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Identification of groundwater sources for municipal wells using geochemical data on the Platte alluvial aquifer and underlying limestone at the Lincoln Water Well Field near Ashland Nebraska

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by

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Identification of groundwater sources for municipal wells using geochemical data on the Platte alluvial aquifer and underlying limestone at the Lincoln Water Well Field near Ashland Nebraska

Juanita Cruz Torres, M.S.

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Adviser: Darryll Pederson

Alluvial aquifer systems where pumping of municipal wells induces recharge from the adjacent river are the primary source of water for many cities. The city of Lincoln, NE has a primary water source in an alluvial aquifer adjacent to the Platte River. The Lincoln Water System manages the stream/aquifer system by using integrated models for a better understanding during periods of high stress such as a drought. The integrated models set the limestone aquifer as an impermeable boundary to understand the alluvial aquifer system without having a secondary water source. The limestone aquifer is permeable and the purpose of this study is to determine if water is being extracted from the limestone during a drought.

Low river flows and groundwater exploitation during drought can cause water extraction from the underlying limestone aquifer due to high water demands. This study has focused on characterizing raw water entering the water treatment plant to determine if water from the underlying limestone is being pumped during dry periods.

The cone of depression around a well would change with high stress levels in the aquifer, evidenced by decreased groundwater levels, can form what is known as up-coning in the limestone. The ion chemistry data used are from three different years, 2008

representing a wet year and 2012-2013 representing dry years. The ions analyzed are, manganese, bromide, fluoride and iron. Water chemistry data collected from treatment plants at the Lincoln Well Field near Ashland Nebraska have shown

that especially during the summer manganese and bromide concentrations increased with increased stress caused by lower river and groundwater levels. A delay in groundwater movement was observed for all four ions studied, ion increases were shown one to two months after heavy pumping. During the winter months, when water is much colder manganese concentration increased significantly, this could be attributed to higher water viscosity affecting induced recharge and groundwater flow.

Acknowledgements

I would like express my gratitude to all of the people that have helped make this research possible. I would like to thanks Dr. John Gates, Dr. Vitaly Zlotnik and Dr. David Loope for contributing in the process of my education and research. I would also like to thank the City of Lincoln, especially the Lincoln Water System for providing all the necessary data needed to complete this research. A special thanks to Eric Lee from the Lincoln Water System who has aided me with understanding important features regarding the Lincoln well field. The Water Science Laboratory for a great service and for working with me during my research. I would also like to thank the Geological Society of America for awarding me a grant for my research. Finally I would like to give a special thanks to Dr. Darryll Pederson who has guided me throughout this research process.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

PURPOSE AND SCOPE OF INVESTIGATION

The municipality of Lincoln, Nebraska gets its water supply from a well field in an alluvial aquifer system adjacent to the Platte River near Ashland, Nebraska. The production wells are located near the river and when pumping, the wells form a cone of depression which causes induced recharge from the river. The induced water makes up the primary source of the water produced at the Lincoln well field. The Lincoln Water System (LWS) manages the stream/aquifer system with groundwater models that help understand the system during periods of higher stress such as that of a drought that causes river stages to drop.

When conditions of high stress are occurring due to an excess of water being pumped out the primary aquifer, a secondary water source can supply water to the wells. In the Lincoln well field there is a limestone formation underlying the alluvial aquifer. Models used by the LWS assume that the water face between the alluvial and limestone aquifers interface is as an impermeable boundary.

It is proposed that the underlying limestone aquifer is a significant secondary water source during times of stress such as a period of drought. In the Lincoln well field, some wells fully penetrate the alluvial aquifer including parts of the limestone aquifer where the alluvial meets the underlying limestone, but the water that is being pumped is primarily from the alluvial aquifer. The process that would trigger the water extraction from the limestone aquifer during a period of high stress is called up-coning and this

occurs as there is a change of hydraulic head between the two aquifers as the cone of depression formed around the wells reaches deeper groundwater levels and forms a zone of higher stress at the bottom of the well. Up-coning in the limestone then extracts water from the underlying aquifer. A broader discussion of the effect of up-coning will be available later on in this chapter. A way to identify that up-coning is occurring is by observing the change in hydrochemistry.

The purpose of this study is to determine whether or not wells that produce water for the city of Lincoln, NE are pumping water only from the Platte alluvial aquifer (sand and gravel aquifer) or if it's also extracting water from the underlying limestone aquifer during periods of drought using a hydrochemical approach. By examining the geochemical signatures of the Lincoln well field during the dry years of 2012, and 2013 and comparing with the year 2008, which is considered a year with proficient precipitation, one can delineate any pattern that would occur in the aquifer system with respect to the hydrochemical environment. In 2012, a regional drought that covered Colorado, Wyoming and Nebraska occurred and low precipitation in these areas resulted in very low flows in the Platte River. It is likely that there will be dry seasons in the upcoming years and demonstrating that there are water yields from the limestone aquifer will lead to better well field management.

LOCATION AND STUDY AREA

Lincoln Nebraska's primary water supply comes from a well field in the Platte River Valley near Ashland Nebraska. The primary aquifer in the Platte River Valley is the alluvial aquifer. The well field is divided into the North and South well fields

(Fig.1.1). The South well field is characterized by having a thicker section of the aquifer than that found in the North section of the well field. There are also horizontal wells located on a Platte River island that produce water for the city of Lincoln.

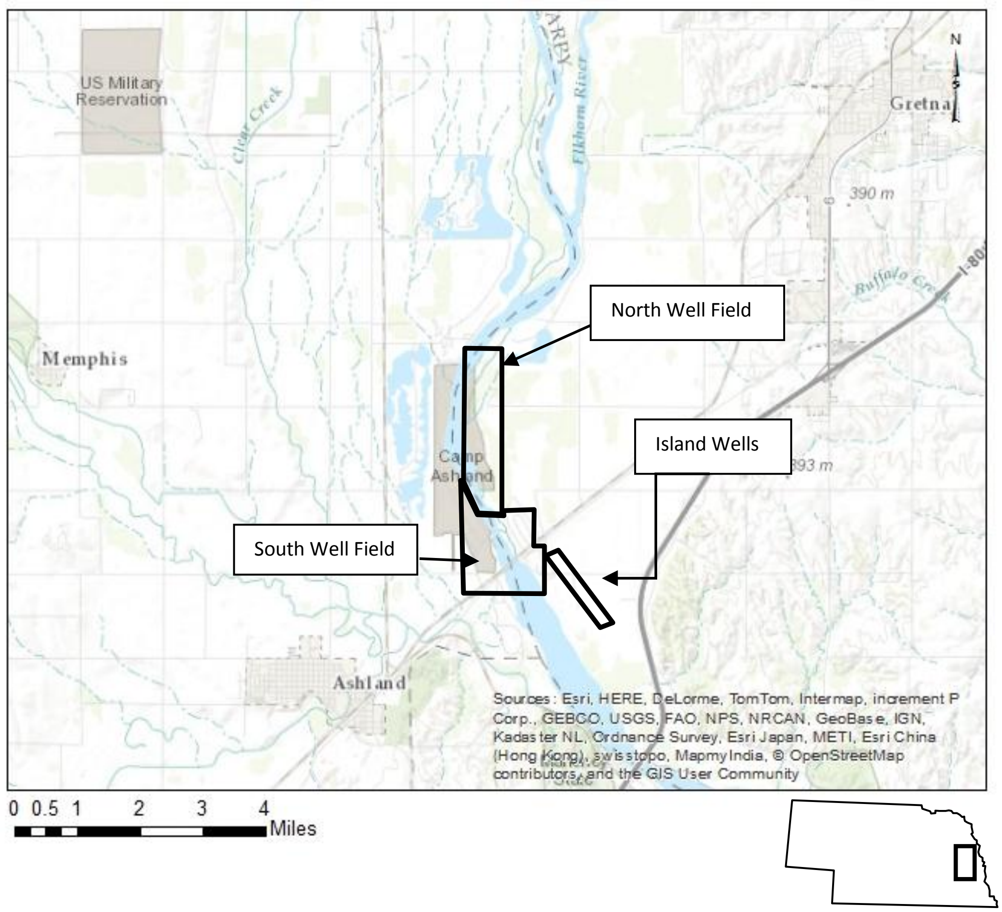

Figure 1.1: Location of the study site, the Lincoln Water well field near Ashland Nebraska, map was created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. Nebraska map was created by outlining the state using Google Earth, (2013).

Context

High water demand for summer lawn irrigation triggers heavy pumping at the well field. Population growth for the city of Lincoln in Lancaster County, NE has also increased water demand. Currently, the Lincoln Water System serves over 262,000 people (Esposito, 2011). Projections based on Trend Models from 1958 to 2000 census for Lancaster County, show that total population is likely to increase 53.7% to 76.8% from the year 2000 to 2040 (Drozd and Deichert, 2010). High water demand for the needs of the increasing population requires more water to be extracted from the aquifer, especially during dry periods when water demand is high.

Approximately 90% of Lincoln Nebraska's water needs come from the Ashland well field (Davis, 1992). Drawdown of water level during pumping of these wells induces recharge from the Platte River. But even though the primary water source is the river, minor recharge in the study area is also from infiltrating of precipitation, there is significant seasonal variation in pumping primarily because of lawn irrigation for the city of Lincoln (Ellis and others, 1985).

The Platte River flow is not dependent on localized precipitation at the well field location. The Platte River originates from the Rocky Mountain in Colorado, the main flow comes from snowmelt at this location. Two streams are formed in the Rocky Mountain, the North and South Platte Rivers, which unite in Nebraska to form the Platte River. The snowmelt runoff is modified by dams and water withdrawals for municipalities along the course of the Platte River. During dry periods, the Platte River stops flowing upstream of Columbus, Nebraska. Inflow from the Loup and Elkhorn rivers

starts downstream from Columbus augmented flow in the Platte River. During dry periods virtually all flow in the Platte River by the well field is from the Loup and Elkhorn Rivers. Figure 1.2 shows the North and South Platte Rivers originating from the Rocky Mt. in Colorado and connection in Nebraska.

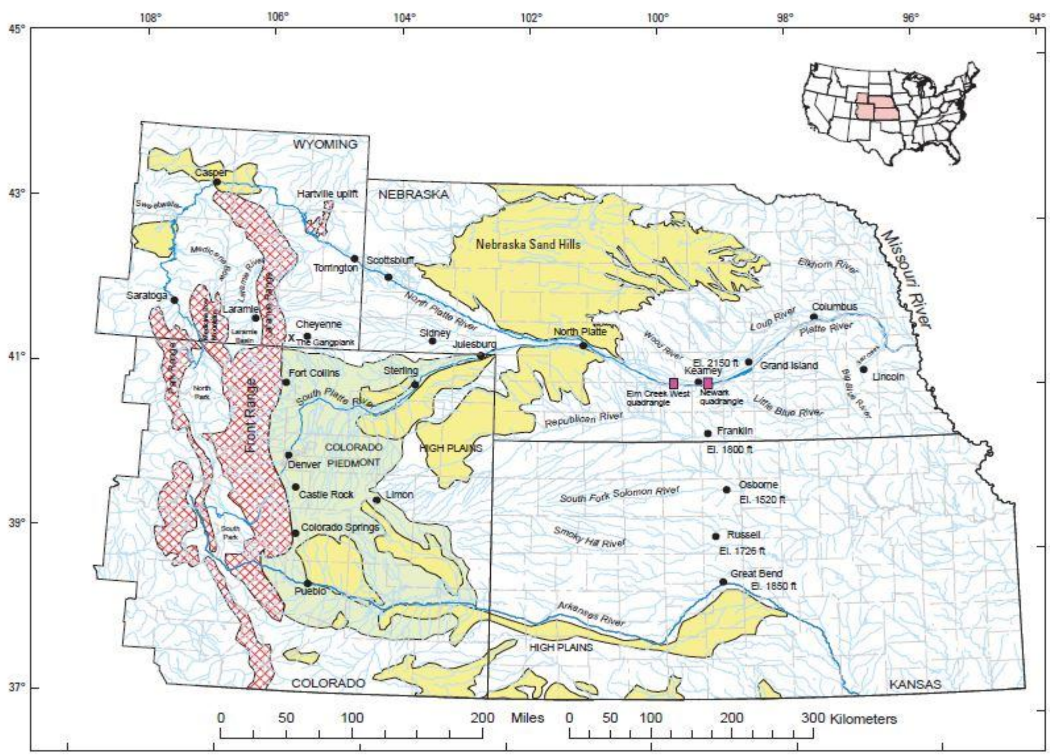

Figure 1.2: Map showing the Platte River streams origin and flow from Colorado to Nebraska, diagram by Codon (2005).

