauneta	3	11-Nov-06												
Wauneta	3	11-Nov-06												
Wauneta	3	11-Nov-06												
Wauneta	3	12-Nov-06												
Wauneta	3	12-Nov-06												
Wauneta	3	12-Nov-06				0.09	n.d.	0.09						
Wauneta	3	12-Nov-06	2.0	3	16	0.09	n.d.	0.09	n.d.	n.d.		8.38		
Wauneta	3	12-Nov-06				0.15	0.03	0.12						
Wauneta	3	15-Nov-06												
Wauneta	3	15-Nov-06												
Wauneta	3	23-Nov-06												
Wauneta	3	23-Nov-06												
Wauneta	3	29-Nov-06												
Wauneta	3	29-Nov-06												
Wauneta	3	06-Dec-06												
Wauneta	3	06-Dec-06												
Wauneta	3	12-Dec-06												
Wauneta	3	12-Dec-06												
Wauneta	3	22-Dec-06												
Wauneta	3	22-Dec-06												
Wauneta	3	28-Dec-06												
Wauneta	3	28-Dec-06												
Wauneta	3	04-Jan-07												
Wauneta	3	04-Jan-07												
Wauneta	3	11-Jan-07												
Wauneta	3	11-Jan-07												
Wauneta	3	18-Jan-07												
Wauneta	3	18-Jan-07												
Wauneta	3	25-Jan-07												
Wauneta	3	25-Jan-07												
Wauneta	3	02-Feb-07												
Wauneta	3	02-Feb-07												
Wauneta	3	09-Feb-07												
Wauneta	3	09-Feb-07												
Wauneta	3	16-Feb-07												
Wauneta	3	16-Feb-07												
Wauneta	3	22-Feb-07												
Wauneta	3	22-Feb-07												
Wauneta	3	02-Mar-07												
Wauneta	3	02-Mar-07												
Wauneta	3	19-Mar-07												
Wauneta	3	19-Mar-07												
Wauneta	3	30-Mar-07												
Wauneta	3	06-Apr-07												
Wauneta	3	21-May-07												
Wauneta	3	19-Jun-07												
Wauneta	3	03-Jul-07												
Wauneta	3 & 4 (POE11)	19-Jun-07												
Wauneta	3 & 4 (POE11)	26-Jun-07												
Wauneta	3 & 4 (POE11)	03-Jul-07												
Wauneta	3 & 4 (POE11)	18-Jul-07												
Wauneta	3 & 4 (POE11)	31-Jul-07												
Wauneta	3 & 4 (POE11)	07-Aug-07												
Wauneta	3 & 4 (POE11)	17-Aug-07												
Wauneta	3 & 4 (POE11)	02-Oct-07												

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
Wauneta	4	22-Feb-05	1415	N/A	140	195	P27307-23	10.00		n.d.	11.1			
Wauneta	4	11-Apr-05	1612	N/A	140	195	P27621-33	9.15						
Wauneta	4	16-Aug-05	816	N/A	140	195		9.98						
Wauneta	4	18-Oct-05	826	N/A	140	195	P28350-36	9.90						
Wauneta	501	02-Oct-07	0	30			P33004-42	10.30						
Wauneta	721	02-Oct-07	0	30			P33004-41	10.20						
York	731	19-Jul-05	1158	38	226	500								
York	731	19-Jul-05	1220	60	226	500		3.92	5.00	n.d.	5.2	16.20		
York	731	19-Jul-05	1320	120	226	500		3.93	4.90			16.00		
York	731	19-Jul-05	1520	240	226	500		3.85	4.70			15.50		
York	731	19-Jul-05	1120	0	226	500		9.80	9.30			1.72		
York	731	19-Jul-05	1150	30	226	500		3.93	5.40			16.90		
York	731	19-Jul-05	1350	150	226	500								
York	731	19-Jul-05	1420	180	226	500		3.81	4.70			15.60		
York	731	19-Jul-05	1133	13	226	500								
York	731	19-Jul-05	1127	7	226	500		4.97				16.70		
York	731	19-Jul-05	1140	20	226	500								
York	731	02-Aug-05	1439	15	281	2.2			4.80			16.00		
York	731	02-Aug-05	1454	30	281	3.3			4.60	n.d.	4.7	15.70		
York	731	02-Aug-05	1545	30	270	4.0			5.50	n.d.	4.8	15.40		
York	731	02-Aug-05	1523	8	270	4.0								
York	731	02-Aug-05	1424	0	281	1.2			5.20			16.70		
York	731	02-Aug-05	1431	7	281	1.2								
York	731	02-Aug-05	1530	15	270	4.0			6.00			15.10		
York	731	02-Aug-05	1118	0	352.8	0.5			31.50			18.20		
York	731	02-Aug-05	1515	0	270	4.0			5.40			15.40		
York	731	02-Aug-05	1333	30	318	0.5			5.20	n.d.	4.6	16.20		
York	731	02-Aug-05	1122	4	352.8	0.5								
York	731	02-Aug-05	951	0	364.8	0.5			53.90			21.90		
York	731	02-Aug-05	1133	15	352.8	0.5			12.70			16.50		
York	731	02-Aug-05	1148	30	352.8	0.5			8.70	n.d.	3.4	17.20		
York	731	02-Aug-05	1303	0	318	5.0			5.80			16.10		
York	731	02-Aug-05	1310	7	318	0.5								
York	731	02-Aug-05	1318	15	318	0.5			5.00			16.40		
York	731	02-Aug-05	1128	10	352.8	0.5								
York	731	03-Aug-05	1053	15	217	3.0			5.90			16.00		
York	731	03-Aug-05	923	0	190	0.5			6.00			12.60		
York	731	03-Aug-05	933	10	190	0.5								
York	731	03-Aug-05	940	15	190	0.5			5.50			12.90		
York	731	03-Aug-05	953	30	190	0.5			5.60	n.d.	4.7	12.80		
York	731	03-Aug-05	1047	9	217	2.1								
York	731	03-Aug-05	1132	0	190	3.0			5.40			12.40		
York	731	03-Aug-05	1141	9	190	3.0								
York	731	03-Aug-05	1147	15	190	3.0			5.20			13.00		
York	731	03-Aug-05	1202	30	190	3.0			5.20	n.d.	4.6	12.50		
York	731	03-Aug-05	1322	0	170	3.0			5.20			11.70		
York	731	03-Aug-05	1352	30	170	3.0			5.20	n.d.	4.9	12.00		
York	731	03-Aug-05	1345	23	170	3.0								
York	731	03-Aug-05	1108	30	217	3.0			5.10	n.d.	4.7	16.10		
York	731	03-Aug-05	1337	15	170	3.0			5.10			12.20		
York	731	03-Aug-05	1038	0	217	2.1			6.00			16.00		
York	731	03-Aug-05	1330	8	170	3.0								
York	731	22-May-06	1312	120	226	500						13.50		
York	731	22-May-06	1212	60	226	500						13.90		
York	731	22-May-06	1142	30	226	500						13.40		
York	731	22-May-06	1112	0	226	500						14.50	12.00	
York	731	24-May-06	1035	2940	226	500	149039-7A						22.00	
York	731	26-May-06	1325	5990	226	500							28.80	
York	731	29-May-06	1340	10325	226	500							47.90	
York	731	31-May-06	830	12895	226	500							53.40	
York	731	02-Jun-06	1545	15350	226	500	149039-3A						69.00	

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
Wauneta	4	22-Feb-05	7.30	287	6.5	14.0	172	210						
Wauneta	4	11-Apr-05	7.00	307	7.2	14.2	161	196						
Wauneta	4	16-Aug-05	7.55	400	6.1	14.0	173	211	43.0	18.0	12.7	10.3	n.d.	n.d.
Wauneta	4	18-Oct-05	7.30	298	6.0	14.0								
Wauneta	501	02-Oct-07												
Wauneta	721	02-Oct-07												
York	731	19-Jul-05	7.34	517	0.9	12.0								
York	731	19-Jul-05	7.09	515	0.5	12.0	223	272	79.6	26.1	12.1	6.1	n.d.	n.d.
York	731	19-Jul-05	7.10	505	0.3	12.0	220	268						
York	731	19-Jul-05	7.30	505	0.1	12.0	223	272						
York	731	19-Jul-05	7.17	490	3.3	15.0	211	257						
York	731	19-Jul-05	7.18	509	1.7	11.9	223	272						
York	731	19-Jul-05	7.03	508	0.2	12.0								
York	731	19-Jul-05	7.12	494	0.2	12.0	219	267						
York	731	19-Jul-05	7.27	514	1.6	12.2								
York	731	19-Jul-05	7.21	507	2.3	12.5	212	258						
York	731	19-Jul-05	7.27	515	1.3	12.2	221	269						
York	731	02-Aug-05	7.11	482	1.0	14.7	229	279						
York	731	02-Aug-05	7.18	481	0.9	13.3	224	273	80.9	27.6	12.2	5.6	0.01	0.01
York	731	02-Aug-05	7.20	485	0.8	13.2	224	273	79.3	26.7	12.0	5.8	n.d.	n.d.
York	731	02-Aug-05	7.13	484	0.6	13.3								
York	731	02-Aug-05	7.20	474	1.0	14.5	233	284						
York	731	02-Aug-05	7.20	481	0.9	15.0								
York	731	02-Aug-05	7.17	485	0.6	13.2	223	272						
York	731	02-Aug-05	6.60	426	1.6	13.3	230	280						
York	731	02-Aug-05	7.04	486	2.0	13.8	231	282						
York	731	02-Aug-05	7.12	482	0.6	19.0	222	271	79.7	28.1	12.2	6.0	0.03	0.02
York	731	02-Aug-05	6.85	479	1.2	13.0								
York	731	02-Aug-05	6.90	435	1.8	14.0	225	274						
York	731	02-Aug-05	7.11	481	0.7	13.0	229	279						
York	731	02-Aug-05	7.15	480	0.6	13.0	224	273	79.8	27.6	12.2	5.4	0.05	0.05
York	731	02-Aug-05	7.12	477	1.4	13.0	220	268						
York	731	02-Aug-05	7.15	484	0.9	17.0								
York	731	02-Aug-05	7.16	486	0.6	17.0	232	283						
York	731	02-Aug-05	7.06	480	0.8	13.0								
York	731	03-Aug-05	7.15	535	1.3		238	290						
York	731	03-Aug-05	6.88	561	3.2	14.7	245	299						
York	731	03-Aug-05	6.94	563	3.0	15.8								
York	731	03-Aug-05	6.98	560	2.3	18.2	243	296						
York	731	03-Aug-05	7.00	562	1.9	19.0			79.6	37.4	13.3	5.7	n.d.	0.02
York	731	03-Aug-05	7.10	538	2.3	14.2								
York	731	03-Aug-05	7.07	530	4.3	14.0	247	301						
York	731	03-Aug-05	7.06	551	3.3	14.0								
York	731	03-Aug-05	7.07	549	2.4	14.0	237	289						
York	731	03-Aug-05	7.07	551	2.3	14.2	242	295	79.8	35.9	13.2	5.8	n.d.	0.02
York	731	03-Aug-05	6.95	547	5.4	14.0	269	328						
York	731	03-Aug-05	6.97	595	3.6	14.6	252	307	81.4	44.5	14.2	6.2	0.34	0.04
York	731	03-Aug-05	6.97	592	3.6	14.3								
York	731	03-Aug-05	7.10	538	1.3	13.9	236	288	80.7	31.1	12.6	5.7	n.d.	n.d.
York	731	03-Aug-05	6.93	605	4.6	14.3	259	316						
York	731	03-Aug-05	7.10	535	3.1	14.0	241	294						
York	731	03-Aug-05	6.93	607	4.1	14.3								
York	731	22-May-06	6.40	293	0.1	23.0	203	248						
York	731	22-May-06	5.40	447	0.1	13.1	229	280						
York	731	22-May-06	6.80	441	1.0	13.1	239	291	72.8	19.3	10.1	4.7	0.12	0.13
York	731	22-May-06	6.90	260	2.8	13.4	227	277						
York	731	24-May-06	7.20	540		13.0								
York	731	26-May-06	7.10	560		13.0								
York	731	29-May-06	7.40	590		13.0								
York	731	31-May-06	7.10	600	n.d	14.0								
York	731	02-Jun-06	7.20	620		14.0								

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
Wauneta	4	22-Feb-05									-69.5			
Wauneta	4	11-Apr-05									9.39			
Wauneta	4	16-Aug-05	1.8	2	16				n.d.			4.44		
Wauneta	4	18-Oct-05									-164.4			
Wauneta	501	02-Oct-07												
Wauneta	721	02-Oct-07												
York	731	19-Jul-05									798.2			
York	731	19-Jul-05	0.9	11	38				0.2	2.20	754.9	5.79		
York	731	19-Jul-05									727.2			
York	731	19-Jul-05									706			
York	731	19-Jul-05									772.9			
York	731	19-Jul-05									798.6			
York	731	19-Jul-05									755.6			
York	731	19-Jul-05									724.6			
York	731	19-Jul-05									812.7			
York	731	19-Jul-05									803.5			
York	731	19-Jul-05									812.2			
York	731	02-Aug-05									926.3			
York	731	02-Aug-05	1.4	11	38				0.2	5.45	924	6.57		
York	731	02-Aug-05	1.3	12	39				0.2	2.30	968.7	5.11		
York	731	02-Aug-05									914.3			
York	731	02-Aug-05									965.1			
York	731	02-Aug-05									949.6			
York	731	02-Aug-05									931.1			
York	731	02-Aug-05									789.9			
York	731	02-Aug-05									925.9			
York	731	02-Aug-05	1.4	11	39				0.2	6.85	925.6	6.46		
York	731	02-Aug-05									804.7			
York	731	02-Aug-05									824.4			
York	731	02-Aug-05									816.3			
York	731	02-Aug-05	1.3	14	38				0.1	6.16	869	5.39		
York	731	02-Aug-05									825.2			
York	731	02-Aug-05									849.5			
York	731	02-Aug-05									862.1			
York	731	02-Aug-05									800			
York	731	03-Aug-05									661.6			
York	731	03-Aug-05									958.3			
York	731	03-Aug-05									738.9			
York	731	03-Aug-05									774			
York	731	03-Aug-05	4.7	10	36				0.3	10.2	585.1	14.98		
York	731	03-Aug-05									638.4			
York	731	03-Aug-05									574.3			
York	731	03-Aug-05									599.7			
York	731	03-Aug-05									632.1			
York	731	03-Aug-05	3.9	11	36				0.3	2.17	641.2	6.45		
York	731	03-Aug-05									863.6			
York	731	03-Aug-05	7.1	10	35				0.3	2.63	812.8	8.53		
York	731	03-Aug-05									791			
York	731	03-Aug-05	2.5	11	38				0.2	3.18	608.2	6.17		
York	731	03-Aug-05									785.2			
York	731	03-Aug-05									649			
York	731	03-Aug-05									736.5			
York	731	22-May-06				0.10	0.05	0.05						
York	731	22-May-06												
York	731	22-May-06	n.d.	11	37	0.09	0.05	0.04	0.2			-4.66		
York	731	22-May-06												
York	731	24-May-06												
York	731	26-May-06												
York	731	29-May-06												
York	731	31-May-06												
York	731	02-Jun-06												

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL	
York	731	04-Jun-06	840	30	226	500	149039-9A						80.00	
York	731	06-Jun-06	1550	30	226	250							82.00	
York	731	07-Jun-06	1330	1330	226	250							84.00	
York	731	08-Jun-06	1320	2760	226	250								
York	731	09-Jun-06	945	3985	226	250								
York	731	12-Jun-06	835	8235	226	250								
York	731	20-Jun-06	950	0	226	250							31.50	
York	731	20-Jun-06	1020	30	226	250							84.40	
York	731	20-Jun-06	1050	60	226	250							83.00	
York	731	27-Jun-06	940	0	226	250							5.00	
York	731	27-Jun-06	1015	35	226	250							80.00	
York	731	27-Jun-06	1045	65	226	250							82.00	
York	731	05-Jul-06	1030	0	226	250							4.00	
York	731	05-Jul-06	1100	30	226	250							80.00	
York	731	05-Jul-06	1130	60	226	250							75.00	
York	731	11-Jul-06	1140	60	226	250	149039-24a						73.70	
York	731	11-Jul-06	1040	0	226	250	149039-23a						1.60	
York	731	11-Jul-06	1110	30	226	250	149039-18a						71.30	
York	731	18-Jul-06	1005	0	226	250	149039-30a						4.40	
York	731	18-Jul-06	1105	60	226	250	149039-25a						75.10	
York	731	18-Jul-06	1035	30	226	250	149039-19a						76.20	
York	731	26-Jul-06	1105	30	226	250	151094-49a						91.00	
York	731	26-Jul-06	1035	0	226	250	151094-51a						4.00	
York	731	26-Jul-06	1135	60	226	250	151094-48a						91.00	
York	731	01-Aug-06	1110	60	226	250	151094-43a						89.00	
York	731	01-Aug-06	1010	0	226	250	151094-42a						3.00	
York	731	01-Aug-06	1040	30	226	250	151094-46a						93.00	
York	731	08-Aug-06	1020	30	226	250							87.00	
York	731	08-Aug-06	950	0	226	250							2.00	
York	731	08-Aug-06	1050	60	226	250							86.00	
York	731	15-Aug-06	1012	0	226	250							3.80	
York	731	15-Aug-06	1112	60	226	250							94.00	
York	731	15-Aug-06	1042	30	226	250							96.50	
York	731	05-Sep-06	1315	0	226	100							1.80	
York	731	05-Sep-06	1345	30	226	100							81.90	
York	731	05-Sep-06	1415	60	226	100							85.40	
York	731	19-Sep-06	1050	30	226	100							80.00	
York	731	19-Sep-06	1120	60	226	100							82.00	
York	731	19-Sep-06	1020	0	226	100							80.10	
York	731	03-Oct-06	1015	0	226	50							0.90	
York	731	03-Oct-06	1115	60	226	50							75.70	
York	731	03-Oct-06	1047	30	226	50							75.50	
York	731	18-Oct-06	930	0	226	50							2.30	
York	731	18-Oct-06	1030	60	226	50							59.60	
York	731	18-Oct-06	1000	30	226	50							61.60	
York	731	01-Nov-06	1012	0	226	50							2.20	
York	731	01-Nov-06	1037	25	226	50							58.10	
York	731	01-Nov-06	1112	60	226	50							55.70	
York	731	14-Nov-06	1035	0	226	50							1.10	
York	731	14-Nov-06	1135	60	226	50							52.00	
York	731	14-Nov-06	1105	30	226	50							49.00	
York	731	29-Nov-06	1025	0	226	50							0.00	
York	731	29-Nov-06	1125	60	226	50							47.80	
York	731	29-Nov-06	1055	30	226	50							48.00	
York	731	12-Dec-06	1520	60	226	50							39.70	
York	731	12-Dec-06	1420	0	226	50							1.30	
York	731	12-Dec-06	1450	30	226	50							41.80	
York	731	27-Dec-06	1005	0	226	50							2.00	
York	731	27-Dec-06	1035	30	226	50							36.80	
York	731	27-Dec-06	1105	60	226	50							35.50	
York	731	10-Jan-07	1010	0	226	50							2.20	

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
York	731	04-Jun-06	6.90	620	0.3	13.0								
York	731	06-Jun-06	7.00	610		13.0			82.4	31.5	11.7	4.5	0.07	0.27
York	731	07-Jun-06	7.10	610	0.3	13.0								
York	731	08-Jun-06	7.20	610		13.0	244	297						
York	731	09-Jun-06	7.10	620		13.0	293	357						
York	731	12-Jun-06	7.20			13.0	288	351						
York	731	20-Jun-06	7.40	610		13.0	238	290						
York	731	20-Jun-06	7.20	630		13.0	243	296						
York	731	20-Jun-06	7.10	620		13.0	245	299						
York	731	27-Jun-06	7.50	590		14.0	252	307						
York	731	27-Jun-06	7.50	630		13.0	245	299						
York	731	27-Jun-06	7.40	620		13.0	245	299						
York	731	05-Jul-06	7.50	590		13.0	238	290						
York	731	05-Jul-06	7.20	610		13.0	246	300						
York	731	05-Jul-06	7.30	600		13.0	245	299						
York	731	11-Jul-06	7.20	610		13.0	252	308						
York	731	11-Jul-06	7.10	590		13.0	261	319						
York	731	11-Jul-06	7.10	600		13.0	253	309						
York	731	18-Jul-06	7.10	600		13.0	244	297						
York	731	18-Jul-06	7.10	600		13.0	245	299						
York	731	18-Jul-06	7.30	610		13.0								
York	731	26-Jul-06	8.10	610		13.0	256	312						
York	731	26-Jul-06	8.40	590		15.0	250	305						
York	731	26-Jul-06	8.70			13.0	258	315						
York	731	01-Aug-06	7.60	620		14.0	294	359						
York	731	01-Aug-06	9.20	600		15.0	256	312						
York	731	01-Aug-06	7.80	610		14.0	265	324						
York	731	08-Aug-06	7.10	520		13.0	277	338						
York	731	08-Aug-06	7.10	540		14.0	308	376						
York	731	08-Aug-06	7.10	530		14.0	291	355						
York	731	15-Aug-06	7.16	410		14.0	305	372						
York	731	15-Aug-06	7.40	490		13.0	284	347						
York	731	15-Aug-06	7.28	500		14.0	298	363						
York	731	05-Sep-06	7.42	620		13.0	429	522						
York	731	05-Sep-06	7.40	630		13.0	288	351						
York	731	05-Sep-06	7.43	620		14.0	300	367						
York	731	19-Sep-06	7.60	640		13.0	307	375						
York	731	19-Sep-06	7.60	640		13.0	272	331						
York	731	19-Sep-06	7.40	630		14.0	287	350						
York	731	03-Oct-06	8.00	530		16.0	319	389						
York	731	03-Oct-06	7.70	590		14.0	306	373						
York	731	03-Oct-06	7.60	590		14.0	347	424						
York	731	18-Oct-06	7.60	580		14.0	280	342						
York	731	18-Oct-06	7.60	630		13.0	267	326						
York	731	18-Oct-06	7.60	630		13.0	266	324						
York	731	01-Nov-06	7.20	560		14.0	270	329						
York	731	01-Nov-06	7.50	640		13.0	264	322						
York	731	01-Nov-06	7.20	630		13.0	273	333						
York	731	14-Nov-06	7.20	550		13.0	240	292						
York	731	14-Nov-06	7.50	620		13.0	265	323						
York	731	14-Nov-06	7.40	620		13.0	262	320						
York	731	29-Nov-06	7.20	550		13.0	256	312						
York	731	29-Nov-06	7.10	610		13.0	267	326						
York	731	29-Nov-06	7.00	620		13.0	260	317						
York	731	12-Dec-06	7.10	630		13.0	290	354						
York	731	12-Dec-06	6.90	570		20.0	245	299						
York	731	12-Dec-06	7.10	640		13.0	270	329						
York	731	27-Dec-06	7.80	560		14.0	253	309						
York	731	27-Dec-06	7.60	630		13.0	274	334						
York	731	27-Dec-06	7.70	600		13.0	256	313						
York	731	10-Jan-07	7.20	470		12.0	225	275						

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
York	731	04-Jun-06												
York	731	06-Jun-06	n.d.	13	71				0.2			17.5		
York	731	07-Jun-06												
York	731	08-Jun-06												
York	731	09-Jun-06												
York	731	12-Jun-06												
York	731	20-Jun-06												
York	731	20-Jun-06												
York	731	20-Jun-06												
York	731	27-Jun-06												
York	731	27-Jun-06												
York	731	27-Jun-06												
York	731	05-Jul-06												
York	731	05-Jul-06												
York	731	05-Jul-06												
York	731	11-Jul-06												
York	731	11-Jul-06												
York	731	11-Jul-06												
York	731	18-Jul-06												
York	731	18-Jul-06												
York	731	18-Jul-06												
York	731	26-Jul-06												
York	731	26-Jul-06												
York	731	26-Jul-06												
York	731	01-Aug-06												
York	731	01-Aug-06												
York	731	01-Aug-06												
York	731	08-Aug-06												
York	731	08-Aug-06												
York	731	08-Aug-06												
York	731	15-Aug-06												
York	731	15-Aug-06												
York	731	15-Aug-06												
York	731	05-Sep-06												
York	731	05-Sep-06												
York	731	05-Sep-06												
York	731	19-Sep-06												
York	731	19-Sep-06												
York	731	19-Sep-06												
York	731	03-Oct-06												
York	731	03-Oct-06												
York	731	03-Oct-06												
York	731	18-Oct-06												
York	731	18-Oct-06												
York	731	18-Oct-06												
York	731	01-Nov-06												
York	731	01-Nov-06												
York	731	01-Nov-06												
York	731	14-Nov-06												
York	731	14-Nov-06												
York	731	14-Nov-06												
York	731	29-Nov-06												
York	731	29-Nov-06												
York	731	29-Nov-06												
York	731	12-Dec-06												
York	731	12-Dec-06												
York	731	12-Dec-06												
York	731	27-Dec-06												
York	731	27-Dec-06												
York	731	27-Dec-06												
York	731	10-Jan-07												

Town	Well ID	Date	Time	Interval min.	Depth ft	Rate gpm	StateLab#	As ppb SHL	As ppb MWL	As 3+ ppb MWL	As 5+ ppb MWL	U ppb SHL	U ppb MWL
York	731	10-Jan-07	1040	30	226	50							36.10
York	731	10-Jan-07	1110	60	226	50							35.60
York	731	23-Jan-07	1025	0	226	50							0.90
York	731	23-Jan-07	1055	30	226	50							33.20
York	731	23-Jan-07	1125	60	226	50							32.10
York	731	06-Feb-07	1045	60	226	50							30.50
York	731	06-Feb-07	1015	30	226	50							30.70
York	731	06-Feb-07	945	0	226	50							2.10
York	731	21-Feb-07	1010	30	226	50							29.50
York	731	21-Feb-07	940	0	226	50							1.20
York	731	21-Feb-07	1040	60	226	50							28.10
York	731	08-Mar-07	1350	0	226	50							1.90
York	731	08-Mar-07	1420	30	226	50							29.10
York	731	08-Mar-07	1450	60	226	50							29.40
York	731	13-Mar-07	820	0	226	50	L31736-8	8.20				18.50	
York	731	13-Mar-07	831	15	226	50							
York	731	13-Mar-07	850	30	226	50	L31736-9	7.20				28.40	
York	731	16-May-07	1400	30	226	50	P32100-93					23.60	
York	731	06-Jun-07	940	30	226	50	P32221-2					19.70	
York	731	19-Jun-07	1100	30	226	50	P32217-46					17.30	
York	731	31-Jul-07	1405	0	226	50							
York	731	08-Aug-07	1400	240	226	50	P32619-5						
York	731	15-Aug-07	1430	240	226	50	P32619-6						
York	731	21-Aug-07	1400	240	226	50	P32641-7						
York	731	29-Aug-07	1400		226	50	P32641-3						
York	731	05-Sep-07	1400	240	226	400	P32619-8						
York	731	12-Sep-07	1330	120	226	250	P32619-15						

Town	Well ID	Date	pH	EC µS/cm	DO YSI ppm	Temp C	CaCO3 ppm	HCO3 ppm	Ca ppm	Na ppm	Mg ppm	K ppm	Fe ppm	Mn ppm
York	731	10-Jan-07	7.60	600		13.0	265	323						
York	731	10-Jan-07	7.70	610		13.0	253	309						
York	731	23-Jan-07	7.40	580		10.0	247	303						
York	731	23-Jan-07	7.40	630		13.0	251	306						
York	731	23-Jan-07	7.50	630		13.0	265	323						
York	731	06-Feb-07	7.00	610		13.0	253	309						
York	731	06-Feb-07	6.80	620		12.0	263	321						
York	731	06-Feb-07	6.80	520		12.0	251	306						
York	731	21-Feb-07	7.70	600		12.0	254	309						
York	731	21-Feb-07	7.50	520		11.0	226	275						
York	731	21-Feb-07	7.70	600		12.0	368	327						
York	731	08-Mar-07	6.80	520		11.0	241	294						
York	731	08-Mar-07	6.90	600		12.0	254	310						
York	731	08-Mar-07	7.00	600		13.0	260	317						
York	731	13-Mar-07	7.70	520	8.0	11.0	230	284	73.2	23.8	11.5	5.7	1.79	0.02
York	731	13-Mar-07	7.60	610	1.1	12.0	263	321						
York	731	13-Mar-07	7.50	610	1.8	12.0	249	304	82.8	26.7	11.8	5.6	0.96	0.29
York	731	16-May-07	6.90	530		13.0	288	351						
York	731	06-Jun-07	6.70	570		13.0	241	294						
York	731	19-Jun-07	7.80	600		13.0	267	325						
York	731	31-Jul-07	7.40	600		14.0	231	282						
York	731	08-Aug-07	7.60	590		14.0	240	293						
York	731	15-Aug-07	7.60	590		14.0	240	293						
York	731	21-Aug-07	7.50	610		14.0	251	306						
York	731	29-Aug-07	7.40	1020		13.0	260	300						
York	731	05-Sep-07	7.80	610		13.0	235	287						
York	731	12-Sep-07	7.70	620		13.0	237	289						

Town	Well ID	Date	NO3 ppm	Cl ppm	SO4 ppm	Fe Field ppm	Fe 2+ ppm	Fe 3+ ppm	P ppm	TOC ppm	Eh mv	Charge Balance %		
York	731	10-Jan-07												
York	731	10-Jan-07												
York	731	23-Jan-07												
York	731	23-Jan-07												
York	731	23-Jan-07												
York	731	06-Feb-07												
York	731	06-Feb-07												
York	731	06-Feb-07												
York	731	21-Feb-07												
York	731	21-Feb-07												
York	731	21-Feb-07												
York	731	08-Mar-07												
York	731	08-Mar-07												
York	731	08-Mar-07												
York	731	13-Mar-07	0.4	11	37				0.2	1.40		0.89		
York	731	13-Mar-07												
York	731	13-Mar-07	0.3	11	55	0.41	0.06	0.35	0.2	1.59		0.07		
York	731	16-May-07												
York	731	06-Jun-07												
York	731	19-Jun-07												
York	731	31-Jul-07												
York	731	08-Aug-07												
York	731	15-Aug-07												
York	731	21-Aug-07												
York	731	29-Aug-07												
York	731	05-Sep-07												
York	731	12-Sep-07												

Appendix C

QA/QC Data Tables

QA/QC from NHHS State Lab and Midwest Lab

Report Level As and U = 0.001 mg/L
Report Level NO3 = 0.2 mg/L
Report Level K = 0.5 mg/L
Report Level NO3 = 0.05 mg/L
Report Level Other Cat/An = 0.01 mg/L
Report Level TOC = 1.0 mg/L
n.d. = Not Detected

Duplicates

Sample origin	UNL/CSD Sample ID	Date analyzed	Analyte	Sample (mg/L)	Duplicate (mg/L)	% difference	Laboratory
McCook 4	1268	2/12/2004	Arsenic	0.043	0.042	2	NE State Lab
Cambridge 531	938	9/17/2003	Arsenic	0.0138	0.0143	4	NE State Lab
Stromsburg 1	1020	12/4/2003	Arsenic	0.00466	0.00465	0	NE State Lab
Stromsburg 1	795	9/17/2003	Arsenic	0.00405	0.0039	4	NE State Lab
Shelton 97	1270	2/12/2004	Arsenic	0.00372	0.0039	5	NE State Lab
Stromsburg 1	774	9/17/2003	Arsenic	0.00381	0.00405	6	NE State Lab
Cambridge 531	932	9/17/2003	Arsenic	0.0141	0.0139	1	NE State Lab
Oshkosh 1741	1073	12/4/2003	Arsenic	0.0042	0.00417	1	NE State Lab
Morill 531	1749	4/25/2005	Arsenic	0.0239	0.0241	1	NE State Lab
Bridgeport 691	1785	6/8/2005	Arsenic	0.00293	0.00334	13	NE State Lab
Bridgeport 691-MW	1853	6/8/2005	Arsenic	0.00425	0.00419	1	NE State Lab
Benkelman 961	1954	7/12/2005	Cations				Midwest Lab
			Ca	113	113	0	
			Mg	38.9	38.1	2	
			K	30.7	29.3	5	
			Na	99.6	96.9	3	
			Fe	0.04	0.06	40	
			Mn	0.2	0.17	16	
			P	0.2	0.1	67	
Benkelman 961	1955	7/12/2005	Anions				Midwest Lab
			SO4	210	211	0	
			N-NO3	0.7	1.2	53	
			Cl	100	99	1	
York 731	2088	7/19/2005	Anions				Midwest Lab
			SO4	38	38	0	
			N-NO3	0.9	0.9	0	
			Cl	11	11	0	
York 731	2089	7/19/2005	Cations				Midwest Lab
			Ca	79.9	79.75	0	
			Mg	12.2	12.15	0	
			K	5.7	5.9	3	
			Na	26.6	26.35	1	
			Fe	n.d.	n.d.	0	
			Mn	n.d.	n.d.	0	
			P	0.2	0.2	0	
Shelby 641	2325	8/10/2005	Arsenic	0.0142	0.0151	6	NE State Lab
Clarks 2005-2	2646	1/25/2006	Uranium	0.0387	0.0402	4	NE State Lab
Clarks 2005-2	2663	3/6/2006	Uranium	0.0582	0.0576	1	NE State Lab
York 731	2687	5/22/2006	Uranium	13.4	13.4	0	NE State Lab
York 731	2693	5/22/2006	Nitrate	0.06	0.07	15	NE State Lab
York 731	2730	5/22/2006	Uranium	0.084	0.084	0	Midwest Lab
Bellwood 761	2771	6/19/2006	Uranium	0.175	0.176	1	NE State Lab
Bellwood 761	2779	6/19/2006	Nitrate	n.d.	n.d.		NE State Lab
Bellwood 761	2784	6/19/2006	Cations				Midwest Lab
			Ca	99.8	96.8	3	
			Mg	16.1	15.5	4	
			K	10	9.4	6	
			Na	23.7	22.9	3	
			Fe	0.38	0.37	3	
			Mn	0.37	0.36	3	
			P	n.d.	n.d.		
Bellwood 761	2785	6/19/2006	Anions				Midwest Lab
			SO4	125	125	0	
			N-NO3	n.d.	n.d.		
			Cl	12	11	9	
Bellwood 761	2786	6/19/2006	TOC	5.27	1.33	119	Midwest Lab
Bellwood 761	2807	6/21/2006	Uranium	0.175	0.179	2	NE State Lab
Bellwood 761	2835	6/21/2006	Nitrate	n.d.	n.d.		NE State Lab
Bellwood 761	2840	6/21/2006	Cations				Midwest Lab
			Ca	95.7	101	5	
			Mg	15.6	16.4	5	

			K	9.8	11.5	16	
			Na	22.8	24	5	
			Fe	0.75	0.81	8	
			Mn	0.35	0.36	3	
			P	n.d.	n.d.		
Bellwood 761	2841	6/21/2006	Anions				Midwest Lab
			SO4	123	123	0	
			N-NO3	n.d.	n.d.		
			Cl	11	11	0	
Bellwood 761	2842	6/21/2006	TOC	1.61	1.37	16	Midwest Lab
Bellwood 761	2869	6/23/2006	Nitrate	n.d.	n.d.		NE State Lab
Bellwood 761	2871	6/23/2006	Uranium	0.191	0.196	3	NE State Lab
Stromsburg 3	2891	7/10/2006	Nitrate	2	2	0	NE State Lab
Stromsburg 3	2898	7/10/2006	Arsenic	0.0211	0.0209	1	NE State Lab
Stromsburg 3	2905	7/10/2006	Cations				Midwest Lab
			Ca	108	105	3	
			Mg	16.4	16	2	
			K	9.1	8.4	8	
			Na	23	22.5	2	
			Fe	0.05	0.05	0	
			Mn	0.14	0.14	0	
			P	n.d.	n.d.		
Stromsburg 3	2912	7/10/2006	Anions				Midwest Lab
			SO4	54	54	0	
			N-NO3	2.1	2.2	5	
			Cl	9	10	11	
Stromsburg 3	2919	7/10/2006	TOC	3.1	2.9	7	Midwest Lab
Stromsburg 3	2926	7/10/2006	Arsenic	0.0246	0.025	2	Midwest Lab
Stromsburg 3	2970	7/19/2006	Arsenic	21.1	21.4	1	NE State Lab
Wauneta 3	2971	8/6/2006	Arsenic	0.0104	0.0102	2	NE State Lab
Wauneta 3	2979	8/6/2006	TOC	n.d.	n.d.		Midwest Lab
Stromsburg 3	2985	7/19/2006	TOC	n.d.	n.d.		Midwest Lab
Wauneta 3	2994	8/7/2006	Cations				Midwest Lab
			Ca	44	44	0	
			Mg	13	13	0	
			K	12.3	11.1	10	
			Na	16.9	16.9	0	
			Fe	n.d.	n.d.		
			Mn	n.d.	n.d.		
			P	n.d.	n.d.		
Stromsburg 3	3000	7/19/2006	Cations				Midwest Lab
			Ca	107	108	1	
			Mg	16.8	16.8	0	
			K	8.7	9.1	4	
			Na	24.6	24.6	0	
			Fe	0.05	0.06	18	
			Mn	0.17	0.18	6	
			P	n.d.	n.d.		
Wauneta 3	3009	8/6/2006	Anions				Midwest Lab
			SO4	16	16	0	
			N-NO3	1.9	2	5	
			Cl	1	1	0	
Stromsburg 3	3015	7/19/2006	Anions				Midwest Lab
			SO4	56	56	0	
			N-NO3	3.2	3.2	0	
			Cl	11	11	0	
Stromsburg 3	3030	7/19/2006	Arsenic	0.0257	0.025	3	Midwest Lab
Wauneta 3	3031	8/9/2006	Arsenic	0.0124	0.0131	5	Midwest Lab
Wauneta 3	3079	8/9/2006	Arsenic	0.0103	0.0104	1	NE State Lab
Wauneta 3	3093	8/9/2006	Arsenic	0.0111	0.0111	0	Midwest Lab
Haigler 651	3101	8/7/2006	Arsenic	0.0176	0.0173	2	NE State Lab
Haigler 651	3109	8/7/2006	Nitrate	2.6	2.5	4	NE State Lab
Haigler 651	3117	8/7/2006	Arsenic	0.0208	0.0224	7	Midwest Lab
Haigler 651	3131	8/10/2006	Arsenic	0.0148	0.0145	2	NE State Lab
Haigler 651	3136	8/10/2006	Nitrate	2.2	2.2	0	NE State Lab
Haigler 651	3147	8/10/2006	Cations				Midwest Lab
			Ca	56.7	55.7	2	
			Mg	12	12	0	
			K	14.1	14.1	0	
			Na	16.6	16.6	0	
			Fe	0.02	0.04	67	
			Mn	0.03	0.03	0	
			P	n.d.	n.d.		