When regional drought encompasses parts of Colorado, Wyoming and Nebraska, the Platte River flow is affected. Since most of the Platte River flow is from snowmelt in the Rocky mountain, precipitation data will be discussed from Colorado to Wyoming and finally in Nebraska. Precipitation data was acquired from webpage http://charts.srcc.lsu.edu/trends/ (Srcc, 2014). In Colorado, the annual precipitation for 2012 was 12.31 inches (in) while in 2008 and 2013 were 17.46 in and 18.81in respectively, see Table 1.1. In Wyoming, precipitation in 2012 was of 10.96 in while in 2008 and 2013 precipitation was 16.05 in and 16.32 in respectively.

In Nebraska, rainfall precipitation at the study site varies from year to year. Most of the precipitation occurs from May to September (Davis, 1992). In 2008, annual precipitation was of 36.63 inches while in 2012 it was of 18.50 in and in 2013 with 29.26 in. Table 1.1 shows that precipitation in Nebraska is generally higher than in Colorado and Wyoming and that there was a regional drought in 2012. Table 1.2 has the seasonal and annual precipitation amounts for the years 2008, 2012 and 2013 at the Lincoln well field site and shows that precipitation was low for the summers of 2012 and 2013 and that in the winter precipitation was at its lowest over all.

Years	Colorado Annual Precipitation in inches	Wyoming Annual Precipitation in inches	Nebraska Annual Precipitation in inches
2008	17.46	16.05	36.63
2012	12.31	10.96	18.5
2013	18.81	16.32	29.26

Table 1.1: Annual precipitation amounts in Colorado, Wyoming and Nebraska for the years of 2008, 2012 and 2013 (Srcc, 2014).

Years	Precipitation in the spring in inches (in)	Precipitation in the summer in inches (in)	Precipitation in autumn in inches (in)	Precipitation in the winter in inches (in)
2008	12.14	11.82	10.92	1.89
2012	7.7	4.48	2.98	2.46
2013	12.82	7.35	7.9	0.82

Table 1.2: Seasonal precipitation amounts in Nebraska for the years of 2008, 2012 and 2013 (Srcc, 2014).

During dry seasons the Platte River water level drops. Discharge graphs from the United States Geological Survey (USGS) show that the Platte River stages (herein as river stages) adjacent to the Lincoln well field declines during the summer for the years 2008, 2012 and 2013, but the river stages declined the most during 2012. In the summer when the river stage drops, as a consequence the alluvial aquifer water level drops especially if large volumes of water are being extracted. Duncan (1990) mentions that continuous pumping at the Lincoln well field has created a localized cone of depression and during dry periods, when river discharge is less, the river channel tends to be located farther from the well field and water from the river to the wells moves a longer distance. Regional low precipitation during the summer triggers high water demand for lawn irrigation which causes heavy pumping from the wells at the Lincoln well field.

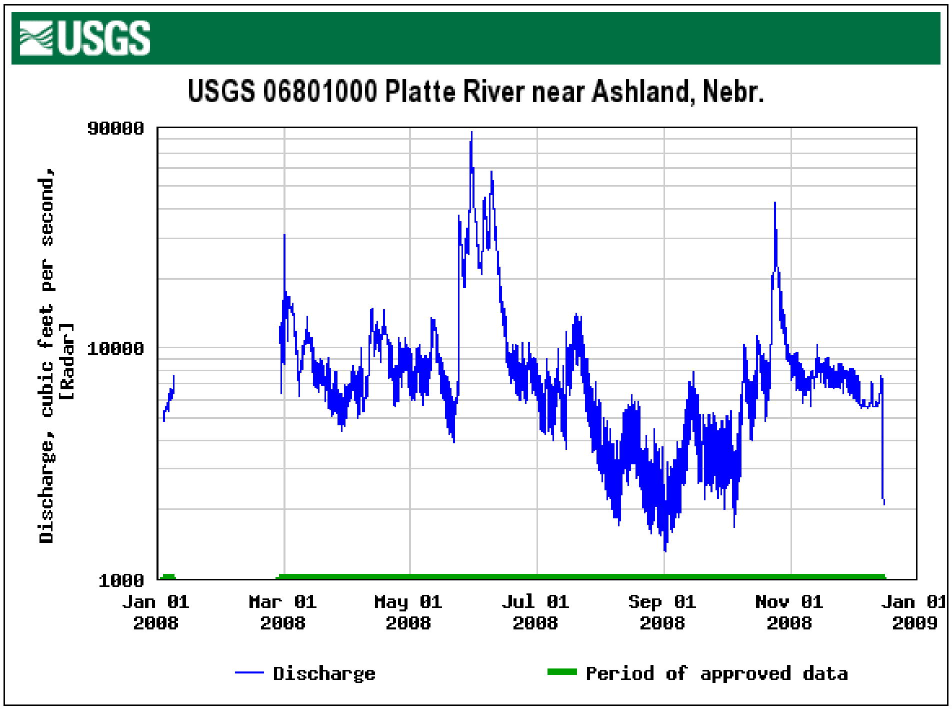

Figure 1.3: Platte River discharge to the Lincoln well field for the year 2008, graph by U.S.G.S (2014).

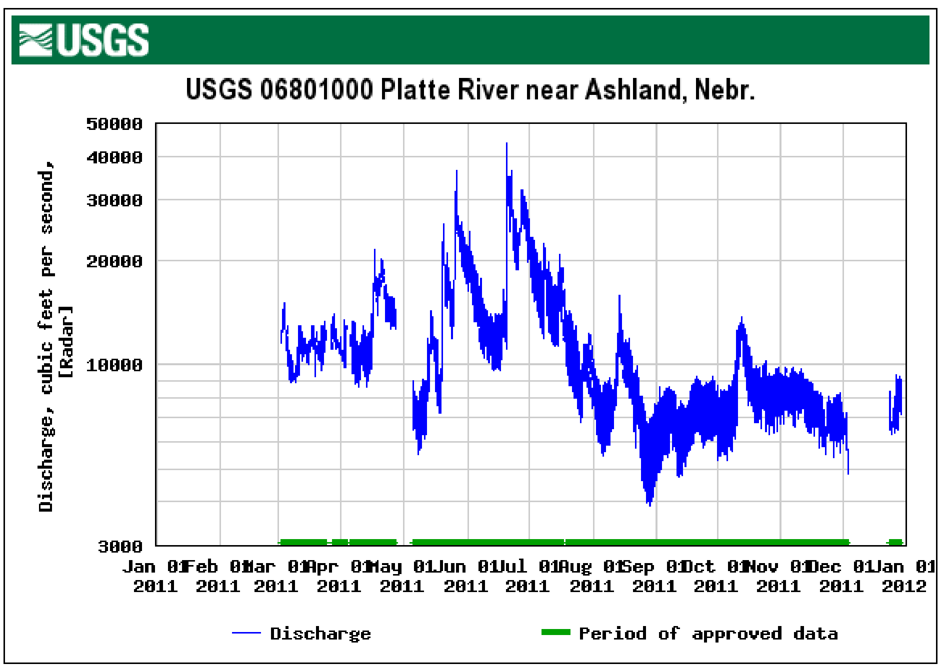

Figure 1.4: Platte River discharge to the Lincoln well field for the year 2011, graph by U.S.G.S (2014).

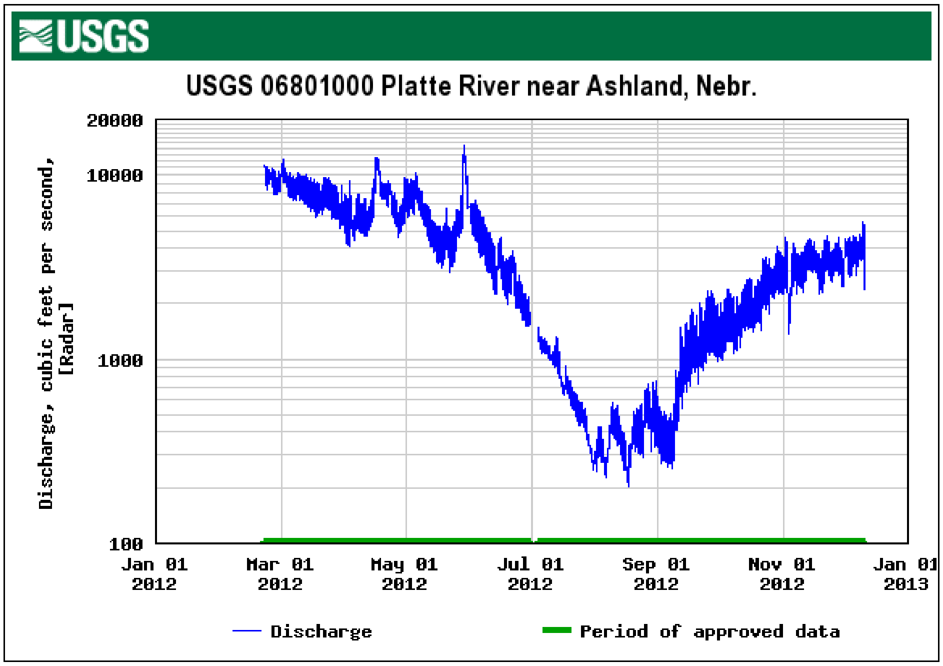

Figure 1.5: Platte River discharge to the Lincoln well field for the year 2012, graph by U.S.G.S (2014).