Haigler 651	3148	8/10/2006	Anions				Midwest Lab
			SO4	14	14	0	
			N-NO3	2.4	2.3	4	
			Cl	4	3	29	
Haigler 651	3149	8/10/2006	TOC	n.d.	n.d.		Midwest Lab
Haigler 651	3165	8/10/2006	Arsenic	0.0175	0.0177	1	Midwest Lab
Clarks 2005-2	3173	8/17/2006	Uranium	0.0309	0.0329	6	NE State Lab
Clarks 2005-2	3181	8/17/2006	Uranium	0.0432	0.0428	1	Midwest Lab
Clarks 2005-2	3186	8/17/2006	Cations				Midwest Lab
			Ca	49.9	48.6	3	
			Mg	8.6	8.35	3	
			K	6.5	5.7	13	
			Na	26.8	25.9	3	
			Fe	0.56	0.56	0	
			Mn	0.27	0.25	8	
			P	n.d.	n.d.		
Clarks 2005-2	3187	8/17/2006	Anions				Midwest Lab
			SO4	76	78	3	
			N-NO3	n.d.	n.d.		
			Cl	12	11	9	
Clarks 2005-2	3188	8/17/2006	TOC	n.d.	n.d.		Midwest Lab
Clarks 2005-2	3201	8/18/2006	Uranium	0.0747	0.0768	3	NE State Lab
Clarks 2005-2	3215	8/18/2006	Uranium	0.0992	0.0914	8	Midwest Lab
Clarks 2005-2	3229	8/18/2006	Cations				Midwest Lab
			Ca	57.4	49.8	14	
			Mg	9.8	8.56	14	
			K	6.7	5.2	25	
			Na	30	26	14	
			Fe	0.09	0.11	20	
			Mn	0.33	0.29	13	
			P	n.d.	n.d.		
Clarks 2005-2	3230	8/18/2006	Anions				Midwest Lab
			SO4	71	79	11	
			N-NO3	n.d.	n.d.		
			Cl	11	12	9	
Clarks 2005-2	3231	8/18/2006	TOC	n.d.	n.d.		Midwest Lab
Clarks NTW	3241	8/17/2006	Uranium	0.234	0.228	3	NE State Lab
Clarks NTW	3249	8/17/2006	Uranium	0.2518	0.2522	0	Midwest Lab
Clarks NTW	3254	8/17/2006	Cations				Midwest Lab
			Ca	108	106	2	
			Mg	18.7	18.6	1	
			K	13.7	13.9	1	
			Na	74.1	74.1	0	
			Fe	1.47	1.4	5	
			Mn	0.18	0.16	12	
			P	n.d.	n.d.		
Clarks NTW	3255	8/17/2006	Anions				Midwest Lab
			SO4	178	179	1	
			N-NO3	n.d.	n.d.		
			Cl	18	18	0	
Clarks NTW	3256	8/17/2006	TOC	1.44	2.19	41	Midwest Lab
Stromsburg 3	3379	9/7/2006	Arsenic	0.0273	0.0248	10	NE State Lab
Stromsburg 3	3390	9/7/2006	Arsenic	0.0258	0.026	1	Midwest Lab
Haigler 651	3453	11/29/2006	Arsenic	0.0201	0.0203	1	NE State Lab
Wauneta 3	3477	1/26/2006	Arsenic	0.0108	0.0106	2	NE State Lab
Haigler 651	3484	11/14/2006	Cations				Midwest Lab
			Ca	63.8	63	1	
			Mg	13.1	13	1	
			K	14	13.9	1	
			Na	18.3	18.2	1	
			Fe	0.03	0.06	67	
			Mn	n.d.	n.d.		
			P	n.d.	n.d.		
Haigler 651	3485	11/14/2006	Anions				Midwest Lab
			SO4	14	14	0	
			N-NO3	2.8	2.7	4	
			Cl	5	4	22	
Haigler 651	3486	11/14/2006	TOC	n.d.	n.d.		Midwest Lab
Wauneta 3	3507	11/14/2006	Arsenic	0.0119	0.0117	2	Midwest Lab
Haigler 651	3512	11/14/2006	Arsenic	0.0193	0.02	4	NE State Lab
Wauneta 3	3517	11/12/2006	Arsenic	0.0109	0.0109	0	NE State Lab
Wauneta 3	3576	11/29/2006	Arsenic	0.0106	0.0105	1	NE State Lab
Stromsburg 3	3583	12/6/2006	Arsenic	0.0248	0.0251	1	NE State Lab

Stromsburg 3	3585	12/6/2006	TOC	n.d.	n.d.		Midwest Lab
Stromsburg 3	3586	12/6/2006	Cations				Midwest Lab
			Ca	108	108	0	
			Mg	14.8	14.7	1	
			K	7.4	7.3	1	
			Na	21.2	20.9	1	
			Fe	0.13	0.13	0	
			Mn	0.1	0.1	0	
			P	n.d.	n.d.		
Stromsburg 3	3587	12/6/2006	Anions				Midwest Lab
			SO4	56	56	0	
			N-NO3	2.1	2.1	0	
			Cl	13	13	0	
Stromsburg 3	3599	12/13/2006	Arsenic	0.0213	0.0213	0	NE State Lab
Stromsburg 3	3600	12/29/2006	Arsenic	0.026	0.0266	2	NE State Lab
Bellwood 761	3623	2/10/2007	Uranium	0.204	0.203	0	NE State Lab
Clarks NTW	3676	1/25/2007	Uranium	0.248	0.244	2	NE State Lab
Clarks NTW	3682	1/25/2007	Uranium	0.2405	0.2425	1	Midwest Lab
Clarks 2005-2	3686	3/6/2007	TOC	1.77	3.03	53	Midwest Lab
Clarks NTW	3688	1/25/2007	Uranium	0.244	0.245	0	NE State Lab
Clarks NTW	3694	1/25/2007	Uranium	0.2436	0.2378	2	Midwest Lab
Clarks NTW	3700	1/25/2007	Uranium	0.242	0.243	0	NE State Lab
Clarks NTW	3706	1/25/2007	Uranium	0.2381	0.2393	1	Midwest Lab
Clarks NTW	3716	1/25/2007	Cations				Midwest Lab
			Ca	113	116	3	
			Mg	19.5	19.9	2	
			K	13.6	14.4	6	
			Na	75.7	77.8	3	
			Fe	0.68	0.69	1	
			Mn	0.21	0.21	0	
			P	0.1	0.1	0	
Clarks NTW	3717	1/25/2007	Anions				Midwest Lab
			SO4	194	196	1	
			N-NO3	n.d.	n.d.		
			Cl	19	22	15	
Clarks NTW	3718	1/25/2007	TOC	2.74	3.92	35	Midwest Lab
Clarks 2005-2	3730	2/10/2007	Uranium	0.0384	0.0369	4	NE State Lab
York 731	3756	3/13/2007	Cations				Midwest Lab
			Ca	82.7	82.8	0	
			Mg	11.8	11	7	
			K	5.6	5.6	0	
			Na	26.7	26.7	0	
			Fe	0.96	0.46	70	
			Mn	0.29	0.29	0	
			P	n.d.	n.d.		
York 731	3757	3/13/2007	Anions				Midwest Lab
			SO4	55	55	0	
			N-NO3	0.3	0.3	0	
			Cl	11	11	0	
Clarks 2005-2	3791	3/6/2007	Cations				Midwest Lab
			Ca	47.8	47.7	0	
			Mg	7.78	7.7	1	
			K	6.1	6.1	0	
			Na	24.8	24.6	1	
			Fe	0.59	0.59	0	
			Mn	0.23	0.23	0	
			P	n.d.	n.d.		
Clarks 2005-2	3792	3/6/2007	Anions				Midwest Lab
			SO4	71	71	0	
			N-NO3	n.d.	n.d.		
			Cl	11	11	0	
Clarks 2005-2	3794	2/10/2007	Anions				Midwest Lab
			SO4	73	73	0	
			N-NO3	0.3	0.3	0	
			Cl	16	16	0	
Clarks 2005-2	3795	2/10/2007	Cations				Midwest Lab
			Ca	51	49.2	4	
			Mg	7.7	7.44	3	
			K	6.9	6.4	8	
			Na	25.9	25	4	
			Fe	0.36	0.28	25	
			Mn	0.15	0.14	7	
			P	0.1	0.1	0	

Wauneta 3	3821	3/2/2007	Arsenic	0.00889	0.00869	2	NE State Lab
Wauneta 3	3828	2/2/2007	Arsenic	0.00979	0.0103	5	NE State Lab
Stromsburg 3	3867	1/30/2007	Arsenic	0.0208	0.02	4	NE State Lab
Clarks 2005-2	3886	2/10/2007	TOC	3	2.79	7	Midwest Lab
Bellwood 761	3892	2/10/2007	Cations				Midwest Lab
			Ca	105	107	2	
			Mg	17.1	17	1	
			K	11	10.7	3	
			Na	24.9	24.5	2	
			Fe	0.18	0.17	6	
			Mn	0.38	0.37	3	
			P	n.d.	n.d.		
Bellwood 761	3893	2/10/2007	Anions				Midwest Lab
			SO4	143	142	1	
			N-NO3	n.d.	n.d.		
			Cl	13	13	0	
Bellwood 761	3894	2/10/2007	TOC	3.03	2.64	14	Midwest Lab
Cambridge 531	3904	3/13/2007	Arsenic	0.0152	0.0148	3	NE State Lab
McCook 4	3914	3/13/2007	Nitrate	13	12	8	NE State Lab
York 731	3922	3/13/2007	TOC	1.59	2.45	43	Midwest Lab

Blanks (DI)

Sample origin	UNL/CSD Sample ID	Date analyzed	Analyte	Actual value(mg/L)	Lab's value(mg/L)	Laboratory
Cambridge 531	979	9/17/2003	Arsenic	0	n.d.	NE State Lab
Stromsburg 1	1029	12/3/2003	Arsenic	0	n.d.	NE State Lab
Oshkosh 1741	1068	12/3/2003	Arsenic	0	n.d.	NE State Lab
Benkelman 721	1269	2/12/2004	Arsenic	0	n.d.	NE State Lab
Stratton 752	1730	4/11/2005	Arsenic	0	n.d.	NE State Lab
Colon 661	1742	4/25/2005	Arsenic	0	n.d.	NE State Lab
Bridgeport 691	1791	6/8/2005	Uranium	0	n.d.	NE State Lab
Anselmo 641	1806	6/8/2005	Arsenic	0	n.d.	NE State Lab
Benkelman 961	1889	7/12/2005	Arsenic	0	n.d.	Midwest Lab
Benkelman 961	1952	7/12/2005	Cations	0	n.d.	Midwest Lab
Benkelman 961	1953	7/12/2005	Anions	0	n.d.	Midwest Lab
Benkelman 961	1969	7/12/2005	TOC	0	n.d.	Midwest Lab
York 731	2129	8/2/2005	Uranium	0	n.d.	NE State Lab
York 731	2130	8/2/2005	Uranium	0	n.d.	Midwest Lab
York 731	2131	8/2/2005	Cations	0	n.d.	Midwest Lab
York 731	2132	8/2/2005	Anions	0	n.d.	NE State Lab
York 731	2133	8/2/2005	TOC	0	n.d.	Midwest Lab
Bridgeport 691-MW	2440	8/18/2005	Arsenic	0	n.d.	Midwest Lab
Clarks 2005-2	2533	9/22/2005	Uranium	0	n.d.	NE State Lab
Clarks 2005-2	2664	3/6/2006	Uranium	0	n.d.	NE State Lab
York 731	2691	5/22/2006	Uranium	0	n.d.	NE State Lab
York 731	2694	5/22/2006	Nitrate	0	n.d.	NE State Lab
York 731	2706	5/22/2006	Uranium	0	n.d.	NE State Lab
York 731	2728	6/7/2006	Uranium	0	n.d.	NE State Lab
Bellwood 761	2772	6/19/2006	Uranium	0	n.d.	NE State Lab
Bellwood 761	2780	6/19/2006	Nitrate	0	n.d.	NE State Lab
Bellwood 761	2794	6/19/2006	Uranium	0	n.d.	NE State Lab
Bellwood 761	2808	6/21/2006	Uranium	0	n.d.	NE State Lab
Bellwood 761	2822	6/21/2006	Uranium	0	n.d.	NE State Lab
Bellwood 761	2836	6/21/2006	Nitrate	0	n.d.	NE State Lab
Bellwood 761	2870	6/23/2006	Nitrate	0	n.d.	NE State Lab
Bellwood 761	2872	6/23/2006	Uranium	0	n.d.	NE State Lab
Bellwood 761	2874	6/23/2006	Uranium	0	n.d.	NE State Lab
Stromsburg 3	2930	7/10/2006	Nitrate	0	n.d.	NE State Lab
Stromsburg 3	2931	7/10/2006	Arsenic	0	n.d.	NE State Lab
Stromsburg 3	2932	7/10/2006	Cations	0	n.d.	Midwest Lab
Stromsburg 3	2933	7/10/2006	Anions	0	n.d.	Midwest Lab
Stromsburg 3	2934	7/10/2006	TOC	0	n.d.	Midwest Lab
Stromsburg 3	2935	7/10/2006	Arsenic	0	n.d.	NE State Lab
Stromsburg 3	2944	12/13/2006	Arsenic	0	n.d.	NE State Lab
Stromsburg 3	2957	7/12/2006	Nitrate	0	n.d.	NE State Lab
Stromsburg 3	2972	7/12/2006	Arsenic	0	n.d.	NE State Lab
Wauneta 3	2986	8/9/2006	TOC	0	n.d.	Midwest Lab
Stromsburg 3	2987	7/12/2006	TOC	0	n.d.	Midwest Lab
Wauneta 3	3001	8/9/2006	Cations	0	n.d.	Midwest Lab
Stromsburg 3	3002	7/12/2006	Cations	0	n.d.	Midwest Lab
Wauneta 3	3016	8/9/2006	Anions	0	n.d.	Midwest Lab

Stromsburg 3	3017	7/12/2006	Anions	0	n.d.	Midwest Lab
Stromsburg 3	3032	7/12/2006	Arsenic	0	n.d.	NE State Lab
Wauneta 3	3066	8/6/2006	Arsenic	0	n.d.	NE State Lab
Wauneta 3	3080	8/9/2006	Arsenic	0	n.d.	NE State Lab
Wauneta 3	3094	8/9/2006	Arsenic	0	n.d.	NE State Lab
Haigler 651	3102	8/7/2006	Arsenic	0	n.d.	NE State Lab
Haigler 651	3110	8/7/2006	Nitrate	0	n.d.	NE State Lab
Haigler 651	3118	8/7/2006	Arsenic	0	n.d.	NE State Lab
Haigler 651	3132	8/10/2006	Arsenic	0	n.d.	NE State Lab
Haigler 651	3137	8/10/2006	Nitrate	0	n.d.	NE State Lab
Haigler 651	3150	8/10/2006	Cations	0	n.d.	Midwest Lab
Haigler 651	3151	8/10/2006	Anions	0	n.d.	Midwest Lab
Haigler 651	3152	8/10/2006	TOC	0	n.d.	Midwest Lab
Haigler 651	3166	8/10/2006	Arsenic	0	n.d.	NE State Lab
Clarks 2005-2	3174	8/17/2006	Uranium	0	n.d.	NE State Lab
Clarks 2005-2	3182	8/17/2006	Uranium	0	n.d.	NE State Lab
Clarks 2005-2	3202	8/18/2006	Uranium	0	n.d.	NE State Lab
Clarks 2005-2	3216	8/18/2006	Uranium	0	n.d.	NE State Lab
Clarks 2005-2	3232	8/18/2006	Cations	0	n.d.	Midwest Lab
Clarks 2005-2	3233	8/18/2006	Anions	0	n.d.	Midwest Lab
Clarks 2005-2	3234	8/18/2006	TOC	0	n.d.	Midwest Lab
Clarks 2005-2	3284	10/5/2006	Uranium	0	n.d.	NE State Lab
Clarks 2005-2	3300	10/5/2006	Cations	0	n.d.	Midwest Lab
Clarks 2005-2	3301	10/5/2006	Anions	0	n.d.	Midwest Lab
Clarks 2005-2	3302	10/5/2006	TOC	0	n.d.	Midwest Lab
Stromsburg 3	3380	9/7/2006	Arsenic	0	n.d.	NE State Lab
Stromsburg 3	3391	9/7/2006	Arsenic	0	n.d.	NE State Lab
Stromsburg 3	3404	9/7/2006	Cations	0	n.d.	Midwest Lab
Stromsburg 3	3405	9/7/2006	Anions	0	n.d.	Midwest Lab
Stromsburg 3	3406	9/7/2006	TOC	0	n.d.	Midwest Lab
Haigler 651	3455	11/16/2006	Arsenic	0	n.d.	NE State Lab
Wauneta 3	3479	12/22/2006	Arsenic	0	n.d.	NE State Lab
Haigler 651	3487	11/14/2006	Cations	0	n.d.	Midwest Lab
Haigler 651	3488	11/14/2006	Anions	0	n.d.	Midwest Lab
Haigler 651	3489	11/14/2006	TOC	0	n.d.	Midwest Lab
Wauneta 3	3496	11/12/2006	Cations	0	n.d.	Midwest Lab
Wauneta 3	3497	11/12/2006	Anions	0	n.d.	Midwest Lab
Wauneta 3	3498	11/12/2006	TOC	0	n.d.	Midwest Lab
Haigler 651	3503	11/14/2006	Arsenic	0	n.d.	NE State Lab
Wauneta 3	3508	11/12/2006	Arsenic	0	n.d.	NE State Lab
Haigler 651	3513	11/14/2006	Arsenic	0	n.d.	NE State Lab
Wauneta 3	3518	11/12/2006	Arsenic	0	n.d.	NE State Lab
Wauneta 3	3577	12/1/2006	Arsenic	0	n.d.	NE State Lab
Stromsburg 3	3584	12/6/2006	Arsenic	0	n.d.	NE State Lab
Stromsburg 3	3588	12/6/2006	TOC	0	n.d.	Midwest Lab
Stromsburg 3	3602	12/27/2006	Arsenic	0	n.d.	NE State Lab
Stromsburg 3	3603	1/11/2007	Arsenic	0	n.d.	NE State Lab
Bellwood 761	3624	2/10/2007	Uranium	0	n.d.	NE State Lab
Clarks NTW	3675	1/25/2007	Uranium	0	n.d.	NE State Lab
Clarks 2005-2	3681	1/25/2007	Uranium	0	n.d.	NE State Lab
Clarks NTW	3687	1/25/2007	Uranium	0	n.d.	NE State Lab
Clarks NTW	3693	1/25/2007	Uranium	0	n.d.	NE State Lab
Clarks NTW	3699	1/25/2007	Uranium	0	n.d.	NE State Lab
Clarks NTW	3705	1/25/2007	Uranium	0	n.d.	NE State Lab
Clarks 2005-2	3729	2/10/2007	Uranium	0	n.d.	NE State Lab
York 731	3734	3/13/2007	Cations	0	n.d.	Midwest Lab
York 731	3735	3/13/2007	Anions	0	n.d.	Midwest Lab
Clarks NTW	3775	1/31/2007	TOC	0	n.d.	Midwest Lab
Clarks NTW	3782	1/25/2007	Cations	0	n.d.	Midwest Lab
Clarks NTW	3783	1/25/2007	Anions	0	n.d.	Midwest Lab
Clarks 2005-2	3788	2/10/2007	Cations	0	n.d.	Midwest Lab
Clarks 2005-2	3789	2/10/2007	Anions	0	n.d.	Midwest Lab
Clarks 2005-2	3790	2/10/2007	TOC	0	n.d.	Midwest Lab
Clarks 2005-2	3793	3/6/2007	TOC	0	n.d.	Midwest Lab
Stromsburg 3	3814	2/8/2007	Arsenic	0	n.d.	NE State Lab
Wauneta 3	3831	3/19/2007	Arsenic	0	n.d.	NE State Lab
Wauneta 3	3832	2/16/2007	Arsenic	0	n.d.	NE State Lab
Haigler 651	3848	3/6/2007	Arsenic	0	n.d.	NE State Lab
Clarks 2005-2	3862	3/2/2007	Uranium	0	n.d.	NE State Lab
Clarks 2005-2	3865	2/12/2007	Uranium	0	n.d.	NE State Lab
Clarks 2005-2	3887	2/10/2007	TOC	0	n.d.	Midwest Lab
Bellwood 761	3895	2/10/2007	Cations	0	n.d.	Midwest Lab
Bellwood 761	3896	2/10/2007	Anions	0	n.d.	Midwest Lab

Bellwood 761	3897	2/10/2007	TOC	0	n.d.	Midwest Lab
McCook 4	3907	3/13/2007	As & U	0	n.d.	NE State Lab
Cambridge 531	3912	3/13/2007	Nitrate	0	n.d.	NE State Lab
York 731	3919	3/13/2007	TOC	0	n.d.	Midwest Lab

Standards

Sample origin	UNL/CSD Sample ID	Date analyzed	Standard	Actual value(mg/L)	Lab's value(mg/L)	% recovery	Laboratory
UNL CSD	900	9/17/2003	As104ppb	0.1039	0.0969	93	NE State Lab
UNL CSD	978	9/17/2003	As125ppb	0.1248	0.114	91	NE State Lab
UNL CSD	1130	12/3/2003	As104ppb	0.1024	0.1042	102	NE State Lab
UNL CSD	1131	12/4/2003	As125ppb	0.1254	0.131	104	NE State Lab
UNL CSD	1403	2/12/2004	As145ppb	0.1461	0.147	101	NE State Lab
Midwest Labs	1706	4/12/2005	As15ppb	0.015	0.0149	99	NE State Lab
Midwest Labs	1754	4/29/2005	As15ppb	0.015	0.015	100	NE State Lab
Midwest Labs	1837	6/10/2005	As15ppb	0.015	0.0154	103	NE State Lab
UNL CSD	1928	6/28/2005	As15ppb	0.0149	0.0156	105	NE State Lab
UNL CSD	2115	7/28/2005	U35ppb	0.035	0.034	97	NE State Lab
UNL CSD	2666	3/6/2006	U 40ppb	0.04	0.0418	105	NE State Lab
Midwest Labs	2690	5/22/2006	U35ppb	0.035	0.0356	102	NE State Lab
Midwest Labs	2705	5/22/2006	U35ppb	0.035	0.032	91	Midwest Lab
UNL CSD	2856	6/22/2006	U 40ppb	0.04	0.0406	102	Midwest Lab
UNL CSD	3042	7/20/2006	As50ppb	0.05	0.0456	91	Midwest Lab
UNL CSD	3043	7/20/2006	As50ppb	0.05	0.0423	85	NE State Lab
UNL CSD	3199	8/18/2006	U 40ppb	0.04	0.0398	100	Midwest Lab
UNL CSD	3240	10/6/2006	U 40ppb	0.04	0.0396	99	NE State Lab
UNL CSD	3264	10/6/2006	U36.3ppb	0.0363	0.0297	82	NE State Lab
UNL CSD	3268	11/27/2006	As10ppb	0.01	0.00933	93	NE State Lab
UNL CSD	3367	8/21/2006	U 40ppb	0.04	0.0316	79	NE State Lab
UNL CSD	3368	8/21/2006	U 40ppb	0.04	0.0323	81	NE State Lab
UNL CSD	3412	9/13/2006	As10ppb	0.01	0.0104	104	NE State Lab
UNL CSD	3578	1/21/2006	As15ppb	0.015	0.0147	98	NE State Lab
UNL CSD	3625	1/8/2007	As10ppb	0.01	0.00951	95	NE State Lab
UNL CSD	3761	3/19/2007	U 40ppb	0.04	0.0421	105	NE State Lab
UNL CSD	3798	1/26/2007	U 40ppb	0.04	0.04	100	NE State Lab
UNL CSD	3899	2/10/2007	U 40ppb	0.04	0.0417	104	NE State Lab
UNL CSD	3926	4/6/2007	As10ppb	0.01	0.01	100	NE State Lab

Appendix D

PhreeqC Geochemical Data Tables

Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic and Uranium\Arsenic2.pqi
Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC results\Anselmo 8.14.03.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\wateq4f.dat

```
                                       pH  =   7.400
                                       pe  =   0.000
                        Activity of water  =   1.000
                           Ionic strength  =  5.576e-003
                       Mass of water (kg)  =  1.000e+000
                    Total carbon (mol/kg)  =  4.030e-003
                       Total CO2 (mol/kg)  =  4.030e-003
                      Temperature (deg C)  =  13.300
                  Electrical balance (eq)  = -5.675e-004
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -7.07
                               Iterations  =   7
                                  Total H  = 1.110161e+002
                                  Total O  = 5.551966e+001
```

----------------------------Distribution of species----------------------------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
OH-	1.059e-007	9.799e-008	-6.975	-7.009	-0.034
H+	4.272e-008	3.981e-008	-7.369	-7.400	-0.031
H2O	5.551e+001	9.999e-001	1.744	-0.000	0.000
As(3)	6.625e-008				
H3AsO3	6.545e-008	6.554e-008	-7.184	-7.184	0.001
H2AsO3-	8.004e-010	7.403e-010	-9.097	-9.131	-0.034
H4AsO3+	1.398e-015	1.293e-015	-14.855	-14.889	-0.034
HAsO3-2	2.999e-017	2.195e-017	-16.523	-16.659	-0.136
AsO3-3	1.463e-025	7.248e-026	-24.835	-25.140	-0.305
As(5)	1.113e-007				
HAsO4-2	7.520e-008	5.504e-008	-7.124	-7.259	-0.136
H2AsO4-	3.611e-008	3.340e-008	-7.442	-7.476	-0.034
AsO4-3	4.629e-012	2.293e-012	-11.334	-11.640	-0.305
H3AsO4	2.358e-013	2.361e-013	-12.627	-12.627	0.001
C(4)	4.030e-003				
HCO3-	3.618e-003	3.353e-003	-2.442	-2.475	-0.033
CO2	3.614e-004	3.619e-004	-3.442	-3.441	0.001
CaHCO3+	3.351e-005	3.100e-005	-4.475	-4.509	-0.034
MgHCO3+	7.065e-006	6.534e-006	-5.151	-5.185	-0.034
CO3-2	4.069e-006	3.003e-006	-5.390	-5.522	-0.132
CaCO3	3.831e-006	3.836e-006	-5.417	-5.416	0.001
NaHCO3	7.444e-007	7.454e-007	-6.128	-6.128	0.001
S(6)	9.517e-005				
SO4-2	8.319e-005	6.120e-005	-4.080	-4.213	-0.133
CaSO4	9.929e-006	9.942e-006	-5.003	-5.003	0.001
MgSO4	1.810e-006	1.812e-006	-5.742	-5.742	0.001

```
Phase                SI log IAP  log KT

Anhydrite        -2.92   -7.25   -4.33  CaSO4
Aragonite        -0.29   -8.56   -8.27  CaCO3
Arsenolite      -12.77  -14.37   -1.59  As2O3
Artinite         -8.71    1.75   10.46  MgCO3:Mg(OH)2:3H2O
As2O5(cr)       -33.71  -25.25    8.45  As2O5
As_native       -16.03  -29.38  -13.36  As
Birnessite      -19.77   23.83   43.60  MnO2
Bixbyite        -19.55  -19.71   -0.15  Mn2O3
Brucite          -6.61   11.04   17.65  Mg(OH)2
Ca3(AsO4)2:4w   -13.49  -32.40  -18.91  Ca3(AsO4)2:4H2O
Calcite          -0.14   -8.56   -8.42  CaCO3
Claudetite      -12.82  -14.37   -1.54  As2O3
CO2(g)           -2.12   -3.44   -1.32  CO2
Dolomite         -1.04  -17.85  -16.81  CaMg(CO3)2
Dolomite(d)      -1.64  -17.85  -16.21  CaMg(CO3)2
Epsomite         -5.75   -7.98   -2.22  MgSO4:7H2O
Gypsum           -2.67   -7.25   -4.59  CaSO4:2H2O
H2(g)           -14.80  -17.90   -3.10  H2
H2O(g)           -1.83   -0.00    1.83  H2O
Halite           -9.20   -7.64    1.55  NaCl
Hausmannite     -22.16   41.89   64.04  Mn3O4
Huntite          -7.22  -36.42  -29.20  CaMg3(CO3)4
Hydromagnesite  -18.90  -26.10   -7.20  Mg5(CO3)4(OH)2:4H2O
Magnesite        -1.44   -9.28   -7.84  MgCO3
Manganite        -8.91   16.43   25.34  MnOOH
Mirabilite       -9.34  -11.02   -1.68  Na2SO4:10H2O
Mn2(SO4)3       -72.21  -76.75   -4.54  Mn2(SO4)3
Mn3(AsO4)2:8H2O -11.89  -40.59  -28.71  Mn3(AsO4)2:8H2O
MnCl2:4H2O      -16.44  -14.25    2.19  MnCl2:4H2O
MnSO4           -13.12   -9.98    3.13  MnSO4
Nahcolite        -5.22   -5.88   -0.66  NaHCO3
Natron          -10.55  -12.33   -1.78  Na2CO3:10H2O
Nesquehonite     -3.84   -9.28   -5.45  MgCO3:3H2O
Nsutite         -18.74   23.83   42.56  MnO2
O2(g)           -57.72  -60.52   -2.80  O2
Portlandite     -11.97   11.76   23.73  Ca(OH)2
Pyrochroite      -6.17    9.03   15.20  Mn(OH)2
Pyrolusite      -19.50   23.83   43.33  MnO2
Rhodochrosite    -0.21  -11.29  -11.09  MnCO3
Rhodochrosite(d)  -0.90  -11.29  -10.39  MnCO3
Thenardite      -10.86  -11.02   -0.16  Na2SO4
Thermonatrite   -12.54  -12.33    0.21  Na2CO3:H2O
Trona           -17.95  -18.21   -0.26  NaHCO3:Na2CO3:2H2O
```

```
   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Uranium.pqi
  Output file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Beemer 1.20.06 1152 80' 100gpm 60min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat

                                       pH  =   7.200
                                       pe  =   0.000
```

```
                    Activity of water  =   1.000
                       Ionic strength  =  9.324e-003
                   Mass of water (kg)  =  1.000e+000
                Total carbon (mol/kg)  =  6.518e-003
                   Total CO2 (mol/kg)  =  6.518e-003
                  Temperature (deg C)  =   9.000
              Electrical balance (eq)  =  2.357e-004
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =   1.84
                           Iterations  =  10
                              Total H  = 1.110180e+002
                              Total O  = 5.552621e+001

----------------------------Distribution of species--------------------
--------

                                            Log       Log         Log
   Species    Molality    Activity  Molality  Activity     Gamma

   H+         6.877e-008  6.310e-008    -7.163    -7.200    -0.037
   OH-        4.674e-008  4.239e-008    -7.330    -7.373    -0.042
   H2O        5.551e+001  9.998e-001     1.744    -0.000     0.000

C(4)          6.518e-003
   HCO3-      5.474e-003  4.981e-003    -2.262    -2.303    -0.041
   CO2        9.326e-004  9.346e-004    -3.030    -3.029     0.001
   CaHCO3+    6.651e-005  6.033e-005    -4.177    -4.219    -0.042
   MgHCO3+    2.838e-005  2.575e-005    -4.547    -4.589    -0.042
   CaCO3      4.524e-006  4.533e-006    -5.345    -5.344     0.001
   CO3-2      3.637e-006  2.493e-006    -5.439    -5.603    -0.164
   NaHCO3     2.575e-006  2.581e-006    -5.589    -5.588     0.001

Fe(2)           7.703e-006
   Fe+2         5.385e-006  3.645e-006    -5.269    -5.438    -0.169
   FeHCO3+      2.002e-006  1.816e-006    -5.699    -5.741    -0.042
   FeCO3        2.175e-007  2.180e-007    -6.663    -6.662     0.001
   FeSO4        9.220e-008  9.240e-008    -7.035    -7.034     0.001

Fe(3)           3.004e-011
   Fe(OH)2+     1.588e-011  1.440e-011   -10.799   -10.842    -0.042
   Fe(OH)3      1.404e-011  1.407e-011   -10.853   -10.852     0.001

S(6)            3.437e-004
   SO4-2        2.847e-004  1.942e-004    -3.546    -3.712    -0.166
   CaSO4        4.430e-005  4.440e-005    -4.354    -4.353     0.001
   MgSO4        1.355e-005  1.358e-005    -4.868    -4.867     0.001

U(4)            4.995e-012
   U(OH)4       4.994e-012  5.004e-012   -11.302   -11.301     0.001
   U(OH)3+      1.558e-015  1.414e-015   -14.807   -14.850    -0.042

U(6)            7.775e-007
   UO2(CO3)3-4  4.295e-007  9.019e-008    -6.367    -7.045    -0.678
   UO2(CO3)2-2  3.425e-007  2.319e-007    -6.465    -6.635    -0.169
   UO2CO3       5.388e-009  5.400e-009    -8.269    -8.268     0.001
   UO2(OH)3-    1.576e-010  1.430e-010    -9.802    -9.845    -0.042
   UO2OH+       2.188e-011  1.984e-011   -10.660   -10.702    -0.042
   UO2+2        8.414e-013  5.696e-013   -12.075   -12.244    -0.169
```

```
   UO2SO4       9.942e-014  9.963e-014   -13.003   -13.002     0.001


------------------------------Saturation indices-----------------------
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      Phase               SI log IAP  log KT

      Anhydrite         -2.25   -6.58   -4.34  CaSO4
      Aragonite         -0.22   -8.48   -8.25  CaCO3
      Artinite          -8.67    2.12   10.79  MgCO3:Mg(OH)2:3H2O
      B-UO2(OH)2        -3.96    2.16    6.11  UO2(OH)2
      Birnessite       -20.74   22.87   43.60  MnO2
      Bixbyite         -21.86  -21.83    0.02  Mn2O3
      Brucite           -6.90   11.06   17.97  Mg(OH)2
      Calcite           -0.07   -8.48   -8.41  CaCO3
      CO2(g)            -1.77   -3.03   -1.25  CO2
      Dolomite          -0.72  -17.42  -16.70  CaMg(CO3)2
      Dolomite(d)       -1.34  -17.42  -16.08  CaMg(CO3)2
      Epsomite          -4.79   -7.05   -2.26  MgSO4:7H2O
      Fe(OH)2.7Cl.3      2.51   -0.53   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)        -2.15    2.74    4.89  Fe(OH)3
      Fe3(OH)8          -5.78   14.44   20.22  Fe3(OH)8
      Goethite           3.14    2.74   -0.40  FeOOH
      Gummite           -9.20    2.16   11.36  UO3
      Gypsum            -1.99   -6.58   -4.59  CaSO4:2H2O
      H2(g)            -14.40  -17.48   -3.08  H2
      H2O(g)            -1.95   -0.00    1.95  H2O
      Halite            -8.27   -6.72    1.54  NaCl
      Hausmannite      -25.42   39.80   65.21  Mn3O4
      Hematite           8.20    5.48   -2.73  Fe2O3
      Huntite           -6.40  -35.29  -28.90  CaMg3(CO3)4
      Hydromagnesite   -18.10  -24.69   -6.59  Mg5(CO3)4(OH)2:4H2O
      Jarosite(ss)     -15.53  -25.36   -9.83
(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
      Jarosite-K       -16.82  -24.73   -7.91  KFe3(SO4)2(OH)6
      Jarosite-Na      -20.07  -23.84   -3.78  NaFe3(SO4)2(OH)6
      JarositeH        -24.91  -28.01   -3.10  (H3O)Fe3(SO4)2(OH)6
      Maghemite         -0.91    5.48    6.39  Fe2O3
      Magnesite         -1.17   -8.94   -7.77  MgCO3
      Magnetite          8.61   14.44    5.83  Fe3O4
      Manganite         -9.67   15.67   25.34  MnOOH
      Melanterite       -6.73   -9.15   -2.42  FeSO4:7H2O
      Mirabilite        -7.88   -9.78   -1.90  Na2SO4:10H2O
      Mn2(SO4)3        -72.08  -76.17   -4.09  Mn2(SO4)3
      MnCl2:4H2O       -15.30  -13.31    1.99  MnCl2:4H2O
      MnSO4            -12.96   -9.65    3.31  MnSO4
      Na4UO2(CO3)3     -24.91  -41.20  -16.29  Na4UO2(CO3)3
      Nahcolite         -4.64   -5.34   -0.70  NaHCO3
      Natron            -9.71  -11.68   -1.97  Na2CO3:10H2O
      Nesquehonite      -3.56   -8.94   -5.38  MgCO3:3H2O
      Nsutite          -19.70   22.87   42.56  MnO2
      O2(g)            -60.13  -62.88   -2.76  O2
      Portlandite      -12.56   11.53   24.09  Ca(OH)2
      Pyrochroite       -6.73    8.47   15.20  Mn(OH)2
      Pyrolusite       -21.22   22.87   44.09  MnO2
      Rhodochrosite     -0.47  -11.54  -11.07  MnCO3
```

```
      Rhodochrosite(d)  -1.15  -11.54  -10.39  MnCO3
      Rutherfordine    -3.46  -17.85  -14.39  UO2CO3
      Schoepite        -3.75    2.16    5.90  UO2(OH)2:H2O
      Siderite         -0.25  -11.04  -10.79  FeCO3
      Siderite(d)(3)   -0.59  -11.04  -10.45  FeCO3
      Thenardite       -9.63   -9.78   -0.16  Na2SO4
      Thermonatrite   -11.92  -11.67    0.24  Na2CO3:H2O
      Trona           -16.97  -17.01   -0.05  NaHCO3:Na2CO3:2H2O
      U(OH)2SO4       -16.69  -19.89   -3.20  U(OH)2SO4
      U3O8(c)          -1.87   23.48   25.35  U3O8
      U4O9(c)           6.48    7.31    0.82  U4O9
      UO2(a)           -1.87   -1.77    0.10  UO2
      UO3(gamma)       -6.37    2.16    8.52  UO3
      Uraninite(c)      2.25   -1.77   -4.03  UO2
```

```
   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Uranium.pqi
  Output file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Beemer 1.20.06 1525 80' 500gpm 60min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat
```

```
                                        pH  =   7.200
                                        pe  =   0.000
                         Activity of water  =   1.000
                            Ionic strength  =  9.714e-003
                        Mass of water (kg)  =  1.000e+000
                     Total carbon (mol/kg)  =  7.496e-003
                        Total CO2 (mol/kg)  =  7.496e-003
                       Temperature (deg C)  =   9.000
                  Electrical balance (eq)  = -6.787e-004
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -4.99
                                Iterations  =  10
                                   Total H  = 1.110188e+002
                                   Total O  = 5.552909e+001
```

```
----------------------------Distribution of species--------------------
--------

                                          Log       Log         Log
   Species      Molality    Activity  Molality  Activity     Gamma

   H+          6.886e-008  6.310e-008    -7.162    -7.200    -0.038
   OH-         4.682e-008  4.239e-008    -7.330    -7.373    -0.043
   H2O         5.551e+001  9.998e-001     1.744    -0.000     0.000

C(4)            7.496e-003
   HCO3-       6.300e-003  5.723e-003    -2.201    -2.242    -0.042
   CO2         1.071e-003  1.074e-003    -2.970    -2.969     0.001
   CaHCO3+     7.505e-005  6.796e-005    -4.125    -4.168    -0.043
   MgHCO3+     3.205e-005  2.902e-005    -4.494    -4.537    -0.043
   CaCO3       5.095e-006  5.106e-006    -5.293    -5.292     0.001

Fe(2)          5.554e-006
   Fe+2        3.727e-006  2.505e-006    -5.429    -5.601    -0.173
   FeHCO3+     1.583e-006  1.434e-006    -5.800    -5.844    -0.043
```

```
   FeCO3        1.717e-007  1.721e-007    -6.765    -6.764     0.001
   FeSO4        6.704e-008  6.719e-008    -7.174    -7.173     0.001

Fe(3)            2.066e-011
   Fe(OH)2+     1.093e-011  9.898e-012   -10.961   -11.004    -0.043
   Fe(OH)3      9.648e-012  9.669e-012   -11.016   -11.015     0.001

S(6)             3.645e-004
   SO4-2        3.033e-004  2.055e-004    -3.518    -3.687    -0.169
   CaSO4        4.595e-005  4.606e-005    -4.338    -4.337     0.001
   MgSO4        1.407e-005  1.410e-005    -4.852    -4.851     0.001

U(4)             2.894e-012
   U(OH)4       2.893e-012  2.899e-012   -11.539   -11.538     0.001
   U(OH)3+      9.046e-016  8.191e-016   -15.044   -15.087    -0.043

U(6)             6.557e-007
   UO2(CO3)3-4  3.882e-007  7.925e-008    -6.411    -7.101    -0.690
   UO2(CO3)2-2  2.638e-007  1.773e-007    -6.579    -6.751    -0.173
   UO2CO3       3.587e-009  3.595e-009    -8.445    -8.444     0.001
   UO2(OH)3-    9.150e-011  8.285e-011   -10.039   -10.082    -0.043
   UO2OH+       1.270e-011  1.150e-011   -10.896   -10.939    -0.043
   UO2+2        4.910e-013  3.300e-013   -12.309   -12.481    -0.173
   UO2SO4       6.095e-014  6.109e-014   -13.215   -13.214     0.001
   ------------------------------Saturation indices--------------------
-----------

      Phase               SI log IAP  log KT

      Anhydrite        -2.23   -6.57   -4.34  CaSO4
      Aragonite        -0.17   -8.42   -8.25  CaCO3
      Artinite         -8.63    2.17   10.79  MgCO3:Mg(OH)2:3H2O
      B-UO2(OH)2       -4.20    1.92    6.11  UO2(OH)2
      Birnessite      -20.76   22.84   43.60  MnO2
      Bixbyite        -21.90  -21.88    0.02  Mn2O3
      Brucite          -6.91   11.06   17.97  Mg(OH)2
      Calcite          -0.02   -8.42   -8.41  CaCO3
      CO2(g)           -1.71   -2.97   -1.25  CO2
      Dolomite         -0.61  -17.31  -16.70  CaMg(CO3)2
      Dolomite(d)      -1.23  -17.31  -16.08  CaMg(CO3)2
      Epsomite         -4.78   -7.03   -2.26  MgSO4:7H2O
      Fe(OH)2.7Cl.3     2.35   -0.69   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)       -2.31    2.58    4.89  Fe(OH)3
      Fe3(OH)8         -6.27   13.95   20.22  Fe3(OH)8
      Goethite          2.97    2.58   -0.40  FeOOH
      Gummite          -9.44    1.92   11.36  UO3
      Gypsum           -1.98   -6.57   -4.59  CaSO4:2H2O
      H2(g)           -14.40  -17.48   -3.08  H2
      H2O(g)           -1.95   -0.00    1.95  H2O
      Halite           -8.27   -6.72    1.54  NaCl
      Hausmannite     -25.48   39.73   65.21  Mn3O4
      Hematite          7.88    5.15   -2.73  Fe2O3
      Huntite          -6.19  -35.09  -28.90  CaMg3(CO3)4
      Hydromagnesite  -17.90  -24.50   -6.59  Mg5(CO3)4(OH)2:4H2O
      Jarosite(ss)    -15.95  -25.78   -9.83
(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
      Jarosite-K      -17.24  -25.15   -7.91  KFe3(SO4)2(OH)6
```

```
      Jarosite-Na      -20.50  -24.28   -3.78  NaFe3(SO4)2(OH)6
      JarositeH        -25.35  -28.45   -3.10  (H3O)Fe3(SO4)2(OH)6
      Maghemite         -1.23    5.15    6.39  Fe2O3
      Magnesite         -1.11   -8.89   -7.77  MgCO3
      Magnetite          8.12   13.95    5.83  Fe3O4
      Manganite         -9.70   15.64   25.34  MnOOH
      Melanterite       -6.86   -9.29   -2.42  FeSO4:7H2O
      Mirabilite        -7.85   -9.76   -1.90  Na2SO4:10H2O
      Mn2(SO4)3        -72.05  -76.14   -4.09  Mn2(SO4)3
      MnCl2:4H2O       -15.32  -13.34    1.99  MnCl2:4H2O
      MnSO4            -12.96   -9.64    3.31  MnSO4
      Na4UO2(CO3)3     -24.96  -41.25  -16.29  Na4UO2(CO3)3
      Nahcolite         -4.57   -5.28   -0.70  NaHCO3
      Natron            -9.65  -11.61   -1.97  Na2CO3:10H2O
      Nesquehonite      -3.51   -8.89   -5.38  MgCO3:3H2O
      Nsutite          -19.72   22.84   42.56  MnO2
      O2(g)            -60.13  -62.88   -2.76  O2
      Portlandite      -12.57   11.52   24.09  Ca(OH)2
      Pyrochroite       -6.76    8.44   15.20  Mn(OH)2
      Pyrolusite       -21.24   22.84   44.09  MnO2
      Rhodochrosite     -0.43  -11.50  -11.07  MnCO3
      Rhodochrosite(d)  -1.11  -11.50  -10.39  MnCO3
      Rutherfordine     -3.63  -18.02  -14.39  UO2CO3
      Schoepite         -3.99    1.92    5.90  UO2(OH)2:H2O
      Siderite          -0.36  -11.14  -10.79  FeCO3
      Siderite(d)(3)    -0.69  -11.14  -10.45  FeCO3
      Thenardite        -9.60   -9.76   -0.16  Na2SO4
      Thermonatrite    -11.85  -11.61    0.24  Na2CO3:H2O
      Trona            -16.84  -16.89   -0.05  NaHCO3:Na2CO3:2H2O
      U(OH)2SO4        -16.90  -20.10   -3.20  U(OH)2SO4
      U3O8(c)           -2.58   22.77   25.35  U3O8
      U4O9(c)            5.53    6.36    0.82  U4O9
      UO2(a)            -2.11   -2.01    0.10  UO2
      UO3(gamma)        -6.60    1.92    8.52  UO3
      Uraninite(c)       2.02   -2.01   -4.03  UO2

   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Uranium.pqi
  Output file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Bellwood761 6.19.06 0850 41' 250gpm 60min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat
                                           pH  =   6.400
                                           pe  =   0.000
                            Activity of water  =   1.000
                               Ionic strength  =  1.047e-002
                           Mass of water (kg)  =  1.000e+000
                        Total carbon (mol/kg)  =  1.188e-002
                           Total CO2 (mol/kg)  =  1.188e-002
                          Temperature (deg C)  =  11.500
                      Electrical balance (eq)  = -2.571e-003
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  = -18.03
                                   Iterations  =  12
                                      Total H  = 1.110184e+002
                                      Total O  = 5.554115e+001
```

----------------------------Distribution of species--------------------
----

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
H+	4.357e-007	3.981e-007	-6.361	-6.400	-0.039
OH-	9.294e-009	8.384e-009	-8.032	-8.077	-0.045
H2O	5.551e+001	9.997e-001	1.744	-0.000	0.000
C(4)	1.188e-002				
CO2	5.928e-003	5.942e-003	-2.227	-2.226	0.001
HCO3-	5.860e-003	5.305e-003	-2.232	-2.275	-0.043
CaHCO3+	8.458e-005	7.630e-005	-4.073	-4.117	-0.045
NaHCO3	2.756e-006	2.762e-006	-5.560	-5.559	0.001
Fe(2)	6.808e-006				
Fe+2	4.650e-006	3.080e-006	-5.333	-5.511	-0.179
FeHCO3+	1.811e-006	1.634e-006	-5.742	-5.787	-0.045
FeSO4	3.112e-007	3.120e-007	-6.507	-6.506	0.001
FeCO3	3.333e-008	3.341e-008	-7.477	-7.476	0.001
Fe(3)	5.979e-013				
Fe(OH)2+	5.153e-013	4.649e-013	-12.288	-12.333	-0.045
Fe(OH)3	8.101e-014	8.120e-014	-13.091	-13.090	0.001
FeOH+2	1.443e-015	9.559e-016	-14.841	-15.020	-0.179
U(4)	1.909e-010				
U(OH)4	1.906e-010	1.910e-010	-9.720	-9.719	0.001
U(OH)3+	3.652e-013	3.294e-013	-12.438	-12.482	-0.045
U(OH)2+2	1.357e-016	8.990e-017	-15.867	-16.046	-0.179
U(6)	7.007e-007				
UO2(CO3)2-2	5.485e-007	3.633e-007	-6.261	-6.440	-0.179
UO2(CO3)3-4	1.077e-007	2.073e-008	-6.968	-7.683	-0.716
UO2CO3	4.424e-008	4.435e-008	-7.354	-7.353	0.001
UO2OH+	1.840e-010	1.660e-010	-9.735	-9.780	-0.045
UO2+2	3.820e-011	2.531e-011	-10.418	-10.597	-0.179
UO2(OH)3-	2.803e-011	2.528e-011	-10.552	-10.597	-0.045
UO2SO4	1.806e-011	1.810e-011	-10.743	-10.742	0.001

------------------------------Saturation indices--------------------
----

Phase	SI	log IAP	log KT	
Anhydrite	-1.63	-5.96	-4.33	CaSO4
Aragonite	-0.91	-9.17	-8.26	CaCO3
Artinite	-14.22	-3.62	10.60	MgCO3:Mg(OH)2:3H2O
B-UO2(OH)2	-3.82	2.20	6.02	UO2(OH)2
Birnessite	-23.51	20.09	43.60	MnO2
Bixbyite	-25.35	-25.43	-0.08	Mn2O3
Brucite	-10.02	7.76	17.78	Mg(OH)2
Calcite	-0.76	-9.17	-8.42	CaCO3
CO2(g)	-0.93	-2.23	-1.29	CO2
Dolomite	-3.79	-20.56	-16.76	CaMg(CO3)2
Dolomite(d)	-4.40	-20.56	-16.15	CaMg(CO3)2
Epsomite	-5.93	-8.17	-2.24	MgSO4:7H2O

Fe(OH)2.7Cl.3	0.40	-2.64	-3.04	Fe(OH)2.7Cl0.3
Fe(OH)3(a)	-4.56	0.33	4.89	Fe(OH)3
Fe3(OH)8	-12.27	7.95	20.22	Fe3(OH)8
Goethite	0.83	0.33	-0.50	FeOOH
Gummite	-9.00	2.20	11.20	UO3
Gypsum	-1.37	-5.96	-4.59	CaSO4:2H2O
H2(g)	-12.80	-15.89	-3.09	H2
H2O(g)	-1.88	-0.00	1.88	H2O
Halite	-8.10	-6.55	1.55	NaCl
Hausmannite	-29.85	34.68	64.53	Mn3O4
Hematite	3.60	0.66	-2.94	Fe2O3
Huntite	-14.25	-43.32	-29.07	CaMg3(CO3)4
Hydromagnesite	-30.83	-37.78	-6.95	Mg5(CO3)4(OH)2:4H2O
Jarosite(ss)	-18.81	-28.64	-9.83	(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
Jarosite-K	-19.99	-28.11	-8.12	KFe3(SO4)2(OH)6
Jarosite-Na	-23.48	-27.50	-4.02	NaFe3(SO4)2(OH)6
JarositeH	-27.40	-30.87	-3.47	(H3O)Fe3(SO4)2(OH)6
Maghemite	-5.72	0.66	6.39	Fe2O3
Magnesite	-3.57	-11.38	-7.81	MgCO3
Magnetite	2.46	7.95	5.49	Fe3O4
Manganite	-11.65	13.69	25.34	MnOOH
Melanterite	-6.26	-8.64	-2.39	FeSO4:7H2O
Mirabilite	-7.43	-9.20	-1.77	Na2SO4:10H2O
Mn2(SO4)3	-68.87	-73.23	-4.35	Mn2(SO4)3
MnCl2:4H2O	-14.65	-12.54	2.11	MnCl2:4H2O
MnSO4	-11.85	-8.64	3.21	MnSO4
Na4UO2(CO3)3	-25.47	-41.76	-16.29	Na4UO2(CO3)3
Nahcolite	-4.63	-5.31	-0.68	NaHCO3
Natron	-10.55	-12.41	-1.86	Na2CO3:10H2O
Nesquehonite	-5.96	-11.38	-5.42	MgCO3:3H2O
Nsutite	-22.47	20.09	42.56	MnO2
O2(g)	-62.39	-65.17	-2.78	O2
Portlandite	-13.91	9.97	23.88	Ca(OH)2
Pyrochroite	-7.91	7.29	15.20	Mn(OH)2
Pyrolusite	-23.55	20.09	43.64	MnO2
Rhodochrosite	-0.77	-11.85	-11.08	MnCO3
Rhodochrosite(d)	-1.46	-11.85	-10.39	MnCO3
Rutherfordine	-2.54	-16.94	-14.40	UO2CO3
Schoepite	-3.62	2.20	5.82	UO2(OH)2:H2O
Siderite	-1.05	-11.86	-10.80	FeCO3
Siderite(d)(3)	-1.41	-11.86	-10.45	FeCO3
Thenardite	-9.04	-9.20	-0.16	Na2SO4
Thermonatrite	-12.63	-12.41	0.22	Na2CO3:H2O
Trona	-17.55	-17.72	-0.17	NaHCO3:Na2CO3:2H2O
U(OH)2SO4	-13.09	-16.29	-3.20	U(OH)2SO4
U3O8(c)	-0.04	24.52	24.56	U3O8
U4O9(c)	11.23	11.36	0.14	U4O9
UO2(a)	-0.46	-0.36	0.10	UO2
UO3(gamma)	-6.19	2.20	8.39	UO3
Uraninite(c)	3.79	-0.36	-4.15	UO2

Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic and Uranium\Uranium.pqi

Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC results\Bellwood761 6.21.06 1107 104' 3gpm 1-30min.pqo

Database file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\wateq4f.dat

```
                                       pH  =   7.300
                                       pe  =   0.000
                        Activity of water  =   1.000
                           Ionic strength  =  1.127e-002
                       Mass of water (kg)  =  1.000e+000
                 Total carbon (mol/kg)     =  6.603e-003
                    Total CO2 (mol/kg)     =  6.603e-003
                    Temperature (deg C)    =  12.000
                 Electrical balance (eq)   = -1.424e-003
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -9.51
                               Iterations  =   9
                                  Total H  = 1.110183e+002
                                  Total O  = 5.553043e+001
```

----------------------------Distribution of species----------------------------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
OH-	7.738e-008	6.957e-008	-7.111	-7.158	-0.046
H+	5.500e-008	5.012e-008	-7.260	-7.300	-0.040
H2O	5.551e+001	9.998e-001	1.744	-0.000	0.000
C(4)	6.603e-003				
HCO3-	5.752e-003	5.191e-003	-2.240	-2.285	-0.045
CO2	7.223e-004	7.242e-004	-3.141	-3.140	0.001
CaHCO3+	7.987e-005	7.181e-005	-4.098	-4.144	-0.046
MgHCO3+	2.480e-005	2.229e-005	-4.606	-4.652	-0.046
CaCO3	6.940e-006	6.958e-006	-5.159	-5.158	0.001
CO3-2	5.376e-006	3.564e-006	-5.270	-5.448	-0.178
Fe(2)	1.344e-005				
Fe+2	8.970e-006	5.861e-006	-5.047	-5.232	-0.185
FeHCO3+	3.384e-006	3.042e-006	-5.471	-5.517	-0.046
FeSO4	5.662e-007	5.677e-007	-6.247	-6.246	0.001
FeCO3	4.998e-007	5.011e-007	-6.301	-6.300	0.001
FeOH+	1.489e-008	1.339e-008	-7.827	-7.873	-0.046
Fe(3)	1.545e-010				
Fe(OH)3	8.598e-011	8.620e-011	-10.066	-10.064	0.001
Fe(OH)2+	6.747e-011	6.066e-011	-10.171	-10.217	-0.046
S(6)	1.281e-003				
SO4-2	1.060e-003	6.984e-004	-2.975	-3.156	-0.181
CaSO4	1.727e-004	1.732e-004	-3.763	-3.762	0.001
MgSO4	4.393e-005	4.404e-005	-4.357	-4.356	0.001
NaSO4-	3.172e-006	2.852e-006	-5.499	-5.545	-0.046
U(4)	1.547e-012				
U(OH)4	1.546e-012	1.550e-012	-11.811	-11.810	0.001
U(OH)3+	3.719e-016	3.344e-016	-15.430	-15.476	-0.046
U(6)	7.482e-007				

```
   UO2(CO3)3-4   4.525e-007  8.249e-008    -6.344    -7.084    -0.739
   UO2(CO3)2-2   2.927e-007  1.913e-007    -6.534    -6.718    -0.185
   UO2CO3        2.925e-009  2.933e-009    -8.534    -8.533     0.001
   UO2(OH)3-     1.179e-010  1.060e-010    -9.929    -9.975    -0.046

------------------------------Saturation indices-----------------------
--------

      Phase               SI log IAP  log KT

      Anhydrite        -1.67   -6.01   -4.33  CaSO4
      Aragonite        -0.03   -8.30   -8.26  CaCO3
      Artinite         -8.25    2.32   10.56  MgCO3:Mg(OH)2:3H2O
      B-UO2(OH)2       -4.08    1.93    6.00  UO2(OH)2
      Birnessite      -19.98   23.62   43.60  MnO2
      Bixbyite        -20.00  -20.10   -0.10  Mn2O3
      Brucite          -6.56   11.18   17.75  Mg(OH)2
      Calcite           0.12   -8.30   -8.42  CaCO3
      CO2(g)           -1.84   -3.14   -1.30  CO2
      Dolomite         -0.39  -17.16  -16.77  CaMg(CO3)2
      Dolomite(d)      -1.00  -17.16  -16.17  CaMg(CO3)2
      Epsomite         -4.34   -6.57   -2.23  MgSO4:7H2O
      Fe(OH)2.7Cl.3     3.11    0.07   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)       -1.57    3.32    4.89  Fe(OH)3
      Fe3(OH)8         -4.21   16.02   20.22  Fe3(OH)8
      Goethite          3.84    3.32   -0.52  FeOOH
      Gummite          -9.25    1.93   11.17  UO3
      Gypsum           -1.42   -6.01   -4.59  CaSO4:2H2O
      H2(g)           -14.60  -17.69   -3.09  H2
      H2O(g)           -1.86   -0.00    1.86  H2O
      Halite           -8.16   -6.61    1.55  NaCl
      Hausmannite     -22.73   41.66   64.39  Mn3O4
      Hematite          9.63    6.65   -2.98  Fe2O3
      Huntite          -5.79  -34.90  -29.11  CaMg3(CO3)4
      Hydromagnesite  -17.27  -24.28   -7.02  Mg5(CO3)4(OH)2:4H2O
      Jarosite(ss)    -12.77  -22.60   -9.83
(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
      Jarosite-K      -13.72  -21.89   -8.16  KFe3(SO4)2(OH)6
      Jarosite-Na     -17.22  -21.29   -4.07  NaFe3(SO4)2(OH)6
      JarositeH       -21.99  -25.54   -3.55  (H3O)Fe3(SO4)2(OH)6
      Maghemite         0.26    6.65    6.39  Fe2O3
      Magnesite        -1.04   -8.87   -7.82  MgCO3
      Magnetite        10.59   16.02    5.42  Fe3O4
      Manganite        -9.02   16.32   25.34  MnOOH
      Melanterite      -6.01   -8.39   -2.38  FeSO4:7H2O
      Mirabilite       -7.51   -9.26   -1.75  Na2SO4:10H2O
      Mn2(SO4)3       -68.97  -73.37   -4.41  Mn2(SO4)3
      MnCl2:4H2O      -14.82  -12.69    2.13  MnCl2:4H2O
      MnSO4           -11.92   -8.74    3.19  MnSO4
      Na4UO2(CO3)3    -24.93  -41.22  -16.29  Na4UO2(CO3)3
      Nahcolite        -4.66   -5.34   -0.67  NaHCO3
      Natron           -9.71  -11.55   -1.84  Na2CO3:10H2O
      Nesquehonite     -3.44   -8.87   -5.43  MgCO3:3H2O
      Nsutite         -18.94   23.62   42.56  MnO2
      O2(g)           -58.60  -61.38   -2.78  O2
      Portlandite     -12.09   11.75   23.84  Ca(OH)2
      Pyrochroite      -6.18    9.02   15.20  Mn(OH)2
```

```
      Pyrolusite      -19.94   23.62   43.56  MnO2
      Rhodochrosite     0.05  -11.03  -11.08  MnCO3
      Rhodochrosite(d)  -0.64  -11.03  -10.39  MnCO3
      Rutherfordine    -3.72  -18.12  -14.40  UO2CO3
      Schoepite        -3.88    1.93    5.81  UO2(OH)2:H2O
      Siderite          0.13  -10.68  -10.81  FeCO3
      Siderite(d)(3)   -0.23  -10.68  -10.45  FeCO3
      Thenardite       -9.10   -9.26   -0.16  Na2SO4
      Thermonatrite   -11.77  -11.55    0.22  Na2CO3:H2O
      Trona           -16.69  -16.89   -0.19  NaHCO3:Na2CO3:2H2O
      U(OH)2SO4       -17.04  -20.24   -3.20  U(OH)2SO4
      U3O8(c)          -2.66   21.75   24.41  U3O8
      U4O9(c)           4.67    4.66   -0.00  U4O9
      UO2(a)           -2.58   -2.48    0.10  UO2
      UO3(gamma)       -6.44    1.93    8.36  UO3
      Uraninite(c)      1.69   -2.48   -4.18  UO2

   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Uranium.pqi
  Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC
results\Benkelman96-1 8.13.03 0820 36' 400gpm.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat

                                      pH  =   7.400
                                      pe  =   0.000
                       Activity of water  =   1.000
                          Ionic strength  =  1.808e-002
                      Mass of water (kg)  =  1.000e+000
                   Total carbon (mol/kg)  =  7.626e-003
                      Total CO2 (mol/kg)  =  7.626e-003
                     Temperature (deg C)  =  12.800
                 Electrical balance (eq)  =  7.848e-004
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =   3.01
                              Iterations  =   9
                                 Total H  = 1.110194e+002
                                 Total O  = 5.553917e+001

----------------------------Distribution of species--------------------
--------

                                            Log       Log         Log
   Species       Molality    Activity  Molality  Activity     Gamma

   OH-         1.069e-007  9.385e-008    -6.971    -7.028    -0.056
   H+          4.448e-008  3.981e-008    -7.352    -7.400    -0.048
   H2O         5.551e+001  9.996e-001     1.744    -0.000     0.000

As(3)          4.850e-008
   H3AsO3      4.790e-008  4.810e-008    -7.320    -7.318     0.002
   H2AsO3-     6.064e-010  5.324e-010    -9.217    -9.274    -0.056
   H4AsO3+     1.080e-015  9.486e-016   -14.966   -15.023    -0.056
   HAsO3-2     2.594e-017  1.542e-017   -16.586   -16.812    -0.226
   AsO3-3      1.612e-025  4.998e-026   -24.793   -25.301    -0.508

As(5)          8.777e-008
   HAsO4-2     6.217e-008  3.695e-008    -7.206    -7.432    -0.226
```

```
   H2AsO4-      2.559e-008  2.247e-008    -7.592    -7.648    -0.056
   AsO4-3       4.898e-012  1.519e-012   -11.310   -11.818    -0.508
   H3AsO4       1.574e-013  1.581e-013   -12.803   -12.801     0.002

C(4)            7.626e-003
   HCO3-        6.790e-003  5.992e-003    -2.168    -2.222    -0.054
   CO2          6.507e-004  6.534e-004    -3.187    -3.185     0.002
   CaHCO3+      8.452e-005  7.421e-005    -4.073    -4.130    -0.056
   MgHCO3+      5.135e-005  4.509e-005    -4.289    -4.346    -0.056
   NaHCO3       1.950e-005  1.958e-005    -4.710    -4.708     0.002
   CaCO3        9.092e-006  9.130e-006    -5.041    -5.040     0.002
   CO3-2        8.730e-006  5.295e-006    -5.059    -5.276    -0.217

Fe(2)           1.864e-005
   Fe+2         1.181e-005  7.017e-006    -4.928    -5.154    -0.226
   FeHCO3+      4.789e-006  4.205e-006    -5.320    -5.376    -0.056
   FeSO4        1.118e-006  1.123e-006    -5.952    -5.950     0.002
   FeCO3        8.875e-007  8.912e-007    -6.052    -6.050     0.002
   FeOH+        2.453e-008  2.154e-008    -7.610    -7.667    -0.056

Fe(3)           3.964e-010
   Fe(OH)3      2.430e-010  2.440e-010    -9.614    -9.613     0.002
   Fe(OH)2+     1.496e-010  1.313e-010    -9.825    -9.882    -0.056
   Fe(OH)4-     3.816e-012  3.351e-012   -11.418   -11.475    -0.056

S(6)            2.303e-003
   SO4-2        1.889e-003  1.135e-003    -2.724    -2.945    -0.221
   CaSO4        2.479e-004  2.489e-004    -3.606    -3.604     0.002
   MgSO4        1.276e-004  1.281e-004    -3.894    -3.892     0.002

------------------------------Saturation indices-----------------------
--------

      Phase               SI log IAP  log KT

      Anhydrite        -1.52   -5.85   -4.33  CaSO4
      Aragonite         0.08   -8.18   -8.27  CaCO3
      Arsenolite      -13.03  -14.64   -1.60  As2O3
      Artinite         -7.33    3.17   10.50  MgCO3:Mg(OH)2:3H2O
      As2O5(cr)       -34.07  -25.60    8.46  As2O5
      As_native       -16.12  -29.52  -13.39  As
      B-UO2(OH)2       -5.06    0.92    5.97  UO2(OH)2
      Birnessite      -19.55   24.05   43.60  MnO2
      Bixbyite        -19.19  -19.32   -0.13  Mn2O3
      Brucite          -6.06   11.62   17.69  Mg(OH)2
      Ca3(AsO4)2:4w   -13.45  -32.36  -18.91  Ca3(AsO4)2:4H2O
      Calcite           0.24   -8.18   -8.42  CaCO3
      Claudetite      -13.08  -14.64   -1.55  As2O3
      CO2(g)           -1.87   -3.18   -1.31  CO2
      Dolomite          0.16  -16.63  -16.79  CaMg(CO3)2
      Dolomite(d)      -0.44  -16.63  -16.19  CaMg(CO3)2
      Epsomite         -3.89   -6.12   -2.23  MgSO4:7H2O
      Fe(OH)2.7Cl.3     3.68    0.64   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)       -1.17    3.72    4.89  Fe(OH)3
      Fe3(OH)8         -3.13   17.09   20.22  Fe3(OH)8
      Goethite          4.27    3.72   -0.55  FeOOH
      Gummite         -10.21    0.92   11.12  UO3
```

Gypsum	-1.27	-5.85	-4.59	CaSO4:2H2O
H2(g)	-14.80	-17.89	-3.09	H2
H2O(g)	-1.84	-0.00	1.84	H2O
Halite	-6.67	-5.12	1.55	NaCl
Hausmannite	-21.61	42.57	64.18	Mn3O4
Hematite	10.49	7.45	-3.04	Fe2O3
Huntite	-4.38	-33.54	-29.16	CaMg3(CO3)4
Hydromagnesite	-15.05	-22.18	-7.13	Mg5(CO3)4(OH)2:4H2O
Jarosite(ss)	-11.32	-21.15	-9.83	(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
Jarosite-K	-12.17	-20.40	-8.23	KFe3(SO4)2(OH)6
Jarosite-Na	-15.01	-19.16	-4.15	NaFe3(SO4)2(OH)6
JarositeH	-20.66	-24.32	-3.67	(H3O)Fe3(SO4)2(OH)6
Maghemite	1.06	7.45	6.39	Fe2O3
Magnesite	-0.62	-8.45	-7.84	MgCO3
Magnetite	11.78	17.09	5.32	Fe3O4
Manganite	-8.69	16.65	25.34	MnOOH
Melanterite	-5.73	-8.10	-2.37	FeSO4:7H2O
Mirabilite	-5.71	-7.42	-1.71	Na2SO4:10H2O
Mn2(SO4)3	-68.07	-72.56	-4.49	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-11.57	-40.27	-28.71	Mn3(AsO4)2:8H2O
MnCl2:4H2O	-13.47	-11.30	2.17	MnCl2:4H2O
MnSO4	-11.64	-8.49	3.15	MnSO4
Na4UO2(CO3)3	-22.36	-38.65	-16.29	Na4UO2(CO3)3
Nahcolite	-3.79	-4.46	-0.66	NaHCO3
Natron	-7.95	-9.75	-1.80	Na2CO3:10H2O
Nesquehonite	-3.01	-8.45	-5.44	MgCO3:3H2O
Nsutite	-18.51	24.05	42.56	MnO2
O2(g)	-57.90	-60.70	-2.79	O2
Portlandite	-11.88	11.89	23.77	Ca(OH)2
Pyrochroite	-5.95	9.25	15.20	Mn(OH)2
Pyrolusite	-19.36	24.05	43.42	MnO2
Rhodochrosite	0.26	-10.82	-11.09	MnCO3
Rhodochrosite(d)	-0.43	-10.82	-10.39	MnCO3
Rutherfordine	-4.75	-19.16	-14.40	UO2CO3
Schoepite	-4.86	0.92	5.78	UO2(OH)2:H2O
Scorodite	-10.05	-30.30	-20.25	FeAsO4:2H2O
Siderite	0.38	-10.43	-10.81	FeCO3
Siderite(d)(3)	0.02	-10.43	-10.45	FeCO3
Thenardite	-7.26	-7.42	-0.16	Na2SO4
Thermonatrite	-9.96	-9.75	0.21	Na2CO3:H2O
Trona	-13.97	-14.21	-0.23	NaHCO3:Na2CO3:2H2O
U(OH)2SO4	-18.31	-21.51	-3.20	U(OH)2SO4
U3O8(c)	-5.86	18.30	24.16	U3O8
U4O9(c)	-0.04	-0.26	-0.22	U4O9
UO2(a)	-3.87	-3.77	0.10	UO2
UO3(gamma)	-7.41	0.92	8.32	UO3
Uraninite(c)	0.45	-3.77	-4.22	UO2

Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic and Uranium\Uranium.pqi
Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC results\Benkelman96-1 8.13.03 0820 36' 400gpm.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\wateq4f.dat

```
                                 pH  =   7.400
                                 pe  =   0.000
                  Activity of water  =   1.000
                     Ionic strength  =  1.808e-002
                 Mass of water (kg)  =  1.000e+000
              Total carbon (mol/kg)  =  7.626e-003
                 Total CO2 (mol/kg)  =  7.626e-003
                Temperature (deg C)  =  12.800
            Electrical balance (eq)  =  7.848e-004
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =   3.01
                         Iterations  =   9
                            Total H  = 1.110194e+002
                            Total O  = 5.553917e+001
```

----------------------------Distribution of species----------------------------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
OH-	1.069e-007	9.385e-008	-6.971	-7.028	-0.056
H+	4.448e-008	3.981e-008	-7.352	-7.400	-0.048
H2O	5.551e+001	9.996e-001	1.744	-0.000	0.000
As(3)	4.850e-008				
H3AsO3	4.790e-008	4.810e-008	-7.320	-7.318	0.002
H2AsO3-	6.064e-010	5.324e-010	-9.217	-9.274	-0.056
H4AsO3+	1.080e-015	9.486e-016	-14.966	-15.023	-0.056
HAsO3-2	2.594e-017	1.542e-017	-16.586	-16.812	-0.226
AsO3-3	1.612e-025	4.998e-026	-24.793	-25.301	-0.508
As(5)	8.777e-008				
HAsO4-2	6.217e-008	3.695e-008	-7.206	-7.432	-0.226
H2AsO4-	2.559e-008	2.247e-008	-7.592	-7.648	-0.056
AsO4-3	4.898e-012	1.519e-012	-11.310	-11.818	-0.508
H3AsO4	1.574e-013	1.581e-013	-12.803	-12.801	0.002
C(4)	7.626e-003				
HCO3-	6.790e-003	5.992e-003	-2.168	-2.222	-0.054
CO2	6.507e-004	6.534e-004	-3.187	-3.185	0.002
CaHCO3+	8.452e-005	7.421e-005	-4.073	-4.130	-0.056
MgHCO3+	5.135e-005	4.509e-005	-4.289	-4.346	-0.056
NaHCO3	1.950e-005	1.958e-005	-4.710	-4.708	0.002
CaCO3	9.092e-006	9.130e-006	-5.041	-5.040	0.002
CO3-2	8.730e-006	5.295e-006	-5.059	-5.276	-0.217
Fe(2)	1.864e-005				
Fe+2	1.181e-005	7.017e-006	-4.928	-5.154	-0.226
FeHCO3+	4.789e-006	4.205e-006	-5.320	-5.376	-0.056
FeSO4	1.118e-006	1.123e-006	-5.952	-5.950	0.002
FeCO3	8.875e-007	8.912e-007	-6.052	-6.050	0.002
FeOH+	2.453e-008	2.154e-008	-7.610	-7.667	-0.056
Fe(3)	3.964e-010				
Fe(OH)3	2.430e-010	2.440e-010	-9.614	-9.613	0.002
Fe(OH)2+	1.496e-010	1.313e-010	-9.825	-9.882	-0.056
Fe(OH)4-	3.816e-012	3.351e-012	-11.418	-11.475	-0.056

```
S(6)            2.303e-003
   SO4-2        1.889e-003  1.135e-003    -2.724    -2.945    -0.221
   CaSO4        2.479e-004  2.489e-004    -3.606    -3.604     0.002
   MgSO4        1.276e-004  1.281e-004    -3.894    -3.892     0.002
   NaSO4-       3.474e-005  3.050e-005    -4.459    -4.516    -0.056


------------------------------Saturation indices-----------------------
--------

      Phase               SI log IAP  log KT

      Anhydrite         -1.52   -5.85   -4.33  CaSO4
      Aragonite          0.08   -8.18   -8.27  CaCO3
      Arsenolite       -13.03  -14.64   -1.60  As2O3
      Artinite          -7.33    3.17   10.50  MgCO3:Mg(OH)2:3H2O
      As2O5(cr)        -34.07  -25.60    8.46  As2O5
      As_native        -16.12  -29.52  -13.39  As
      B-UO2(OH)2        -5.06    0.92    5.97  UO2(OH)2
      Birnessite       -19.55   24.05   43.60  MnO2
      Bixbyite         -19.19  -19.32   -0.13  Mn2O3
      Brucite           -6.06   11.62   17.69  Mg(OH)2
      Ca3(AsO4)2:4w    -13.45  -32.36  -18.91  Ca3(AsO4)2:4H2O
      Calcite            0.24   -8.18   -8.42  CaCO3
      Claudetite       -13.08  -14.64   -1.55  As2O3
      CO2(g)            -1.87   -3.18   -1.31  CO2
      Dolomite           0.16  -16.63  -16.79  CaMg(CO3)2
      Dolomite(d)       -0.44  -16.63  -16.19  CaMg(CO3)2
      Epsomite          -3.89   -6.12   -2.23  MgSO4:7H2O
      Fe(OH)2.7Cl.3      3.68    0.64   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)        -1.17    3.72    4.89  Fe(OH)3
      Fe3(OH)8          -3.13   17.09   20.22  Fe3(OH)8
      Goethite           4.27    3.72   -0.55  FeOOH
      Gummite          -10.21    0.92   11.12  UO3
      Gypsum            -1.27   -5.85   -4.59  CaSO4:2H2O
      H2(g)            -14.80  -17.89   -3.09  H2
      H2O(g)            -1.84   -0.00    1.84  H2O
      Halite            -6.67   -5.12    1.55  NaCl
      Hausmannite      -21.61   42.57   64.18  Mn3O4
      Hematite          10.49    7.45   -3.04  Fe2O3
      Huntite           -4.38  -33.54  -29.16  CaMg3(CO3)4
      Hydromagnesite   -15.05  -22.18   -7.13  Mg5(CO3)4(OH)2:4H2O
      Jarosite(ss)     -11.32  -21.15   -9.83
(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
      Jarosite-K       -12.17  -20.40   -8.23  KFe3(SO4)2(OH)6
      Jarosite-Na      -15.01  -19.16   -4.15  NaFe3(SO4)2(OH)6
      JarositeH        -20.66  -24.32   -3.67  (H3O)Fe3(SO4)2(OH)6
      Maghemite          1.06    7.45    6.39  Fe2O3
      Magnesite         -0.62   -8.45   -7.84  MgCO3
      Magnetite         11.78   17.09    5.32  Fe3O4
      Manganite         -8.69   16.65   25.34  MnOOH
      Melanterite       -5.73   -8.10   -2.37  FeSO4:7H2O
      Mirabilite        -5.71   -7.42   -1.71  Na2SO4:10H2O
      Mn2(SO4)3        -68.07  -72.56   -4.49  Mn2(SO4)3
      Mn3(AsO4)2:8H2O  -11.57  -40.27  -28.71  Mn3(AsO4)2:8H2O
      MnCl2:4H2O       -13.47  -11.30    2.17  MnCl2:4H2O
```

MnSO4	-11.64	-8.49	3.15	MnSO4
Na4UO2(CO3)3	-22.36	-38.65	-16.29	Na4UO2(CO3)3
Nahcolite	-3.79	-4.46	-0.66	NaHCO3
Natron	-7.95	-9.75	-1.80	Na2CO3:10H2O
Nesquehonite	-3.01	-8.45	-5.44	MgCO3:3H2O
Nsutite	-18.51	24.05	42.56	MnO2
O2(g)	-57.90	-60.70	-2.79	O2
Portlandite	-11.88	11.89	23.77	Ca(OH)2
Pyrochroite	-5.95	9.25	15.20	Mn(OH)2
Pyrolusite	-19.36	24.05	43.42	MnO2
Rhodochrosite	0.26	-10.82	-11.09	MnCO3
Rhodochrosite(d)	-0.43	-10.82	-10.39	MnCO3
Rutherfordine	-4.75	-19.16	-14.40	UO2CO3
Schoepite	-4.86	0.92	5.78	UO2(OH)2:H2O
Scorodite	-10.05	-30.30	-20.25	FeAsO4:2H2O
Siderite	0.38	-10.43	-10.81	FeCO3
Siderite(d)(3)	0.02	-10.43	-10.45	FeCO3
Thenardite	-7.26	-7.42	-0.16	Na2SO4
Thermonatrite	-9.96	-9.75	0.21	Na2CO3:H2O
Trona	-13.97	-14.21	-0.23	NaHCO3:Na2CO3:2H2O
U(OH)2SO4	-18.31	-21.51	-3.20	U(OH)2SO4
U3O8(c)	-5.86	18.30	24.16	U3O8
U4O9(c)	-0.04	-0.26	-0.22	U4O9
UO2(a)	-3.87	-3.77	0.10	UO2
UO3(gamma)	-7.41	0.92	8.32	UO3
Uraninite(c)	0.45	-3.77	-4.22	UO2

Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic and Uranium\Uranium.pqi
Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC results\Bridgeport691-2 6.8.05 1325 1200gpm 30min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\wateq4f.dat

```
                                      pH  =   7.500
                                      pe  =   0.000
                       Activity of water  =   1.000
                          Ionic strength  =  2.265e-002
                      Mass of water (kg)  =  1.000e+000
                   Total carbon (mol/kg)  =  9.009e-003
                      Total CO2 (mol/kg)  =  9.009e-003
                     Temperature (deg C)  =  12.000
                 Electrical balance (eq)  = -4.354e-004
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -1.36
                              Iterations  =   9
                                 Total H  = 1.110208e+002
                                 Total O  = 5.554945e+001
```