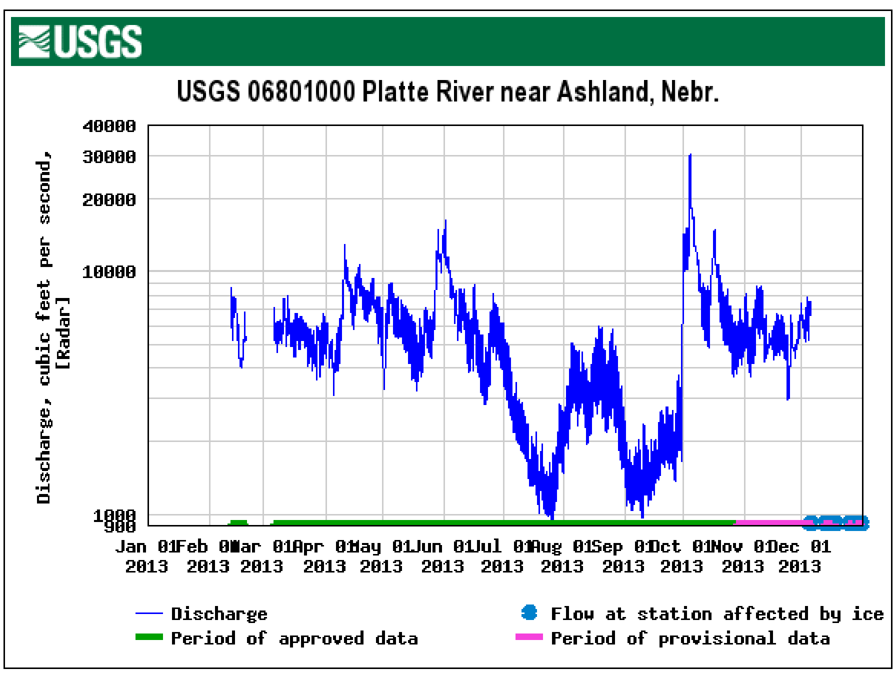

Figure 1.6: Platte River discharge to the Lincoln well field for the year 2013, graph by U.S.G.S (2014).

Continuous heavy pumping at the well field causes water level in the alluvial aquifer to drop when the river stages are low. A brief description of what is the cone of depression or drawdown around a pumping well is essential to understand the process that would trigger up-coning. Assume that the static water level is almost the same throughout the aquifer before there is any pumping (note that water is always being pumped from the aquifer at the well field). When the wells start pumping, a lower hydraulic head develops around the well as a lower head known as cone of depression or drawdown. The increase in pumping causes lower hydraulic head in the aquifer and can trigger what is known as up-coning.

The effect of up-coning is that the cone of depression, or cone that forms in around a well from the water table lowering by pumping is accompanied by up-coning of hydraulic head in the permeable space below the well (see Figure 1.7). This effect can cause the extracted water quality to change if there are different concentrations of solutes in the underlying aquifer. Hamza, (2006) states that when an underlying aquifer contains saline water and has a well penetrating and pumping the freshwater portion above, a local rise of the interface below the pumping well occurs, an up-coning.

Up-coning is a common problem in areas were groundwater production is located in a coastal zone also known as coastal aquifers where salt water intrusion occurs (Motz, 1992; Werner et al., 2009). Motz (1992) mentions that up-coning in the United States include potential or actual intrusion from deep saline aquifers into producing aquifers. Studies involving up-coning are usually approached using a numerical method. Reilly and Goodman (1987) mention that the movement of fresh and salty groundwater in up-coning are studied using two different methods, the sharp interface and the density

dependent solute transport methods. In my study, I used hydrochemical signatures to determine if up-coning was occurring during periods of drought where heavy pumping (groundwater exploitation) caused higher stress in the freshwater aquifer.

In the Lincoln well field, the situation is roughly comparable to a partially penetrating well in an aquifer. The alluvial aquifer is not in direct contact with a coast line but it is underlain by a limestone aquifer that has different water chemistry than the alluvial aquifer. For the Lincoln well field, water yield from the limestone is usually not as high as the yield from the alluvial aquifer to the pumping wells. If up-coning occurs, a change in water chemistry will occur in the water being extracted.

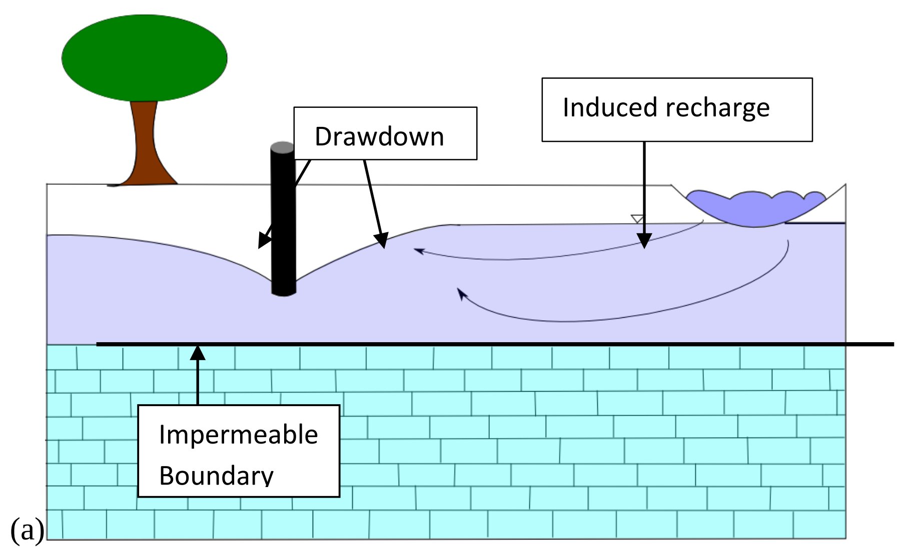

Figure 1.7: (a) shows the change in water level around the well (drawdown) caused by pumping.

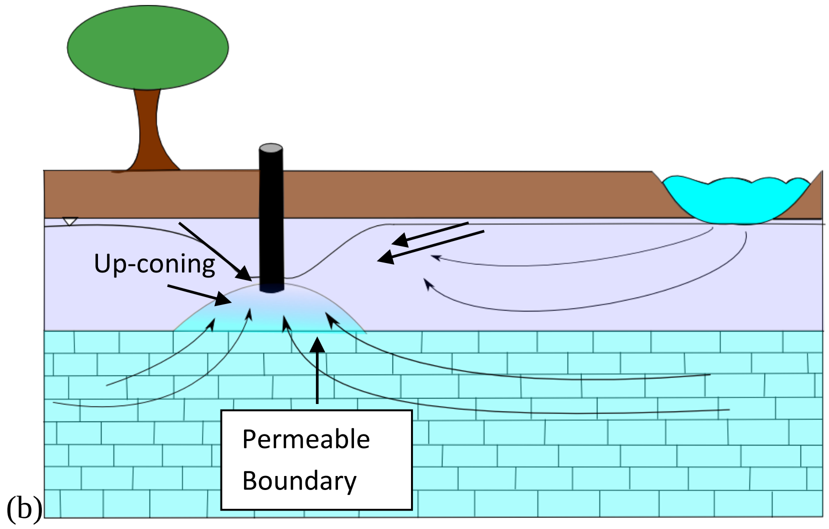

Figure 1.7: (b) shows that as water pumping increases, a change in the interface occurs and up-coning forms at the bottom of the well. This is caused by heavy pumping during dry periods.

GEOLOGY

There are three potential aquifers in the field location, the Platte River alluvial aquifer (herein as alluvial aquifer), the limestone aquifer and the Dakota Sandstone aquifer. The limestone and the Dakota Sandstone aquifers can be considered as secondary aquifers. The alluvial aquifer is the primary aquifer for water production in the Lincoln well field, but most of the water produced from the alluvium comes from Platte River during induced recharge.

The alluvial aquifer overlies bedrock as loose sand and gravel with thin layers of silt (Druliner and Mason, 1994). A study by Rogers, (1994) suggests that most of the sediments in the alluvial aquifer come from the Platte River deposits. A cross section for the Platte Alluvial valley (Figure 1.8) shows that sand and gravel represents the alluvial aquifer. A surficial geologic map of the Platte River Valley and surrounding area is shown in Fig.1.9. The alluvial aquifer is labeled as Quaternary Alluvium (Qal). At the base of the alluvial aquifer is the limestone aquifer.

The bedrock underlying the alluvial aquifer is composed of limestone-shale rocks of Pennsylvanian age and belong to the Lansing and Kansas City groups (Divine et al. 2009). Figure 1.10 shows the bedrock of the study area and the limestone that underlies the alluvial aquifer. The Kansas City and Lansing groups are marine sediments primarily interbedded limestones and shale deposits and are of the Upper Pennsylvanian age (Hanson et al. 2011). Another secondary aquifer found throughout the area is the Dakota Sandstone.

The Dakota Sandstone is part of the Great Plains Aquifer System and represents deposits from the Cretaceous (Gosselin et al. 2001). The Dakota Sandstone underlies the northern part of the alluvial aquifer outside of the Lincoln well field bounds, but the Dakota Sandstone is also exposed as a valley wall at the far east of the Platte River Valley where the south section of the well field is located, see Fig.1.8. The Platte River Valley is also characterized by having a terrace exposed at the far west of the valley.

The Todd Valley is exposed at the western edge of the Platte River Valley, see Figure 1.9. The Todd Valley is a paleovalley which is an abandoned part of the Late

Pleistocene Platte River course (Divine et al. 2009). The paleovalley fill is composed of sandy to gravelly alluvium and serves as an aquifer for the use of irrigated agriculture (Divine et al. 2009). Figure 1.9 shows the Todd Valley terrace at the western edge of the map labeled as Quaternary-Loess (Ql).

HYDROGEOLOGY

Water produced from the Lincoln water well field represents induced recharge from the Platte River. Figure 1.11 shows the water table/potentiometric surface of the regional sand and gravel aquifer. Arrows indicate groundwater flows from the Todd Valley into the Platte River valley. The drop in groundwater level caused by pumping of the wells from the Lincoln well field is shown here explicitly (Divine et al. 2009).

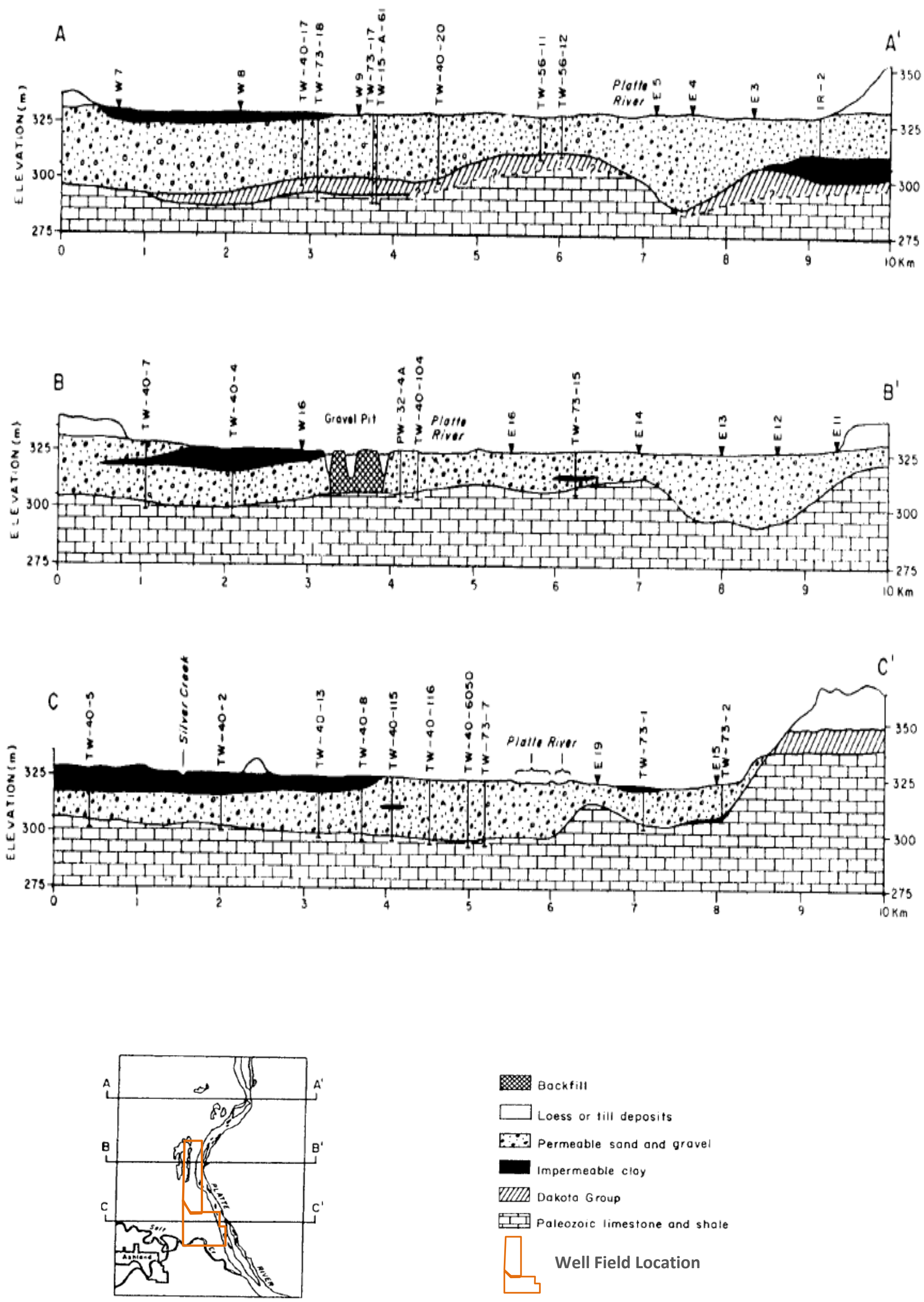

Figure 1.8: A hydrogeologic cross section of the Platte River alluvial valley, modified from Ayers, 1989.

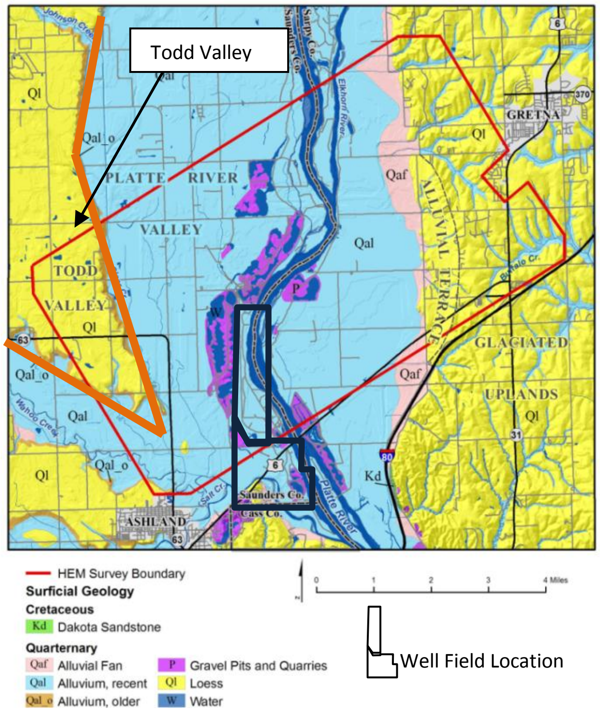

Figure 1.9: Map showing the Surficial Geology for the Platte River Valley, modified from Hanson et al. (2011).Red lines represent the Helicopter Electromagnetics (HEM) study location from Hanson et al. (2011), it could not be edited out of the image.

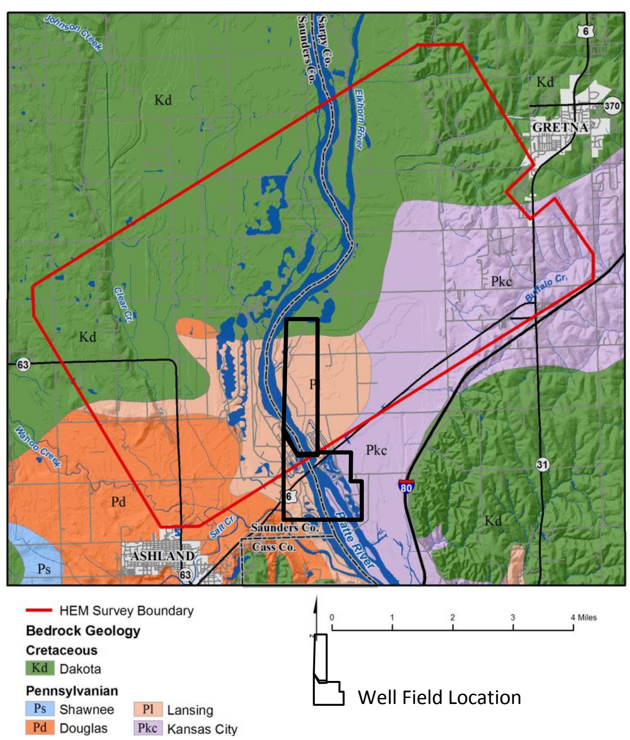

Figure 1.10: Map showing the bedrock for the Platte River Valley, modified from Hanson et al. (2011).

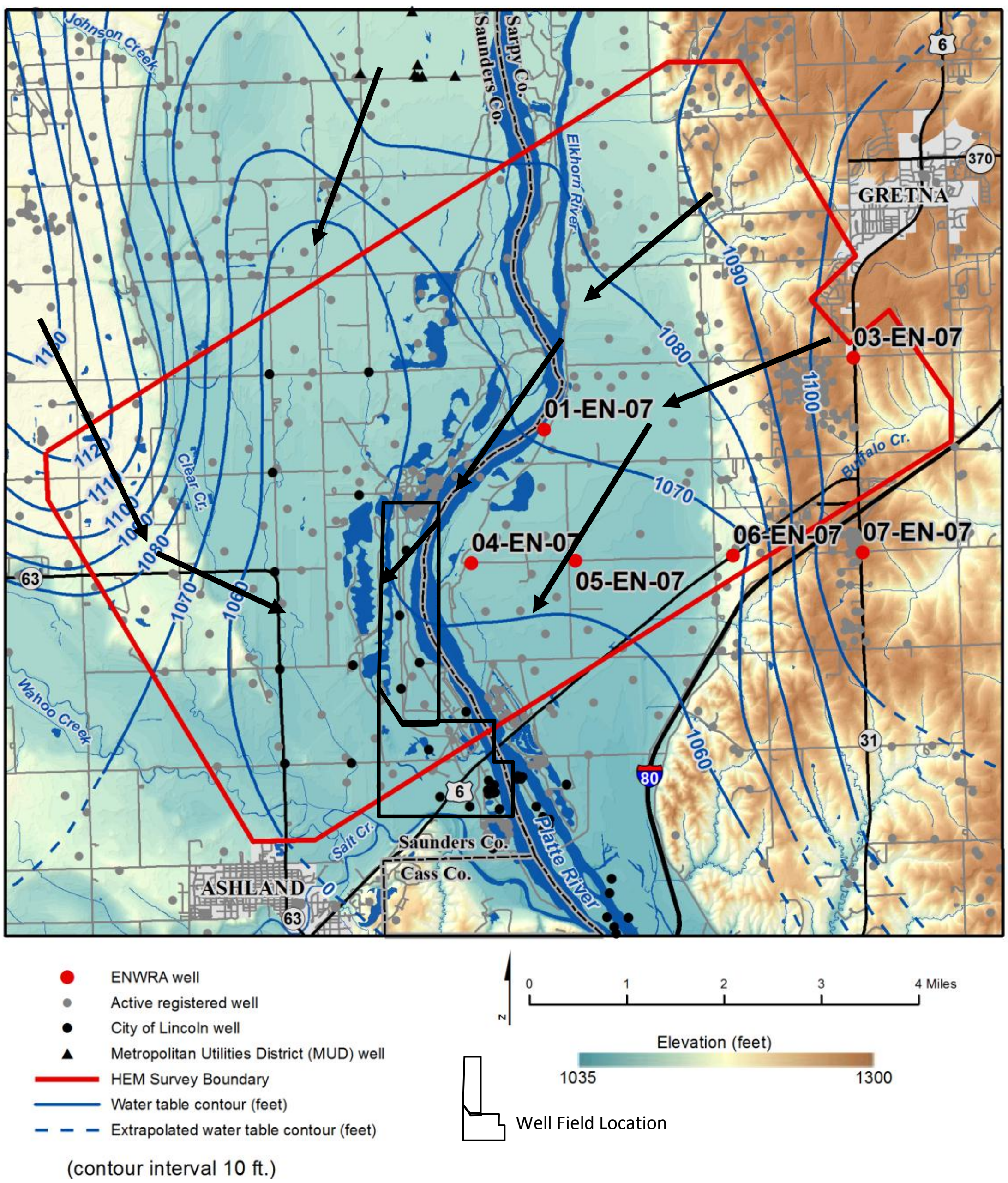

Figure 1.11: Groundwater flow from the Todd Valley to the Platte River Valley, modified from Hanson et al. (2011). Red lines represent the Helicopter Electromagnetics study location from the study by Hanson et al. (2011), it could not be edited out of the image.

HYDROCHEMISTRY

The Lincoln Water System tests chemical parameters for water produced at the well field. There are two treatment plants, the West treatment plant and the East treatment plant. The West treatment plant analyses water from the North and South sections of the well field as an amalgamation of water produced from both North and South sections of the aquifer, while the East treatment plant analyses water from the Platte River island wells which are horizontal wells. The water data used for this study is the raw water data (water before being treated). The ions chosen for this study are iron (Fe), manganese (Mn^{+2}), bromide (Br^{-}) and fluoride (F^{-}). Each ion has a unique behavior in natural water which is described in the following text. For this purpose it is necessary to include a section describing each ion in natural water.

Iron precipitates from a weathering environment as a redox reaction (Hem, 1985). In water, when iron is present in excess amounts it forms red oxyhydroxide precipitates that stain plumbing fixtures (Hem, 1985). Water pumped from the alluvial aquifer has iron present in smaller concentrations than manganese, bromide and fluoride.

Manganese chemistry is somewhat similar to iron in that both metals precipitate under weathering environment as a redox process (Hem, 1985). In aerated water, Mn^{+2} is more stable than iron and can be transported at higher concentrations (Hem, 1985). In water reservoirs such as aquifers and lakes, thermal stratification develops and the bottom sediments may become anoxic, here the previous manganese oxide that was deposited becomes reduced and dissolves (Hem, 1985). Deeper water in an aquifer at times contains significant concentrations of dissolved manganese (Hem, 1985). There are small

amounts of manganese in limestones and dolomites and many igneous rocks contain divalent manganese as a minor constituent (Hem, 1985). The limestone at the Lincoln well field is considered to have higher manganese concentration than the alluvial aquifer because water from the limestone is deeper and older than water from the alluvial aquifer, this statement comes from the basis of the manganese weathering environment described by Hem (1985) and (John Gates Personal Communications).

Fluoride concentration in most natural water is small and it's the lightest member of the halogen group (Hem, 1985). Fluoride can also form strong solute complexes with cations (Hem, 1985). Fluorite (CaF_2) is a common fluoride bearing mineral and it has a low solubility, its occurrence is in both igneous and sedimentary rocks (Hem, 1985).