----------------------------Distribution of species--------------------------------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
OH-	1.271e-007	1.102e-007	-6.896	-6.958	-0.062
H+	3.565e-008	3.162e-008	-7.448	-7.500	-0.052
H2O	5.551e+001	9.995e-001	1.744	-0.000	0.000

```
C(4)             9.009e-003
   HCO3-       8.150e-003  7.109e-003    -2.089    -2.148    -0.059
   CO2         6.227e-004  6.260e-004    -3.206    -3.203     0.002
   CaHCO3+     1.247e-004  1.082e-004    -3.904    -3.966    -0.062
   MgHCO3+     4.883e-005  4.235e-005    -4.311    -4.373    -0.062
   NaHCO3      2.826e-005  2.841e-005    -4.549    -4.547     0.002
   CaCO3       1.653e-005  1.661e-005    -4.782    -4.780     0.002
   CO3-2       1.336e-005  7.736e-006    -4.874    -5.111    -0.237

S(6)             3.752e-003
   SO4-2       3.056e-003  1.750e-003    -2.515    -2.757    -0.242
   CaSO4       4.750e-004  4.774e-004    -3.323    -3.321     0.002
   MgSO4       1.523e-004  1.531e-004    -3.817    -3.815     0.002
   NaSO4-      6.596e-005  5.720e-005    -4.181    -4.243    -0.062

U(4)             4.947e-014
   U(OH)4      4.946e-014  4.972e-014   -13.306   -13.303     0.002
   U(OH)3+     7.803e-018  6.767e-018   -17.108   -17.170    -0.062

U(6)             3.159e-007
   UO2(CO3)3-4 2.645e-007  2.707e-008    -6.578    -7.568    -0.990
   UO2(CO3)2-2 5.112e-008  2.891e-008    -7.291    -7.539    -0.248
   UO2CO3      2.032e-010  2.043e-010    -9.692    -9.690     0.002
   ------------------------------Saturation indices--------------------
-----------

      Phase               SI  log IAP  log KT

      Anhydrite        -1.23   -5.57   -4.33  CaSO4
      Aragonite         0.34   -7.92   -8.26  CaCO3
      Arsenolite      -14.86  -16.48   -1.62  As2O3
      Artinite         -7.23    3.34   10.56  MgCO3:Mg(OH)2:3H2O
      As2O5(cr)       -35.66  -27.18    8.48  As2O5
      As_native       -17.29  -30.74  -13.45  As
      B-UO2(OH)2       -5.17    0.83    6.00  UO2(OH)2
      Birnessite      -20.17   23.43   43.60  MnO2
      Bixbyite        -20.78  -20.88   -0.10  Mn2O3
      Brucite          -6.02   11.72   17.75  Mg(OH)2
      Ca3(AsO4)2:4w   -14.15  -33.06  -18.91  Ca3(AsO4)2:4H2O
      Calcite           0.50   -7.92   -8.42  CaCO3
      Claudetite      -14.92  -16.48   -1.57  As2O3
      CO2(g)           -1.90   -3.20   -1.30  CO2
      Dolomite          0.47  -16.31  -16.77  CaMg(CO3)2
      Dolomite(d)      -0.14  -16.31  -16.17  CaMg(CO3)2
      Epsomite         -3.80   -6.03   -2.23  MgSO4:7H2O
      Gummite         -10.34    0.83   11.17  UO3
      Gypsum           -0.98   -5.57   -4.59  CaSO4:2H2O
      H2(g)           -15.00  -18.09   -3.09  H2
      H2O(g)           -1.86   -0.00    1.86  H2O
      Halite           -6.67   -5.12    1.55  NaCl
      Hausmannite     -24.09   40.30   64.39  Mn3O4
      Huntite          -3.98  -33.08  -29.11  CaMg3(CO3)4
      Hydromagnesite  -14.81  -21.83   -7.02  Mg5(CO3)4(OH)2:4H2O
      Magnesite        -0.56   -8.39   -7.82  MgCO3
      Manganite        -9.41   15.93   25.34  MnOOH
      Mirabilite       -5.31   -7.06   -1.75  Na2SO4:10H2O
      Mn2(SO4)3       -69.74  -74.15   -4.41  Mn2(SO4)3
```

```
      Mn3(AsO4)2:8H2O -15.62  -44.33  -28.71  Mn3(AsO4)2:8H2O
      MnCl2:4H2O      -14.63  -12.51    2.13  MnCl2:4H2O
      MnSO4           -12.51   -9.32    3.19  MnSO4
      Na4UO2(CO3)3    -21.81  -38.10  -16.29  Na4UO2(CO3)3
      Nahcolite        -3.62   -4.30   -0.67  NaHCO3
      Natron           -7.57   -9.41   -1.84  Na2CO3:10H2O
      Nesquehonite     -2.96   -8.39   -5.43  MgCO3:3H2O
      Nsutite         -19.13   23.43   42.56  MnO2
      O2(g)           -57.80  -60.58   -2.78  O2
      Portlandite     -11.65   12.19   23.84  Ca(OH)2
      Pyrochroite      -6.77    8.43   15.20  Mn(OH)2
      Pyrolusite      -20.12   23.43   43.56  MnO2
      Rhodochrosite    -0.60  -11.68  -11.08  MnCO3
      Rhodochrosite(d)  -1.29  -11.68  -10.39  MnCO3
      Rutherfordine    -4.88  -19.28  -14.40  UO2CO3
      Schoepite        -4.98    0.83    5.81  UO2(OH)2:H2O
      Thenardite       -6.89   -7.05   -0.16  Na2SO4
      Thermonatrite    -9.63   -9.41    0.22  Na2CO3:H2O
      Trona           -13.51  -13.71   -0.19  NaHCO3:Na2CO3:2H2O
      U(OH)2SO4       -18.53  -21.73   -3.20  U(OH)2SO4
      U3O8(c)          -6.34   18.07   24.41  U3O8
      U4O9(c)          -0.91   -0.91   -0.00  U4O9
      UO2(a)           -4.08   -3.98    0.10  UO2
      UO3(gamma)       -7.53    0.83    8.36  UO3
      Uraninite(c)      0.20   -3.98   -4.18  UO2


   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Uranium.pqi
  Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC
results\Bridgeport691-MW 8.15.05 0946 4gpm 99' 30min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat


                                       pH  =   7.300
                                       pe  =   0.000
                        Activity of water  =   0.999
                           Ionic strength  =  2.512e-002
                       Mass of water (kg)  =  1.000e+000
                   Total carbon (mol/kg)  =  1.007e-002
                      Total CO2 (mol/kg)  =  1.007e-002
                     Temperature (deg C)  =  12.000
                 Electrical balance (eq)  = -5.587e-004
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -1.56
                               Iterations  =  10
                                  Total H  = 1.110214e+002
                                  Total O  = 5.555534e+001

----------------------------Distribution of species--------------------
--------
                                              Log       Log         Log
   Species         Molality    Activity  Molality  Activity     Gamma

   OH-             8.069e-008  6.955e-008    -7.093    -7.158    -0.065
   H+              5.675e-008  5.012e-008    -7.246    -7.300    -0.054
   H2O             5.551e+001  9.995e-001     1.744    -0.000     0.000
```

```
C(4)            1.007e-002
   HCO3-          8.769e-003  7.606e-003    -2.057    -2.119    -0.062
   CO2            1.055e-003  1.062e-003    -2.977    -2.974     0.003
   CaHCO3+        1.269e-004  1.094e-004    -3.897    -3.961    -0.065
   MgHCO3+        6.425e-005  5.539e-005    -4.192    -4.257    -0.065
   NaHCO3         3.507e-005  3.527e-005    -4.455    -4.453     0.003
   CaCO3          1.053e-005  1.059e-005    -4.977    -4.975     0.003
   CO3-2          9.229e-006  5.222e-006    -5.035    -5.282    -0.247

S(6)            4.242e-003
   SO4-2          3.452e-003  1.931e-003    -2.462    -2.714    -0.252
   CaSO4          4.947e-004  4.976e-004    -3.306    -3.303     0.003
   MgSO4          2.053e-004  2.065e-004    -3.688    -3.685     0.003
   NaSO4-         8.495e-005  7.323e-005    -4.071    -4.135    -0.065

U(4)            1.134e-013
   U(OH)4        1.134e-013  1.141e-013   -12.945   -12.943     0.003
   U(OH)3+       2.855e-017  2.461e-017   -16.544   -16.609    -0.065

U(6)            2.608e-007
   UO2(CO3)3-4   2.057e-007  1.911e-008    -6.687    -7.719    -1.032
   UO2(CO3)2-2   5.477e-008  3.024e-008    -7.261    -7.519    -0.258
   UO2CO3        3.146e-010  3.164e-010    -9.502    -9.500     0.003


------------------------------Saturation indices-----------------------
--------

      Phase               SI log IAP  log KT

      Anhydrite        -1.21   -5.55   -4.33  CaSO4
      Aragonite         0.15   -8.12   -8.26  CaCO3
      Arsenolite      -13.10  -14.72   -1.62  As2O3
      Artinite         -7.62    2.94   10.56  MgCO3:Mg(OH)2:3H2O
      As2O5(cr)       -34.70  -26.22    8.48  As2O5
      As_native       -15.81  -29.26  -13.45  As
      B-UO2(OH)2       -5.21    0.79    6.00  UO2(OH)2
      Birnessite      -21.36   22.25   43.60  MnO2
      Bixbyite        -22.75  -22.85   -0.10  Mn2O3
      Brucite          -6.33   11.41   17.75  Mg(OH)2
      Ca3(AsO4)2:4w   -14.46  -33.37  -18.91  Ca3(AsO4)2:4H2O
      Calcite           0.30   -8.12   -8.42  CaCO3
      Claudetite      -13.16  -14.72   -1.57  As2O3
      CO2(g)           -1.68   -2.97   -1.30  CO2
      Dolomite          0.19  -16.59  -16.77  CaMg(CO3)2
      Dolomite(d)      -0.42  -16.59  -16.17  CaMg(CO3)2
      Epsomite         -3.67   -5.90   -2.23  MgSO4:7H2O
      Gummite         -10.38    0.79   11.17  UO3
      Gypsum           -0.96   -5.55   -4.59  CaSO4:2H2O
      H2(g)           -14.60  -17.69   -3.09  H2
      H2O(g)           -1.86   -0.00    1.86  H2O
      Halite           -6.54   -4.99    1.55  NaCl
      Hausmannite     -26.86   37.54   64.39  Mn3O4
      Huntite          -4.42  -33.53  -29.11  CaMg3(CO3)4
      Hydromagnesite  -15.46  -22.47   -7.02  Mg5(CO3)4(OH)2:4H2O
      Magnesite        -0.65   -8.47   -7.82  MgCO3
      Manganite       -10.39   14.95   25.34  MnOOH
```

```
      Mirabilite        -5.14   -6.88   -1.75  Na2SO4:10H2O
      Mn2(SO4)3        -70.39  -74.80   -4.41  Mn2(SO4)3
      Mn3(AsO4)2:8H2O -17.02  -45.73  -28.71  Mn3(AsO4)2:8H2O
      MnCl2:4H2O       -14.90  -12.77    2.13  MnCl2:4H2O
      MnSO4            -12.85   -9.67    3.19  MnSO4
      Na4UO2(CO3)3     -21.70  -37.99  -16.29  Na4UO2(CO3)3
      Nahcolite         -3.53   -4.20   -0.67  NaHCO3
      Natron            -7.61   -9.45   -1.84  Na2CO3:10H2O
      Nesquehonite      -3.04   -8.47   -5.43  MgCO3:3H2O
      Nsutite          -20.32   22.25   42.56  MnO2
      O2(g)            -58.60  -61.38   -2.78  O2
      Portlandite      -12.07   11.77   23.84  Ca(OH)2
      Pyrochroite       -7.55    7.65   15.20  Mn(OH)2
      Pyrolusite       -21.31   22.25   43.56  MnO2
      Rhodochrosite     -1.15  -12.24  -11.08  MnCO3
      Rhodochrosite(d)  -1.85   -12.24  -10.39  MnCO3
      Rutherfordine     -4.69  -19.09  -14.40  UO2CO3
      Schoepite         -5.01    0.79    5.81  UO2(OH)2:H2O
      Thenardite        -6.72   -6.88   -0.16  Na2SO4
      Thermonatrite     -9.67   -9.45    0.22  Na2CO3:H2O
      Trona            -13.46  -13.65   -0.19  NaHCO3:Na2CO3:2H2O
      U(OH)2SO4        -17.73  -20.93   -3.20  U(OH)2SO4
      U3O8(c)           -6.06   18.35   24.41  U3O8
      U4O9(c)            0.13    0.13   -0.00  U4O9
      UO2(a)            -3.72   -3.62    0.10  UO2
      UO3(gamma)        -7.57    0.79    8.36  UO3
      Uraninite(c)       0.56   -3.62   -4.18  UO2


Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Uranium.pqi
  Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC
results\Clarks 2005-2 8.18.06 1455 3gpm 115.9' 30 min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat

                                     pH  =   7.100
                                     pe  =   0.000
                      Activity of water  =   1.000
                         Ionic strength  =  7.376e-003
                     Mass of water (kg)  =  1.000e+000
                  Total carbon (mol/kg)  =  5.245e-003
                     Total CO2 (mol/kg)  =  5.245e-003
                    Temperature (deg C)  =  13.300
                Electrical balance (eq)  = -1.413e-003
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  = -13.63
                             Iterations  =  10
                                Total H  = 1.110168e+002
                                Total O  = 5.552393e+001

----------------------------Distribution of species--------------------
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                                             Log       Log         Log
   Species          Molality     Activity  Molality  Activity     Gamma

   H+            8.596e-008  7.943e-008    -7.066    -7.100    -0.034
```

```
   OH-           5.366e-008  4.911e-008    -7.270    -7.309    -0.038
   H2O           5.551e+001  9.998e-001     1.744    -0.000     0.000
C(4)             5.245e-003
   HCO3-         4.331e-003  3.974e-003    -2.363    -2.401    -0.037
   CO2           8.544e-004  8.558e-004    -3.068    -3.068     0.001
   CaHCO3+       3.857e-005  3.530e-005    -4.414    -4.452    -0.038
   MgHCO3+       1.143e-005  1.047e-005    -4.942    -4.980    -0.038
   CO3-2         2.515e-006  1.784e-006    -5.599    -5.749    -0.149

Fe(2)            2.687e-006
   Fe+2          1.947e-006  1.367e-006    -5.711    -5.864    -0.154
   FeHCO3+       5.934e-007  5.432e-007    -6.227    -6.265    -0.038
   FeSO4         8.499e-008  8.514e-008    -7.071    -7.070     0.001
   FeCO3         5.839e-008  5.849e-008    -7.234    -7.233     0.001

Fe(3)            1.432e-011
   Fe(OH)2+      7.625e-012  6.979e-012   -11.118   -11.156    -0.038
   Fe(OH)3       6.644e-012  6.656e-012   -11.178   -11.177     0.001
   Fe(OH)4-      5.117e-014  4.683e-014   -13.291   -13.329    -0.038

S(6)             7.082e-004
   SO4-2         6.195e-004  4.377e-004    -3.208    -3.359    -0.151
   CaSO4         6.820e-005  6.831e-005    -4.166    -4.165     0.001
   MgSO4         1.748e-005  1.751e-005    -4.757    -4.757     0.001
   NaSO4-        2.281e-006  2.088e-006    -5.642    -5.680    -0.038

U(4)             4.021e-012
   U(OH)4        4.020e-012  4.026e-012   -11.396   -11.395     0.001
   U(OH)3+       1.478e-015  1.353e-015   -14.830   -14.869    -0.038

U(6)             3.139e-007
   UO2(CO3)2-2   1.985e-007  1.393e-007    -6.702    -6.856    -0.154
   UO2(CO3)3-4   1.112e-007  2.698e-008    -6.954    -7.569    -0.615
   UO2CO3        4.152e-009  4.159e-009    -8.382    -8.381     0.001
   UO2(OH)3-     8.161e-011  7.470e-011   -10.088   -10.127    -0.038
   UO2OH+        2.411e-011  2.206e-011   -10.618   -10.656    -0.038

------------------------------Saturation indices-----------------------
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      Phase               SI log IAP  log KT

      Anhydrite        -2.08   -6.42   -4.33  CaSO4
      Aragonite        -0.54   -8.81   -8.27  CaCO3
      Artinite         -9.27    1.19   10.46  MgCO3:Mg(OH)2:3H2O
      B-UO2(OH)2       -3.98    1.97    5.96  UO2(OH)2
      Birnessite      -20.73   22.87   43.60  MnO2
      Bixbyite        -20.86  -21.02   -0.15  Mn2O3
      Brucite          -7.08   10.57   17.65  Mg(OH)2
      Calcite          -0.38   -8.81   -8.42  CaCO3
      CO2(g)           -1.75   -3.07   -1.32  CO2
      Dolomite         -1.38  -18.19  -16.81  CaMg(CO3)2
      Dolomite(d)      -1.98  -18.19  -16.21  CaMg(CO3)2
      Epsomite         -4.77   -6.99   -2.22  MgSO4:7H2O
      Fe(OH)2.7Cl.3     1.97   -1.07   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)       -2.77    2.13    4.89  Fe(OH)3
      Fe3(OH)8         -7.64   12.59   20.22  Fe3(OH)8
```

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      Goethite          2.69    2.13   -0.57  FeOOH
      Gummite          -9.12    1.97   11.09  UO3
      Gypsum           -1.83   -6.42   -4.59  CaSO4:2H2O
      H2(g)           -14.20  -17.30   -3.10  H2
      H2O(g)           -1.83   -0.00    1.83  H2O
      Halite           -8.09   -6.53    1.55  NaCl
      Hausmannite     -23.82   40.22   64.04  Mn3O4
      Hematite          7.34    4.25   -3.08  Fe2O3
      Huntite          -7.75  -36.95  -29.20  CaMg3(CO3)4
      Hydromagnesite  -19.75  -26.95   -7.20  Mg5(CO3)4(OH)2:4H2O
      Jarosite(ss)    -16.27  -26.10   -9.83
(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
      Jarosite-K      -17.20  -25.47   -8.27  KFe3(SO4)2(OH)6
      Jarosite-Na     -20.43  -24.63   -4.20  NaFe3(SO4)2(OH)6
      JarositeH       -25.00  -28.74   -3.74  (H3O)Fe3(SO4)2(OH)6
      Maghemite        -2.13    4.25    6.39  Fe2O3
      Magnesite        -1.54   -9.38   -7.84  MgCO3
      Magnetite         7.34   12.59    5.25  Fe3O4
      Manganite        -9.57   15.77   25.34  MnOOH
      Melanterite      -6.86   -9.22   -2.36  FeSO4:7H2O
      Mirabilite       -7.65   -9.34   -1.68  Na2SO4:10H2O
      Mn2(SO4)3       -69.15  -73.69   -4.54  Mn2(SO4)3
      MnCl2:4H2O      -14.81  -12.62    2.19  MnCl2:4H2O
      MnSO4           -12.02   -8.88    3.13  MnSO4
      Na4UO2(CO3)3    -25.13  -41.42  -16.29  Na4UO2(CO3)3
      Nahcolite        -4.73   -5.39   -0.66  NaHCO3
      Natron           -9.94  -11.73   -1.78  Na2CO3:10H2O
      Nesquehonite     -3.93   -9.38   -5.45  MgCO3:3H2O
      Nsutite         -19.69   22.87   42.56  MnO2
      O2(g)           -58.92  -61.72   -2.80  O2
      Portlandite     -12.59   11.14   23.73  Ca(OH)2
      Pyrochroite      -6.53    8.67   15.20  Mn(OH)2
      Pyrolusite      -20.46   22.87   43.33  MnO2
      Rhodochrosite    -0.19  -11.27  -11.09  MnCO3
      Rhodochrosite(d)  -0.88  -11.27  -10.39  MnCO3
      Rutherfordine    -3.57  -17.98  -14.41  UO2CO3
      Schoepite        -3.79    1.97    5.76  UO2(OH)2:H2O
      Siderite         -0.80  -11.61  -10.82  FeCO3
      Siderite(d)(3)   -1.16  -11.61  -10.45  FeCO3
      Thenardite       -9.17   -9.33   -0.16  Na2SO4
      Thermonatrite   -11.93  -11.72    0.21  Na2CO3:H2O
      Trona           -16.86  -17.11   -0.26  NaHCO3:Na2CO3:2H2O
      U(OH)2SO4       -16.51  -19.71   -3.20  U(OH)2SO4
      U3O8(c)          -2.07   21.93   24.00  U3O8
      U4O9(c)           5.93    5.58   -0.35  U4O9
      UO2(a)           -2.26   -2.16    0.10  UO2
      UO3(gamma)       -6.32    1.97    8.30  UO3
      Uraninite(c)      2.09   -2.16   -4.24  UO2

   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Uranium.pqi
  Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC
results\Clarks 2005-2 10.5.06 1349 3.5gpm 113.8-118' 30 min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat
```

pH = 7.800
pe = 0.000
Activity of water = 1.000
Ionic strength = 6.600e-003
Mass of water (kg) = 1.000e+000
Total carbon (mol/kg) = 3.573e-003
Total CO2 (mol/kg) = 3.573e-003
Temperature (deg C) = 12.000
Electrical balance (eq) = -5.419e-004
Percent error, 100*(Cat-|An|)/(Cat+|An|) = -5.98
Iterations = 15
Total H = 1.110158e+002
Total O = 5.551930e+001

----------------------------Distribution of species----------------------------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
OH-	2.393e-007	2.200e-007	-6.621	-6.658	-0.037
H+	1.709e-008	1.585e-008	-7.767	-7.800	-0.033
H2O	5.551e+001	9.999e-001	1.744	-0.000	0.000
C(4)	3.573e-003				
HCO3-	3.373e-003	3.108e-003	-2.472	-2.507	-0.035
CO2	1.369e-004	1.371e-004	-3.864	-3.863	0.001
CaHCO3+	2.882e-005	2.650e-005	-4.540	-4.577	-0.037
CO3-2	9.356e-006	6.749e-006	-5.029	-5.171	-0.142
CaCO3	8.105e-006	8.118e-006	-5.091	-5.091	0.001
MgHCO3+	8.091e-006	7.438e-006	-5.092	-5.129	-0.037
FeHCO3+	2.129e-006	1.957e-006	-5.672	-5.708	-0.037
NaHCO3	1.720e-006	1.723e-006	-5.764	-5.764	0.001
Fe(2)	1.236e-005				
Fe+2	8.813e-006	6.297e-006	-5.055	-5.201	-0.146
FeHCO3+	2.129e-006	1.957e-006	-5.672	-5.708	-0.037
FeCO3	1.018e-006	1.019e-006	-5.992	-5.992	0.001
FeSO4	3.436e-007	3.441e-007	-6.464	-6.463	0.001
FeOH+	4.948e-008	4.549e-008	-7.306	-7.342	-0.037
Fe(3)	3.740e-009				
Fe(OH)3	2.925e-009	2.929e-009	-8.534	-8.533	0.001
Fe(OH)2+	7.089e-010	6.518e-010	-9.149	-9.186	-0.037
Fe(OH)4-	1.062e-010	9.760e-011	-9.974	-10.011	-0.037
S(6)	6.248e-004				
SO4-2	5.482e-004	3.940e-004	-3.261	-3.405	-0.143
CaSO4	6.010e-005	6.019e-005	-4.221	-4.220	0.001
MgSO4	1.382e-005	1.384e-005	-4.859	-4.859	0.001
NaSO4-	1.942e-006	1.785e-006	-5.712	-5.748	-0.037
U(3)	0.000e+000				
U+3	0.000e+000	0.000e+000	-44.919	-45.247	-0.329
U(4)	1.729e-014				
U(OH)4	1.729e-014	1.732e-014	-13.762	-13.761	0.001

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   U(OH)3+      1.285e-018  1.181e-018   -17.891   -17.928    -0.037
U(6)            3.484e-008
   UO2(CO3)3-4  2.401e-008  6.257e-009    -7.620    -8.204    -0.584
   UO2(CO3)2-2  1.072e-008  7.662e-009    -7.970    -8.116    -0.146
   UO2CO3       6.195e-011  6.204e-011   -10.208   -10.207     0.001
   UO2(OH)3-    4.072e-011  3.744e-011   -10.390   -10.427    -0.037
   UO2OH+       4.384e-013  4.031e-013   -12.358   -12.395    -0.037


------------------------------Saturation indices-----------------------
--------

      Phase               SI log IAP  log KT

      Anhydrite        -2.13   -6.47   -4.33  CaSO4
      Aragonite         0.03   -8.23   -8.26  CaCO3
      Artinite         -7.48    3.08   10.56  MgCO3:Mg(OH)2:3H2O
      B-UO2(OH)2       -5.03    0.97    6.00  UO2(OH)2
      Birnessite      -17.91   25.69   43.60  MnO2
      Bixbyite        -16.86  -16.96   -0.10  Mn2O3
      Brucite          -5.82   11.93   17.75  Mg(OH)2
      Calcite           0.19   -8.23   -8.42  CaCO3
      CO2(g)           -2.56   -3.86   -1.30  CO2
      Dolomite         -0.30  -17.07  -16.77  CaMg(CO3)2
      Dolomite(d)      -0.91  -17.07  -16.17  CaMg(CO3)2
      Epsomite         -4.84   -7.08   -2.23  MgSO4:7H2O
      Fe(OH)2.7Cl.3     4.49    1.45   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)       -0.04    4.86    4.89  Fe(OH)3
      Fe3(OH)8         -0.11   20.11   20.22  Fe3(OH)8
      Goethite          5.37    4.86   -0.52  FeOOH
      Gummite         -10.20    0.97   11.17  UO3
      Gypsum           -1.88   -6.47   -4.59  CaSO4:2H2O
      H2(g)           -15.60  -18.69   -3.09  H2
      H2O(g)           -1.86   -0.00    1.86  H2O
      Halite           -8.10   -6.55    1.55  NaCl
      Hausmannite     -18.52   45.87   64.39  Mn3O4
      Hematite         12.69    9.71   -2.98  Fe2O3
      Huntite          -5.65  -34.76  -29.11  CaMg3(CO3)4
      Hydromagnesite  -16.43  -23.44   -7.02  Mg5(CO3)4(OH)2:4H2O
      Jarosite(ss)    -10.50  -20.33   -9.83
(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
      Jarosite-K      -11.43  -19.59   -8.16  KFe3(SO4)2(OH)6
      Jarosite-Na     -14.58  -18.65   -4.07  NaFe3(SO4)2(OH)6
      JarositeH       -19.90  -23.44   -3.55  (H3O)Fe3(SO4)2(OH)6
      Maghemite         3.33    9.71    6.39  Fe2O3
      Magnesite        -1.02   -8.84   -7.82  MgCO3
      Magnetite        14.69   20.11    5.42  Fe3O4
      Manganite        -7.45   17.89   25.34  MnOOH
      Melanterite      -6.22   -8.61   -2.38  FeSO4:7H2O
      Mirabilite       -7.67   -9.42   -1.75  Na2SO4:10H2O
      Mn2(SO4)3       -69.57  -73.98   -4.41  Mn2(SO4)3
      MnCl2:4H2O      -14.73  -12.60    2.13  MnCl2:4H2O
      MnSO4           -12.10   -8.91    3.19  MnSO4
      Na4UO2(CO3)3    -25.87  -42.16  -16.29  Na4UO2(CO3)3
      Nahcolite        -4.84   -5.51   -0.67  NaHCO3
      Natron           -9.35  -11.18   -1.84  Na2CO3:10H2O
      Nesquehonite     -3.42   -8.84   -5.43  MgCO3:3H2O
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     Nsutite          -16.87   25.69   42.56  MnO2
     O2(g)            -56.60  -59.38   -2.78  O2
     Portlandite      -11.30   12.54   23.84  Ca(OH)2
     Pyrochroite       -5.11   10.09   15.20  Mn(OH)2
     Pyrolusite       -17.86   25.69   43.56  MnO2
     Rhodochrosite      0.40  -10.68  -11.08  MnCO3
     Rhodochrosite(d)  -0.29  -10.68  -10.39  MnCO3
     Rutherfordine     -5.40  -19.80  -14.40  UO2CO3
     Schoepite         -4.83    0.97    5.81  UO2(OH)2:H2O
     Siderite           0.44  -10.37  -10.81  FeCO3
     Siderite(d)(3)     0.08  -10.37  -10.45  FeCO3
     Thenardite        -9.26   -9.42   -0.16  Na2SO4
     Thermonatrite    -11.40  -11.18    0.22  Na2CO3:H2O
     Trona            -16.50  -16.70   -0.19  NaHCO3:Na2CO3:2H2O
     U(OH)2SO4        -20.24  -23.44   -3.20  U(OH)2SO4
     U3O8(c)           -6.51   17.89   24.41  U3O8
     U4O9(c)           -2.14   -2.14   -0.00  U4O9
     UO2(a)            -4.54   -4.44    0.10  UO2
     UO3(gamma)        -7.39    0.97    8.36  UO3
     Uraninite(c)      -0.26   -4.44   -4.18  UO2


   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Uranium.pqi
  Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC
results\Clarks 2005-2 3.6.07 1430 50gpm xxx' 30 min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat


                                       pH  =   7.300
                                       pe  =   0.000
                        Activity of water  =   1.000
                           Ionic strength  =  6.380e-003
                       Mass of water (kg)  =  1.000e+000
                    Total carbon (mol/kg)  =  3.335e-003
                       Total CO2 (mol/kg)  =  3.335e-003
                      Temperature (deg C)  =  11.000
                  Electrical balance (eq)  = -4.559e-004
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -5.29
                               Iterations  =   9
                                  Total H  = 1.110154e+002
                                  Total O  = 5.551880e+001

----------------------------Distribution of species--------------------
--------

                                            Log       Log         Log
   Species       Molality    Activity  Molality  Activity     Gamma

   OH-          6.925e-008  6.375e-008    -7.160    -7.195    -0.036
   H+           5.398e-008  5.012e-008    -7.268    -7.300    -0.032
   H2O          5.551e+001  9.999e-001     1.744    -0.000     0.000

C(4)            3.335e-003
   HCO3-        2.913e-003  2.688e-003    -2.536    -2.570    -0.035
   CO2          3.826e-004  3.831e-004    -3.417    -3.417     0.001
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   CaHCO3+      2.229e-005  2.052e-005    -4.652    -4.688    -0.036
   MgHCO3+       7.076e-006  6.515e-006    -5.150    -5.186    -0.036
   CO3-2         2.475e-006  1.795e-006    -5.606    -5.746    -0.140
   CaCO3         1.967e-006  1.970e-006    -5.706    -5.706     0.001
   FeHCO3+       1.720e-006  1.584e-006    -5.764    -5.800    -0.036
   NaHCO3        1.496e-006  1.498e-006    -5.825    -5.825     0.001
Fe(2)            1.057e-005
   Fe+2          8.200e-006  5.891e-006    -5.086    -5.230    -0.144
   FeHCO3+       1.720e-006  1.584e-006    -5.764    -5.800    -0.036
   FeSO4         3.780e-007  3.786e-007    -6.423    -6.422     0.001
   FeCO3         2.533e-007  2.537e-007    -6.596    -6.596     0.001

Fe(3)            1.267e-010
   Fe(OH)3       6.986e-011  6.996e-011   -10.156   -10.155     0.001
   Fe(OH)2+     5.609e-011  5.164e-011   -10.251   -10.287    -0.036
   Fe(OH)4-      7.661e-013  7.053e-013   -12.116   -12.152    -0.036
S(6)            7.393e-004
   SO4-2        6.541e-004  4.727e-004    -3.184    -3.325    -0.141
   CaSO4        6.564e-005  6.573e-005    -4.183    -4.182     0.001
   MgSO4        1.635e-005  1.637e-005    -4.787    -4.786     0.001
   NaSO4-       2.322e-006  2.138e-006    -5.634    -5.670    -0.036

U(3)             0.000e+000
   U+3          0.000e+000  0.000e+000   -40.780   -41.103    -0.323

U(4)            2.406e-012
   U(OH)4       2.405e-012  2.409e-012   -11.619   -11.618     0.001
   U(OH)3+      5.717e-016  5.263e-016   -15.243   -15.279    -0.036
   U(OH)2+2     2.555e-020  1.836e-020   -19.593   -19.736    -0.144

U(6)             1.597e-007
   UO2(CO3)2-2 9.612e-008  6.906e-008    -7.017    -7.161    -0.144
   UO2(CO3)3-4 6.124e-008  1.632e-008    -7.213    -7.787    -0.574
   UO2CO3       2.142e-009  2.145e-009    -8.669    -8.669     0.001
   UO2(OH)3-    1.684e-010  1.551e-010    -9.774    -9.809    -0.036
   UO2OH+       1.693e-011  1.559e-011   -10.771   -10.807    -0.036


------------------------------Saturation indices-----------------------
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      Phase               SI log IAP  log KT

      Anhydrite        -2.09   -6.42   -4.33  CaSO4
      Aragonite        -0.58   -8.84   -8.26  CaCO3
      Artinite         -9.12    1.52   10.64  MgCO3:Mg(OH)2:3H2O
      B-UO2(OH)2       -3.95    2.09    6.04  UO2(OH)2
      Birnessite      -20.05   23.55   43.60  MnO2
      Bixbyite        -20.32  -20.38   -0.06  Mn2O3
      Brucite          -6.88   10.93   17.82  Mg(OH)2
      Calcite          -0.43   -8.84   -8.41  CaCO3
      CO2(g)           -2.13   -3.42   -1.28  CO2
      Dolomite         -1.51  -18.26  -16.75  CaMg(CO3)2
      Dolomite(d)      -2.12  -18.26  -16.14  CaMg(CO3)2
      Epsomite         -4.75   -6.99   -2.24  MgSO4:7H2O
      Fe(OH)2.7Cl.3     3.09    0.05   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)       -1.59    3.30    4.89  Fe(OH)3
```

Fe3(OH)8	-4.25	15.97	20.22	Fe3(OH)8
Goethite	3.78	3.30	-0.48	FeOOH
Gummite	-9.14	2.09	11.23	UO3
Gypsum	-1.83	-6.42	-4.59	CaSO4:2H2O
H2(g)	-14.60	-17.69	-3.09	H2
H2O(g)	-1.89	-0.00	1.89	H2O
Halite	-8.10	-6.55	1.55	NaCl
Hausmannite	-23.21	41.46	64.66	Mn3O4
Hematite	9.50	6.60	-2.89	Fe2O3
Huntite	-8.04	-37.08	-29.04	CaMg3(CO3)4
Hydromagnesite	-19.84	-26.71	-6.88	Mg5(CO3)4(OH)2:4H2O
Jarosite(ss)	-13.33	-23.16	-9.83	(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
Jarosite-K	-14.41	-22.49	-8.08	KFe3(SO4)2(OH)6
Jarosite-Na	-17.68	-21.65	-3.97	NaFe3(SO4)2(OH)6
JarositeH	-22.55	-25.95	-3.40	(H3O)Fe3(SO4)2(OH)6
Maghemite	0.22	6.60	6.39	Fe2O3
Magnesite	-1.61	-9.41	-7.81	MgCO3
Magnetite	10.41	15.97	5.56	Fe3O4
Manganite	-9.09	16.25	25.34	MnOOH
Melanterite	-6.16	-8.56	-2.40	FeSO4:7H2O
Mirabilite	-7.53	-9.33	-1.80	Na2SO4:10H2O
Mn2(SO4)3	-69.85	-74.15	-4.30	Mn2(SO4)3
MnCl2:4H2O	-14.82	-12.74	2.08	MnCl2:4H2O
MnSO4	-12.20	-8.97	3.23	MnSO4
Na4UO2(CO3)3	-25.47	-41.76	-16.29	Na4UO2(CO3)3
Nahcolite	-4.89	-5.57	-0.68	NaHCO3
Natron	-9.87	-11.75	-1.88	Na2CO3:10H2O
Nesquehonite	-4.00	-9.41	-5.41	MgCO3:3H2O
Nsutite	-19.01	23.55	42.56	MnO2
O2(g)	-58.97	-61.75	-2.78	O2
Portlandite	-12.42	11.50	23.92	Ca(OH)2
Pyrochroite	-6.25	8.95	15.20	Mn(OH)2
Pyrolusite	-20.18	23.55	43.73	MnO2
Rhodochrosite	-0.31	-11.39	-11.08	MnCO3
Rhodochrosite(d)	-1.00	-11.39	-10.39	MnCO3
Rutherfordine	-3.86	-18.26	-14.40	UO2CO3
Schoepite	-3.75	2.09	5.84	UO2(OH)2:H2O
Siderite	-0.18	-10.98	-10.80	FeCO3
Siderite(d)(3)	-0.53	-10.98	-10.45	FeCO3
Thenardite	-9.18	-9.33	-0.16	Na2SO4
Thermonatrite	-11.98	-11.75	0.23	Na2CO3:H2O
Trona	-17.18	-17.33	-0.14	NaHCO3:Na2CO3:2H2O
U(OH)2SO4	-16.95	-20.15	-3.20	U(OH)2SO4
U3O8(c)	-2.20	22.52	24.72	U3O8
U4O9(c)	5.42	5.70	0.27	U4O9
UO2(a)	-2.33	-2.23	0.10	UO2
UO3(gamma)	-6.33	2.09	8.42	UO3
Uraninite(c)	1.90	-2.23	-4.13	UO2

Input file: Y:\Arsenic and Uranium Project\Arsenic and Uranium Project Data and Graphs\As & U PhreeqC results\uranium input.pqi
Output file: Y:\Arsenic and Uranium Project\Arsenic and Uranium Project Data and Graphs\As & U PhreeqC results\Clarks NTW 1.25.2007 100' 30min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive 2.15.0\wateq4f.dat

```
                                       pH  =   7.400
                                       pe  =   4.000
                        Activity of water  =   1.000
                           Ionic strength  =  1.551e-002
                       Mass of water (kg)  =  1.000e+000
                    Total carbon (mol/kg)  =  8.378e-003
                       Total CO2 (mol/kg)  =  8.378e-003
                      Temperature (deg C)  =  11.000
                  Electrical balance (eq)  = -1.480e-003
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -6.91
                               Iterations  =  10
                                  Total H  = 1.110200e+002
                                  Total O  = 5.553886e+001

----------------------------Distribution of species--------------------
--------

                                               Log       Log          Log
   Species          Molality    Activity  Molality  Activity      Gamma

   OH-             9.063e-008  8.025e-008    -7.043    -7.096    -0.053
   H+              4.420e-008  3.981e-008    -7.355    -7.400    -0.045
   H2O             5.551e+001  9.997e-001     1.744    -0.000     0.000

C(4)               8.378e-003
   HCO3-           7.445e-003  6.622e-003    -2.128    -2.179    -0.051
   CO2             7.471e-004  7.497e-004    -3.127    -3.125     0.002
   CaHCO3+         1.074e-004  9.505e-005    -3.969    -4.022    -0.053
   MgHCO3+         3.626e-005  3.210e-005    -4.441    -4.493    -0.053
   CaCO3           1.144e-005  1.148e-005    -4.941    -4.940     0.002
   NaHCO3          1.078e-005  1.082e-005    -4.967    -4.966     0.002
   CO3-2           8.894e-006  5.566e-006    -5.051    -5.254    -0.204
   FeHCO3+         3.954e-006  3.501e-006    -5.403    -5.456    -0.053

Fe(2)              1.403e-005
   Fe+2            8.602e-006  5.286e-006    -5.065    -5.277    -0.211
   FeHCO3+         3.954e-006  3.501e-006    -5.403    -5.456    -0.053
   FeSO4           7.546e-007  7.573e-007    -6.122    -6.121     0.002
   FeCO3           7.033e-007  7.059e-007    -6.153    -6.151     0.002

Fe(3)              2.095e-006
   Fe(OH)3         1.247e-006  1.252e-006    -5.904    -5.902     0.002
   Fe(OH)2+        8.292e-007  7.341e-007    -6.081    -6.134    -0.053
   Fe(OH)4-        1.794e-008  1.589e-008    -7.746    -7.799    -0.053

S(6)               2.063e-003
   SO4-2           1.697e-003  1.054e-003    -2.770    -2.977    -0.207
   CaSO4           2.746e-004  2.756e-004    -3.561    -3.560     0.002
   MgSO4           7.276e-005  7.302e-005    -4.138    -4.137     0.002
   NaSO4-          1.579e-005  1.398e-005    -4.802    -4.854    -0.053

U(4)               5.496e-021
   U(OH)4          5.495e-021  5.514e-021   -20.260   -20.259     0.002
   U(OH)3+         1.081e-024  9.572e-025   -23.966   -24.019    -0.053
   U(CO3)4-4       1.829e-028  2.609e-029   -27.738   -28.584    -0.846
```

```
U(6)             1.030e-006
   UO2(CO3)3-4   7.811e-007  1.114e-007    -6.107    -6.953    -0.846
   UO2(CO3)2-2   2.474e-007  1.521e-007    -6.607    -6.818    -0.211
   UO2CO3        1.518e-009  1.523e-009    -8.819    -8.817     0.002

------------------------------Saturation indices-----------------------
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      Phase               SI log IAP  log KT

      Anhydrite        -1.47   -5.80   -4.33  CaSO4
      Aragonite         0.18   -8.08   -8.26  CaCO3
      Artinite         -7.82    2.81   10.64  MgCO3:Mg(OH)2:3H2O
      B-UO2(OH)2       -4.39    1.65    6.04  UO2(OH)2
      Birnessite      -11.90   31.70   43.60  MnO2
      Bixbyite        -12.22  -12.28   -0.06  Mn2O3
      Brucite          -6.38   11.43   17.82  Mg(OH)2
      Calcite           0.34   -8.08   -8.41  CaCO3
      CO2(g)           -1.84   -3.13   -1.28  CO2
      Dolomite          0.05  -16.70  -16.75  CaMg(CO3)2
      Dolomite(d)      -0.56  -16.70  -16.14  CaMg(CO3)2
      Epsomite         -4.10   -6.34   -2.24  MgSO4:7H2O
      Fe(OH)2.7Cl.3     7.38    4.34   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)        2.66    7.55    4.89  Fe(OH)3
      Fe3(OH)8          4.41   24.63   20.22  Fe3(OH)8
      Goethite          8.03    7.55   -0.48  FeOOH
      Gummite          -9.58    1.65   11.23  UO3
      Gypsum           -1.21   -5.80   -4.59  CaSO4:2H2O
      H2(g)           -22.80  -25.89   -3.09  H2
      H2O(g)           -1.89   -0.00    1.89  H2O
      Halite           -7.39   -5.84    1.55  NaCl
      Hausmannite     -15.16   49.51   64.66  Mn3O4
      Hematite         18.00   15.11   -2.89  Fe2O3
      Huntite          -4.90  -33.94  -29.04  CaMg3(CO3)4
      Hydromagnesite  -16.17  -23.04   -6.88  Mg5(CO3)4(OH)2:4H2O
      Jarosite(ss)      0.07   -9.76   -9.83
(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
      Jarosite-K       -0.94   -9.02   -8.08  KFe3(SO4)2(OH)6
      Jarosite-Na      -4.06   -8.03   -3.97  NaFe3(SO4)2(OH)6
      JarositeH        -9.50  -12.89   -3.40  (H3O)Fe3(SO4)2(OH)6
      Maghemite         8.72   15.11    6.39  Fe2O3
      Magnesite        -0.81   -8.62   -7.81  MgCO3
      Magnetite        19.07   24.63    5.56  Fe3O4
      Manganite        -5.04   20.30   25.34  MnOOH
      Melanterite      -5.86   -8.26   -2.40  FeSO4:7H2O
      Mirabilite       -6.25   -8.05   -1.80  Na2SO4:10H2O
      Mn2(SO4)3       -61.31  -65.61   -4.30  Mn2(SO4)3
      MnCl2:4H2O      -14.59  -12.50    2.08  MnCl2:4H2O
      MnSO4           -12.10   -8.87    3.23  MnSO4
      Na4UO2(CO3)3    -22.77  -39.06  -16.29  Na4UO2(CO3)3
      Nahcolite        -4.03   -4.72   -0.68  NaHCO3
      Natron           -8.45  -10.33   -1.88  Na2CO3:10H2O
      Nesquehonite     -3.21   -8.62   -5.41  MgCO3:3H2O
      Nsutite         -10.86   31.70   42.56  MnO2
      O2(g)           -42.57  -45.35   -2.78  O2
      Portlandite     -11.94   11.98   23.92  Ca(OH)2
```

Pyrochroite	-6.30	8.90	15.20	Mn(OH)2
Pyrolusite	-12.03	31.70	43.73	MnO2
Rhodochrosite	-0.07	-11.15	-11.08	MnCO3
Rhodochrosite(d)	-0.76	-11.15	-10.39	MnCO3
Rutherfordine	-4.01	-18.40	-14.40	UO2CO3
Schoepite	-4.19	1.65	5.84	UO2(OH)2:H2O
Siderite	0.27	-10.53	-10.80	FeCO3
Siderite(d)(3)	-0.08	-10.53	-10.45	FeCO3
Thenardite	-7.89	-8.05	-0.16	Na2SO4
Thermonatrite	-10.55	-10.33	0.23	Na2CO3:H2O
Trona	-14.90	-15.04	-0.14	NaHCO3:Na2CO3:2H2O
U(OH)2SO4	-25.44	-28.64	-3.20	U(OH)2SO4
U3O8(c)	-11.72	13.00	24.72	U3O8
U4O9(c)	-20.94	-20.66	0.27	U4O9
UO2(a)	-10.97	-10.87	0.10	UO2
UO3(gamma)	-6.77	1.65	8.42	UO3
Uraninite(c)	-6.74	-10.87	-4.13	UO2

Input file: Y:\Arsenic and Uranium Project\Arsenic and Uranium Project Data and Graphs\As & U PhreeqC results\uranium input.pqi
Output file: Y:\Arsenic and Uranium Project\Arsenic and Uranium Project Data and Graphs\As & U PhreeqC results\Clarks NTW 8.17.2006.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive 2.15.0\wateq4f.dat

pH	= 7.600
pe	= 4.000
Activity of water	= 1.000
Ionic strength	= 1.537e-002
Mass of water (kg)	= 1.000e+000
Total carbon (mol/kg)	= 7.970e-003
Total CO2 (mol/kg)	= 7.970e-003
Temperature (deg C)	= 15.600
Electrical balance (eq)	= -1.024e-003
Percent error, 100*(Cat-|An|)/(Cat+|An|)	= -4.81
Iterations	= 12
Total H	= 1.110200e+002
Total O	= 5.553769e+001

----------------------------Distribution of species----------------------------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
OH-	2.132e-007	1.887e-007	-6.671	-6.724	-0.053
H+	2.790e-008	2.512e-008	-7.554	-7.600	-0.046
H2O	5.551e+001	9.997e-001	1.744	-0.000	0.000
C(4)	7.970e-003				
HCO3-	7.334e-003	6.521e-003	-2.135	-2.186	-0.051
CO2	4.235e-004	4.250e-004	-3.373	-3.372	0.002
CaHCO3+	1.175e-004	1.040e-004	-3.930	-3.983	-0.053
MgHCO3+	3.601e-005	3.187e-005	-4.444	-4.497	-0.053
CaCO3	2.098e-005	2.105e-005	-4.678	-4.677	0.002
CO3-2	1.573e-005	9.830e-006	-4.803	-5.007	-0.204
NaHCO3	1.122e-005	1.126e-005	-4.950	-4.949	0.002

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Fe(2)           7.231e-006
   Fe+2         4.273e-006  2.622e-006    -5.369    -5.581    -0.212
   FeHCO3+      1.932e-006  1.710e-006    -5.714    -5.767    -0.053
   FeCO3        6.161e-007  6.183e-007    -6.210    -6.209     0.002
   FeSO4        3.909e-007  3.923e-007    -6.408    -6.406     0.002

Fe(3)           8.897e-006
   Fe(OH)3      6.516e-006  6.539e-006    -5.186    -5.185     0.002
   Fe(OH)2+     2.200e-006  1.947e-006    -5.658    -5.711    -0.053
   Fe(OH)4-     1.815e-007  1.607e-007    -6.741    -6.794    -0.053

S(6)            1.990e-003
   SO4-2        1.620e-003  1.005e-003    -2.790    -2.998    -0.207
   CaSO4        2.720e-004  2.729e-004    -3.565    -3.564     0.002
   MgSO4        7.886e-005  7.914e-005    -4.103    -4.102     0.002
   NaSO4-       1.642e-005  1.454e-005    -4.785    -4.838    -0.053
U(4)            1.124e-021
   U(OH)4       1.124e-021  1.128e-021   -20.949   -20.948     0.002
   U(OH)3+      1.315e-025  1.164e-025   -24.881   -24.934    -0.053
U(6)            1.135e-006
   UO2(CO3)3-4 8.991e-007  1.275e-007    -6.046    -6.895    -0.848
   UO2(CO3)2-2 2.353e-007  1.444e-007    -6.628    -6.840    -0.212
   UO2CO3       7.453e-010  7.479e-010    -9.128    -9.126     0.002


------------------------------Saturation indices-----------------------
--------

      Phase                SI log IAP  log KT

      Anhydrite         -1.49   -5.82   -4.34  CaSO4
      Aragonite          0.45   -7.83   -8.28  CaCO3
      Artinite          -6.82    3.46   10.29  MgCO3:Mg(OH)2:3H2O
      B-UO2(OH)2        -4.39    1.48    5.87  UO2(OH)2
      Birnessite       -11.22   32.38   43.60  MnO2
      Bixbyite         -10.44  -10.68   -0.25  Mn2O3
      Brucite           -5.65   11.83   17.49  Mg(OH)2
      Calcite            0.60   -7.83   -8.43  CaCO3
      CO2(g)            -2.02   -3.37   -1.35  CO2
      Dolomite           0.66  -16.21  -16.86  CaMg(CO3)2
      Dolomite(d)        0.07  -16.21  -16.28  CaMg(CO3)2
      Epsomite          -4.16   -6.36   -2.21  MgSO4:7H2O
      Fe(OH)2.7Cl.3      7.73    4.69   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)         3.08    7.97    4.89  Fe(OH)3
      Fe3(OH)8           5.33   25.55   20.22  Fe3(OH)8
      Goethite           8.62    7.97   -0.65  FeOOH
      Gummite           -9.47    1.48   10.95  UO3
      Gypsum            -1.24   -5.82   -4.58  CaSO4:2H2O
      H2(g)            -23.20  -26.31   -3.11  H2
      H2O(g)            -1.76   -0.00    1.76  H2O
      Halite            -7.40   -5.84    1.56  NaCl
      Hausmannite      -12.68   50.75   63.43  Mn3O4
      Hematite          19.21   15.93   -3.27  Fe2O3
      Huntite           -3.60  -32.95  -29.35  CaMg3(CO3)4
      Hydromagnesite  -14.14  -21.66   -7.52  Mg5(CO3)4(OH)2:4H2O
      Jarosite(ss)       0.65   -9.18   -9.83
(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
```

```
     Jarosite-K        0.08   -8.38   -8.46  KFe3(SO4)2(OH)6
     Jarosite-Na      -2.99   -7.41   -4.42  NaFe3(SO4)2(OH)6
     JarositeH        -8.42  -12.49   -4.07  (H3O)Fe3(SO4)2(OH)6
     Maghemite         9.55   15.93    6.39  Fe2O3
     Magnesite        -0.49   -8.37   -7.88  MgCO3
     Magnetite        20.61   25.55    4.94  Fe3O4
     Manganite        -4.56   20.78   25.34  MnOOH
     Melanterite      -6.25   -8.58   -2.33  FeSO4:7H2O
     Mirabilite       -6.46   -8.02   -1.57  Na2SO4:10H2O
     Mn2(SO4)3       -60.50  -65.28   -4.78  Mn2(SO4)3
     MnCl2:4H2O      -14.96  -12.67    2.30  MnCl2:4H2O
     MnSO4           -12.05   -9.01    3.04  MnSO4
     Na4UO2(CO3)3    -22.50  -38.79  -16.29  Na4UO2(CO3)3
     Nahcolite        -4.06   -4.70   -0.64  NaHCO3
     Natron           -8.35  -10.03   -1.69  Na2CO3:10H2O
     Nesquehonite     -2.89   -8.37   -5.48  MgCO3:3H2O
     Nsutite         -10.18   32.38   42.56  MnO2
     O2(g)           -40.08  -42.90   -2.82  O2
     Portlandite     -11.17   12.37   23.54  Ca(OH)2
     Pyrochroite      -6.02    9.18   15.20  Mn(OH)2
     Pyrolusite      -10.55   32.38   42.93  MnO2
     Rhodochrosite     0.07  -11.02  -11.10  MnCO3
     Rhodochrosite(d)  -0.63  -11.02  -10.39  MnCO3
     Rutherfordine    -4.31  -18.73  -14.42  UO2CO3
     Schoepite        -4.21    1.48    5.69  UO2(OH)2:H2O
     Siderite          0.24  -10.59  -10.83  FeCO3
     Siderite(d)(3)   -0.14  -10.59  -10.45  FeCO3
     Thenardite       -7.86   -8.02   -0.17  Na2SO4
     Thermonatrite   -10.23  -10.03    0.19  Na2CO3:H2O
     Trona           -14.37  -14.73   -0.37  NaHCO3:Na2CO3:2H2O
     U(OH)2SO4       -26.86  -30.06   -3.20  U(OH)2SO4
     U3O8(c)         -12.47   10.82   23.30  U3O8
     U4O9(c)         -23.27  -24.23   -0.97  U4O9
     UO2(a)          -11.96  -11.86    0.10  UO2
     UO3(gamma)       -6.70    1.48    8.18  UO3
     Uraninite(c)     -7.50  -11.86   -4.36  UO2

   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Arsenic2.pqi
  Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC
results\Haigler 651 8.7.06 0903 95' 330gpm 30 min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat

                                     pH  =   7.400
                                     pe  =   0.000
                      Activity of water  =   1.000
                         Ionic strength  =  7.236e-003
                     Mass of water (kg)  =  1.000e+000
                 Total carbon (mol/kg)  =  5.636e-003
                    Total CO2 (mol/kg)  =  5.636e-003
                   Temperature (deg C)  =  14.100
               Electrical balance (eq)  = -6.456e-004
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -6.17
                             Iterations  =   7
                                Total H  = 1.110176e+002
                                Total O  = 5.552369e+001
```

----------------------------Distribution of species--------------------
----

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
OH-	1.145e-007	1.049e-007	-6.941	-6.979	-0.038
H+	4.306e-008	3.981e-008	-7.366	-7.400	-0.034
H2O	5.551e+001	9.998e-001	1.744	-0.000	0.000
As(3)	9.508e-008				
H3AsO3	9.388e-008	9.404e-008	-7.027	-7.027	0.001
H2AsO3-	1.198e-009	1.097e-009	-8.922	-8.960	-0.038
H4AsO3+	2.025e-015	1.855e-015	-14.694	-14.732	-0.038
HAsO3-2	4.797e-017	3.376e-017	-16.319	-16.472	-0.153
AsO3-3	2.532e-025	1.148e-025	-24.597	-24.940	-0.343
As(5)	1.893e-007				
HAsO4-2	1.293e-007	9.097e-008	-6.888	-7.041	-0.153
H2AsO4-	6.004e-008	5.499e-008	-7.222	-7.260	-0.038
AsO4-3	8.537e-012	3.872e-012	-11.069	-11.412	-0.343
H3AsO4	3.914e-013	3.920e-013	-12.407	-12.407	0.001
C(4)	5.636e-003				
HCO3-	5.057e-003	4.644e-003	-2.296	-2.333	-0.037
CO2	4.925e-004	4.933e-004	-3.308	-3.307	0.001
CaHCO3+	5.229e-005	4.790e-005	-4.282	-4.320	-0.038
MgHCO3+	1.948e-005	1.784e-005	-4.710	-4.749	-0.038
CaCO3	5.978e-006	5.988e-006	-5.223	-5.223	0.001
CO3-2	5.975e-006	4.248e-006	-5.224	-5.372	-0.148
NaHCO3	1.742e-006	1.745e-006	-5.759	-5.758	0.001
MgCO3	1.165e-006	1.167e-006	-5.934	-5.933	0.001
S(6)	1.354e-004				
SO4-2	1.154e-004	8.176e-005	-3.938	-4.087	-0.150
CaSO4	1.463e-005	1.465e-005	-4.835	-4.834	0.001
MgSO4	4.865e-006	4.873e-006	-5.313	-5.312	0.001
NaSO4-	2.783e-007	2.549e-007	-6.555	-6.594	-0.038

------------------------------Saturation indices-----------------------
----

Phase	SI	log IAP	log KT	
Anhydrite	-2.75	-7.09	-4.33	CaSO4
Aragonite	-0.10	-8.37	-8.27	CaCO3
Arsenolite	-12.47	-14.05	-1.58	As2O3
Artinite	-7.91	2.49	10.40	MgCO3:Mg(OH)2:3H2O
As2O5(cr)	-33.25	-24.81	8.44	As2O5
As_native	-15.93	-29.23	-13.30	As
Brucite	-6.26	11.33	17.59	Mg(OH)2
Ca3(AsO4)2:4w	-12.92	-31.83	-18.91	Ca3(AsO4)2:4H2O
Calcite	0.05	-8.37	-8.43	CaCO3
Claudetite	-12.52	-14.05	-1.53	As2O3
CO2(g)	-1.98	-3.31	-1.33	CO2
Dolomite	-0.38	-17.21	-16.83	CaMg(CO3)2

```
      Dolomite(d)      -0.98  -17.21  -16.23  CaMg(CO3)2
      Epsomite         -5.34   -7.56   -2.22  MgSO4:7H2O
      Gypsum           -2.50   -7.09   -4.59  CaSO4:2H2O
      H2(g)           -14.80  -17.90   -3.10  H2
      H2O(g)           -1.80   -0.00    1.80  H2O
      Halite           -8.84   -7.29    1.56  NaCl
      Huntite          -5.64  -34.89  -29.25  CaMg3(CO3)4
      Hydromagnesite  -16.72  -24.03   -7.31  Mg5(CO3)4(OH)2:4H2O
      Magnesite        -0.98   -8.84   -7.86  MgCO3
      Mirabilite       -8.80  -10.44   -1.64  Na2SO4:10H2O
      Nahcolite        -4.86   -5.51   -0.65  NaHCO3
      Natron           -9.97  -11.72   -1.75  Na2CO3:10H2O
      Nesquehonite     -3.38   -8.84   -5.46  MgCO3:3H2O
      O2(g)           -57.42  -60.23   -2.80  O2
      Portlandite     -11.86   11.80   23.66  Ca(OH)2
      Thenardite      -10.27  -10.44   -0.16  Na2SO4
      Thermonatrite   -11.92  -11.72    0.20  Na2CO3:H2O
      Trona           -16.94  -17.23   -0.29  NaHCO3:Na2CO3:2H2O


   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Arsenic2.pqi
  Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC
results\Haigler 651 11.14.06 1230 102gpm 95' 30 min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat


                                       pH  =   7.700
                                       pe  =   0.000
                        Activity of water  =   1.000
                           Ionic strength  =  7.353e-003
                       Mass of water (kg)  =  1.000e+000
                    Total carbon (mol/kg)  =  4.812e-003
                       Total CO2 (mol/kg)  =  4.812e-003
                      Temperature (deg C)  =  14.000
                  Electrical balance (eq)  =  1.684e-004
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =   1.62
                               Iterations  =   8
                                  Total H  = 1.110170e+002
                                  Total O  = 5.552162e+001

----------------------------Distribution of species--------------------
--------

                                            Log       Log         Log
   Species       Molality    Activity  Molality  Activity     Gamma

   OH-          2.268e-007  2.076e-007    -6.644    -6.683    -0.038
   H+           2.159e-008  1.995e-008    -7.666    -7.700    -0.034
   H2O          5.551e+001  9.999e-001     1.744    -0.000     0.000
As(3)           9.949e-009
   H3AsO3       9.703e-009  9.720e-009    -8.013    -8.012     0.001
   H2AsO3-      2.462e-010  2.253e-010    -9.609    -9.647    -0.038
   H4AsO3+      1.050e-016  9.608e-017   -15.979   -16.017    -0.038
   HAsO3-2      1.962e-017  1.377e-017   -16.707   -16.861    -0.154
   AsO3-3       2.064e-025  9.312e-026   -24.685   -25.031    -0.346
```

```
As(5)            2.571e-007
   HAsO4-2      2.086e-007  1.464e-007    -6.681    -6.834    -0.154
   H2AsO4-      4.849e-008  4.438e-008    -7.314    -7.353    -0.038
   AsO4-3       2.749e-011  1.240e-011   -10.561   -10.907    -0.346
   H3AsO4       1.581e-013  1.584e-013   -12.801   -12.800     0.001
C(4)             4.812e-003
   HCO3-        4.498e-003  4.128e-003    -2.347    -2.384    -0.037
   CO2          2.198e-004  2.202e-004    -3.658    -3.657     0.001
   CaHCO3+      4.991e-005  4.569e-005    -4.302    -4.340    -0.038
   MgHCO3+      1.859e-005  1.702e-005    -4.731    -4.769    -0.038
   CaCO3        1.136e-005  1.138e-005    -4.945    -4.944     0.001
   CO3-2        1.059e-005  7.515e-006    -4.975    -5.124    -0.149
   MgCO3        2.208e-006  2.212e-006    -5.656    -5.655     0.001
   NaHCO3       1.686e-006  1.689e-006    -5.773    -5.772     0.001

Fe(2)            5.373e-007
   Fe+2         3.687e-007  2.588e-007    -6.433    -6.587    -0.154
   FeHCO3+      1.167e-007  1.068e-007    -6.933    -6.971    -0.038
   FeCO3        4.659e-008  4.667e-008    -7.332    -7.331     0.001
   FeSO4        3.242e-009  3.247e-009    -8.489    -8.488     0.001

Fe(3)            1.206e-010
   Fe(OH)3      9.204e-011  9.219e-011   -10.036   -10.035     0.001
   Fe(OH)2+     2.567e-011  2.349e-011   -10.591   -10.629    -0.038

S(6)             1.458e-004
   SO4-2        1.230e-004  8.693e-005    -3.910    -4.061    -0.151
   CaSO4        1.671e-005  1.674e-005    -4.777    -4.776     0.001
   MgSO4        5.537e-006  5.546e-006    -5.257    -5.256     0.001
   NaSO4-       3.222e-007  2.949e-007    -6.492    -6.530    -0.038

------------------------------Saturation indices-----------------------
--------

      Phase               SI log IAP  log KT

      Anhydrite        -2.70   -7.03   -4.33  CaSO4
      Aragonite         0.18   -8.09   -8.27  CaCO3
      Arsenolite      -14.44  -16.02   -1.58  As2O3
      Artinite         -7.01    3.40   10.41  MgCO3:Mg(OH)2:3H2O
      As2O5(cr)       -34.04  -25.60    8.44  As2O5
      As_native       -17.81  -31.11  -13.30  As
      Brucite          -5.64   11.96   17.60  Mg(OH)2
      Ca3(AsO4)2:4w   -11.82  -30.72  -18.91  Ca3(AsO4)2:4H2O
      Calcite           0.33   -8.09   -8.43  CaCO3
      Claudetite      -14.49  -16.02   -1.53  As2O3
      CO2(g)           -2.33   -3.66   -1.33  CO2
      Dolomite          0.17  -16.65  -16.83  CaMg(CO3)2
      Dolomite(d)      -0.43  -16.65  -16.23  CaMg(CO3)2
      Epsomite         -5.28   -7.50   -2.22  MgSO4:7H2O
      Fe(OH)2.7Cl.3     2.78   -0.26   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)       -1.67    3.22    4.89  Fe(OH)3
      Fe3(OH)8         -4.97   15.26   20.22  Fe3(OH)8
      Goethite          3.81    3.22   -0.59  FeOOH
      Gypsum           -2.44   -7.03   -4.59  CaSO4:2H2O
      H2(g)           -15.40  -18.50   -3.10  H2
      H2O(g)           -1.81   -0.00    1.81  H2O
```

```
      Halite           -8.58   -7.03    1.56  NaCl
      Hematite          9.58    6.44   -3.14  Fe2O3
      Huntite          -4.53  -33.78  -29.24  CaMg3(CO3)4
      Hydromagnesite  -14.99  -22.28   -7.30  Mg5(CO3)4(OH)2:4H2O
      Jarosite(ss)    -16.05  -25.88   -9.83
(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
      Jarosite-K      -16.71  -25.04   -8.33  KFe3(SO4)2(OH)6
      Jarosite-Na     -20.43  -24.70   -4.26  NaFe3(SO4)2(OH)6
      JarositeH       -25.42  -29.26   -3.84  (H3O)Fe3(SO4)2(OH)6
      Maghemite         0.06    6.44    6.39  Fe2O3
      Magnesite        -0.71   -8.56   -7.86  MgCO3
      Magnetite        10.10   15.26    5.15  Fe3O4
      Melanterite      -8.30  -10.65   -2.35  FeSO4:7H2O
      Mirabilite       -8.69  -10.34   -1.65  Na2SO4:10H2O
      Nahcolite        -4.87   -5.52   -0.65  NaHCO3
      Natron           -9.65  -11.40   -1.75  Na2CO3:10H2O
      Nesquehonite     -3.10   -8.56   -5.46  MgCO3:3H2O
      O2(g)           -56.26  -59.06   -2.80  O2
      Portlandite     -11.24   12.43   23.67  Ca(OH)2
      Scorodite       -10.54  -30.79  -20.25  FeAsO4:2H2O
      Siderite         -0.89  -11.71  -10.82  FeCO3
      Siderite(d)(3)   -1.26  -11.71  -10.45  FeCO3
      Thenardite      -10.17  -10.34   -0.16  Na2SO4
      Thermonatrite   -11.60  -11.40    0.20  Na2CO3:H2O
      Trona           -16.63  -16.92   -0.29  NaHCO3:Na2CO3:2H2O
```

Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic and Uranium\Arsenic2.pqi
Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC results\Stromsburg 3 7.10.06 0835 490gpm 161' 30 min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\wateq4f.dat

```
                                      pH  =   7.100
                                      pe  =   0.000
                       Activity of water  =   1.000
                          Ionic strength  =  1.163e-002
                      Mass of water (kg)  =  1.000e+000
                   Total carbon (mol/kg)  =  8.778e-003
                      Total CO2 (mol/kg)  =  8.778e-003
                     Temperature (deg C)  =  13.400
                 Electrical balance (eq)  = -9.429e-004
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -5.85
                              Iterations  =  10
                                 Total H  = 1.110198e+002
                                 Total O  = 5.553386e+001
```

----------------------------Distribution of species----------------------------

```
                                          Log       Log         Log
   Species      Molality    Activity  Molality  Activity     Gamma

   H+          8.728e-008  7.943e-008    -7.059    -7.100    -0.041
   OH-         5.518e-008  4.953e-008    -7.258    -7.305    -0.047
   H2O         5.551e+001  9.998e-001     1.744    -0.000     0.000
```

```
As(3)           2.428e-007
   H3AsO3       2.412e-007  2.419e-007    -6.618    -6.616     0.001
   H2AsO3-      1.532e-009  1.375e-009    -8.815    -8.862    -0.047
   H4AsO3+      1.061e-014  9.520e-015   -13.974   -14.021    -0.047
   HAsO3-2      3.162e-017  2.053e-017   -16.500   -16.688    -0.188
   AsO3-3       9.016e-026  3.410e-026   -25.045   -25.467    -0.422

As(5)           3.768e-008
   HAsO4-2      2.010e-008  1.304e-008    -7.697    -7.885    -0.188
   H2AsO4-      1.759e-008  1.579e-008    -7.755    -7.802    -0.047
   AsO4-3       7.222e-013  2.731e-013   -12.141   -12.564    -0.422
   H3AsO4       2.223e-013  2.229e-013   -12.653   -12.652     0.001

C(4)            8.778e-003
   HCO3-        7.214e-003  6.500e-003    -2.142    -2.187    -0.045
   CO2          1.393e-003  1.397e-003    -2.856    -2.855     0.001
   CaHCO3+      1.203e-004  1.080e-004    -3.920    -3.967    -0.047
   MgHCO3+      3.355e-005  3.011e-005    -4.474    -4.521    -0.047
   CaCO3        6.686e-006  6.704e-006    -5.175    -5.174     0.001
   CO3-2        4.440e-006  2.925e-006    -5.353    -5.534    -0.181
   NaHCO3       3.264e-006  3.273e-006    -5.486    -5.485     0.001

Fe(2)           8.958e-007
   Fe+2         5.801e-007  3.765e-007    -6.236    -6.424    -0.188
   FeHCO3+      2.727e-007  2.447e-007    -6.564    -6.611    -0.047
   FeCO3        2.635e-008  2.642e-008    -7.579    -7.578     0.001
   FeSO4        1.590e-008  1.595e-008    -7.799    -7.797     0.001

Fe(3)           4.061e-012
   Fe(OH)2+     2.177e-012  1.954e-012   -11.662   -11.709    -0.047
   Fe(OH)3      1.867e-012  1.872e-012   -11.729   -11.728     0.001
   Fe(OH)4-     1.474e-014  1.323e-014   -13.831   -13.878    -0.047

S(6)            5.625e-004
   SO4-2        4.534e-004  2.969e-004    -3.343    -3.527    -0.184
   CaSO4        8.631e-005  8.654e-005    -4.064    -4.063     0.001
   MgSO4        2.090e-005  2.096e-005    -4.680    -4.679     0.001
   NaSO4-       1.375e-006  1.234e-006    -5.862    -5.909    -0.047

------------------------------Saturation indices-----------------------
--------

      Phase               SI log IAP  log KT

      Anhydrite        -1.98   -6.31   -4.33  CaSO4
      Aragonite        -0.05   -8.32   -8.27  CaCO3
      Arsenolite      -11.64  -13.23   -1.59  As2O3
      Artinite         -8.56    1.89   10.45  MgCO3:Mg(OH)2:3H2O
      As2O5(cr)       -33.76  -25.30    8.45  As2O5
      As_native       -14.57  -27.92  -13.35  As
      Birnessite      -21.19   22.42   43.60  MnO2
      Bixbyite        -21.76  -21.92   -0.16  Mn2O3
      Brucite          -6.83   10.81   17.64  Mg(OH)2
      Ca3(AsO4)2:4w   -14.58  -33.49  -18.91  Ca3(AsO4)2:4H2O
      Calcite           0.10   -8.32   -8.42  CaCO3
      Claudetite      -11.69  -13.23   -1.54  As2O3
      CO2(g)           -1.54   -2.85   -1.32  CO2
```

Dolomite	-0.43	-17.24	-16.81	CaMg(CO3)2
Dolomite(d)	-1.03	-17.24	-16.21	CaMg(CO3)2
Epsomite	-4.69	-6.91	-2.22	MgSO4:7H2O
Fe(OH)2.7Cl.3	1.39	-1.65	-3.04	Fe(OH)2.7Cl0.3
Fe(OH)3(a)	-3.32	1.57	4.89	Fe(OH)3
Fe3(OH)8	-9.31	10.91	20.22	Fe3(OH)8
Goethite	2.14	1.57	-0.57	FeOOH
Gypsum	-1.73	-6.31	-4.59	CaSO4:2H2O
H2(g)	-14.20	-17.30	-3.10	H2
H2O(g)	-1.82	-0.00	1.82	H2O
Halite	-8.25	-6.69	1.55	NaCl
Hausmannite	-25.17	38.85	64.02	Mn3O4
Hematite	6.23	3.14	-3.09	Fe2O3
Huntite	-5.88	-35.08	-29.20	CaMg3(CO3)4
Hydromagnesite	-17.66	-24.87	-7.21	Mg5(CO3)4(OH)2:4H2O
Jarosite(ss)	-18.17	-28.00	-9.83	(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
Jarosite-K	-19.05	-27.33	-8.28	KFe3(SO4)2(OH)6
Jarosite-Na	-22.49	-26.70	-4.21	NaFe3(SO4)2(OH)6
JarositeH	-27.00	-30.75	-3.75	(H3O)Fe3(SO4)2(OH)6
Maghemite	-3.25	3.14	6.39	Fe2O3
Magnesite	-1.07	-8.92	-7.85	MgCO3
Magnetite	5.68	10.91	5.23	Fe3O4
Manganite	-10.02	15.32	25.34	MnOOH
Melanterite	-7.59	-9.95	-2.36	FeSO4:7H2O
Mirabilite	-7.95	-9.62	-1.68	Na2SO4:10H2O
Mn2(SO4)3	-70.55	-75.10	-4.55	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-14.37	-43.08	-28.71	Mn3(AsO4)2:8H2O
MnCl2:4H2O	-15.47	-13.27	2.19	MnCl2:4H2O
MnSO4	-12.64	-9.51	3.13	MnSO4
Nahcolite	-4.58	-5.24	-0.66	NaHCO3
Natron	-9.85	-11.63	-1.78	Na2CO3:10H2O
Nesquehonite	-3.47	-8.92	-5.45	MgCO3:3H2O
Nsutite	-20.15	22.42	42.56	MnO2
O2(g)	-58.88	-61.68	-2.80	O2
Portlandite	-12.31	11.41	23.72	Ca(OH)2
Pyrochroite	-6.98	8.22	15.20	Mn(OH)2
Pyrolusite	-20.90	22.42	43.31	MnO2
Rhodochrosite	-0.43	-11.52	-11.09	MnCO3
Rhodochrosite(d)	-1.13	-11.52	-10.39	MnCO3
Scorodite	-12.05	-32.30	-20.25	FeAsO4:2H2O
Siderite	-1.14	-11.96	-10.82	FeCO3
Siderite(d)(3)	-1.51	-11.96	-10.45	FeCO3
Thenardite	-9.46	-9.62	-0.16	Na2SO4
Thermonatrite	-11.84	-11.63	0.21	Na2CO3:H2O
Trona	-16.60	-16.87	-0.26	NaHCO3:Na2CO3:2H2O

Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic and Uranium\Arsenic2.pqi
Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC results\Stromsburg 3 12.6.06 1147 120gpm 125' 30 min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\wateq4f.dat

pH = 7.200
pe = 0.000

Activity of water	=	1.000
Ionic strength	=	1.121e-002
Mass of water (kg)	=	1.000e+000
Total carbon (mol/kg)	=	7.701e-003
Total CO2 (mol/kg)	=	7.701e-003
Temperature (deg C)	=	12.700
Electrical balance (eq)	=	-6.499e-004
Percent error, 100*(Cat-|An|)/(Cat+|An|)	=	-4.23
Iterations	=	10
Total H	=	1.110191e+002
Total O	=	5.553109e+001

----------------------------Distribution of species----------------------------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
H+	6.924e-008	6.310e-008	-7.160	-7.200	-0.040
OH-	6.529e-008	5.871e-008	-7.185	-7.231	-0.046
H2O	5.551e+001	9.998e-001	1.744	-0.000	0.000
As(3)	2.559e-007				
H3AsO3	2.540e-007	2.546e-007	-6.595	-6.594	0.001
H2AsO3-	1.970e-009	1.771e-009	-8.706	-8.752	-0.046
H4AsO3+	8.852e-015	7.960e-015	-14.053	-14.099	-0.046
HAsO3-2	4.927e-017	3.222e-017	-16.307	-16.492	-0.185
AsO3-3	1.708e-025	6.564e-026	-24.768	-25.183	-0.415
As(5)	7.926e-008				
HAsO4-2	4.659e-008	3.046e-008	-7.332	-7.516	-0.185
H2AsO4-	3.267e-008	2.938e-008	-7.486	-7.532	-0.046
AsO4-3	2.050e-012	7.880e-013	-11.688	-12.103	-0.415
H3AsO4	3.263e-013	3.271e-013	-12.486	-12.485	0.001
C(4)	7.701e-003				
HCO3-	6.530e-003	5.893e-003	-2.185	-2.230	-0.045
CO2	1.018e-003	1.020e-003	-2.992	-2.991	0.001
CaHCO3+	1.080e-004	9.712e-005	-3.967	-4.013	-0.046
MgHCO3+	2.764e-005	2.485e-005	-4.558	-4.605	-0.046
CaCO3	7.511e-006	7.531e-006	-5.124	-5.123	0.001
CO3-2	4.939e-006	3.277e-006	-5.306	-5.485	-0.178
NaHCO3	2.734e-006	2.741e-006	-5.563	-5.562	0.001
Fe(2)	2.329e-006				
Fe+2	1.542e-006	1.008e-006	-5.812	-5.996	-0.185
FeHCO3+	6.609e-007	5.943e-007	-6.180	-6.226	-0.046
FeCO3	7.906e-008	7.927e-008	-7.102	-7.101	0.001
FeSO4	4.398e-008	4.410e-008	-7.357	-7.356	0.001
Fe(3)	1.691e-011				
Fe(OH)3	8.605e-012	8.627e-012	-11.065	-11.064	0.001
S(6)	5.833e-004				
SO4-2	4.714e-004	3.109e-004	-3.327	-3.507	-0.181
CaSO4	9.060e-005	9.084e-005	-4.043	-4.042	0.001
MgSO4	1.956e-005	1.961e-005	-4.709	-4.707	0.001

```
   NaSO4-       1.321e-006  1.188e-006    -5.879    -5.925    -0.046

------------------------------Saturation indices-----------------------
--------

      Phase                SI log IAP  log KT

      Anhydrite         -1.96   -6.29   -4.33  CaSO4
      Aragonite          0.00   -8.27   -8.27  CaCO3
      Arsenolite       -11.58  -13.19   -1.61  As2O3
      Artinite          -8.44    2.06   10.51  MgCO3:Mg(OH)2:3H2O
      As2O5(cr)        -33.44  -24.97    8.47  As2O5
      As_native        -14.79  -28.19  -13.40  As
      Birnessite       -20.92   22.68   43.60  MnO2
      Bixbyite         -21.56  -21.69   -0.13  Mn2O3
      Brucite           -6.72   10.97   17.69  Mg(OH)2
      Ca3(AsO4)2:4w    -13.65  -32.55  -18.91  Ca3(AsO4)2:4H2O
      Calcite            0.15   -8.27   -8.42  CaCO3
      Claudetite       -11.63  -13.19   -1.55  As2O3
      CO2(g)            -1.68   -2.99   -1.31  CO2
      Dolomite          -0.39  -17.18  -16.79  CaMg(CO3)2
      Dolomite(d)       -0.99  -17.18  -16.19  CaMg(CO3)2
      Epsomite          -4.71   -6.93   -2.23  MgSO4:7H2O
      Fe(OH)2.7Cl.3      2.11   -0.93   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)        -2.61    2.28    4.89  Fe(OH)3
      Fe3(OH)8          -7.26   12.96   20.22  Fe3(OH)8
      Goethite           2.82    2.28   -0.54  FeOOH
      Gypsum            -1.70   -6.29   -4.59  CaSO4:2H2O
      H2(g)            -14.40  -17.49   -3.09  H2
      H2O(g)            -1.84   -0.00    1.84  H2O
      Halite            -8.12   -6.56    1.55  NaCl
      Hausmannite      -24.97   39.23   64.20  Mn3O4
      Hematite           7.59    4.56   -3.04  Fe2O3
      Huntite           -5.84  -35.00  -29.16  CaMg3(CO3)4
      Hydromagnesite   -17.56  -24.67   -7.11  Mg5(CO3)4(OH)2:4H2O
      Jarosite(ss)     -16.39  -26.22   -9.83
(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
      Jarosite-K       -17.33  -25.55   -8.22  KFe3(SO4)2(OH)6
      Jarosite-Na      -20.72  -24.86   -4.14  NaFe3(SO4)2(OH)6
      JarositeH        -25.33  -28.98   -3.65  (H3O)Fe3(SO4)2(OH)6
      Maghemite         -1.83    4.56    6.39  Fe2O3
      Magnesite         -1.08   -8.91   -7.83  MgCO3
      Magnetite          7.63   12.96    5.33  Fe3O4
      Manganite         -9.86   15.48   25.34  MnOOH
      Melanterite       -7.13   -9.50   -2.37  FeSO4:7H2O
      Mirabilite        -7.96   -9.67   -1.71  Na2SO4:10H2O
      Mn2(SO4)3        -70.94  -75.42   -4.48  Mn2(SO4)3
      Mn3(AsO4)2:8H2O  -13.87  -42.58  -28.71  Mn3(AsO4)2:8H2O
      MnCl2:4H2O       -15.25  -13.09    2.16  MnCl2:4H2O
      MnSO4            -12.79   -9.63    3.16  MnSO4
      Nahcolite         -4.65   -5.31   -0.67  NaHCO3
      Natron            -9.84  -11.65   -1.81  Na2CO3:10H2O
      Nesquehonite      -3.47   -8.91   -5.44  MgCO3:3H2O
      Nsutite          -19.89   22.68   42.56  MnO2
      O2(g)            -58.74  -61.53   -2.79  O2
      Portlandite      -12.16   11.62   23.78  Ca(OH)2
      Pyrochroite       -6.92    8.28   15.20  Mn(OH)2
```

```
      Pyrolusite      -20.76   22.68   43.43  MnO2
      Rhodochrosite    -0.52  -11.61  -11.08  MnCO3
      Rhodochrosite(d)  -1.22  -11.61  -10.39  MnCO3
      Scorodite       -11.18  -31.43  -20.25  FeAsO4:2H2O
      Siderite         -0.67  -11.48  -10.81  FeCO3
      Siderite(d)(3)   -1.03  -11.48  -10.45  FeCO3
      Thenardite       -9.51   -9.67   -0.16  Na2SO4
      Thermonatrite   -11.86  -11.65    0.21  Na2CO3:H2O
      Trona           -16.73  -16.96   -0.23  NaHCO3:Na2CO3:2H2O
```

```
   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Arsenic2.pqi
  Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC
results\Wauneta 3 8.16.05 0733 450gpm 144' 30 min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat
```

```
                                      pH  =   7.300
                                      pe  =   0.000
                       Activity of water  =   1.000
                          Ionic strength  =  6.180e-003
                      Mass of water (kg)  =  1.000e+000
                   Total carbon (mol/kg)  =  4.745e-003
                      Total CO2 (mol/kg)  =  4.745e-003
                     Temperature (deg C)  =  14.000
                 Electrical balance (eq)  = -4.736e-004
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -5.32
                              Iterations  =   7
                                 Total H  = 1.110167e+002
                                 Total O  = 5.552107e+001
```

```
----------------------------Distribution of species--------------------
--------
```

```
                                          Log       Log         Log
   Species     Molality    Activity  Molality  Activity      Gamma

   OH-        8.968e-008  8.263e-008    -7.047    -7.083     -0.036
   H+         5.395e-008  5.012e-008    -7.268    -7.300     -0.032
   H2O        5.551e+001  9.999e-001     1.744    -0.000      0.000
As(3)           7.367e-008
   H3AsO3     7.294e-008  7.304e-008    -7.137    -7.136      0.001
   H2AsO3-    7.316e-010  6.741e-010    -9.136    -9.171     -0.036
   H4AsO3+    1.968e-015  1.814e-015   -14.706   -14.741     -0.036
   HAsO3-2    2.275e-017  1.640e-017   -16.643   -16.785     -0.142
   AsO3-3     9.222e-026  4.415e-026   -25.035   -25.355     -0.320
As(5)           6.118e-008
   HAsO4-2    3.834e-008  2.764e-008    -7.416    -7.558     -0.142
   H2AsO4-    2.284e-008  2.104e-008    -7.641    -7.677     -0.036
   AsO4-3     1.947e-012  9.319e-013   -11.711   -12.031     -0.320
   H3AsO4     1.884e-013  1.887e-013   -12.725   -12.724      0.001
C(4)            4.745e-003
   HCO3-      4.169e-003  3.850e-003    -2.380    -2.415     -0.035
   CO2        5.152e-004  5.160e-004    -3.288    -3.287      0.001
   CaHCO3+    3.324e-005  3.063e-005    -4.478    -4.514     -0.036
   MgHCO3+    1.767e-005  1.628e-005    -4.753    -4.788     -0.036
```

```
   CO3-2      3.836e-006  2.791e-006    -5.416    -5.554    -0.138
   CaCO3      3.033e-006  3.038e-006    -5.518    -5.517     0.001
   NaHCO3     1.480e-006  1.482e-006    -5.830    -5.829     0.001
S(6)            1.770e-004
   SO4-2      1.538e-004  1.115e-004    -3.813    -3.953    -0.140
   CaSO4      1.541e-005  1.543e-005    -4.812    -4.812     0.001
   MgSO4      7.285e-006  7.295e-006    -5.138    -5.137     0.001