Bromine in natural water is present as bromide ion Br-. Bromide is present in some brines as major concentrations (Hem, 1985). Bromide oxidation to elemental bromine can increase mobility of elements, this effect can occur in marine aerosols (Hem, 1985).

METHODS OF INVESTIGATIONS

Daily ion chemistry, well depth and pumping rates data for the alluvial aquifer was provided by the Lincoln Water System for the years 2008, 2012 and 2013.The following methods are the process for the determination if water is being pumped from the limestone aquifer during periods of higher stress such as a period of drought. The hydrochemical environment for the aquifers in the Lincoln well field is such that the limestone aquifer has a greater manganese, bromide, fluoride and iron concentrations

than the alluvial aquifer and the water being pumped during periods of high stress will reflect the hydrochemistry of the limestone aquifer.

The analytical methods used are as follow:

1. Scatter plots were created for each individual ion concentration from raw water data to determine if there is a pattern for any of these ions during the years of 2008, 2012 and 2013.
2. Bar graphs showing the average, minimum and maximum concentration for each individual ion were plotted and compared to the stress levels in the aquifer caused by well pumping.
3. Water samples were collected for major inorganic ion analysis in both the alluvial and the limestone aquifers. Water was analyzed for calcium, magnesium, sodium, potassium, chloride, bicarbonate, sulfate and fluoride. Samples were used to calculate Saturation indicies for Fluorite mineral in both aquifers.
4. Ion ratios were plotted in order to get a better understanding of Mn^{+2}, Br^{-} and Fe distributions in the hydrochemical system. Fluoride was used as the conservative ion for the ionic ratios because it is known as a good conservative ion. It is also an ion that is mostly constant in concentration and there are no fluoride bearing minerals precipitating in the alluvial aquifer that would lead for changes in concentration caused by dissolution.

5. Running averages ion ratio distributions were compared with pumping rates in the Lincoln water well field to delineate a relationship between ratio concentrations at different levels of stress caused by pumping in the aquifer.

Major ion analyses were made for water from six different wells in the well field and two samples were taken from the limestone aquifer exposed at the Fish hatchery in Gretna Nebraska on August of 2013. Samples were analyzed using titration for the HCO_3^- concentration, cation analyses were made using the Atomic Absorption Spectrometer and for the anion analysis, the Ion Chromatograph was used, all laboratory work was conducted in the Water Science Laboratory at the University of Nebraska, Lincoln.

PRESENTATION OF DATA

Data provided by the Lincoln Water System are shown in Tables 1.3, 1.4 and 1.5. These tables show the data distribution for the East and West treatment plants, raw water data from the island wells and the well field respectively. These tables serve as a guide for data availability for a specific ion during the time periods studied, in some cases there was a hiatus for individual ions.

Year 2008	Island Wells	Well Field
Number of wells	Two island wells Note: Wells are horizontal.	All production wells active.
Fluorite (F^-)	Data from April to December. Note: Skips June samples.	Data from May, September and October. Note: Few monthly data.
Manganese (Mn^{+2})	Data from April to December.	Data from January to October.
Bromide (Br^-)	Data from April to December.	Data from May, September and October. Note: Few Monthly data.
Iron (Fe)	No data.	No data.
Typical Pumping Months	Data not available	All year.

Table 1.3: Table showing available data for the year 2008.

Year 2012	Island Wells	Well Field
Number of wells	Two island wells Note: Wells are horizontal.	All production wells active.
Fluorite (F^-)	Data from January to December. Note: Two sample points in January.	Data from August to December.
Manganese (Mn^{+2})	All year data.	All year data.
Bromide (Br^-)	All year data.	Data from August to November.
Iron (Fe)	Few data points.	Data from January to November. Note: Few monthly data.
Typical Pumping Months	Data not available	All year.

Table 1.4: Table showing available data for the year 2012.

Year 2013	**Island Wells**	**Well Field**
Number of wells	Two island wells. Note: Wells are horizontal.	All production wells active.
Fluorite (F^-)	Data from March to July. Note: Three samples in July.	Data from March to July. Note: Few monthly data.
Manganese (Mn^{+2})	Data from March to July.	Data from January to July.
Bromide (Br^-)	Data from March to July. Note: Three samples in July.	Data from March to July. Note: Few monthly data.
Iron (Fe)	Data from March to July. Note: Few monthly data.	Data from January to July. Note: Few monthly data.
Typical Pumping Months	Data not available	All year.

Table 1.5: Table showing available data for the year 2013.

Chapter 2 Ion Distribution

Manganese (Mn^{+2}), bromide (Br^-), fluoride (F^-) and iron (Fe) data over time showed the patterns of concentration for the years, 2008, and 2011-2013 (summer 2013). Ion chemistry data for the year 2011 were used solely to observe how each of the ion concentrations were distributed the year before the drought in 2012. Data are organized to show concentration over time for each individual ion, Mn^{+2}, Br^-, F^- and Fe in this consecutive order. Discussion starts with Mn^{+2} concentration at the North and South sections of the well field (herein as well field), then a discussion of Mn^{+2} ion in the island wells in a consecutive order. After the discussion of manganese concentration in water at the well field and the island wells, the same style of discussion is used for bromide, fluoride and iron.

Manganese Concentration in the North and South Well Field Locations

In 2008, Mn^{+2} concentrations decreased from January to February and increased from April to July, there is also an increase in concentration at the end of the year see Figure 2.1. There was an increase in water production during March and from June to August. There were high average Mn^{+2} concentrations from May to July but the highest was in May. The river stages were higher in June, and low from July to September. Figure 2.2 shows that the average Mn^{+2} concentrations increased in May, dropped in June but remained fairly high through to July.

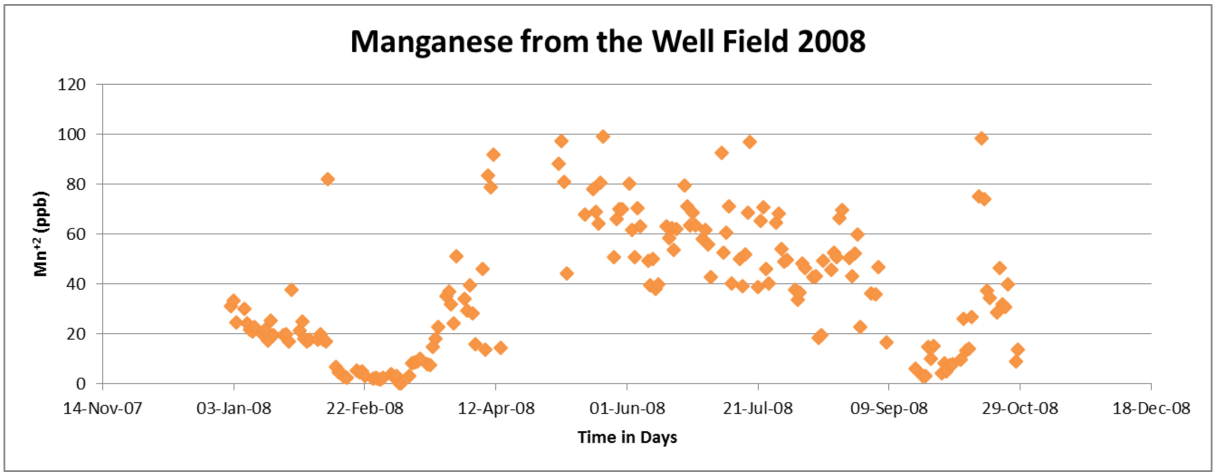

Figure 2.1: Graph representing manganese concentration from the well field at a daily basis from January to November 2008.

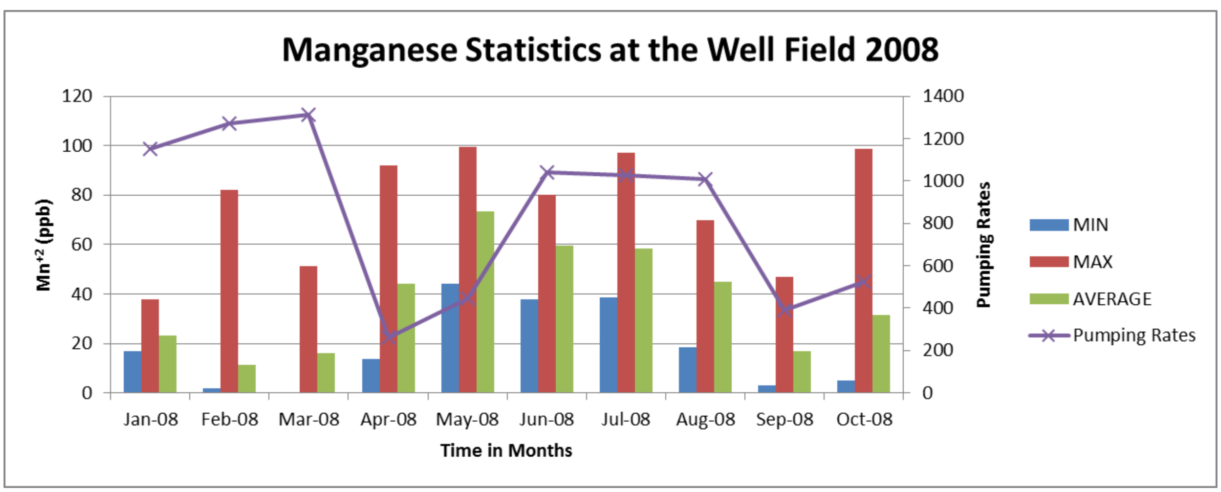

Figure 2.2: Graph representing the pumping rates and statistical minimum (MIN), maximum (MAX) and average values for manganese at each month in 2008.

In 2011, Mn^{+2} concentrations increased starting in May to the end of September, see Fig.2.3. The monthly average for Mn^{+2} concentration in 2011 increased in May and June, and then decreased from July to September as shown in Figure 2.4. In 2011, Mn^{+2} concentration also increased from May to June where greater water yields are most likely to be happening.

In 2012, Mn^{+2} concentrations increased from May to July and decreased toward October (Fig. 2.3). The river stages dropped periodically from June to September. The stress in the aquifer that was caused by the drought in 2012, and the drop in river stages coincided with the extraction of more Mn^{+2} concentrations during the period of May to August where June had the highest concentrations (Fig.2.5). Figure.2.3 shows that Mn^{+2} concentration also increased in November.

Stress in the aquifer caused by high pumping rates began in May and reached a maximum peak in July. There were high Mn^{+2} concentrations in November, but pumping rates were lower than in the summer. Figure 2.5 shows a delay in the maximum Mn^{+2} concentrations that increased months after pumping rates were high which were from June to August.

The delay in movement of Mn^{+2} concentrations could be caused by the slow movement of water in the alluvial aquifer. The delay in groundwater travel time occurred during the period where pumping rates were the highest, which was during the summer. Manganese ions increased because of the intrusion of water from the limestone aquifer caused by up-coning. Water from the limestone aquifer can also deviate into the alluvial aquifer. The water mixture is then pumped out a month after the heavy pumping in the

summer. Groundwater movement in the alluvial can also be slow going into the fall because of colder water being induced from the river.

In 2013, Mn^{+2} concentrations were higher from January to February and then from May to July (Fig.2.3). The higher Mn^{+2} concentrations from January to February in 2013 were higher than concentrations during that time period in 2012. The increase in concentration during November 2012 and from January to February 2013 is an unexpected find because the original expectation for this study was to observe if concentrations would increase during the summer.