------------------------------Saturation indices----------------------
--------

      Phase               SI log IAP  log KT

      Anhydrite         -2.73   -7.07   -4.33  CaSO4
      Aragonite         -0.39   -8.67   -8.27  CaCO3
      Arsenolite       -12.69  -14.27   -1.58  As2O3
      Artinite          -8.21    2.19   10.41  MgCO3:Mg(OH)2:3H2O
      As2O5(cr)        -33.89  -25.45    8.44  As2O5
      As_native        -15.73  -29.04  -13.30  As
      Brucite           -6.43   11.17   17.60  Mg(OH)2
      Ca3(AsO4)2:4w    -14.49  -33.40  -18.91  Ca3(AsO4)2:4H2O
      Calcite           -0.24   -8.67   -8.43  CaCO3
      Claudetite       -12.74  -14.27   -1.53  As2O3
      CO2(g)            -1.96   -3.29   -1.33  CO2
      Dolomite          -0.82  -17.65  -16.83  CaMg(CO3)2
      Dolomite(d)       -1.42  -17.65  -16.23  CaMg(CO3)2
      Epsomite          -5.16   -7.38   -2.22  MgSO4:7H2O
      Gypsum            -2.48   -7.07   -4.59  CaSO4:2H2O
      H2(g)            -14.60  -17.70   -3.10  H2
      H2O(g)            -1.81   -0.00    1.81  H2O
      Halite            -9.01   -7.45    1.56  NaCl
      Huntite           -6.36  -35.61  -29.24  CaMg3(CO3)4
      Hydromagnesite   -17.45  -24.75   -7.30  Mg5(CO3)4(OH)2:4H2O
      Magnesite         -1.12   -8.98   -7.86  MgCO3
      Mirabilite        -8.64  -10.28   -1.65  Na2SO4:10H2O
      Nahcolite         -4.93   -5.58   -0.65  NaHCO3
      Natron           -10.13  -11.88   -1.75  Na2CO3:10H2O
      Nesquehonite      -3.52   -8.98   -5.46  MgCO3:3H2O
      O2(g)            -57.86  -60.66   -2.80  O2
      Portlandite      -12.18   11.49   23.67  Ca(OH)2
      Thenardite       -10.12  -10.28   -0.16  Na2SO4
      Thermonatrite    -12.09  -11.88    0.20  Na2CO3:H2O
      Trona            -17.17  -17.46   -0.29  NaHCO3:Na2CO3:2H2O


   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Arsenic2.pqi
  Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC
results\Wauneta 3 11.12.06 0915 155gpm 174' 30 min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat

                                    pH  =   7.800
                                    pe  =   0.000
                       Activity of water  =   1.000
                          Ionic strength  =  6.007e-003
                      Mass of water (kg)  =  1.000e+000
```

```
                    Total carbon (mol/kg)  =  4.040e-003
                       Total CO2 (mol/kg)  =  4.040e-003
                      Temperature (deg C)  =  15.200
                  Electrical balance (eq)  = -1.452e-004
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -1.69
                               Iterations  =   8
                                  Total H  = 1.110163e+002
                                  Total O  = 5.551929e+001

----------------------------Distribution of species--------------------
--------

                                             Log       Log         Log
   Species       Molality    Activity  Molality  Activity     Gamma

   OH-        3.136e-007  2.892e-007    -6.504    -6.539    -0.035
   H+         1.705e-008  1.585e-008    -7.768    -7.800    -0.032
   H2O        5.551e+001  9.999e-001     1.744    -0.000     0.000

As(3)           1.931e-009
   H3AsO3     1.869e-009  1.871e-009    -8.728    -8.728     0.001
   H2AsO3-    6.214e-011  5.731e-011   -10.207   -10.242    -0.035
   H4AsO3+    1.593e-017  1.469e-017   -16.798   -16.833    -0.035
   HAsO3-2    6.443e-018  4.661e-018   -17.191   -17.332    -0.141
   AsO3-3     8.592e-026  4.147e-026   -25.066   -25.382    -0.316

As(5)           1.436e-007
   HAsO4-2    1.209e-007  8.744e-008    -6.918    -7.058    -0.141
   H2AsO4-    2.270e-008  2.094e-008    -7.644    -7.679    -0.035
   AsO4-3     1.994e-011  9.624e-012   -10.700   -11.017    -0.316
   H3AsO4     6.001e-014  6.009e-014   -13.222   -13.221     0.001

C(4)            4.040e-003
   HCO3-      3.821e-003  3.532e-003    -2.418    -2.452    -0.034
   CO2        1.461e-004  1.463e-004    -3.835    -3.835     0.001
   CaHCO3+    3.141e-005  2.896e-005    -4.503    -4.538    -0.035
   MgHCO3+    1.591e-005  1.468e-005    -4.798    -4.833    -0.035
   CO3-2      1.144e-005  8.353e-006    -4.941    -5.078    -0.137
   CaCO3      9.223e-006  9.236e-006    -5.035    -5.035     0.001
   MgCO3      2.514e-006  2.517e-006    -5.600    -5.599     0.001
   NaHCO3     1.359e-006  1.361e-006    -5.867    -5.866     0.001

Fe(2)           1.253e-006
   Fe+2       8.699e-007  6.293e-007    -6.061    -6.201    -0.141
   FeHCO3+    2.410e-007  2.223e-007    -6.618    -6.653    -0.035
   FeCO3      1.259e-007  1.261e-007    -6.900    -6.899     0.001
   FeSO4      9.752e-009  9.765e-009    -8.011    -8.010     0.001

Fe(3)           7.176e-010
   Fe(OH)3    5.743e-010  5.751e-010    -9.241    -9.240     0.001
   Fe(OH)2+   1.193e-010  1.101e-010    -9.923    -9.958    -0.035
   Fe(OH)4-   2.388e-011  2.202e-011   -10.622   -10.657    -0.035
   FeOH+2     1.070e-014  7.737e-015   -13.971   -14.111    -0.141

S(6)            1.666e-004
   SO4-2      1.444e-004  1.050e-004    -3.841    -3.979    -0.138
   CaSO4      1.472e-005  1.474e-005    -4.832    -4.831     0.001
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   MgSO4       6.953e-006  6.962e-006    -5.158    -5.157     0.001
   NaSO4-      3.667e-007  3.381e-007    -6.436    -6.471    -0.035
   ------------------------------Saturation indices---------------------
-----------

      Phase               SI log IAP  log KT

      Anhydrite        -2.75   -7.09   -4.34  CaSO4
      Aragonite         0.09   -8.19   -8.28  CaCO3
      Arsenolite      -15.90  -17.46   -1.56  As2O3
      Artinite         -6.66    3.65   10.32  MgCO3:Mg(OH)2:3H2O
      As2O5(cr)       -34.86  -26.44    8.42  As2O5
      As_native       -18.91  -32.13  -13.22  As
      Brucite          -5.35   12.16   17.52  Mg(OH)2
      Ca3(AsO4)2:4w   -12.46  -31.37  -18.91  Ca3(AsO4)2:4H2O
      Calcite           0.24   -8.19   -8.43  CaCO3
      Claudetite      -15.95  -17.46   -1.51  As2O3
      CO2(g)           -2.49   -3.83   -1.34  CO2
      Dolomite          0.15  -16.70  -16.85  CaMg(CO3)2
      Dolomite(d)      -0.44  -16.70  -16.26  CaMg(CO3)2
      Epsomite         -5.20   -7.41   -2.21  MgSO4:7H2O
      Fe(OH)2.7Cl.3     3.41    0.37   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)       -0.95    3.94    4.89  Fe(OH)3
      Fe3(OH)8         -2.95   17.27   20.22  Fe3(OH)8
      Goethite          4.58    3.94   -0.64  FeOOH
      Gypsum           -2.51   -7.09   -4.58  CaSO4:2H2O
      H2(g)           -15.60  -18.71   -3.11  H2
      H2O(g)           -1.77   -0.00    1.77  H2O
      Halite           -8.83   -7.27    1.56  NaCl
      Hematite         11.11    7.88   -3.24  Fe2O3
      Huntite          -4.40  -33.73  -29.33  CaMg3(CO3)4
      Hydromagnesite  -14.43  -21.89   -7.46  Mg5(CO3)4(OH)2:4H2O
      Jarosite(ss)    -14.11  -23.94   -9.83
(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
      Jarosite-K      -14.67  -23.10   -8.43  KFe3(SO4)2(OH)6
      Jarosite-Na     -18.33  -22.71   -4.38  NaFe3(SO4)2(OH)6
      JarositeH       -23.33  -27.34   -4.02  (H3O)Fe3(SO4)2(OH)6
      Maghemite         1.49    7.88    6.39  Fe2O3
      Magnesite        -0.64   -8.51   -7.88  MgCO3
      Magnetite        12.28   17.27    4.99  Fe3O4
      Melanterite      -7.84  -10.18   -2.34  FeSO4:7H2O
      Mirabilite       -8.72  -10.31   -1.59  Na2SO4:10H2O
      Nahcolite        -4.98   -5.62   -0.64  NaHCO3
      Natron           -9.70  -11.41   -1.70  Na2CO3:10H2O
      Nesquehonite     -3.04   -8.51   -5.48  MgCO3:3H2O
      O2(g)           -55.42  -58.24   -2.81  O2
      Portlandite     -11.08   12.49   23.57  Ca(OH)2
      Scorodite       -10.23  -30.48  -20.25  FeAsO4:2H2O
      Siderite         -0.45  -11.28  -10.83  FeCO3
      Siderite(d)(3)   -0.83  -11.28  -10.45  FeCO3
      Thenardite      -10.14  -10.31   -0.16  Na2SO4
      Thermonatrite   -11.60  -11.41    0.19  Na2CO3:H2O
      Trona           -16.68  -17.02   -0.35  NaHCO3:Na2CO3:2H2O


   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Uranium.pqi
```

Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC results\York 731 8.3.05 1142 500gpm 226' 30 min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\wateq4f.dat

pH	=	6.800
pe	=	0.000
Activity of water	=	1.000
Ionic strength	=	8.374e-003
Mass of water (kg)	=	1.000e+000
Total carbon (mol/kg)	=	8.062e-003
Total CO2 (mol/kg)	=	8.062e-003
Temperature (deg C)	=	13.100
Electrical balance (eq)	=	-1.463e-003
Percent error, 100*(Cat-|An|)/(Cat+|An|)	=	-12.28
Iterations	=	12
Total H	=	1.110182e+002
Total O	=	5.552969e+001

----------------------------Distribution of species----------------------------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
H+	1.722e-007	1.585e-007	-6.764	-6.800	-0.036
OH-	2.657e-008	2.419e-008	-7.576	-7.616	-0.041
H2O	5.551e+001	9.998e-001	1.744	-0.000	0.000
C(4)	8.062e-003				
HCO3-	5.719e-003	5.224e-003	-2.243	-2.282	-0.039
CO2	2.249e-003	2.253e-003	-2.648	-2.647	0.001
CaHCO3+	6.835e-005	6.225e-005	-4.165	-4.206	-0.041
MgHCO3+	1.751e-005	1.595e-005	-4.757	-4.797	-0.041
NaHCO3	2.236e-006	2.241e-006	-5.650	-5.650	0.001
CaCO3	1.927e-006	1.930e-006	-5.715	-5.714	0.001
CO3-2	1.680e-006	1.169e-006	-5.775	-5.932	-0.158
FeHCO3+	5.903e-007	5.376e-007	-6.229	-6.270	-0.041
Fe(2)	2.150e-006				
Fe+2	1.496e-006	1.029e-006	-5.825	-5.988	-0.163
FeHCO3+	5.903e-007	5.376e-007	-6.229	-6.270	-0.041
FeSO4	3.292e-008	3.299e-008	-7.483	-7.482	0.001
Fe(3)	2.010e-012				
Fe(OH)2+	1.402e-012	1.277e-012	-11.853	-11.894	-0.041
Fe(OH)3	6.035e-013	6.047e-013	-12.219	-12.218	0.001
S(6)	3.853e-004				
SO4-2	3.264e-004	2.261e-004	-3.486	-3.646	-0.159
CaSO4	4.739e-005	4.749e-005	-4.324	-4.323	0.001
MgSO4	1.041e-005	1.043e-005	-4.982	-4.982	0.001
NaSO4-	8.774e-007	7.990e-007	-6.057	-6.097	-0.041
U(4)	1.855e-012				
U(OH)4	1.854e-012	1.857e-012	-11.732	-11.731	0.001
U(OH)3+	1.371e-015	1.248e-015	-14.863	-14.904	-0.041
U(6)	5.631e-008				
UO2(CO3)2-2	3.942e-008	2.711e-008	-7.404	-7.567	-0.163

```
   UO2(CO3)3-4 1.564e-008  3.498e-009    -7.806    -8.456    -0.650
   UO2CO3      1.238e-009  1.240e-009    -8.907    -8.906     0.001

------------------------------Saturation indices-----------------------
--------

      Phase               SI log IAP  log KT

      Anhydrite         -2.24   -6.57   -4.33  CaSO4
      Aragonite         -0.59   -8.86   -8.27  CaCO3
      Artinite          -9.94    0.53   10.48  MgCO3:Mg(OH)2:3H2O
      B-UO2(OH)2        -4.93    1.03    5.96  UO2(OH)2
      Birnessite       -22.35   21.25   43.60  MnO2
      Bixbyite         -23.54  -23.68   -0.15  Mn2O3
      Brucite           -7.63   10.03   17.67  Mg(OH)2
      Calcite           -0.44   -8.86   -8.42  CaCO3
      CO2(g)            -1.33   -2.65   -1.31  CO2
      Dolomite          -1.56  -18.36  -16.80  CaMg(CO3)2
      Dolomite(d)       -2.16  -18.36  -16.20  CaMg(CO3)2
      Epsomite          -4.99   -7.21   -2.23  MgSO4:7H2O
      Fe(OH)2.7Cl.3      1.03   -2.01   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)        -3.79    1.10    4.89  Fe(OH)3
      Fe3(OH)8         -10.42    9.81   20.22  Fe3(OH)8
      Goethite           1.66    1.10   -0.56  FeOOH
      Gummite          -10.07    1.03   11.10  UO3
      Gypsum            -1.99   -6.57   -4.59  CaSO4:2H2O
      H2(g)            -13.60  -16.70   -3.10  H2
      H2O(g)            -1.83   -0.00    1.83  H2O
      Halite            -8.22   -6.67    1.55  NaCl
      Hausmannite      -27.54   36.56   64.10  Mn3O4
      Hematite           5.26    2.19   -3.07  Fe2O3
      Huntite           -8.18  -37.36  -29.18  CaMg3(CO3)4
      Hydromagnesite   -20.80  -27.97   -7.17  Mg5(CO3)4(OH)2:4H2O
      Jarosite(ss)     -19.07  -28.90   -9.83
(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
      Jarosite-K       -20.10  -28.36   -8.26  KFe3(SO4)2(OH)6
      Jarosite-Na      -23.34  -27.52   -4.18  NaFe3(SO4)2(OH)6
      JarositeH        -27.49  -31.20   -3.71  (H3O)Fe3(SO4)2(OH)6
      Maghemite         -4.19    2.19    6.39  Fe2O3
      Magnesite         -1.66   -9.50   -7.84  MgCO3
      Magnetite          4.53    9.81    5.27  Fe3O4
      Manganite        -10.89   14.45   25.34  MnOOH
      Melanterite       -7.27   -9.63   -2.37  FeSO4:7H2O
      Mirabilite        -8.19   -9.88   -1.69  Na2SO4:10H2O
      Mn2(SO4)3        -70.90  -75.42   -4.52  Mn2(SO4)3
      MnCl2:4H2O       -15.23  -13.05    2.18  MnCl2:4H2O
      MnSO4            -12.73   -9.59    3.14  MnSO4
      Na4UO2(CO3)3     -26.54  -42.83  -16.29  Na4UO2(CO3)3
      Nahcolite         -4.74   -5.40   -0.66  NaHCO3
      Natron           -10.38  -12.17   -1.79  Na2CO3:10H2O
      Nesquehonite      -4.06   -9.50   -5.44  MgCO3:3H2O
      Nsutite          -21.31   21.25   42.56  MnO2
      O2(g)            -60.19  -62.99   -2.80  O2
      Portlandite      -13.07   10.67   23.74  Ca(OH)2
      Pyrochroite       -7.55    7.65   15.20  Mn(OH)2
      Pyrolusite       -22.11   21.25   43.36  MnO2
      Rhodochrosite     -0.79  -11.88  -11.09  MnCO3
```

```
      Rhodochrosite(d)  -1.49  -11.88  -10.39  MnCO3
      Rutherfordine    -4.09  -18.50  -14.41  UO2CO3
      Schoepite        -4.74    1.03    5.77  UO2(OH)2:H2O
      Siderite         -1.11  -11.92  -10.81  FeCO3
      Siderite(d)(3)   -1.47  -11.92  -10.45  FeCO3
      Thenardite       -9.72   -9.88   -0.16  Na2SO4
      Thermonatrite   -12.38  -12.17    0.21  Na2CO3:H2O
      Trona           -17.32  -17.57   -0.25  NaHCO3:Na2CO3:2H2O
      U(OH)2SO4       -16.52  -19.72   -3.20  U(OH)2SO4
      U3O8(c)          -4.30   19.76   24.06  U3O8
      U4O9(c)           3.99    3.69   -0.30  U4O9
      UO2(a)           -2.58   -2.48    0.10  UO2
      UO3(gamma)       -7.28    1.03    8.31  UO3
      Uraninite(c)      1.75   -2.48   -4.23  UO2


   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Uranium.pqi
  Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC
results\York 731 6.6.06 1550 250gpm 226' 30 min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat

                                       pH  =   7.000
                                       pe  =   0.000
                        Activity of water  =   1.000
                           Ionic strength  =  8.092e-003
                       Mass of water (kg)  =  1.000e+000
                    Total carbon (mol/kg)  =  4.221e-003
                       Total CO2 (mol/kg)  =  4.221e-003
                      Temperature (deg C)  =  13.000
                  Electrical balance (eq)  =  2.040e-003
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  19.04
                               Iterations  =  10
                                  Total H  = 1.110158e+002
                                  Total O  = 5.551959e+001

----------------------------Distribution of species--------------------
--------

                                            Log       Log          Log
   Species     Molality     Activity   Molality  Activity      Gamma

   H+         1.085e-007  1.000e-007    -6.964    -7.000    -0.036
   OH-        4.169e-008  3.802e-008    -7.380    -7.420    -0.040
   H2O        5.551e+001  9.998e-001     1.744    -0.000     0.000

C(4)             4.221e-003
   HCO3-      3.327e-003  3.043e-003    -2.478    -2.517    -0.039
   CO2        8.283e-004  8.298e-004    -3.082    -3.081     0.001
   CaHCO3+    4.587e-005  4.183e-005    -4.338    -4.379    -0.040
   MgHCO3+    1.207e-005  1.101e-005    -4.918    -4.958    -0.040
   NaHCO3     2.131e-006  2.135e-006    -5.671    -5.671     0.001
   CaCO3      2.050e-006  2.054e-006    -5.688    -5.687     0.001
   CO3-2      1.538e-006  1.076e-006    -5.813    -5.968    -0.155

Fe(2)            1.254e-006
```

```
   Fe+2       9.861e-007  6.821e-007    -6.006    -6.166    -0.160
   FeHCO3+    2.276e-007  2.075e-007    -6.643    -6.683    -0.040
   FeSO4      2.133e-008  2.137e-008    -7.671    -7.670     0.001
   FeCO3      1.757e-008  1.761e-008    -7.755    -7.754     0.001

Fe(3)            3.864e-012
   Fe(OH)2+   2.294e-012  2.092e-012   -11.639   -11.679    -0.040
   Fe(OH)3    1.559e-012  1.562e-012   -11.807   -11.806     0.001

S(6)             3.853e-004
   SO4-2      3.180e-004  2.214e-004    -3.498    -3.655    -0.157
   CaSO4      5.364e-005  5.374e-005    -4.271    -4.270     0.001
   MgSO4      1.206e-005  1.208e-005    -4.919    -4.918     0.001
   NaSO4-     1.403e-006  1.279e-006    -5.853    -5.893    -0.040

U(4)             1.388e-011
   U(OH)4     1.388e-011  1.390e-011   -10.858   -10.857     0.001
   U(OH)3+    6.474e-015  5.904e-015   -14.189   -14.229    -0.040

U(6)             3.445e-007
   UO2(CO3)2-2 2.466e-007  1.705e-007    -6.608    -6.768    -0.160
   UO2(CO3)3-4 8.926e-008  2.043e-008    -7.049    -7.690    -0.640
   UO2CO3      8.475e-009  8.491e-009    -8.072    -8.071     0.001
   UO2(OH)3-   1.393e-010  1.270e-010    -9.856    -9.896    -0.040

------------------------------Saturation indices-----------------------
--------

      Phase               SI log IAP  log KT

      Anhydrite        -2.18   -6.52   -4.33  CaSO4
      Aragonite        -0.56   -8.83   -8.27  CaCO3
      Artinite         -9.44    1.05   10.48  MgCO3:Mg(OH)2:3H2O
      B-UO2(OH)2       -3.66    2.30    5.97  UO2(OH)2
      Birnessite      -21.18   22.42   43.60  MnO2
      Bixbyite        -21.62  -21.76   -0.14  Mn2O3
      Brucite          -7.17   10.51   17.67  Mg(OH)2
      Calcite          -0.41   -8.83   -8.42  CaCO3
      CO2(g)           -1.77   -3.08   -1.31  CO2
      Dolomite         -1.49  -18.29  -16.80  CaMg(CO3)2
      Dolomite(d)      -2.09  -18.29  -16.20  CaMg(CO3)2
      Epsomite         -4.92   -7.15   -2.23  MgSO4:7H2O
      Fe(OH)2.7Cl.3     1.41   -1.63   -3.04  Fe(OH)2.7Cl0.3
      Fe(OH)3(a)       -3.37    1.52    4.89  Fe(OH)3
      Fe3(OH)8         -9.36   10.87   20.22  Fe3(OH)8
      Goethite          2.07    1.52   -0.55  FeOOH
      Gummite          -8.81    2.30   11.11  UO3
      Gypsum           -1.93   -6.52   -4.59  CaSO4:2H2O
      H2(g)           -14.00  -17.10   -3.10  H2
      H2O(g)           -1.83   -0.00    1.83  H2O
      Halite           -7.93   -6.38    1.55  NaCl
      Hausmannite     -24.86   39.27   64.12  Mn3O4
      Hematite          6.09    3.03   -3.06  Fe2O3
      Huntite          -8.04  -37.22  -29.18  CaMg3(CO3)4
      Hydromagnesite  -20.18  -27.34   -7.16  Mg5(CO3)4(OH)2:4H2O
      Jarosite(ss)    -18.48  -28.31   -9.83
(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
```

```
     Jarosite-K       -19.49  -27.74   -8.25  KFe3(SO4)2(OH)6
     Jarosite-Na      -22.50  -26.66   -4.17  NaFe3(SO4)2(OH)6
     JarositeH        -27.07  -30.76   -3.69  (H3O)Fe3(SO4)2(OH)6
     Maghemite         -3.35    3.03    6.39  Fe2O3
     Magnesite         -1.62   -9.46   -7.84  MgCO3
     Magnetite          5.58   10.87    5.29  Fe3O4
     Manganite         -9.92   15.42   25.34  MnOOH
     Melanterite       -7.45   -9.82   -2.37  FeSO4:7H2O
     Mirabilite        -7.77   -9.46   -1.70  Na2SO4:10H2O
     Mn2(SO4)3        -70.22  -74.73   -4.51  Mn2(SO4)3
     MnCl2:4H2O       -14.71  -12.53    2.18  MnCl2:4H2O
     MnSO4            -12.38   -9.23    3.14  MnSO4
     Na4UO2(CO3)3     -24.93  -41.22  -16.29  Na4UO2(CO3)3
     Nahcolite         -4.76   -5.42   -0.66  NaHCO3
     Natron            -9.98  -11.78   -1.79  Na2CO3:10H2O
     Nesquehonite      -4.02   -9.46   -5.44  MgCO3:3H2O
     Nsutite          -20.14   22.42   42.56  MnO2
     O2(g)            -59.43  -62.22   -2.79  O2
     Portlandite      -12.62   11.14   23.75  Ca(OH)2
     Pyrochroite       -6.78    8.42   15.20  Mn(OH)2
     Pyrolusite       -20.96   22.42   43.38  MnO2
     Rhodochrosite     -0.46  -11.55  -11.09  MnCO3
     Rhodochrosite(d)   -1.16  -11.55  -10.39  MnCO3
     Rutherfordine     -3.26  -17.66  -14.41  UO2CO3
     Schoepite         -3.47    2.30    5.77  UO2(OH)2:H2O
     Siderite          -1.32  -12.13  -10.81  FeCO3
     Siderite(d)(3)    -1.68  -12.13  -10.45  FeCO3
     Thenardite        -9.30   -9.46   -0.16  Na2SO4
     Thermonatrite    -11.99  -11.78    0.21  Na2CO3:H2O
     Trona            -16.95  -17.20   -0.24  NaHCO3:Na2CO3:2H2O
     U(OH)2SO4        -16.05  -19.25   -3.20  U(OH)2SO4
     U3O8(c)           -0.89   23.21   24.10  U3O8
     U4O9(c)            7.88    7.61   -0.27  U4O9
     UO2(a)            -1.70   -1.60    0.10  UO2
     UO3(gamma)        -6.01    2.30    8.31  UO3
     Uraninite(c)       2.63   -1.60   -4.23  UO2
```

```
   Input file: C:\Program Files\USGS\Phreeqc Interactive 2.13.0\Arsenic
and Uranium\Uranium.pqi
  Output file: Y:\ArsenicProject\Arsenic Project Data\PhreeqC
results\York 731 3.13.07 0850 50gpm 226' 30 min.pqo
Database file: C:\Program Files\USGS\Phreeqc Interactive
2.13.0\wateq4f.dat
```

```
                                     pH  =   7.500
                                     pe  =   0.000
                      Activity of water  =   1.000
                         Ionic strength  =  9.545e-003
                     Mass of water (kg)  =  1.000e+000
               Total carbon (mol/kg)  =  6.527e-003
                  Total CO2 (mol/kg)  =  6.527e-003
                 Temperature (deg C)  =  12.000
             Electrical balance (eq)  = -1.099e-003
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -8.22
                             Iterations  =   9
                                Total H  = 1.110185e+002
```

```
                                  Total O  = 5.552768e+001

----------------------------Distribution of species--------------------
--------
                                            Log       Log         Log
   Species   Molality    Activity  Molality  Activity     Gamma

   OH-       1.217e-007  1.103e-007    -6.915    -6.958    -0.043
   H+        3.450e-008  3.162e-008    -7.462    -7.500    -0.038
   H2O       5.551e+001  9.998e-001     1.744    -0.000     0.000

C(4)            6.527e-003
   HCO3-     5.926e-003  5.385e-003    -2.227    -2.269    -0.042
   CO2       4.730e-004  4.740e-004    -3.325    -3.324     0.001
   CaHCO3+   7.572e-005  6.859e-005    -4.121    -4.164    -0.043
   MgHCO3+   2.050e-005  1.857e-005    -4.688    -4.731    -0.043
   CaCO3     1.051e-005  1.053e-005    -4.978    -4.977     0.001
   CO3-2     8.595e-006  5.860e-006    -5.066    -5.232    -0.166
   FeHCO3+   4.504e-006  4.080e-006    -5.346    -5.389    -0.043
   NaHCO3    3.170e-006  3.177e-006    -5.499    -5.498     0.001
   MgCO3     1.401e-006  1.404e-006    -5.854    -5.853     0.001
   MnHCO3+   1.108e-006  1.003e-006    -5.956    -5.999    -0.043
   FeCO3     1.063e-006  1.065e-006    -5.974    -5.973     0.001

Fe(2)           1.720e-005
   Fe+2      1.126e-005  7.576e-006    -4.949    -5.121    -0.172
   FeHCO3    4.504e-006  4.080e-006    -5.346    -5.389    -0.043
   FeCO3     1.063e-006  1.065e-006    -5.974    -5.973     0.001
   FeSO4     3.413e-007  3.420e-007    -6.467    -6.466     0.001

Fe(3)           6.683e-010
   Fe(OH)3   4.426e-010  4.436e-010    -9.354    -9.353     0.001
   Fe(OH)2+  2.175e-010  1.970e-010    -9.663    -9.706    -0.043
   Fe(OH)4-  8.178e-012  7.407e-012   -11.087   -11.130    -0.043

S(6)            5.728e-004
   SO4-2     4.798e-004  3.255e-004    -3.319    -3.487    -0.169
   CaSO4     7.414e-005  7.431e-005    -4.130    -4.129     0.001
   MgSO4     1.645e-005  1.648e-005    -4.784    -4.783     0.001
   NaSO4-    1.733e-006  1.570e-006    -5.761    -5.804    -0.043
   FeSO4     3.413e-007  3.420e-007    -6.467    -6.466     0.001

U(4)            7.216e-014
   U(OH)4    7.215e-014  7.230e-014   -13.142   -13.141     0.001
   U(OH)3+   1.086e-017  9.838e-018   -16.964   -17.007    -0.043

U(6)            1.194e-007
   UO2(CO3)3-4 8.330e-008  1.710e-008    -7.079    -7.767    -0.688
   UO2(CO3)2-2 3.583e-008  2.411e-008    -7.446    -7.618    -0.172