In 2013, Fig. 2.6 shows that pumping rates decreased from January to April and the average Mn^{+2} concentration also decreased during that time period where river stages were fairly high. Pumping rates increased from May to July, and the monthly average Mn^{+2} concentration increased, concentration being highest in May. It would appear that in the well field, as the well pumping rates are high, the more Mn^{+2} rich water is being withdrawn from the limestone aquifer.

In the well field, when water demand increases and more water is being pumped from the aquifer, the water that is being induced from the river reaches a certain level where the river can no longer provide water to the wells. Groundwater levels in the aquifer drop and water levels in production wells drop, stress in these wells increases causing water from the underlying limestone to flow to the well via up-coning.

A possible reason for increase in concentration during the winter is that there would be an increase in water viscosity at shallow depths in the aquifer because of colder induced recharge which causes the water from deeper zones to be withdrawn. Chu (1988) found that cooler water has lower velocity of movement than warm water, he also found that the higher viscosity of water in the well field is the main factor for slow water movement.

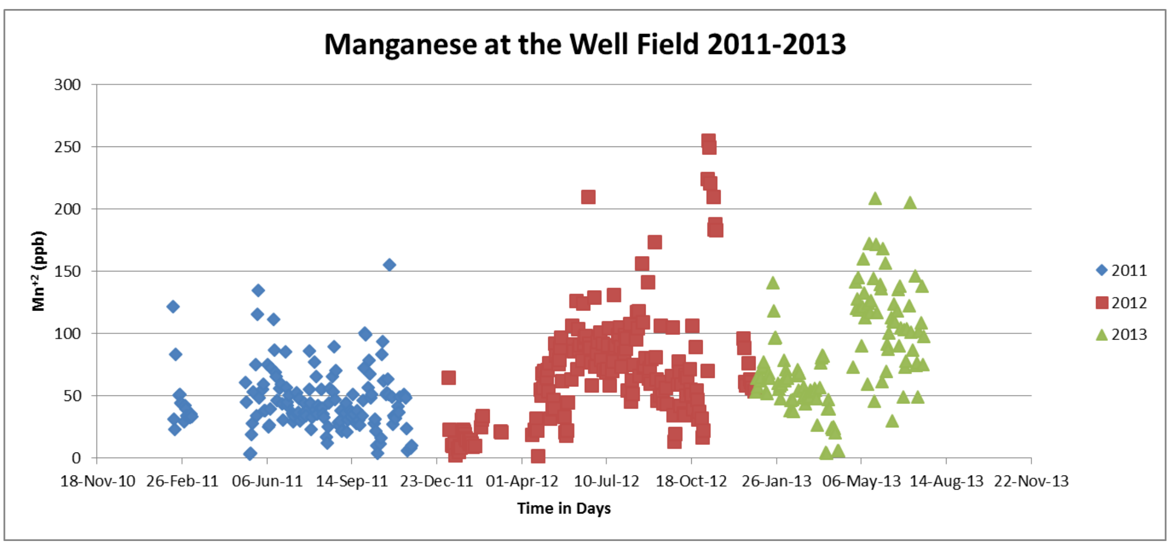

Figure 2.3: Graph showing daily manganese concentration from the well field during the years 2011-2013 (summer).

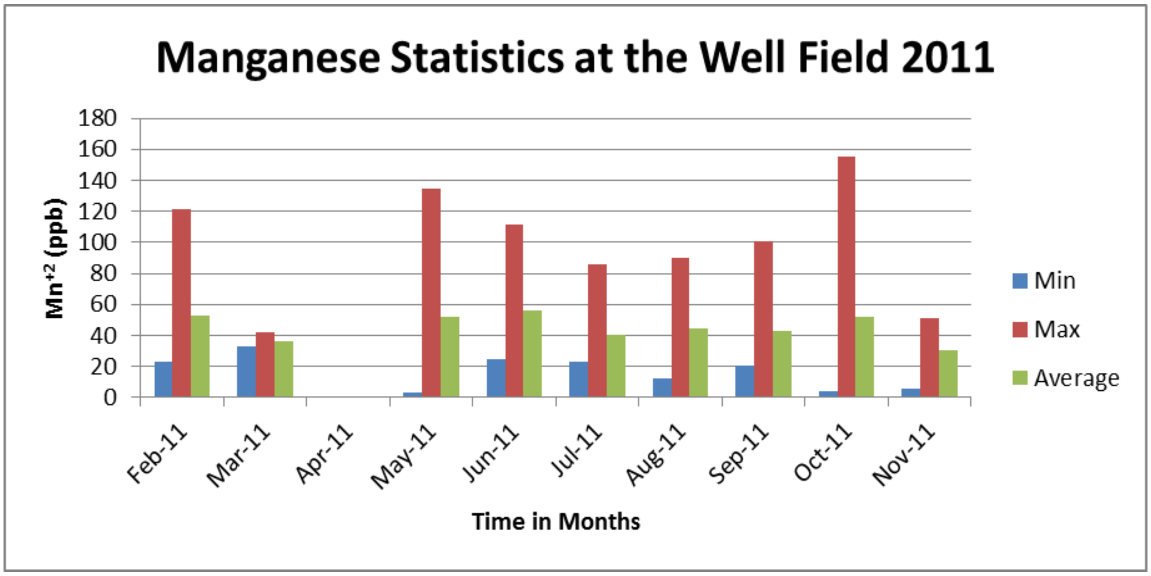

Figure 2.4: Graph representing statistical minimum (MIN), maximum (MAX) and average values for manganese at each month at the wells field in 2011.

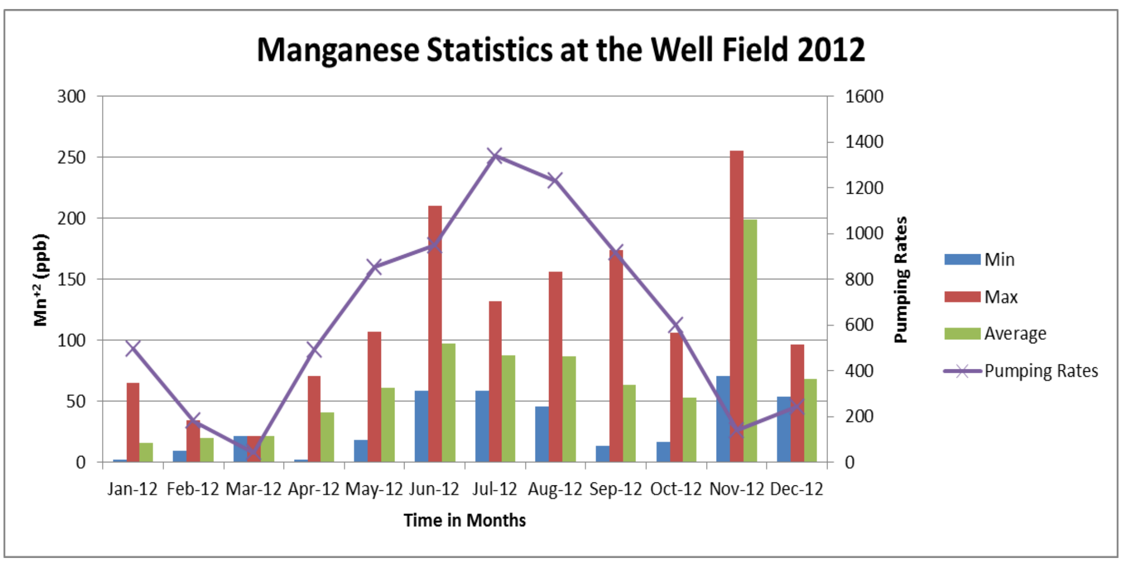

Figure 2.5: Graph representing pumping rates and statistical minimum (MIN), maximum (MAX) and average values for manganese at each month at the north and south sections of the well field in 2012.

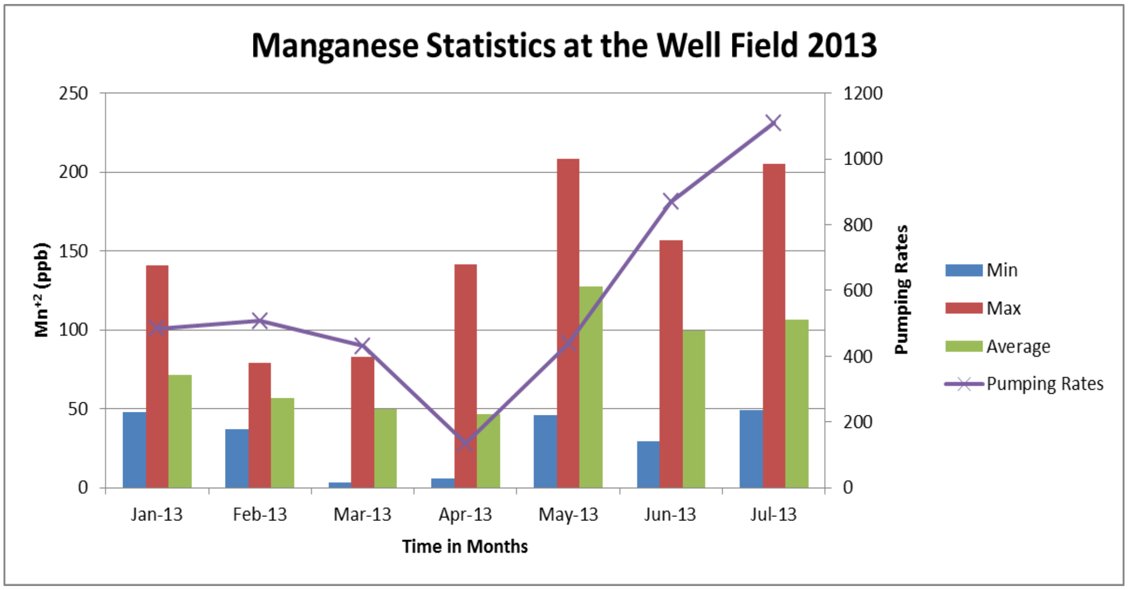

Figure 2.6: Graph representing pumping rates and statistical minimum (MIN), maximum (MAX) and average values for manganese each month at the north and south sections of the well field in 2013.

Manganese Concentration in the Island Wells

In 2008, Mn^{+2} concentration decreased from April to May. There is a slight increase from August to October followed by decreases into December (Figure 2.7). The stress caused by pumping high volumes of water from the wells increased from August to September along with the average Mn^{+2} concentration. River stages were low from July to September. Figure 2.8 shows that the average Mn^{+2} concentration increased from August to October a pattern also shown in Figure 2.7. This same increase in Mn^{+2} concentration occurred in December. River stages were fairly high during December. It is likely that increased water viscosity was responsible for increased stress at deeper levels of the aquifer that could cause water from the limestone to be extracted. Raw water

shows that as more water is being extracted, Mn^{+2} concentration increases. As large volumes of water are being extracted from the aquifer an increase in stress around the wells occurs as the groundwater level drops, it is highly possible that water from the limestone was being extracted as an up-coning effect.

In 2011, Mn^{+2} concentration increased from January to March and decreased in September (Fig. 2.9). It is also important to note that Mn^{+2} concentration was higher in January and February. The monthly average Mn^{+2} concentration increased from January to March and in October, but the value in October was influenced by one analyzed samples that peaked above the rest of the sample that month, see Figure 2.10. The high maximum values were affected by the very few samples that had high concentrations that deviated from the average concentrations.