------------------------------Saturation indices-----------------------
--------

      Phase               SI log IAP  log KT

      Anhydrite        -2.04   -6.37   -4.33  CaSO4
      Aragonite         0.15   -8.12   -8.26  CaCO3
```

Artinite	-7.82	2.74	10.56	MgCO3:Mg(OH)2:3H2O
B-UO2(OH)2	-5.01	0.99	6.00	UO2(OH)2
Birnessite	-19.28	24.32	43.60	MnO2
Bixbyite	-19.00	-19.10	-0.10	Mn2O3
Brucite	-6.26	11.49	17.75	Mg(OH)2
Calcite	0.30	-8.12	-8.42	CaCO3
CO2(g)	-2.03	-3.32	-1.30	CO2
Dolomite	-0.09	-16.86	-16.77	CaMg(CO3)2
Dolomite(d)	-0.69	-16.86	-16.17	CaMg(CO3)2
Epsomite	-4.77	-7.00	-2.23	MgSO4:7H2O
Fe(OH)2.7Cl.3	3.76	0.72	-3.04	Fe(OH)2.7Cl0.3
Fe(OH)3(a)	-0.86	4.04	4.89	Fe(OH)3
Fe3(OH)8	-2.27	17.95	20.22	Fe3(OH)8
Goethite	4.55	4.04	-0.52	FeOOH
Gummite	-10.18	0.99	11.17	UO3
Gypsum	-1.79	-6.37	-4.59	CaSO4:2H2O
H2(g)	-15.00	-18.09	-3.09	H2
H2O(g)	-1.86	-0.00	1.86	H2O
Halite	-8.08	-6.53	1.55	NaCl
Hausmannite	-21.43	42.96	64.39	Mn3O4
Hematite	11.05	8.07	-2.98	Fe2O3
Huntite	-5.25	-34.36	-29.11	CaMg3(CO3)4
Hydromagnesite	-16.48	-23.50	-7.02	Mg5(CO3)4(OH)2:4H2O
Jarosite(ss)	-12.12	-21.95	-9.83	(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
Jarosite-K	-13.09	-21.26	-8.16	KFe3(SO4)2(OH)6
Jarosite-Na	-16.28	-20.35	-4.07	NaFe3(SO4)2(OH)6
JarositeH	-21.32	-24.87	-3.55	(H3O)Fe3(SO4)2(OH)6
Maghemite	1.69	8.07	6.39	Fe2O3
Magnesite	-0.92	-8.75	-7.82	MgCO3
Magnetite	12.53	17.95	5.42	Fe3O4
Manganite	-8.52	16.82	25.34	MnOOH
Melanterite	-6.23	-8.61	-2.38	FeSO4:7H2O
Mirabilite	-7.70	-9.45	-1.75	Na2SO4:10H2O
Mn2(SO4)3	-70.16	-74.57	-4.41	Mn2(SO4)3
MnCl2:4H2O	-14.91	-12.78	2.13	MnCl2:4H2O
MnSO4	-12.35	-9.17	3.19	MnSO4
Na4UO2(CO3)3	-25.33	-41.62	-16.29	Na4UO2(CO3)3
Nahcolite	-4.58	-5.25	-0.67	NaHCO3
Natron	-9.35	-11.19	-1.84	Na2CO3:10H2O
Nesquehonite	-3.32	-8.75	-5.43	MgCO3:3H2O
Nsutite	-18.24	24.32	42.56	MnO2
O2(g)	-57.80	-60.58	-2.78	O2
Portlandite	-11.72	12.11	23.84	Ca(OH)2
Pyrochroite	-5.88	9.32	15.20	Mn(OH)2
Pyrolusite	-19.24	24.32	43.56	MnO2
Rhodochrosite	0.17	-10.91	-11.08	MnCO3
Rhodochrosite(d)	-0.52	-10.91	-10.39	MnCO3
Rutherfordine	-4.84	-19.24	-14.40	UO2CO3
Schoepite	-4.81	0.99	5.81	UO2(OH)2:H2O
Siderite	0.45	-10.35	-10.81	FeCO3
Siderite(d)(3)	0.10	-10.35	-10.45	FeCO3
Thenardite	-9.29	-9.45	-0.16	Na2SO4
Thermonatrite	-11.41	-11.19	0.22	Na2CO3:H2O
Trona	-16.25	-16.44	-0.19	NaHCO3:Na2CO3:2H2O
U(OH)2SO4	-19.10	-22.30	-3.20	U(OH)2SO4
U3O8(c)	-5.85	18.55	24.41	U3O8

U4O9(c)	-0.26	-0.26	-0.00	U4O9
UO2(a)	-3.92	-3.82	0.10	UO2
UO3(gamma)	-7.37	0.99	8.36	UO3
Uraninite(c)	0.36	-3.82	-4.18	UO2

Appendix E

WDS Analyses of Well Sediments

Unknown Specimen No. 1
Group : Clients Sample : WellSeds2
UNK No. : 1 Comment : Hematite std
Stage : X= 75.2319 Y= 21.4190 Z= 10.1795
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 09:52 2008
WDS only No. of accumulation : 1

Curr.(A) : 2.972E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	12.3	110.5	67.8	24.75	118
2 P	197.190	-0.4	9.3	7.7	100.00 ?	93
3 As	105.125	-2.9	453.5	334.0	100.00 ?	303
4 U	125.157	5.5	123.4	102.3	28.01	75
5 Mn	146.386	0.7	14.6	13.9	134.75 ?	462
6 Si	77.757	-1.7	221.8	148.2	100.00 ?	160
7 S	172.143	0.2	13.9	11.9	561.39 ?	104
8 Mg	107.478	-15.2	413.2	283.8	100.00 ?	159
9 Fe	134.892	1976.8	16.9	13.2	0.51	624
10 Ca	107.734	0.7	68.2	56.9	343.98 ?	71

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F	
Al2O3	0.061	0.0038	0.049	0.239	1.2536	0.9637	1.2930	1.0060	
P2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000	?
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000	?
UO2	0.033	0.0004	0.027	0.027	1.2073	1.2745	0.9473	1.0000	
MnO	0.033	0.0015	0.035	0.086	0.9556	0.9571	0.9984	1.0000	?
SiO2	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000	?
SO3	0.002	0.0001	0.002	0.001	1.0773	0.9990	1.0788	0.9996	?
MgO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000	?
Fe2O3	100.555	3.9944	100.552	100.552	1.0000	1.0000	1.0000	1.0000	
CaO	0.002	0.0001	0.002	0.008	0.9044	0.9228	0.9989	0.9811	?
Total	100.686	4.0003	100.667	100.914	Total O = 6.0		Iteration = 3		

Unknown Specimen No. 7
Group : Clients Sample : WellSeds2
UNK No. : 7 Comment : York filter map 3 dark circle
Stage : X= 40.9078 Y= 67.2334 Z= 11.4080
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 10:48 2008
WDS only No. of accumulation : 1

Curr.(A) : 2.973E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	8044.0	93.4	55.0	0.25	107
2 P	197.190	6.3	5.0	3.5	11.03	66
3 As	105.125	-9.6	159.4	119.5	100.00 ?	180
4 U	125.157	3.3	57.2	45.6	31.83	50
5 Mn	146.386	0.1	8.7	6.6	719.29 ?	338
6 Si	77.757	12829.3	198.1	90.1	0.20	142
7 S	172.143	1.6	6.4	6.5	53.35 ?	74
8 Mg	107.478	7.1	139.7	93.3	39.07 ?	92
9 Fe	134.892	42.7	6.7	6.2	3.90	408
10 Ca	107.734	3560.9	38.6	31.5	0.38	53

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	27.614	1.1971	32.116	156.663	0.8598	1.0392	0.8323	0.9941
P2O5	0.102	0.0032	0.079	0.193	1.2964	1.0160	1.2703	1.0045
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.021	0.0002	0.016	0.016	1.3252	1.3784	0.9613	1.0000
MnO	0.005	0.0002	0.005	0.012	1.0520	1.0444	1.0074	1.0000 ?
SiO2	50.193	1.8460	47.450	85.975	1.0578	0.9989	1.0584	1.0005
SO3	0.018	0.0005	0.015	0.011	1.2063	1.0782	1.1197	0.9992
MgO	0.023	0.0013	0.024	0.133	0.9769	0.9989	0.9840	0.9939
Fe2O3	2.391	0.0662	2.171	2.171	1.1009	1.0935	1.0068	1.0000
CaO	10.199	0.4019	10.127	40.219	1.0071	0.9992	1.0082	0.9998

Total 90.566 3.5165 92.002 285.393 Total O = 6.0 Iteration = 5

Unknown Specimen No. 8
Group : Clients Sample : AsWellSeds
UNK No. : 8 Comment : York sed 2
Stage : X= 55.8317 Y= 65.2453 Z= 10.8095
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 11:56 2008
WDS only No. of accumulation : 1

Curr.(A) : 2.993E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	-2.1	135.8	89.7	100.00 ?	132
2 Ca	107.734	524.2	68.4	73.4	1.10	75
3 As	105.125	35.1	680.9	403.7	10.83	346
4 Mn	146.386	1.5	20.1	17.0	73.97 ?	523
5 Si	77.757	2451.4	275.9	193.8	0.49	179

6 S	172.143	236.5	17.1	13.8	1.55	113
7 Mg	107.478	-1.5	585.7	417.6	100.00 ?	190
8 Fe	134.897	1261.6	21.8	20.4	0.64	734

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
CaO	1.371	0.0871	1.481	5.882	0.9260	0.9381	1.0019	0.9852
As2O5	0.404	0.0125	0.299	0.494	1.3497	1.1902	1.1340	1.0000
MnO	0.070	0.0035	0.072	0.178	0.9744	0.9744	1.0001	1.0000
SiO2	10.207	0.6053	9.006	16.318	1.1334	0.9410	1.2038	1.0006
SO3	2.376	0.1057	2.163	1.621	1.0982	1.0150	1.0824	0.9996
MgO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
Fe2O3	64.982	2.9001	63.726	63.726	1.0197	1.0184	1.0013	0.9999

Total 79.410 3.7144 76.747 88.218 Total O = 6.0 Iteration = 4

Unknown Specimen No. 9

Group : Clients Sample : AsWellSeds
UNK No. : 9 Comment : York sed 3
Stage : X= 55.8334 Y= 65.2369 Z= 10.8095
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 12:00 2008
WDS only No. of accumulation : 1

Curr.(A) : 2.990E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	2.4	170.5	115.1	157.51 ?	148
2 Ca	107.734	486.2	59.2	67.7	1.14	71
3 As	105.125	15.9	337.4	194.2	16.63	242
4 Mn	146.386	0.9	22.1	21.4	140.13 ?	567
5 Si	77.757	2417.0	350.6	243.4	0.51	202
6 S	172.143	212.0	13.4	11.9	1.62	103
7 Mg	107.478	3.9	298.2	190.0	101.22 ?	132
8 Fe	134.897	1139.1	22.6	20.5	0.67	742

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.011	0.0009	0.009	0.046	1.1910	0.9801	1.2105	1.0039 ?
CaO	1.275	0.0882	1.375	5.460	0.9271	0.9391	1.0019	0.9853
As2O5	0.183	0.0062	0.136	0.224	1.3461	1.1914	1.1298	1.0000
MnO	0.040	0.0022	0.041	0.101	0.9756	0.9755	1.0001	1.0000 ?
SiO2	10.045	0.6483	8.888	16.105	1.1302	0.9420	1.1991	1.0006

SO3	2.134	0.1034	1.941	1.454	1.0995	1.0161	1.0826	0.9996
MgO	0.020	0.0019	0.013	0.073	1.5407	0.9421	1.6285	1.0043
Fe2O3	58.803	2.8561	57.596	57.596	1.0210	1.0196	1.0013	1.0000

Total 72.511 3.7071 69.999 81.059 Total O = 6.0 Iteration = 4

Unknown Specimen No. 10
Group : Clients Sample : AsWellSeds
UNK No. : 10 Comment : York sed 4
Stage : X= 55.9054 Y= 65.1671 Z= 10.8090
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 12:05 2008
WDS only No. of accumulation : 1

Curr.(A) : 2.990E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	571.7	146.2	97.2	1.11	137
2 Ca	107.734	309.1	52.4	55.5	1.48	66
3 As	105.125	28.2	505.3	297.4	11.57	297
4 Mn	146.386	2.6	14.9	11.5	37.32 ?	441
5 Si	77.757	5355.8	336.9	213.7	0.32	195
6 S	172.143	408.2	15.1	9.1	1.14	100
7 Mg	107.478	137.7	445.1	290.5	3.87	162
8 Fe	134.897	563.5	15.8	13.4	0.97	611

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	2.444	0.1868	2.269	11.070	1.0771	1.0064	1.0704	0.9998
CaO	0.843	0.0586	0.874	3.471	0.9650	0.9657	1.0081	0.9913
As2O5	0.282	0.0096	0.241	0.398	1.1718	1.2234	0.9578	1.0000
MnO	0.125	0.0069	0.124	0.306	1.0069	1.0057	1.0013	1.0000
SiO2	21.218	1.3754	19.696	35.688	1.0773	0.9673	1.1136	1.0001
SO3	4.270	0.2078	3.738	2.800	1.1426	1.0436	1.0948	1.0000
MgO	0.607	0.0587	0.456	2.543	1.3311	0.9674	1.3730	1.0021
Fe2O3	30.034	1.4651	28.490	28.490	1.0542	1.0520	1.0022	0.9999

Total 59.823 3.3687 55.888 84.766 Total O = 6.0 Iteration = 4

Unknown Specimen No. 11
Group : Clients Sample : AsWellSeds

UNK No. : 11 Comment : York sed 5
Stage : X= 55.9507 Y= 65.2190 Z= 10.8070
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 12:10 2008
WDS only No. of accumulation : 1

Curr.(A) : 2.990E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	6.6	75.4	48.6	37.94 ?	98
2 Ca	107.734	342.4	58.3	67.3	1.41	71
3 As	105.125	9.3	699.6	428.5	41.93 ?	354
4 Mn	146.386	-0.4	24.1	22.1	100.00 ?	585
5 Si	77.757	1170.1	140.8	105.2	0.72	130
6 S	172.143	277.1	14.2	11.4	1.40	103
7 Mg	107.478	14.0	605.2	416.8	41.57 ?	191
8 Fe	134.897	1133.2	27.4	24.8	0.68	817

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.032	0.0027	0.026	0.129	1.2122	0.9751	1.2372	1.0048
CaO	0.891	0.0691	0.968	3.846	0.9205	0.9342	1.0013	0.9841
As2O5	0.110	0.0042	0.080	0.132	1.3767	1.1854	1.1614	1.0000
MnO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
SiO2	4.919	0.3559	4.303	7.797	1.1432	0.9372	1.2192	1.0005
SO3	2.759	0.1498	2.537	1.901	1.0877	1.0109	1.0764	0.9996
MgO	0.073	0.0079	0.046	0.258	1.5776	0.9373	1.6754	1.0047
Fe2O3	58.136	3.1649	57.295	57.295	1.0147	1.0137	1.0010	1.0000
Total	66.920	3.7544	65.256	71.357	Total O = 6.0	Iteration = 4		

Unknown Specimen No. 12
Group : Clients Sample : AsWellSeds
UNK No. : 12 Comment : York sed 6
Stage : X= 55.9543 Y= 65.2148 Z= 10.8070
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 12:14 2008
WDS only No. of accumulation : 1

Curr.(A) : 2.989E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	-2.3	147.4	96.3	100.00 ?	137
2 Ca	107.734	241.5	61.2	68.1	1.78	72
3 As	105.125	50.6	862.0	525.7	8.54	392

4 Mn	146.386	1.2	14.1	12.7	80.54 ?	445
5 Si	77.757	2077.1	306.4	210.0	0.55	188
6 S	172.143	345.2	14.7	13.2	1.25	108
7 Mg	107.478	0.2	758.4	518.1	2928.99 ?	214
8 Fe	134.897	1204.3	16.1	15.5	0.65	636

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
CaO	0.633	0.0421	0.683	2.713	0.9263	0.9378	1.0027	0.9851
As2O5	0.584	0.0189	0.432	0.713	1.3514	1.1898	1.1358	1.0000
MnO	0.055	0.0029	0.057	0.140	0.9737	0.9740	0.9998	0.9999
SiO2	8.680	0.5384	7.641	13.845	1.1359	0.9407	1.2070	1.0004
SO3	3.465	0.1614	3.161	2.369	1.0962	1.0147	1.0806	0.9997
MgO	0.001	0.0001	0.001	0.004	1.5473	0.9408	1.6374	1.0044 ?
Fe2O3	62.073	2.8978	60.913	60.913	1.0190	1.0181	1.0010	0.9999
Total	75.491	3.6616	72.887	80.696	Total O = 6.0	Iteration = 4		

Unknown Specimen No. 13
Group : Clients Sample : AsWellSeds
UNK No. : 13 Comment : York sed 7 bkg test
Stage : X= 56.0055 Y= 65.1009 Z= 10.8325
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 13:14 2008
WDS only No. of accumulation : 1

Curr.(A) : 2.997E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	-7.5	120.1	78.2	100.00 ?	123
2 Ca	107.734	1.5	43.0	39.6	137.07 ?	57
3 As	105.125	20.0	565.3	356.1	17.53	320
4 Mn	146.386	-1.0	14.1	12.3	100.00 ?	440
5 Si	77.757	26807.6	370.8	174.8	0.14	194
6 S	172.143	30.2	9.9	9.6	5.22	90
7 Mg	107.478	0.8	494.4	350.4	695.40 ?	174
8 Fe	134.897	37.1	14.9	11.5	4.80	580

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
CaO	0.004	0.0002	0.004	0.017	1.0253	1.0085	1.0169	0.9998 ?
As2O5	0.149	0.0026	0.171	0.282	0.8738	1.2746	0.6856	1.0000

MnO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
SiO2	89.966	2.9456	98.355	178.211	0.9147	1.0079	0.9068	1.0009
SO3	0.346	0.0085	0.276	0.207	1.2541	1.0879	1.1521	1.0006
MgO	0.002	0.0001	0.002	0.014	0.9713	1.0079	0.9696	0.9939 ?
Fe2O3	2.073	0.0511	1.872	1.872	1.1076	1.1044	1.0030	1.0000

Total 92.540 3.0080 100.680 180.602 Total O = 6.0 Iteration = 3

Unknown Specimen No. 14
Group : Clients Sample : AsWellSeds
UNK No. : 14 Comment : Haigler Sed Map target 1
Stage : X= 14.4669 Y= 57.0169 Z= 11.1610
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 14:19 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.001E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	-8.2	218.1	146.7	100.00 ?	167
2 Ca	107.734	8.1	63.6	82.0	33.90 ?	76
3 As	105.125	24.5	1113.3	851.8	21.46	475
4 Mn	146.386	3.5	10.3	10.2	25.77	388
5 Si	77.757	1411.3	465.0	316.6	0.75	231
6 S	172.143	314.5	15.0	16.1	1.32	114
7 Mg	107.478	-5.0	1085.0	747.0	100.00 ?	255
8 Fe	134.897	1226.2	12.8	11.7	0.64	558

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
CaO	0.021	0.0015	0.023	0.091	0.9211	0.9342	1.0021	0.9840
As2O5	0.287	0.0100	0.208	0.344	1.3761	1.1854	1.1608	1.0000
MnO	0.158	0.0089	0.163	0.402	0.9691	0.9699	0.9991	1.0000
SiO2	5.915	0.3938	5.171	9.370	1.1439	0.9372	1.2200	1.0005
SO3	3.128	0.1563	2.869	2.149	1.0903	1.0109	1.0788	0.9997
MgO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
Fe2O3	62.652	3.1388	61.772	61.772	1.0142	1.0137	1.0006	1.0000

Total 72.161 3.7093 70.206 74.128 Total O = 6.0 Iteration = 4

Unknown Specimen No. 15
Group : Clients Sample : AsWellSeds
UNK No. : 15 Comment : Hematite std
Stage : X= 74.7651 Y= 21.1009 Z= 10.1720
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 14:26 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.001E-08

Element		Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)		D.L.(ppm)
1	Al	90.965	8.8	111.9	69.8	34.37	?	118
2	Ca	107.734	-12.9	69.4	83.4	100.00	?	78
3	As	105.125	2.1	432.2	333.5	159.73	?	297
4	Mn	146.386	0.4	14.4	13.5	242.37	?	452
5	Si	77.757	5.4	223.5	149.2	81.59	?	159
6	S	172.143	0.9	14.7	12.4	129.64	?	106
7	Mg	107.478	-4.1	419.8	281.1	100.00	?	158
8	Fe	134.897	1975.8	18.1	15.7	0.51		655

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F	
Al2O3	0.044	0.0028	0.035	0.171	1.2537	0.9638	1.2931	1.0060	
CaO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000	?
As2O5	0.025	0.0007	0.018	0.029	1.4396	1.1715	1.2288	1.0000	?
MnO	0.018	0.0008	0.019	0.046	0.9556	0.9572	0.9984	1.0000	?
SiO2	0.023	0.0012	0.020	0.036	1.1691	0.9263	1.2610	1.0009	
SO3	0.009	0.0004	0.008	0.006	1.0774	0.9990	1.0789	0.9996	?
MgO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000	?
Fe2O3	99.536	3.9932	99.530	99.530	1.0001	1.0001	1.0000	1.0000	
Total	99.655	3.9990	99.629	99.818	Total O = 6.0		Iteration = 3		

Unknown Specimen No. 16
Group : Clients Sample : AsWellSeds
UNK No. : 16 Comment : Haigler sed map target 2
Stage : X= 74.7651 Y= 21.1008 Z= 10.1720
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 15:02 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.003E-08

Element		Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)		D.L.(ppm)
1	Al	90.965	7.9	117.7	70.2	38.96	?	119

2 Ca	107.734	-15.1	71.1	87.7	100.00 ?	79
3 As	105.125	-1.5	469.1	339.9	100.00 ?	303
4 Mn	146.386	-0.1	14.1	11.6	100.00 ?	434
5 Si	77.757	9.1	214.3	148.0	47.87 ?	157
6 S	172.143	0.2	12.9	13.7	647.84 ?	105
7 Mg	107.478	-3.7	424.0	288.1	100.00 ?	159
8 Fe	134.897	1971.4	16.8	14.3	0.51	628

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.039	0.0025	0.031	0.152	1.2536	0.9638	1.2929	1.0060
CaO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
MnO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
SiO2	0.039	0.0021	0.033	0.060	1.1690	0.9263	1.2609	1.0009
SO3	0.002	0.0001	0.002	0.001	1.0774	0.9990	1.0788	0.9996 ?
MgO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
Fe2O3	99.252	3.9946	99.244	99.243	1.0001	1.0001	1.0000	1.0000

Total 99.332 3.9992 99.310 99.457 Total O = 6.0 Iteration = 3

Unknown Specimen No. 17
Group : Clients Sample : AsWellSeds
UNK No. : 17 Comment : Haigler sed map target 3
Stage : X= 14.4526 Y= 57.0057 Z= 11.1465
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 15:20 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.001E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	3.3	125.9	80.0	97.96 ?	125
2 Ca	107.734	18.5	61.4	64.1	14.52	71
3 As	105.125	29.9	574.4	443.5	12.74	342
4 Mn	146.386	1.7	8.8	6.2	44.71 ?	332
5 Si	77.757	1223.7	247.6	181.8	0.74	171
6 S	172.143	706.0	12.8	9.9	0.85	97
7 Mg	107.478	-4.3	530.3	376.0	100.00 ?	180
8 Fe	134.897	988.5	10.1	8.4	0.72	484

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.015	0.0013	0.013	0.063	1.1930	0.9811	1.2107	1.0044

CaO	0.048	0.0037	0.052	0.207	0.9308	0.9401	1.0045	0.9856
As2O5	0.342	0.0128	0.254	0.420	1.3445	1.1926	1.1274	1.0000
MnO	0.076	0.0046	0.078	0.193	0.9763	0.9766	0.9997	1.0000
SiO2	5.070	0.3625	4.484	8.124	1.1309	0.9429	1.1996	0.9998
SO3	6.998	0.3755	6.440	4.825	1.0865	1.0171	1.0685	0.9998
MgO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
Fe2O3	50.885	2.7375	49.798	49.798	1.0218	1.0208	1.0010	0.9999

Total 63.434 3.4979 61.120 63.631 Total O = 6.0 Iteration = 4

Unknown Specimen No. 18
Group : Clients Sample : AsWellSeds
UNK No. : 18 Comment : Haigler sed map target 4
Stage : X= 14.5336 Y= 57.0867 Z= 11.1480
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 15:55 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.002E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	0.2	187.7	119.6	2117.35 ?	153
2 Ca	107.734	9.4	64.8	72.1	28.83	74
3 As	105.125	4.8	474.9	348.7	70.15 ?	306
4 Mn	146.386	2.6	11.7	10.7	34.73 ?	406
5 Si	77.757	1323.7	406.6	269.9	0.76	215
6 S	172.143	368.7	16.2	11.4	1.21	107
7 Mg	107.478	-8.0	427.4	294.4	100.00 ?	160
8 Fe	134.897	1299.3	14.4	11.1	0.63	569

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.001	0.0001	0.001	0.004	1.2135	0.9749	1.2388	1.0048 ?
CaO	0.024	0.0017	0.026	0.105	0.9206	0.9339	1.0019	0.9838
As2O5	0.056	0.0019	0.041	0.067	1.3807	1.1851	1.1651	1.0000
MnO	0.120	0.0064	0.124	0.305	0.9688	0.9697	0.9991	1.0000
SiO2	5.545	0.3524	4.849	8.785	1.1436	0.9370	1.2200	1.0004
SO3	3.658	0.1745	3.362	2.519	1.0879	1.0106	1.0767	0.9997
MgO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
Fe2O3	66.344	3.1727	65.432	65.432	1.0139	1.0134	1.0005	1.0000

Total 75.748 3.7095 73.834 77.217 Total O = 6.0 Iteration = 4

Unknown Specimen No. 19
Group : Clients Sample : AsWellSeds
UNK No. : 19 Comment : Haigler sed map target 5
Stage : X= 14.5053 Y= 57.0532 Z= 11.1650
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 15:28 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.002E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	-7.2	213.5	146.3	100.00 ?	166
2 Ca	107.734	7.1	66.5	75.5	38.30 ?	75
3 As	105.125	49.1	634.6	461.9	8.04	353
4 Mn	146.386	1.9	6.9	5.9	37.39 ?	306
5 Si	77.757	1431.3	427.8	293.4	0.73	222
6 S	172.143	289.8	16.2	14.5	1.38	113
7 Mg	107.478	4.7	553.3	378.3	116.26 ?	182
8 Fe	134.897	1264.1	7.4	7.7	0.63	438

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
CaO	0.018	0.0013	0.020	0.080	0.9207	0.9337	1.0021	0.9840
As2O5	0.574	0.0195	0.417	0.689	1.3758	1.1847	1.1613	1.0000
MnO	0.085	0.0047	0.088	0.216	0.9685	0.9694	0.9991	0.9999
SiO2	6.011	0.3911	5.242	9.499	1.1467	0.9367	1.2235	1.0005
SO3	2.884	0.1408	2.643	1.980	1.0912	1.0103	1.0803	0.9997
MgO	0.025	0.0024	0.016	0.087	1.5766	0.9368	1.6752	1.0046
Fe2O3	64.521	3.1588	63.657	63.657	1.0136	1.0131	1.0006	0.9999

Total 74.118 3.7186 72.082 76.208 Total O = 6.0 Iteration = 4

Unknown Specimen No. 20
Group : Clients Sample : AsWellSeds
UNK No. : 20 Comment : Haigler sed map target 6
Stage : X= 14.4233 Y= 57.2251 Z= 11.1485
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 15:59 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.009E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	1.3	51.2	31.7	157.24 ?	79
2 Ca	107.734	29.2	49.5	58.7	8.95	65
3 As	105.125	45.2	140.8	105.7	4.38	168
4 Mn	146.386	6.9	17.8	15.3	16.80	491
5 Si	77.757	743.1	90.1	69.2	0.91	104
6 S	172.143	251.2	7.8	5.9	1.45	75
7 Mg	107.478	0.4	122.9	83.5	736.95 ?	85
8 Fe	134.897	1351.9	20.9	16.8	0.62	690

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.006	0.0005	0.005	0.025	1.2316	0.9704	1.2624	1.0053 ?
CaO	0.075	0.0054	0.082	0.326	0.9147	0.9295	1.0011	0.9830
As2O5	0.536	0.0186	0.383	0.633	1.3987	1.1796	1.1857	1.0000
MnO	0.310	0.0174	0.321	0.794	0.9636	0.9646	0.9990	1.0000
SiO2	3.139	0.2087	2.716	4.920	1.1559	0.9327	1.2387	1.0006
SO3	2.478	0.1237	2.286	1.712	1.0842	1.0060	1.0781	0.9997
MgO	0.002	0.0002	0.001	0.006	1.6041	0.9327	1.7115	1.0048 ?
Fe2O3	68.491	3.4274	67.920	67.920	1.0084	1.0080	1.0004	0.9999
Total	75.037	3.8020	73.715	76.337	Total O = 6.0	Iteration = 3		

Unknown Specimen No. 22
Group : Clients Sample : AsWellSeds
UNK No. : 22 Comment : Wauneta sed map target 1
Stage : X= 15.6425 Y= 72.2942 Z= 10.7705
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 17:02 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.001E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	-1.1	201.5	140.7	100.00 ?	162
2 Ca	107.734	33.3	56.9	50.8	7.99	65
3 As	105.125	0.5	571.3	428.1	714.75 ?	338
4 Mn	146.386	1.3	20.3	18.7	91.37 ?	535
5 Si	77.757	1850.3	433.7	297.4	0.62	223
6 S	172.143	479.2	16.0	11.5	1.05	107
7 Mg	107.478	0.4	512.3	342.2	1435.65 ?	174
8 Fe	134.892	1051.4	22.8	19.8	0.70	735

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
CaO	0.087	0.0064	0.094	0.372	0.9293	0.9400	1.0034	0.9853
As2O5	0.006	0.0002	0.004	0.007	1.3479	1.1924	1.1304	1.0000 ?
MnO	0.058	0.0034	0.059	0.147	0.9759	0.9764	0.9995	1.0000
SiO2	7.652	0.5259	6.779	12.284	1.1288	0.9427	1.1971	1.0002
SO3	4.781	0.2467	4.372	3.275	1.0938	1.0169	1.0758	0.9998
MgO	0.002	0.0002	0.001	0.007	1.5430	0.9428	1.6294	1.0044 ?
Fe2O3	54.106	2.7984	52.967	52.967	1.0215	1.0206	1.0008	1.0000
Total	66.692	3.5812	64.277	69.059	Total O = 6.0		Iteration = 4	

Unknown Specimen No. 23
Group : Clients Sample : AsWellSeds
UNK No. : 23 Comment : Wauneta sed map target 2
Stage : X= 15.6093 Y= 72.2935 Z= 10.7705
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 17:06 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.001E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	4.4	153.4	92.7	78.64 ?	137
2 Ca	107.734	49.0	60.6	51.0	5.79	67
3 As	105.125	18.6	303.2	227.8	14.75	247
4 Mn	146.386	0.1	17.7	15.2	1565.39 ?	492
5 Si	77.757	1941.3	309.7	206.9	0.57	188
6 S	172.143	617.7	12.4	14.4	0.92	106
7 Mg	107.478	11.8	268.2	186.8	32.97	127
8 Fe	134.892	1029.0	17.3	17.3	0.71	663

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.021	0.0016	0.017	0.085	1.1837	0.9830	1.1994	1.0039
CaO	0.129	0.0092	0.138	0.549	0.9329	0.9421	1.0044	0.9859
As2O5	0.211	0.0073	0.158	0.262	1.3337	1.1950	1.1161	1.0000
MnO	0.003	0.0002	0.003	0.008	0.9786	0.9788	0.9997	1.0000 ?
SiO2	8.003	0.5314	7.113	12.888	1.1251	0.9448	1.1909	1.0000
SO3	6.165	0.3072	5.635	4.222	1.0940	1.0191	1.0737	0.9998
MgO	0.060	0.0059	0.039	0.218	1.5260	0.9449	1.6081	1.0043
Fe2O3	53.093	2.6530	51.836	51.836	1.0242	1.0232	1.0010	1.0000
Total	67.685	3.5158	64.940	70.067	Total O = 6.0		Iteration = 4	

Unknown Specimen No. 24
Group : Clients Sample : AsWellSeds
UNK No. : 24 Comment : Wauneta sed map target 3
Stage : X= 15.7476 Y= 72.3822 Z= 10.7775
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 17:10 2008
WDS only No. of accumulation : 1

Curr.(A) : 2.998E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	-4.5	199.5	131.8	100.00 ?	159
2 Ca	107.734	53.2	73.2	61.0	5.76	73
3 As	105.125	-3.8	944.8	713.2	100.00 ?	436
4 Mn	146.386	0.8	10.0	10.3	109.41 ?	387
5 Si	77.757	2388.3	434.6	289.0	0.52	222
6 S	172.143	221.5	18.0	14.8	1.61	117
7 Mg	107.478	-8.3	858.3	592.2	100.00 ?	227
8 Fe	134.892	1309.8	13.1	10.6	0.62	549

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
CaO	0.139	0.0088	0.150	0.596	0.9242	0.9370	1.0020	0.9844
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
MnO	0.035	0.0018	0.036	0.089	0.9723	0.9731	0.9992	1.0000 ?
SiO2	9.947	0.5912	8.760	15.872	1.1356	0.9398	1.2075	1.0006
SO3	2.221	0.0991	2.023	1.516	1.0980	1.0138	1.0833	0.9998
MgO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
Fe2O3	67.217	3.0064	66.050	66.050	1.0177	1.0170	1.0006	1.0000

Total 79.559 3.7074 77.019 84.123 Total O = 6.0 Iteration = 4

Unknown Specimen No. 25
Group : Clients Sample : AsWellSeds
UNK No. : 25 Comment : Wauneta sed map target 4
Stage : X= 15.6848 Y= 72.2747 Z= 10.7690
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 28 17:14 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.000E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	18.8	232.7	156.6	23.69	173
2 Ca	107.734	36.8	64.9	48.2	7.45	67
3 As	105.125	3.1	797.4	608.6	144.37 ?	402
4 Mn	146.386	0.6	22.5	18.3	185.51 ?	548
5 Si	77.757	1584.6	484.6	339.0	0.70	237
6 S	172.143	314.1	13.6	13.5	1.32	106
7 Mg	107.478	8.4	725.3	490.0	75.17 ?	208
8 Fe	134.892	1068.6	22.0	20.3	0.70	733

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.090	0.0077	0.075	0.363	1.2022	0.9778	1.2241	1.0044
CaO	0.096	0.0075	0.104	0.412	0.9245	0.9368	1.0024	0.9845
As2O5	0.036	0.0014	0.026	0.043	1.3641	1.1886	1.1477	1.0000 ?
MnO	0.029	0.0018	0.030	0.073	0.9722	0.9729	0.9993	1.0000 ?
SiO2	6.605	0.4803	5.808	10.524	1.1372	0.9397	1.2096	1.0004
SO3	3.133	0.1710	2.866	2.147	1.0931	1.0136	1.0787	0.9998
MgO	0.043	0.0047	0.028	0.154	1.5625	0.9398	1.6551	1.0045
Fe2O3	54.796	2.9984	53.851	53.851	1.0176	1.0169	1.0007	1.0000
Total	64.828	3.6727	62.787	67.568	Total O = 6.0	Iteration = 4		

Unknown Specimen No. 14

Group : Clients Sample : WellSeds2

UNK No. : 14 Comment : Bellwood filter map 4 irregular bio

Stage : X= 49.1783 Y= 65.6652 Z= 11.3560

Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off

Dated on May 29 12:10 2008

WDS only No. of accumulation : 1

Curr.(A) : 3.015E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	49.1	26.0	12.0	4.20	53
2 P	197.190	164.5	4.0	3.9	1.46	63

3 As	105.125	2.6	395.1	430.3	136.11 ?	316
4 U	125.157	39.6	86.1	67.3	3.53	60
5 Mn	146.386	23.6	17.3	14.3	5.76	480
6 Si	77.757	1221.5	56.6	35.3	0.66	79
7 S	172.143	11.0	6.7	4.8	9.61	69
8 Mg	107.478	146.1	322.6	224.1	3.26	139
9 Fe	134.892	424.9	16.8	12.0	1.12	602
10 Ca	107.734	6065.0	34.1	31.0	0.29	51

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.213	0.0253	0.193	0.944	1.0999	0.9949	1.1016	1.0036
P2O5	2.252	0.1927	2.027	4.952	1.1111	0.9723	1.1396	1.0027
As2O5	0.027	0.0014	0.022	0.037	1.2025	1.2094	0.9943	1.0000 ?
UO2	0.235	0.0053	0.191	0.191	1.2314	1.3169	0.9351	1.0000
MnO	1.111	0.0951	1.101	2.719	1.0089	0.9917	1.0174	1.0000
SiO2	4.765	0.4815	4.455	8.072	1.0697	0.9562	1.1200	0.9989
SO3	0.107	0.0082	0.100	0.075	1.0760	1.0315	1.0481	0.9952
MgO	0.658	0.0990	0.480	2.675	1.3702	0.9563	1.4267	1.0043
Fe2O3	22.411	1.7040	21.307	21.307	1.0518	1.0368	1.0144	1.0000
CaO	15.968	1.7287	17.009	67.548	0.9388	0.9538	0.9916	0.9926

Total 47.747 4.3412 46.885 108.519 Total O = 6.0 Iteration = 4

Unknown Specimen No. 15
Group : Clients Sample : WellSeds2
UNK No. : 15 Comment : Bellwood filter map 5 odd Fe-oxide
Stage : X= 49.2371 Y= 65.7117 Z= 11.3575
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 12:14 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.016E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	34.5	113.1	69.0	9.41	117
2 P	197.190	116.4	8.3	8.2	1.81	91
3 As	105.125	-48.3	437.9	395.0	100.00 ?	312
4 U	125.157	10.7	111.2	93.9	13.82	69
5 Mn	146.386	8.7	17.6	19.0	14.17	516
6 Si	77.757	913.6	239.2	150.7	0.89	162
7 S	172.143	11.1	12.6	11.7	11.96	100
8 Mg	107.478	54.9	416.0	294.8	9.10	158
9 Fe	134.892	1757.0	19.1	20.1	0.54	702

10 Ca 107.734 967.0 58.7 52.5 0.76 66

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F	
Al2O3	0.166	0.0102	0.136	0.662	1.2264	0.9703	1.2572	1.0053	
P2O5	1.639	0.0721	1.433	3.502	1.1436	0.9482	1.2000	1.0050	
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000	?
UO2	0.063	0.0007	0.052	0.052	1.2165	1.2835	0.9478	1.0000	
MnO	0.390	0.0172	0.405	0.999	0.9646	0.9645	1.0001	1.0000	
SiO2	3.837	0.1994	3.331	6.035	1.1521	0.9326	1.2347	1.0005	
SO3	0.110	0.0043	0.101	0.076	1.0858	1.0059	1.0801	0.9994	
MgO	0.289	0.0224	0.180	1.006	1.6030	0.9327	1.7104	1.0049	
Fe2O3	88.879	3.4759	88.067	88.067	1.0092	1.0079	1.0013	1.0000	
CaO	2.476	0.1379	2.711	10.766	0.9132	0.9294	0.9993	0.9833	
Total	97.849	3.9401	96.415	111.164	Total O = 6.0		Iteration = 3		

Unknown Specimen No. 16
Group : Clients Sample : WellSeds2
UNK No. : 16 Comment : Bellwood filter map 6 Fe-oxide plate
Stage : X= 49.3177 Y= 65.6568 Z= 11.3600
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 12:18 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.016E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)		D.L.(ppm)
1 Al	90.965	61.0	179.0	110.3	6.77		148
2 P	197.190	39.8	12.1	8.9	3.56		102
3 As	105.125	-73.9	414.1	382.1	100.00	?	306
4 U	125.157	8.6	86.4	70.9	15.00		61
5 Mn	146.386	17.5	7.7	6.9	5.91		327
6 Si	77.757	1019.8	367.0	235.4	0.89		202
7 S	172.143	16.8	11.2	12.1	8.43		98
8 Mg	107.478	82.5	374.0	247.3	5.80		148
9 Fe	134.892	1474.8	8.7	6.6	0.59		438
10 Ca	107.734	6000.3	58.9	49.2	0.29		65

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F	
Al2O3	0.286	0.0178	0.240	1.171	1.1896	0.9772	1.2110	1.0052	
P2O5	0.554	0.0248	0.491	1.199	1.1288	0.9550	1.1772	1.0041	
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000	?

UO2	0.051	0.0006	0.042	0.042	1.2161	1.2928	0.9407	1.0000
MnO	0.801	0.0358	0.819	2.022	0.9787	0.9720	1.0069	1.0000
SiO2	4.195	0.2215	3.718	6.737	1.1284	0.9392	1.2010	1.0003
SO3	0.164	0.0065	0.153	0.114	1.0734	1.0131	1.0620	0.9976
MgO	0.416	0.0328	0.271	1.511	1.5363	0.9393	1.6277	1.0048
Fe2O3	75.581	3.0032	73.924	73.924	1.0224	1.0158	1.0065	1.0000
CaO	15.453	0.8743	16.822	66.805	0.9186	0.9362	0.9943	0.9868

Total 97.501 4.2173 96.478 153.524 Total O = 6.0 Iteration = 4

Unknown Specimen No. 20
Group : Clients Sample : WellSeds2
UNK No. : 20 Comment : Bellwood filter map 10 High-P
Stage : X= 49.1732 Y= 65.6128 Z= 11.3570
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 12:35 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.018E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	27.8	78.8	45.0	9.75	96
2 P	197.190	324.9	7.7	9.3	1.04	93
3 As	105.125	-55.9	588.5	523.5	100.00 ?	360
4 U	125.157	15.2	113.5	99.2	9.94	70
5 Mn	146.386	7.5	18.5	15.2	15.68	494
6 Si	77.757	2888.4	169.4	110.3	0.44	137
7 S	172.143	57.1	11.6	11.1	3.50	97
8 Mg	107.478	92.6	542.8	371.5	6.19	179
9 Fe	134.892	1345.5	18.6	18.8	0.62	685
10 Ca	107.734	3415.1	58.9	54.4	0.39	67

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.127	0.0073	0.109	0.533	1.1642	0.9844	1.1781	1.0037
P2O5	4.588	0.1888	3.998	9.768	1.1476	0.9621	1.1876	1.0045
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.091	0.0010	0.073	0.073	1.2351	1.3027	0.9481	1.0000
MnO	0.343	0.0141	0.349	0.861	0.9845	0.9804	1.0042	1.0000
SiO2	11.699	0.5685	10.524	19.068	1.1117	0.9461	1.1753	0.9997
SO3	0.570	0.0208	0.518	0.388	1.1009	1.0206	1.0801	0.9987
MgO	0.454	0.0329	0.304	1.694	1.4930	0.9462	1.5711	1.0043
Fe2O3	69.374	2.5367	67.396	67.396	1.0293	1.0248	1.0044	1.0000
CaO	8.911	0.4639	9.568	37.997	0.9314	0.9435	0.9995	0.9876

Total 96.157 3.8339 92.839 137.779 Total O = 6.0 Iteration = 4

Unknown Specimen No. 21
Group : Clients Sample : WellSeds2
UNK No. : 21 Comment : Bellwood filter map 12 irreg globs
Stage : X= 49.2704 Y= 65.7131 Z= 11.3570
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 13:16 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.027E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	28.4	169.8	97.5	13.29	141
2 P	197.190	51.6	10.3	7.5	2.94	93
3 As	105.125	-27.9	769.0	612.3	100.00 ?	396
4 U	125.157	13.4	99.5	84.0	10.50	65
5 Mn	146.386	26.4	10.7	7.0	4.59	357
6 Si	77.757	2035.0	329.0	197.4	0.56	188
7 S	172.143	5.6	13.9	12.8	22.57	104
8 Mg	107.478	76.6	678.3	453.1	8.18	199
9 Fe	134.892	1621.2	9.2	8.6	0.56	471
10 Ca	107.734	3900.7	63.5	53.0	0.36	67

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.133	0.0076	0.111	0.544	1.1939	0.9770	1.2162	1.0047
P2O5	0.725	0.0296	0.633	1.547	1.1444	0.9548	1.1932	1.0045
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.079	0.0008	0.064	0.064	1.2212	1.2926	0.9448	1.0000
MnO	1.200	0.0491	1.230	3.037	0.9757	0.9719	1.0039	1.0000
SiO2	8.361	0.4039	7.392	13.394	1.1311	0.9390	1.2040	1.0005
SO3	0.055	0.0020	0.051	0.038	1.0851	1.0129	1.0729	0.9985
MgO	0.387	0.0279	0.251	1.397	1.5453	0.9391	1.6378	1.0047
Fe2O3	82.591	3.0021	80.967	80.967	1.0201	1.0158	1.0042	1.0000
CaO	10.027	0.5190	10.896	43.271	0.9203	0.9361	0.9972	0.9859

Total 103.558 4.0420 101.596 144.259 Total O = 6.0 Iteration = 3

Unknown Specimen No. 22

Group : Clients Sample : WellSeds2
UNK No. : 22 Comment : Ck2005-2 filter 1 large Fe-ox chunk
Stage : X= 46.9384 Y= 64.3181 Z= 10.9365
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 14:28 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.005E-08

Element		Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1	Al	90.965	12.1	60.5	39.5	19.29	87
2	P	197.190	9.4	6.7	6.9	9.38	83
3	As	105.125	-12.2	101.2	93.9	100.00 ?	152
4	U	125.157	5.2	101.9	87.7	26.99	67
5	Mn	146.386	6.0	9.3	8.1	14.72	357
6	Si	77.757	439.2	113.5	82.5	1.29	115
7	S	172.143	9.3	12.9	9.5	13.44	96
8	Mg	107.478	-10.5	143.6	106.7	100.00 ?	94
9	Fe	134.892	1794.1	9.6	9.6	0.53	493
10	Ca	107.734	206.3	72.0	59.2	1.99	72