In 2012, Mn^{+2} concentrations increased from June to the end of October, concentrations peaking in September. Figure 2.11 shows that in 2012, the monthly average Mn^{+2} concentration increased February and April, and from June to October with highest concentrations in September. Pumping rates increased during June and July, but very low concentrations averages for Mn^{+2} were present during those months. The higher average Mn^{+2} concentrations were from August to October which was after the period of higher pumping rates. Pumping rates remained fairly high from August to October. A delay in groundwater movement is shown after a period of heavy pumping.

In 2013, Mn^{+2} concentration was higher from March to April, but concentrations were not as high as the analyzed samples in 2012 (see Figure 2.9). Pumping rates were high in April and July, and the average Mn^{+2} concentration also increased during these two months showing that while the wells are undergoing heavy pumping the more withdrawal of Mn^{+2} concentration is occurring (Fig.2.12). During April, river stages were fairly high, changes in water temperature causing higher water viscosity in the aquifer could be responsible for up-coning during April.

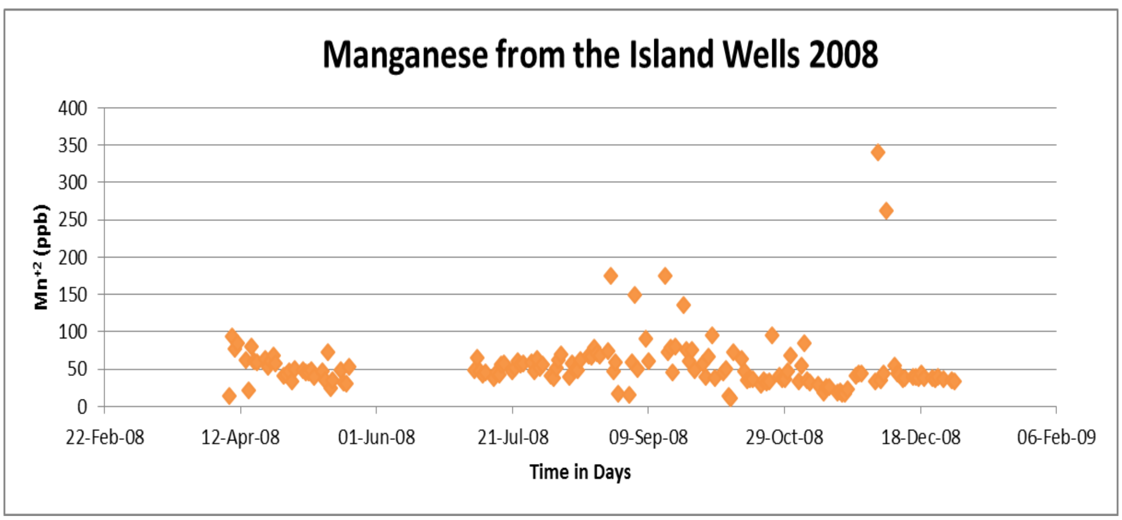

Figure 2.7: Graph showing manganese concentration at the island wells in 2008.

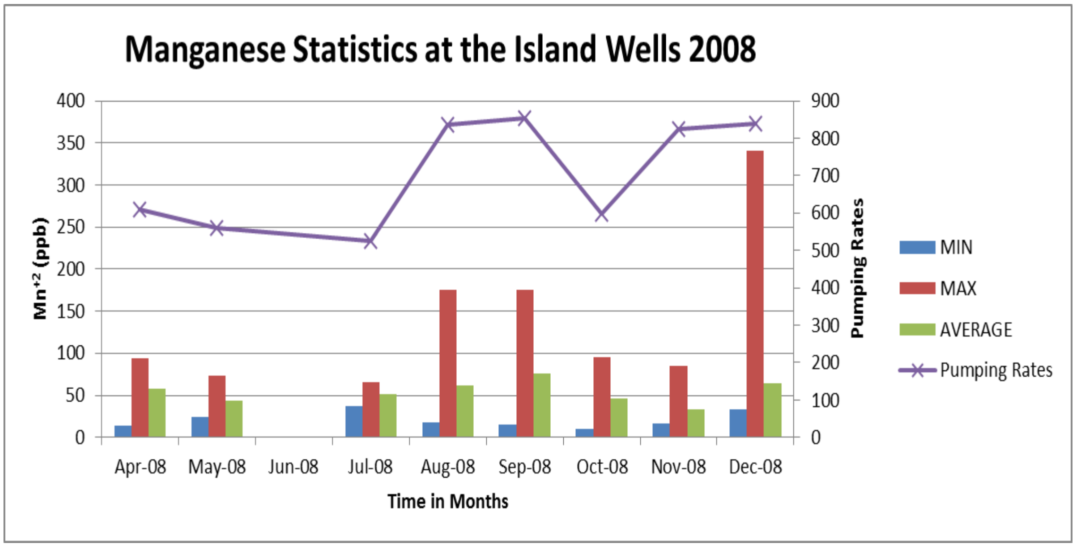

Figure 2.8: Graph representing the pumping rates and statistical minimum (MIN), maximum (MAX) and average values for manganese each month at the island wells in 2008.

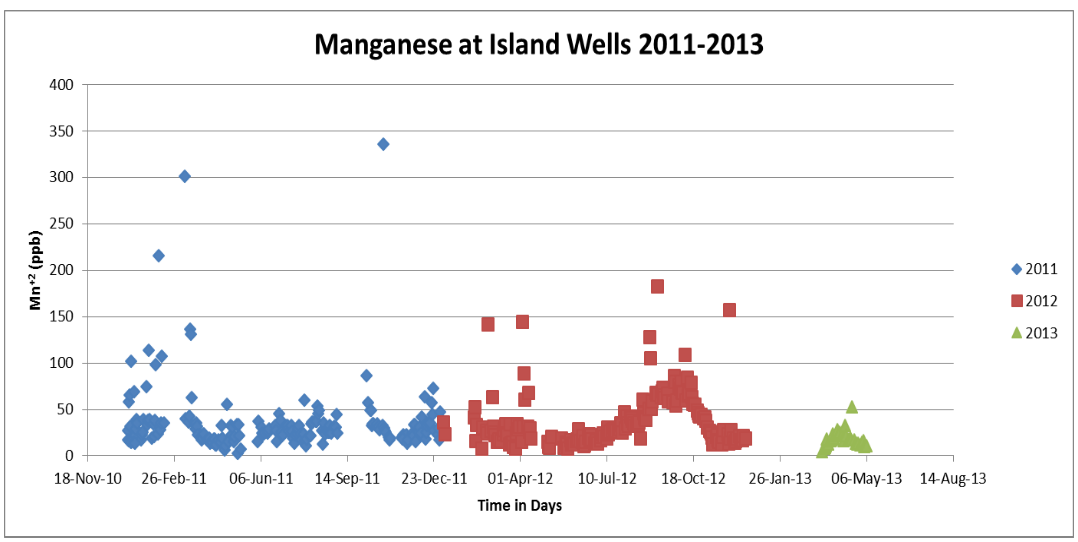

Figure 2.9: Graph representing daily manganese concentration for the years 2011-2013 at the island wells.

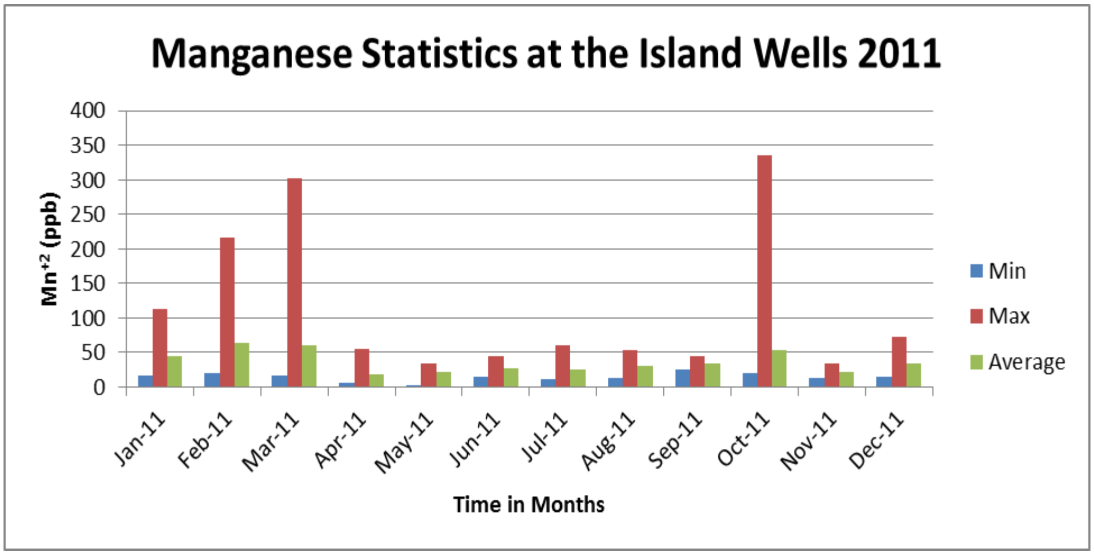

Figure 2.10: Graph representing statistical minimum (Min), maximum (Max) and Average values for manganese each month at the island wells in 2011.

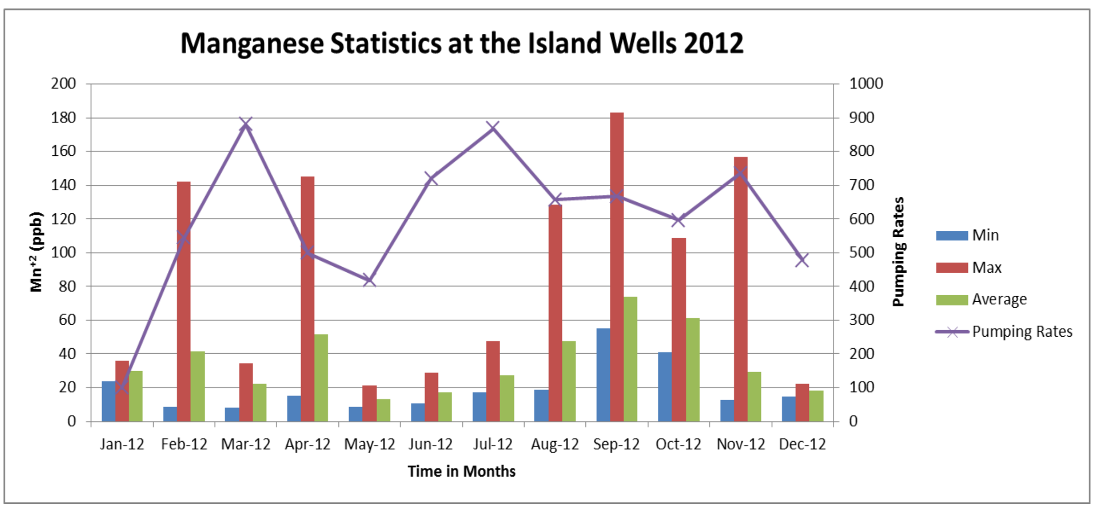

Figure 2.11: Graph representing pumping rates and statistical minimum (Min), maximum (Max) and Average values for manganese each month at the island wells in 2012.