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.060	0.0039	0.048	0.234	1.2441	0.9660	1.2805	1.0057
P2O5	0.132	0.0063	0.116	0.283	1.1435	0.9440	1.2052	1.0051
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.030	0.0004	0.025	0.025	1.2107	1.2776	0.9476	1.0000
MnO	0.270	0.0128	0.281	0.694	0.9585	0.9597	0.9988	1.0000
SiO2	1.869	0.1045	1.607	2.912	1.1631	0.9284	1.2517	1.0008
SO3	0.092	0.0039	0.085	0.064	1.0805	1.0014	1.0795	0.9996
MgO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
Fe2O3	90.536	3.8086	90.258	90.258	1.0031	1.0027	1.0003	1.0000
CaO	0.527	0.0315	0.580	2.305	0.9074	0.9251	0.9992	0.9817

Total 93.516 3.9718 93.001 96.775 Total O = 6.0 Iteration = 3

Unknown Specimen No. 23
Group : Clients Sample : WellSeds2
UNK No. : 23 Comment : Ck2005-2 filter 2 sphere
Stage : X= 46.7195 Y= 64.4342 Z= 10.9185
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 14:32 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.002E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	17.6	7.6	3.9	6.79	29
2 P	197.190	46.9	8.0	8.7	3.11	93
3 As	105.125	-75.0	520.9	513.9	100.00 ?	353
4 U	125.157	9.9	106.8	86.9	14.45	68
5 Mn	146.386	5.6	11.3	9.3	16.76	388
6 Si	77.757	209.4	14.6	7.2	1.63	39
7 S	172.143	20.6	12.0	11.1	7.18	98
8 Mg	107.478	143.6	415.4	281.1	3.65	157
9 Fe	134.892	1221.2	10.2	9.5	0.65	500
10 Ca	107.734	1124.3	60.4	45.1	0.70	64

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.086	0.0078	0.070	0.340	1.2342	0.9692	1.2663	1.0057
P2O5	0.660	0.0429	0.580	1.418	1.1375	0.9471	1.1952	1.0049
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.058	0.0010	0.048	0.048	1.2128	1.2819	0.9461	1.0000
MnO	0.252	0.0164	0.261	0.645	0.9640	0.9632	1.0009	1.0000
SiO2	0.887	0.0680	0.767	1.390	1.1569	0.9315	1.2413	1.0006
SO3	0.202	0.0117	0.188	0.141	1.0792	1.0046	1.0751	0.9991
MgO	0.762	0.0871	0.474	2.641	1.6077	0.9315	1.7172	1.0050
Fe2O3	62.009	3.5784	61.496	61.496	1.0083	1.0064	1.0019	1.0000
CaO	2.885	0.2371	3.167	12.576	0.9111	0.9282	0.9982	0.9833
Total	67.801	4.0502	67.050	80.694	Total O = 6.0	Iteration = 3		

Unknown Specimen No. 24

Group : Clients Sample : WellSeds2
UNK No. : 24 Comment : Ck2005-2 filter 3 hexagonal xtal
Stage : X= 46.9846 Y= 64.5622 Z= 10.8380
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 16:54 2008
WDS only No. of accumulation : 1

Curr.(A) : 1.050E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	77.4	42.0	25.6	3.45	205
2 P	197.190	13.3	2.9	2.2	5.87	145
3 As	105.125	9.6	54.8	30.0	12.21	294
4 U	125.157	3.2	27.1	24.0	23.35	99
5 Mn	146.386	4.2	2.1	3.1	13.25	559

6	Si	77.757	419.0	92.4	60.6	1.28	292
7	S	172.143	16.4	6.1	3.0	6.84	174
8	Mg	107.478	10.9	46.7	29.8	15.48	149
9	Fe	134.892	562.7	3.4	3.3	0.95	833
10	Ca	107.734	191.7	23.9	16.9	1.78	114

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	1.071	0.0693	0.875	4.270	1.2231	0.9713	1.2527	1.0052
P2O5	0.543	0.0252	0.471	1.151	1.1517	0.9492	1.2073	1.0050
As2O5	0.323	0.0093	0.233	0.384	1.3896	1.1807	1.1769	1.0000
UO2	0.053	0.0007	0.044	0.044	1.2193	1.2848	0.9490	1.0000
MnO	0.548	0.0255	0.568	1.402	0.9653	0.9657	0.9996	1.0000
SiO2	5.069	0.2783	4.388	7.950	1.1553	0.9335	1.2366	1.0007
SO3	0.467	0.0192	0.428	0.321	1.0889	1.0069	1.0820	0.9995
MgO	0.163	0.0134	0.103	0.572	1.5931	0.9336	1.6984	1.0047
Fe2O3	81.836	3.3815	81.019	81.019	1.0101	1.0091	1.0010	1.0000
CaO	1.413	0.0831	1.544	6.131	0.9150	0.9304	1.0001	0.9834

Total 91.486 3.9054 89.673 103.244 Total O = 6.0 Iteration = 4

Unknown Specimen No. 25
Group : Clients Sample : WellSeds2
UNK No. : 25 Comment : Ck2005-2 filter 4 flat mica plate
Stage : X= 46.9741 Y= 64.5914 Z= 10.8380
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 16:59 2008
WDS only No. of accumulation : 1

Curr.(A) : 1.050E-08

Element		Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1	Al	90.965	548.4	28.9	18.1	0.99	171
2	P	197.190	10.4	2.9	2.8	7.06	154
3	As	105.125	-5.4	167.5	109.6	100.00 ?	529
4	U	125.157	-0.5	37.2	30.8	100.00 ?	115
5	Mn	146.386	1.4	4.9	6.4	47.61 ?	825
6	Si	77.757	1699.3	68.2	48.0	0.56	254
7	S	172.143	10.9	3.4	4.1	8.83	160
8	Mg	107.478	351.8	160.2	114.1	1.29	283
9	Fe	134.892	249.0	7.1	5.4	1.45	1138
10	Ca	107.734	169.9	17.1	16.8	1.88	105

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F	
Al2O3	6.875	0.4653	6.200	30.242	1.1089	1.0031	1.1037	1.0016	
P2O5	0.448	0.0218	0.367	0.896	1.2218	0.9804	1.2401	1.0050	
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000	?
UO2	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000	?
MnO	0.184	0.0089	0.183	0.453	1.0029	1.0021	1.0007	1.0000	
SiO2	19.998	1.1482	17.795	32.243	1.1238	0.9641	1.1649	1.0007	
SO3	0.325	0.0140	0.284	0.213	1.1468	1.0402	1.1026	0.9999	
MgO	4.437	0.3798	3.319	18.500	1.3370	0.9642	1.3836	1.0022	
Fe2O3	37.646	1.6266	35.853	35.853	1.0500	1.0482	1.0018	1.0000	
CaO	1.311	0.0806	1.368	5.435	0.9578	0.9624	1.0048	0.9905	

Total 71.224 3.7452 65.368 123.834 Total O = 6.0 Iteration = 4

Unknown Specimen No. 26
Group : Clients Sample : WellSeds2
UNK No. : 26 Comment : Ck2005-2 filter 5 crystal
Stage : X= 47.1919 Y= 64.6927 Z= 10.8975
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 14:44 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.001E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	515.2	76.9	47.0	1.09	97
2 P	197.190	23.7	4.3	4.1	4.36	65
3 As	105.125	-10.3	70.5	66.0	100.00 ?	128
4 U	125.157	9.4	79.6	64.4	13.32	58
5 Mn	146.386	9.8	12.1	12.3	10.86	423
6 Si	77.757	1905.1	144.5	89.6	0.54	126
7 S	172.143	14.3	6.2	4.9	7.85	68
8 Mg	107.478	18.0	60.3	39.0	10.84	59
9 Fe	134.892	1208.8	14.3	12.8	0.65	586
10 Ca	107.734	528.2	46.7	42.7	1.05	59

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F	
Al2O3	2.436	0.1846	2.038	9.941	1.1952	0.9773	1.2175	1.0045	
P2O5	0.342	0.0186	0.294	0.717	1.1654	0.9551	1.2141	1.0050	
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000	?
UO2	0.056	0.0008	0.045	0.045	1.2284	1.2931	0.9500	1.0000	
MnO	0.449	0.0244	0.462	1.140	0.9725	0.9725	1.0000	1.0000	
SiO2	8.004	0.5145	6.980	12.648	1.1466	0.9393	1.2198	1.0008	

SO3	0.144	0.0069	0.131	0.098	1.0998	1.0132	1.0859	0.9996
MgO	0.092	0.0088	0.059	0.332	1.5504	0.9394	1.6435	1.0042
Fe2O3	61.971	2.9981	60.893	60.893	1.0177	1.0165	1.0012	1.0000
CaO	1.373	0.0946	1.488	5.910	0.9229	0.9364	1.0009	0.9847

Total 74.867 3.8515 72.391 91.724 Total O = 6.0 Iteration = 4

Unknown Specimen No. 28
Group : Clients Sample : WellSeds2
UNK No. : 28 Comment : Ck2005-2 filter 7 hex crystal flat
Stage : X= 47.2315 Y= 64.6892 Z= 10.8875
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 14:52 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.004E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	523.9	107.5	65.3	1.12	115
2 P	197.190	49.6	6.8	6.3	2.91	81
3 As	105.125	-25.2	173.5	230.4	100.00 ?	226
4 U	125.157	4.9	94.8	82.1	27.72	65
5 Mn	146.386	4.8	15.2	14.3	22.43	465
6 Si	77.757	2752.8	200.7	116.3	0.45	147
7 S	172.143	50.9	10.1	9.0	3.67	89
8 Mg	107.478	92.7	152.0	97.9	3.61	94
9 Fe	134.892	960.9	16.1	13.9	0.73	616
10 Ca	107.734	1219.9	60.0	45.0	0.67	64

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	2.404	0.1886	2.070	10.098	1.1610	0.9859	1.1736	1.0035
P2O5	0.720	0.0406	0.613	1.499	1.1741	0.9634	1.2129	1.0047
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.029	0.0004	0.024	0.024	1.2404	1.3047	0.9507	1.0000
MnO	0.220	0.0124	0.224	0.552	0.9838	0.9821	1.0017	1.0000
SiO2	11.348	0.7554	10.076	18.257	1.1262	0.9475	1.1880	1.0005
SO3	0.515	0.0257	0.464	0.347	1.1097	1.0221	1.0865	0.9993
MgO	0.454	0.0451	0.306	1.704	1.4855	0.9476	1.5617	1.0038
Fe2O3	49.777	2.4937	48.357	48.357	1.0293	1.0267	1.0025	1.0000
CaO	3.207	0.2287	3.434	13.636	0.9339	0.9450	1.0012	0.9871

Total 68.674 3.7907 65.567 94.475 Total O = 6.0 Iteration = 4

Unknown Specimen No. 31
Group : Clients Sample : WellSeds2
UNK No. : 31 Comment : Ck2005-2 filter 10 brite debris on plag
Stage : X= 47.1412 Y= 64.7042 Z= 10.8815
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 15:05 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.002E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	5975.9	110.6	64.1	0.29	115
2 P	197.190	7.9	3.6	2.0	8.42	52
3 As	105.125	-14.4	66.9	86.6	100.00 ?	139
4 U	125.157	1.3	54.3	44.6	74.80 ?	48
5 Mn	146.386	1.0	7.7	6.4	68.80 ?	322
6 Si	77.757	12854.0	217.7	102.0	0.20	148
7 S	172.143	5.3	4.4	4.1	15.77	59
8 Mg	107.478	42.3	59.2	32.2	4.92	57
9 Fe	134.892	89.7	8.2	5.1	2.53	411
10 Ca	107.734	1184.6	34.1	29.1	0.67	50

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	20.543	1.0045	23.629	115.261	0.8694	1.0392	0.8429	0.9925
P2O5	0.128	0.0045	0.098	0.238	1.3171	1.0159	1.2901	1.0049
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.009	0.0001	0.007	0.007	1.3321	1.3784	0.9664	1.0000
MnO	0.051	0.0018	0.048	0.120	1.0483	1.0444	1.0038	1.0000
SiO2	49.225	2.0420	47.082	85.308	1.0455	0.9989	1.0459	1.0007
SO3	0.059	0.0018	0.048	0.036	1.2214	1.0781	1.1328	1.0001
MgO	0.139	0.0086	0.139	0.777	0.9939	0.9989	1.0007	0.9943
Fe2O3	4.960	0.1548	4.518	4.518	1.0980	1.0935	1.0041	1.0000
CaO	3.370	0.1498	3.336	13.250	1.0099	0.9992	1.0116	0.9991

Total 78.484 3.3679 78.904 219.515 Total O = 6.0 Iteration = 5

Unknown Specimen No. 32
Group : Clients Sample : WellSeds2
UNK No. : 32 Comment : Ck2005-2 filter 11 flat plate
Stage : X= 47.1502 Y= 64.6795 Z= 10.8770

Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 15:09 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.003E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	543.5	90.8	55.3	1.08	105
2 P	197.190	49.2	7.6	5.3	2.92	80
3 As	105.125	-21.3	76.2	81.3	100.00 ?	139
4 U	125.157	6.6	72.5	58.2	17.85	56
5 Mn	146.386	7.1	10.5	8.6	13.17	375
6 Si	77.757	3133.2	179.8	112.0	0.42	141
7 S	172.143	32.8	13.3	11.2	5.16	101
8 Mg	107.478	17.0	85.5	54.3	13.26	70
9 Fe	134.892	1217.1	8.6	9.0	0.65	472
10 Ca	107.734	1064.7	62.5	53.8	0.72	68

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	2.515	0.1663	2.148	10.480	1.1708	0.9831	1.1865	1.0037
P2O5	0.714	0.0339	0.608	1.487	1.1733	0.9608	1.2152	1.0049
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.040	0.0005	0.032	0.032	1.2369	1.3010	0.9508	1.0000
MnO	0.326	0.0155	0.333	0.822	0.9800	0.9790	1.0010	1.0000
SiO2	12.967	0.7273	11.473	20.787	1.1303	0.9449	1.1955	1.0006
SO3	0.331	0.0139	0.299	0.224	1.1079	1.0193	1.0876	0.9994
MgO	0.085	0.0071	0.056	0.313	1.5083	0.9450	1.5899	1.0039
Fe2O3	62.829	2.6521	61.269	61.269	1.0255	1.0234	1.0020	1.0000
CaO	2.789	0.1677	2.998	11.905	0.9305	0.9422	1.0013	0.9863
Total	82.596	3.7843	79.216	107.319	Total O = 6.0	Iteration = 4		

Unknown Specimen No. 33
Group : Clients Sample : WellSeds2
UNK No. : 33 Comment : Ck2005-2 filter 12 seds
Stage : X= 47.2056 Y= 64.7127 Z= 10.8770
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 15:13 2008
WDS only No. of accumulation : 1

Curr.(A) : 3.004E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	518.0	81.7	46.8	1.09	99

2 P	197.190	45.7	5.4	5.3	3.00	74
3 As	105.125	-41.5	340.7	325.1	100.00 ?	282
4 U	125.157	4.8	60.3	50.9	22.75	51
5 Mn	146.386	4.6	4.7	4.2	14.48	255
6 Si	77.757	2174.3	169.8	111.1	0.51	138
7 S	172.143	16.6	9.4	7.0	7.71	82
8 Mg	107.478	56.1	317.4	223.4	7.86	139
9 Fe	134.892	890.6	5.5	5.0	0.75	365
10 Ca	107.734	708.1	48.5	44.0	0.89	60

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	2.397	0.2158	2.047	9.984	1.1712	0.9833	1.1866	1.0038
P2O5	0.663	0.0429	0.565	1.381	1.1737	0.9609	1.2154	1.0050
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.028	0.0005	0.023	0.023	1.2373	1.3012	0.9509	1.0000
MnO	0.213	0.0138	0.217	0.536	0.9800	0.9793	1.0008	1.0000
SiO2	9.030	0.6897	7.959	14.420	1.1347	0.9450	1.1999	1.0006
SO3	0.168	0.0096	0.151	0.113	1.1089	1.0194	1.0884	0.9995
MgO	0.279	0.0317	0.185	1.032	1.5052	0.9451	1.5864	1.0038
Fe2O3	45.963	2.6417	44.817	44.817	1.0256	1.0237	1.0018	1.0000
CaO	1.855	0.1518	1.993	7.915	0.9308	0.9424	1.0014	0.9863

Total 60.596 3.7975 57.957 80.222 Total O = 6.0 Iteration = 4

Unknown Specimen No. 36
Group : Clients Sample : WellSeds2
UNK No. : 36 Comment : STR filter 1 sed plate
Stage : X= 4.9061 Y= 68.2187 Z= 10.7890
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 16:06 2008
WDS only No. of accumulation : 1

Curr.(A) : 1.049E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	21.5	29.1	21.5	8.78	178
2 P	197.190	121.7	3.1	2.9	1.70	158
3 As	105.125	-16.3	150.7	132.4	100.00 ?	522
4 U	125.157	0.3	40.7	34.9	259.97 ?	121
5 Mn	146.386	74.0	4.3	4.3	2.24	719
6 Si	77.757	935.2	74.5	45.5	0.78	259
7 S	172.143	3.0	4.4	5.1	26.18	180
8 Mg	107.478	18.7	142.5	98.0	15.50	265

9 Fe 134.892 486.8 5.8 4.7 1.02 1044
10 Ca 107.734 650.4 25.2 22.6 0.91 124

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.286	0.0158	0.243	1.185	1.1770	0.9779	1.1987	1.0041
P2O5	4.941	0.1966	4.310	10.531	1.1462	0.9556	1.1938	1.0048
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.006	0.0001	0.005	0.005	1.2281	1.2938	0.9492	1.0000 ?
MnO	9.686	0.3856	9.937	24.536	0.9747	0.9733	1.0015	1.0000
SiO2	10.976	0.5158	9.803	17.762	1.1196	0.9398	1.1914	0.9999
SO3	0.087	0.0031	0.079	0.059	1.0983	1.0137	1.0843	0.9992
MgO	0.269	0.0188	0.177	0.986	1.5190	0.9399	1.6091	1.0044
Fe2O3	71.543	2.5304	70.161	70.161	1.0197	1.0173	1.0024	1.0000
CaO	4.838	0.2437	5.243	20.821	0.9229	0.9370	1.0001	0.9848

Total 102.632 3.9099 99.958 146.048 Total O = 6.0 Iteration = 4

Unknown Specimen No. 38
Group : Clients Sample : WellSeds2
UNK No. : 38 Comment : STR filter 3 crystal
Stage : X= 5.1305 Y= 68.3007 Z= 10.7985
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 16:17 2008
WDS only No. of accumulation : 1

Curr.(A) : 1.050E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	7.2	25.0	17.8	21.75	164
2 P	197.190	31.7	2.2	2.5	3.48	140
3 As	105.125	-25.4	152.8	133.3	100.00 ?	524
4 U	125.157	0.7	35.8	31.5	120.12 ?	114
5 Mn	146.386	2.7	5.2	4.0	23.58	743
6 Si	77.757	401.1	51.7	33.0	1.23	217
7 S	172.143	-0.4	5.5	4.6	100.00 ?	185
8 Mg	107.478	-0.3	157.4	117.1	100.00 ?	283
9 Fe	134.892	638.8	5.2	3.5	0.89	950
10 Ca	107.734	142.8	23.8	22.2	2.15	122

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.100	0.0060	0.081	0.397	1.2290	0.9697	1.2607	1.0053
P2O5	1.288	0.0551	1.122	2.741	1.1477	0.9476	1.2049	1.0051

As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.012	0.0001	0.010	0.010	1.2167	1.2827	0.9485	1.0000
MnO	0.345	0.0148	0.358	0.883	0.9631	0.9639	0.9992	1.0000
SiO2	4.845	0.2450	4.200	7.610	1.1536	0.9320	1.2370	1.0007
SO3	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
MgO	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
Fe2O3	92.700	3.5275	91.975	91.975	1.0079	1.0072	1.0006	1.0000
CaO	1.050	0.0569	1.150	4.568	0.9125	0.9288	0.9997	0.9827

Total 100.340 3.9054 98.896 108.184 Total O = 6.0 Iteration = 4

Unknown Specimen No. 40
Group : Clients Sample : WellSeds2
UNK No. : 40 Comment : STR filter 6 Fe-ox plate
Stage : X= 5.4825 Y= 69.5866 Z= 10.7965
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 17:34 2008
WDS only No. of accumulation : 1

Curr.(A) : 1.000E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	73.1	21.9	15.2	3.20	160
2 P	197.190	80.5	1.8	2.1	2.09	134
3 As	105.125	5.7	35.2	20.6	16.53	250
4 U	125.157	1.5	28.3	22.1	48.94 ?	104
5 Mn	146.386	1.1	3.1	2.7	42.43 ?	619
6 Si	77.757	1291.8	54.0	34.2	0.64	233
7 S	172.143	20.4	3.1	2.4	5.57	143
8 Mg	107.478	9.4	35.7	22.4	15.73	136
9 Fe	134.892	396.8	4.2	2.9	1.13	901
10 Ca	107.734	561.4	19.3	17.4	0.97	114

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	1.001	0.0604	0.868	4.235	1.1534	0.9875	1.1646	1.0030
P2O5	3.493	0.1512	2.988	7.301	1.1688	0.9650	1.2054	1.0047
As2O5	0.188	0.0050	0.145	0.240	1.2912	1.2004	1.0757	1.0000
UO2	0.027	0.0003	0.022	0.022	1.2439	1.3069	0.9518	1.0000
MnO	0.157	0.0068	0.160	0.394	0.9860	0.9839	1.0021	1.0000
SiO2	15.773	0.8067	14.204	25.736	1.1105	0.9491	1.1701	1.0000
SO3	0.623	0.0239	0.559	0.419	1.1147	1.0238	1.0896	0.9993
MgO	0.137	0.0105	0.093	0.519	1.4749	0.9492	1.5480	1.0038
Fe2O3	61.874	2.3814	59.981	59.981	1.0316	1.0286	1.0029	1.0000

CaO	4.447	0.2437	4.747	18.853	0.9367	0.9466	1.0019	0.9877

Total 87.720 3.6899 83.767 117.700 Total O = 6.0 Iteration = 4

Unknown Specimen No. 41
Group : Clients Sample : WellSeds2
UNK No. : 41 Comment : STR filter 7 blocky xtal
Stage : X= 4.4455 Y= 70.0550 Z= 10.8140
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 17:39 2008
WDS only No. of accumulation : 1

Curr.(A) : 9.990E-09

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	0.1	45.3	28.9	1706.42 ?	226
2 P	197.190	9.8	2.5	3.0	7.31	160
3 As	105.125	16.0	74.2	43.7	8.63	364
4 U	125.157	3.3	34.0	27.4	24.59	114
5 Mn	146.386	2.4	6.2	6.5	29.91	916
6 Si	77.757	280.9	95.3	61.1	1.67	310
7 S	172.143	0.9	6.2	3.4	82.00 ?	188
8 Mg	107.478	4.3	69.9	41.0	44.70 ?	188
9 Fe	134.892	603.9	6.1	4.6	0.92	1107
10 Ca	107.734	66.5	20.4	18.0	3.44	117

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.002	0.0001	0.001	0.006	1.2402	0.9675	1.2748	1.0055 ?
P2O5	0.420	0.0188	0.365	0.893	1.1486	0.9455	1.2086	1.0052
As2O5	0.579	0.0160	0.410	0.677	1.4123	1.1761	1.2008	1.0000
UO2	0.058	0.0007	0.048	0.048	1.2140	1.2797	0.9487	1.0000
MnO	0.320	0.0143	0.334	0.824	0.9604	0.9614	0.9990	1.0000
SiO2	3.591	0.1898	3.092	5.603	1.1613	0.9299	1.2479	1.0008
SO3	0.026	0.0010	0.024	0.018	1.0853	1.0029	1.0825	0.9996
MgO	0.069	0.0054	0.043	0.238	1.6204	0.9300	1.7339	1.0049
Fe2O3	91.846	3.6533	91.390	91.390	1.0050	1.0046	1.0005	0.9999
CaO	0.513	0.0290	0.563	2.236	0.9102	0.9266	1.0000	0.9824

Total 97.424 3.9286 96.271 101.934 Total O = 6.0 Iteration = 3

Unknown Specimen No. 42
Group : Clients Sample : WellSeds2
UNK No. : 42 Comment : STR filter 8 Fe-ox on galionella
Stage : X= 4.4278 Y= 70.0971 Z= 10.8140
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 17:43 2008
WDS only No. of accumulation : 1

Curr.(A) : 9.992E-09

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	5.5	54.1	30.6	38.17 ?	241
2 P	197.190	57.8	3.7	3.5	2.55	181
3 As	105.125	11.1	250.7	161.0	22.32	679
4 U	125.157	2.8	39.3	32.5	31.09	124
5 Mn	146.386	2.2	6.9	6.4	32.64	937
6 Si	77.757	1100.2	97.5	60.9	0.72	312
7 S	172.143	6.9	4.3	2.7	11.98	161
8 Mg	107.478	16.3	228.9	153.8	22.08	350
9 Fe	134.892	422.1	7.3	7.7	1.11	1310
10 Ca	107.734	534.3	17.0	17.2	1.00	111

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.076	0.0048	0.065	0.316	1.1742	0.9831	1.1902	1.0035
P2O5	2.501	0.1128	2.147	5.245	1.1652	0.9608	1.2069	1.0048
As2O5	0.374	0.0104	0.284	0.469	1.3174	1.1951	1.1023	1.0000
UO2	0.050	0.0006	0.041	0.041	1.2367	1.3010	0.9506	1.0000
MnO	0.304	0.0137	0.310	0.766	0.9807	0.9789	1.0019	1.0000
SiO2	13.555	0.7222	12.107	21.937	1.1196	0.9449	1.1846	1.0002
SO3	0.211	0.0084	0.190	0.143	1.1078	1.0192	1.0876	0.9993
MgO	0.244	0.0193	0.162	0.901	1.5064	0.9450	1.5876	1.0041
Fe2O3	65.519	2.6270	63.860	63.860	1.0260	1.0233	1.0026	1.0000
CaO	4.209	0.2403	4.522	17.957	0.9308	0.9422	1.0012	0.9867

Total 87.043 3.7596 83.687 111.635 Total O = 6.0 Iteration = 4

Unknown Specimen No. 43
Group : Clients Sample : WellSeds2
UNK No. : 43 Comment : STR filter 9 seds
Stage : X= 4.5003 Y= 70.0619 Z= 10.8140
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 29 17:47 2008
WDS only No. of accumulation : 1

Curr.(A) : 9.991E-09

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	13.7	17.3	8.6	10.11	133
2 P	197.190	49.9	2.2	1.7	2.68	133
3 As	105.125	2.6	121.7	76.9	66.76 ?	472
4 U	125.157	-1.4	45.4	34.1	100.00 ?	130
5 Mn	146.386	306.1	7.6	9.1	1.07	1051
6 Si	77.757	391.1	31.4	20.9	1.21	179
7 S	172.143	10.3	4.7	3.1	9.21	170
8 Mg	107.478	33.4	107.9	74.3	7.95	242
9 Fe	134.892	170.6	7.9	6.8	1.78	1297
10 Ca	107.734	527.6	18.9	15.5	1.00	111

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.190	0.0160	0.163	0.793	1.1682	0.9611	1.2096	1.0049
P2O5	2.071	0.1250	1.856	4.536	1.1159	0.9392	1.1830	1.0044
As2O5	0.086	0.0032	0.066	0.108	1.3141	1.1683	1.1248	1.0000
UO2	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
MnO	41.269	2.4909	43.155	106.555	0.9563	0.9554	1.0009	1.0000
SiO2	4.772	0.3400	4.304	7.798	1.1088	0.9237	1.2001	1.0003
SO3	0.301	0.0161	0.282	0.211	1.0660	0.9963	1.0714	0.9987
MgO	0.498	0.0529	0.331	1.844	1.5041	0.9238	1.6207	1.0047
Fe2O3	25.829	1.3850	25.819	25.819	1.0004	0.9984	1.0020	1.0000
CaO	4.009	0.3061	4.465	17.731	0.8979	0.9205	0.9969	0.9785
Total	79.025	4.7351	80.440	165.395	Total O =	6.0	Iteration = 4	

Unknown Specimen No. 45
Group : Clients Sample : WellSeds2
UNK No. : 45 Comment : CK2005-2 Map target 2 Fe-ox cluster
Stage : X= 45.7963 Y= 63.1972 Z= 10.8115
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 30 10:17 2008
WDS only No. of accumulation : 1

Curr.(A) : 1.000E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	23.2	45.2	27.9	9.33	224
2 P	197.190	13.2	3.9	3.6	6.31	185
3 As	105.125	-3.6	113.2	77.0	100.00 ?	460
4 U	125.157	3.2	29.9	24.0	23.67	107

5 Mn	146.386	2.8	2.9	2.8	18.86	616
6 Si	77.757	618.0	92.0	62.9	1.01	308
7 S	172.143	16.7	4.1	5.7	6.91	192
8 Mg	107.478	10.0	115.9	79.3	25.74	250
9 Fe	134.892	507.1	3.6	3.6	1.00	907
10 Ca	107.734	214.2	24.0	19.8	1.68	125

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.334	0.0218	0.276	1.344	1.2123	0.9740	1.2387	1.0048
P2O5	0.565	0.0264	0.489	1.194	1.1559	0.9519	1.2084	1.0050
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.057	0.0007	0.047	0.047	1.2232	1.2886	0.9493	1.0000
MnO	0.387	0.0181	0.399	0.985	0.9686	0.9687	0.9999	1.0000
SiO2	7.778	0.4300	6.796	12.313	1.1446	0.9361	1.2218	1.0007
SO3	0.500	0.0207	0.457	0.343	1.0927	1.0097	1.0827	0.9995
MgO	0.157	0.0129	0.099	0.554	1.5798	0.9362	1.6797	1.0046
Fe2O3	77.694	3.2321	76.656	76.656	1.0135	1.0124	1.0011	1.0000
CaO	1.663	0.0985	1.811	7.192	0.9184	0.9331	1.0003	0.9839
Total	89.135	3.8613	87.029	100.629	Total O = 6.0	Iteration = 4		

Unknown Specimen No. 46
Group : Clients Sample : WellSeds2
UNK No. : 46 Comment : CK2005-2 Map target 3 Fe-ox crystals
Stage : X= 45.8085 Y= 63.2932 Z= 10.8025
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 30 10:21 2008
WDS only No. of accumulation : 1

Curr.(A) : 1.000E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	13.5	38.2	25.5	14.43	209
2 P	197.190	10.2	2.9	3.6	7.35	174
3 As	105.125	6.6	213.7	137.0	34.62 ?	626
4 U	125.157	3.6	40.5	34.1	24.78	126
5 Mn	146.386	4.0	5.3	4.1	16.55	786
6 Si	77.757	234.2	69.9	48.1	1.80	269
7 S	172.143	17.6	7.1	5.1	6.92	213
8 Mg	107.478	18.4	201.4	134.5	18.41	328
9 Fe	134.892	568.8	6.2	4.9	0.95	1126
10 Ca	107.734	153.1	26.8	20.8	2.07	130

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.197	0.0129	0.160	0.779	1.2361	0.9684	1.2694	1.0055
P2O5	0.435	0.0203	0.379	0.927	1.1454	0.9463	1.2044	1.0050
As2O5	0.237	0.0068	0.168	0.278	1.4084	1.1772	1.1964	1.0000
UO2	0.063	0.0008	0.052	0.052	1.2145	1.2809	0.9482	1.0000
MnO	0.546	0.0256	0.568	1.403	0.9617	0.9623	0.9994	1.0000
SiO2	2.985	0.1649	2.575	4.666	1.1590	0.9307	1.2444	1.0007
SO3	0.522	0.0217	0.482	0.361	1.0834	1.0038	1.0798	0.9995
MgO	0.295	0.0243	0.182	1.017	1.6157	0.9308	1.7274	1.0049
Fe2O3	86.532	3.5978	85.986	85.986	1.0063	1.0056	1.0008	1.0000
CaO	1.179	0.0698	1.294	5.140	0.9110	0.9275	0.9997	0.9826

Total 92.991 3.9449 91.848 100.610 Total O = 6.0 Iteration = 3

Unknown Specimen No. 47

Group : Clients Sample : WellSeds2

UNK No. : 47 Comment : CK2005-2 Map target 4 rod of balls

Stage : X= 45.8636 Y= 63.2657 Z= 10.8020

Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off

Dated on May 30 10:25 2008

WDS only No. of accumulation : 1

Curr.(A) : 1.000E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	10.0	22.5	14.5	15.16	159
2 P	197.190	2.7	3.4	3.8	21.65	183
3 As	105.125	-10.6	280.6	186.2	100.00 ?	721
4 U	125.157	1.4	45.0	37.4	67.46 ?	132
5 Mn	146.386	1.8	3.3	3.1	29.05	651
6 Si	77.757	268.0	47.9	29.4	1.56	218
7 S	172.143	8.0	4.9	4.2	11.52	184
8 Mg	107.478	5.0	259.7	183.2	76.23 ?	377
9 Fe	134.892	602.8	5.2	2.8	0.92	956
10 Ca	107.734	93.4	24.7	17.6	2.78	122

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.147	0.0092	0.119	0.579	1.2377	0.9678	1.2718	1.0055
P2O5	0.114	0.0051	0.099	0.242	1.1468	0.9457	1.2064	1.0051
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.024	0.0003	0.020	0.020	1.2135	1.2801	0.9480	1.0000
MnO	0.244	0.0110	0.254	0.626	0.9607	0.9617	0.9990	1.0000

SiO2	3.416	0.1824	2.946	5.339	1.1595	0.9302	1.2456	1.0008
SO3	0.238	0.0095	0.220	0.164	1.0832	1.0032	1.0802	0.9996
MgO	0.081	0.0064	0.050	0.277	1.6249	0.9302	1.7382	1.0049
Fe2O3	91.613	3.6805	91.124	91.124	1.0054	1.0049	1.0004	1.0000
CaO	0.719	0.0411	0.790	3.136	0.9098	0.9269	0.9994	0.9822

Total 96.596 3.9457 95.621 101.508 Total O = 6.0 Iteration = 3

Unknown Specimen No. 48
Group : Clients Sample : WellSeds2
UNK No. : 48 Comment : CK2005-2 Map target 6 seds
Stage : X= 45.8492 Y= 63.3379 Z= 10.8065
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 30 10:30 2008
WDS only No. of accumulation : 1

Curr.(A) : 1.000E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	103.0	37.7	23.1	2.76	204
2 P	197.190	15.0	4.1	3.2	5.73	181
3 As	105.125	2.5	247.4	159.5	97.49 ?	674
4 U	125.157	3.1	39.6	34.1	28.59	125
5 Mn	146.386	2.4	3.3	3.2	22.38	654
6 Si	77.757	1330.5	79.1	49.2	0.64	281
7 S	172.143	9.4	6.3	5.4	10.89	209
8 Mg	107.478	38.6	230.7	152.4	9.60	350
9 Fe	134.892	434.2	4.6	3.2	1.08	944
10 Ca	107.734	261.3	20.9	19.1	1.49	119

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	1.432	0.0865	1.222	5.963	1.1715	0.9842	1.1864	1.0033
P2O5	0.657	0.0285	0.557	1.361	1.1797	0.9619	1.2204	1.0050
As2O5	0.084	0.0023	0.064	0.106	1.3150	1.1965	1.0990	1.0000
UO2	0.055	0.0006	0.045	0.045	1.2398	1.3025	0.9518	1.0000
MnO	0.336	0.0146	0.343	0.846	0.9808	0.9803	1.0005	1.0000
SiO2	16.459	0.8438	14.630	26.509	1.1250	0.9460	1.1885	1.0007
SO3	0.287	0.0110	0.258	0.193	1.1124	1.0204	1.0906	0.9996
MgO	0.574	0.0439	0.382	2.129	1.5032	0.9461	1.5827	1.0039
Fe2O3	67.382	2.5997	65.647	65.647	1.0264	1.0248	1.0016	1.0000
CaO	2.060	0.1132	2.209	8.774	0.9324	0.9433	1.0021	0.9863

Total 89.326 3.7442 85.358 111.573 Total O = 6.0 Iteration = 4

Unknown Specimen No. 49
Group : Clients Sample : WellSeds2
UNK No. : 49 Comment : CK2005-2 Map target 7 Fe-ox crystals
Stage : X= 45.8195 Y= 63.3467 Z= 10.8065
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 30 10:34 2008
WDS only No. of accumulation : 1

Curr.(A) : 1.000E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	5.4	19.2	10.1	23.90	141
2 P	197.190	10.9	2.6	2.5	6.70	153
3 As	105.125	-3.5	254.1	161.1	100.00 ?	681
4 U	125.157	1.6	42.3	36.1	57.10 ?	129
5 Mn	146.386	6.4	5.9	6.1	12.29	891
6 Si	77.757	203.0	34.7	24.5	1.79	190
7 S	172.143	27.2	5.3	3.2	4.90	177
8 Mg	107.478	18.6	238.9	161.6	19.88	358
9 Fe	134.892	559.4	6.4	5.7	0.96	1176
10 Ca	107.734	246.3	22.6	23.0	1.55	128

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.079	0.0052	0.064	0.313	1.2335	0.9687	1.2663	1.0056
P2O5	0.464	0.0219	0.406	0.993	1.1420	0.9466	1.2005	1.0049
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.028	0.0003	0.023	0.023	1.2141	1.2813	0.9476	1.0000
MnO	0.863	0.0408	0.897	2.214	0.9624	0.9627	0.9997	1.0000
SiO2	2.581	0.1441	2.232	4.044	1.1563	0.9310	1.2411	1.0007
SO3	0.805	0.0338	0.745	0.558	1.0812	1.0042	1.0774	0.9994
MgO	0.297	0.0247	0.184	1.025	1.6150	0.9311	1.7260	1.0050
Fe2O3	85.160	3.5787	84.571	84.571	1.0070	1.0060	1.0010	1.0000
CaO	1.897	0.1135	2.083	8.271	0.9109	0.9278	0.9991	0.9827
Total	92.174	3.9632	91.205	102.012	Total O = 6.0	Iteration = 3		

Unknown Specimen No. 50
Group : Clients Sample : WellSeds2
UNK No. : 50 Comment : CK2005-2 Map target 8 ave sed 20um spot

Stage : X= 45.9797 Y= 63.2750 Z= 10.8015
Acc. Voltage : 15.0 (kV) Probe Dia. : 20 Scan : Off
Dated on May 30 09:09 2008
WDS only No. of accumulation : 1

Curr.(A) : 1.001E-08

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	412.7	28.1	17.8	1.16	177
2 P	197.190	19.3	2.6	2.7	4.70	156
3 As	105.125	-1.9	125.5	76.9	100.00 ?	476
4 U	125.157	1.3	31.6	27.4	61.06 ?	112
5 Mn	146.386	1.1	3.5	3.8	49.61 ?	696
6 Si	77.757	1639.6	61.3	37.4	0.57	246
7 S	172.143	14.0	3.9	3.1	7.32	161
8 Mg	107.478	72.7	117.1	78.5	4.07	250
9 Fe	134.892	329.6	4.2	4.1	1.25	973
10 Ca	107.734	345.7	17.6	16.5	1.26	110

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	5.495	0.3356	4.893	23.870	1.1230	0.9947	1.1265	1.0022
P2O5	0.857	0.0376	0.715	1.746	1.1993	0.9721	1.2277	1.0049
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.023	0.0003	0.019	0.019	1.2561	1.3169	0.9539	1.0000
MnO	0.149	0.0065	0.150	0.371	0.9937	0.9923	1.0014	1.0000
SiO2	20.117	1.0424	18.010	32.633	1.1170	0.9560	1.1677	1.0006
SO3	0.432	0.0168	0.382	0.286	1.1298	1.0314	1.0959	0.9996
MgO	1.017	0.0786	0.719	4.010	1.4139	0.9561	1.4746	1.0029
Fe2O3	51.772	2.0188	49.780	49.780	1.0400	1.0377	1.0023	1.0000
CaO	2.764	0.1535	2.920	11.597	0.9464	0.9539	1.0033	0.9889
Total	82.626	3.6901	77.588	124.312	Total O = 6.0	Iteration = 4		

Unknown Specimen No. 53
Group : Clients Sample : WellSeds2
UNK No. : 53 Comment : STR Filter Map target 4 cluster
Stage : X= 5.1826 Y= 68.3918 Z= 10.7685
Acc. Voltage : 15.0 (kV) Probe Dia. : 0 Scan : Off
Dated on May 30 10:46 2008
WDS only No. of accumulation : 1

Curr.(A) : 9.995E-09

Element Peak(mm) Net(cps) Bg- Bg+ S.D.(%) D.L.(ppm)

1 Al	90.965	14.1	31.2	19.6	12.58	187
2 P	197.190	98.2	2.8	1.8	1.88	143
3 As	105.125	-0.1	86.7	52.0	100.00 ?	395
4 U	125.157	0.3	28.1	21.8	282.61 ?	103
5 Mn	146.386	0.6	4.1	3.7	88.19 ?	719
6 Si	77.757	843.6	67.9	42.9	0.82	261
7 S	172.143	5.8	3.7	3.3	13.85	162
8 Mg	107.478	8.8	80.6	53.7	24.50	207
9 Fe	134.892	398.0	3.2	3.1	1.13	849
10 Ca	107.734	574.4	17.2	13.6	0.96	105

ZAF Oxide

Element	Mass(%)	Cation	K(%)	K-raw(%)	ZAF	Z	A	F
Al2O3	0.197	0.0132	0.168	0.819	1.1722	0.9829	1.1882	1.0037
P2O5	4.211	0.2033	3.650	8.917	1.1538	0.9606	1.1954	1.0048
As2O5	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.0000	0.0000 ?
UO2	0.005	0.0001	0.004	0.004	1.2357	1.3007	0.9501	1.0000 ?
MnO	0.083	0.0040	0.085	0.209	0.9808	0.9787	1.0021	1.0000
SiO2	10.371	0.5914	9.280	16.815	1.1176	0.9447	1.1832	0.9998
SO3	0.175	0.0075	0.158	0.118	1.1060	1.0190	1.0863	0.9992
MgO	0.132	0.0112	0.087	0.486	1.5106	0.9448	1.5921	1.0042
Fe2O3	61.759	2.6502	60.193	60.193	1.0260	1.0231	1.0028	1.0000
CaO	4.519	0.2761	4.859	19.298	0.9301	0.9420	1.0007	0.9867
Total	81.452	3.7570	78.483	106.859	Total O = 6.0	Iteration = 4		

Unknown Specimen No. 54
Group : Clients   Sample : WellSeds2
UNK No. : 54   Comment : STR Filter Map target 5 rod
Stage : X= 5.2588 Y= 68.3429 Z= 10.7690
Acc. Voltage : 15.0 (kV)   Probe Dia. : 0   Scan : Off
Dated on May 30 10:51 2008
WDS only   No. of accumulation : 1

Curr.(A) : 9.995E-09

Element	Peak(mm)	Net(cps)	Bg-	Bg+	S.D.(%)	D.L.(ppm)
1 Al	90.965	6.2	41.4	26.1	30.75	215
2 P	197.190	108.7	2.5	2.1	1.79	144
3 As	105.125	3.1	166.9	107.5	65.87 ?	554
4 U	125.157	0.8	31.7	26.6	95.75 ?	111
5 Mn	146.386	2.2	5.2	4.5	28.59	800
6 Si	77.757	806.3	78.0	49.8	0.85	280
7 S	172.143	6.0	4.5	3.2	13.78	169

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 8 Mg   107.478     21.2  147.0   99.1   13.89      281
 9 Fe   134.892    367.9    7.2    4.9    1.18     1176
10 Ca   107.734    481.1   19.0   14.7    1.05      109

ZAF Oxide
Element  Mass(%)  Cation  K(%)  K-raw(%)  ZAF    Z      A      F
 Al2O3    0.086   0.0061   0.073   0.356  1.1710  0.9835  1.1863  1.0036
 P2O5     4.662   0.2377   4.040   9.871  1.1540  0.9612  1.1948  1.0048
 As2O5    0.103   0.0032   0.078   0.129  1.3152  1.1956  1.1000  1.0000
 UO2      0.015   0.0002   0.012   0.012  1.2376  1.3015  0.9509  1.0000
 MnO      0.304   0.0155   0.310   0.765  0.9813  0.9795  1.0019  1.0000
 SiO2     9.902   0.5962   8.871  16.073  1.1163  0.9453  1.1813  0.9997
 SO3      0.182   0.0082   0.164   0.123  1.1090  1.0197  1.0884  0.9993
 MgO      0.316   0.0284   0.210   1.173  1.5039  0.9454  1.5842  1.0042
 Fe2O3   57.125   2.5884  55.644  55.644  1.0266  1.0239  1.0027  1.0000
 CaO      3.791   0.2446   4.070  16.164  0.9314  0.9426  1.0013  0.9868
 -----------------------------------------------------------------------
 Total   76.486   3.7285  73.472 100.310    Total O  =   6.0    Iteration = 4



Unknown Specimen No. 55
 Group        : Clients         Sample  : WellSeds2
 UNK No.      :   55            Comment : STR Filter Map 1 ave sed 20um spot
 Stage        :   X=    4.8598  Y=   68.3894  Z=   10.7870
 Acc. Voltage :    15.0 (kV)    Probe Dia. : 20    Scan : Off
 Dated on May 30 10:06 2008
 WDS only      No. of accumulation : 1

Curr.(A) : 1.000E-08
Element Peak(mm) Net(cps)   Bg-   Bg+  S.D.(%)   D.L.(ppm)
 1 Al    90.965     38.6   38.2   24.1    5.76      207
 2 P    197.190     91.2    3.4    3.0    1.98      171
 3 As   105.125      1.5  125.8   79.3  113.84 ?    479
 4 U    125.157      0.9   30.2   26.0   86.08 ?    109
 5 Mn   146.386      1.7    4.5    2.7   31.92      687
 6 Si    77.757   1116.7   82.1   52.9    0.71      288
 7 S    172.143      8.6    6.2    2.7   10.76      181
 8 Mg   107.478     15.5  120.6   77.9   16.98      252
 9 Fe   134.892    387.9    4.9    4.6    1.15     1042
10 Ca   107.734    540.3   19.7   16.1    0.99      113

ZAF Oxide
Element  Mass(%)  Cation  K(%)  K-raw(%)  ZAF    Z      A      F
 Al2O3    0.532   0.0340   0.459   2.237  1.1598  0.9860  1.1725  1.0032
```

P2O5	3.941	0.1812	3.387	8.277	1.1635	0.9636	1.2017	1.0048
As2O5	0.051	0.0014	0.039	0.064	1.3014	1.1986	1.0858	1.0000
UO2	0.016	0.0002	0.013	0.013	1.2412	1.3049	0.9512	1.0000
MnO	0.236	0.0108	0.239	0.591	0.9843	0.9822	1.0021	1.0000
SiO2	13.653	0.7412	12.279	22.249	1.1119	0.9476	1.1734	0.9999
SO3	0.263	0.0107	0.237	0.177	1.1126	1.0222	1.0892	0.9993
MgO	0.228	0.0185	0.154	0.856	1.4872	0.9477	1.5630	1.0040
Fe2O3	60.376	2.4666	58.634	58.634	1.0297	1.0268	1.0028	1.0000
CaO	4.269	0.2483	4.568	18.142	0.9345	0.9451	1.0015	0.9873

Total 83.565 3.7130 80.009 111.241 Total O = 6.0 Iteration = 4