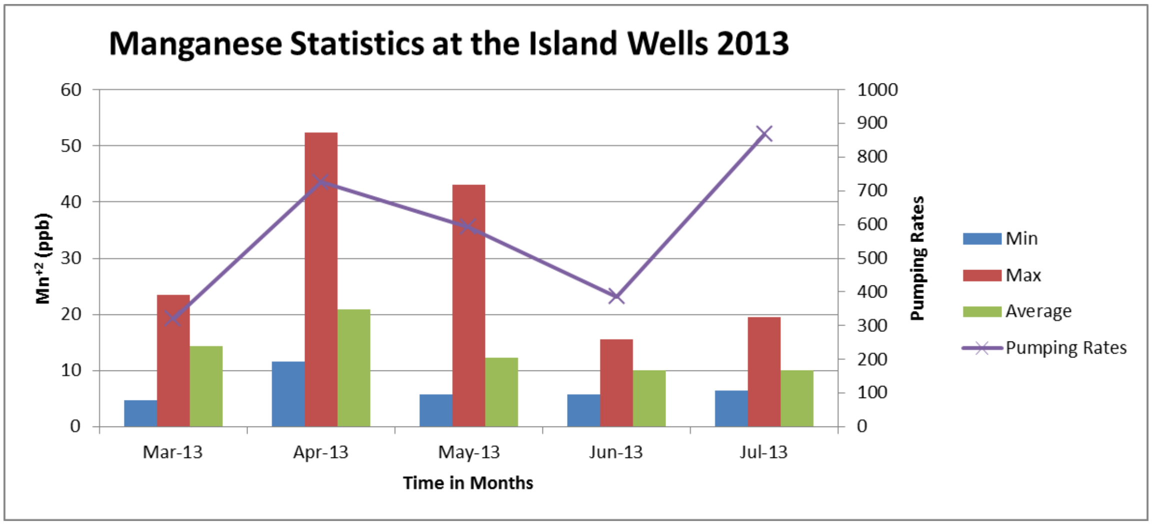

Figure 2.12: Graph representing pumping rates and statistical minimum (MIN), maximum (MAX) and Average values for manganese each month at the island wells in 2013.

Bromide Concentration in the North and South Well Field Locations

Bromide is commonly found in abundant concentrations in high saline waters mostly in marine environments and is often associated with limestone aquifers (Hem, 1985). Water samples collected from the Lincoln well field and the limestone aquifer in August 2013 showed that the limestone aquifer has greater concentrations of calcium, sodium and bicarbonate, which is likely that there are greater Br^- concentrations in the limestone. There is no sufficient data in 2008 for Br^- in the North and South well field locations and overall, there is not sufficient daily data for Br^- concentration in water

produced at these locations for 2012 and 2013, but available data is represented in Figure 2.13.

In 2012, Br^- concentration data was available from August to November. The Br^- concentration decreased from August October, concentrations were higher in November, (see Fig. 2.13). River stages increased from September to October, while pumping rates were decreasing. Figure 2.14 shows that the monthly average Br^- concentration decreased from September to November, but the maximum concentration was higher in November. The high maximum Br^- concentrations in November could be from up-coning activated by water temperature changes in the aquifer. In 2012, pumping rates decreased each month and so did the average Br^- concentration.

In 2013, Br^- concentrations remained at an almost constant rate except for April where concentration decreased (Fig. 2.13). River stages were fairly high during April. Figure 2.15 shows that the monthly average Br^- concentration pattern decreases and then increases, but remains at an almost constant rate. Pumping rates were high in March and from May to July, and Br^- concentration remained fairly constant throughout those months.

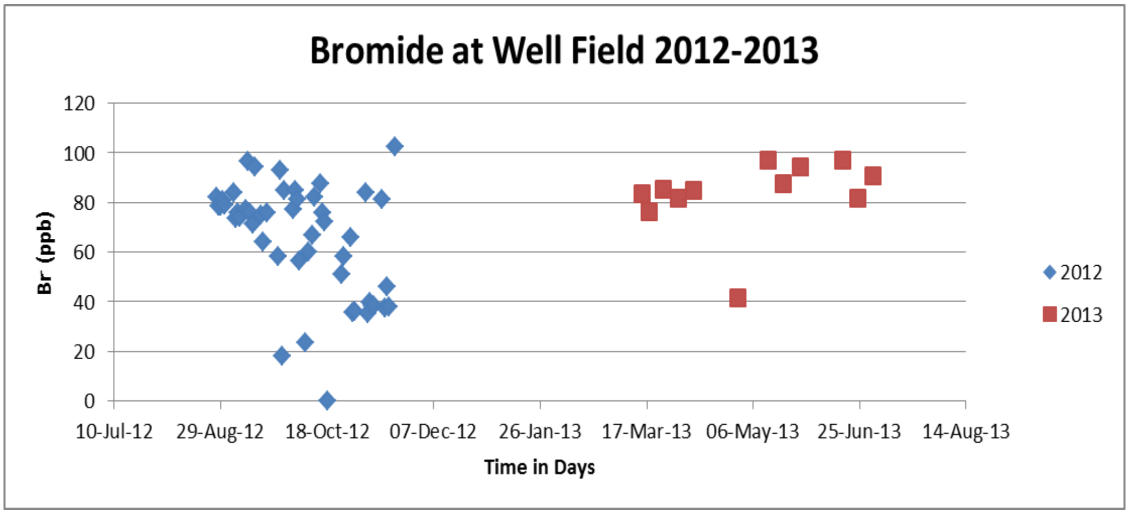

Figure 2.13: Graph showing daily bromide concentration in the well field for 2012 and 2013.

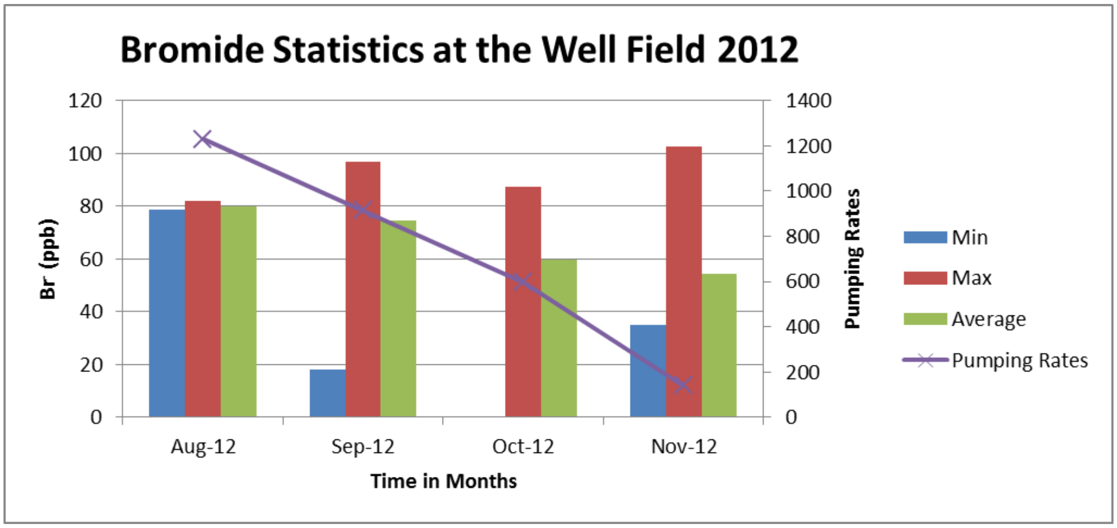

Figure 2.14: Graph representing pumping rates and statistical minimum (MIN), maximum (MAX) and average values for bromide each month at the wells field in 2012.

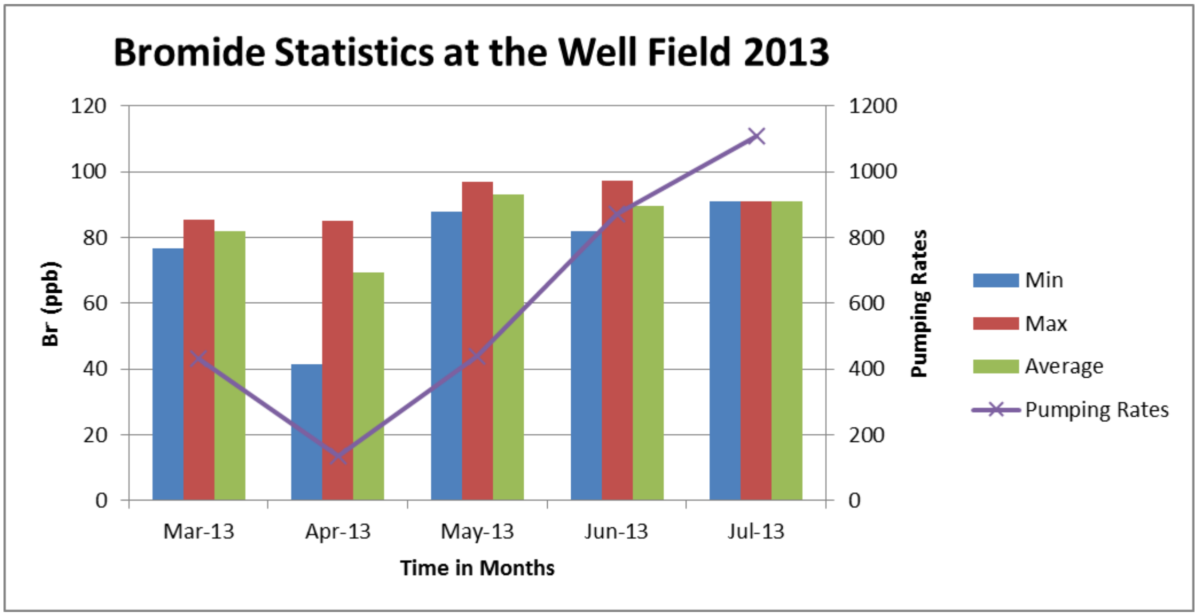

Figure 2.15: Graph representing pumping rates and statistical minimum (MIN), maximum (MAX) and average values for bromide each month at the ell field in 2013.

Bromide Concentration in the Island Wells

In 2008, Br^- concentration remained fairly constant during the beginning of the year and increased from July to August and decreased towards October where concentrations remained at an almost constant rate to the end of the year (Fig. 2.16). Pumping rates were high in August and September, and Br^- concentrations were higher during those months (Fig. 2.17). It is important to notice that river stages decreased from August to September. This shows that as stress caused by pumping increases, the more Br^- concentration increases in the water.

In 2011, Br^- concentration was higher in January and decreased in February where concentrations remained fairly constant throughout the rest of the year, (see Figure 2.18). The monthly average Br^- concentration remained fairly constant throughout the year (Fig. 2.19).

In 2012, Br- concentration remained fairly constant, but concentrations dropped in June and from October to November where concentrations remained low to end of the year. The monthly average Br^- concentration decreased in June and October, (see Figure 2.20). Note that river stages were fairly high during June and October. Pumping rates increased in March and July where the average Br^- concentrations were slightly higher. Pumping rates caused stress in the wells but Br^- concentration increased the month after the high stress in the aquifer. This delay in groundwater travel time is also shown by Mn^{+2} concentration.

In 2013, Br^- concentration remained fairly constant throughout the year (Figure 2.18). The monthly average Br^- concentration increased from March to July, but remained at fairly constant concentrations (Fig. 2.21). Pumping rates were high in April and July, Br^- concentration remained fairly constant throughout the months but increased from May to June. The maximum and minimum Br^- concentrations also remained at a similar level of concentration as the average, but there were much higher maximum concentration levels in April due to one sample analyzed being higher than the rest of the samples in April.

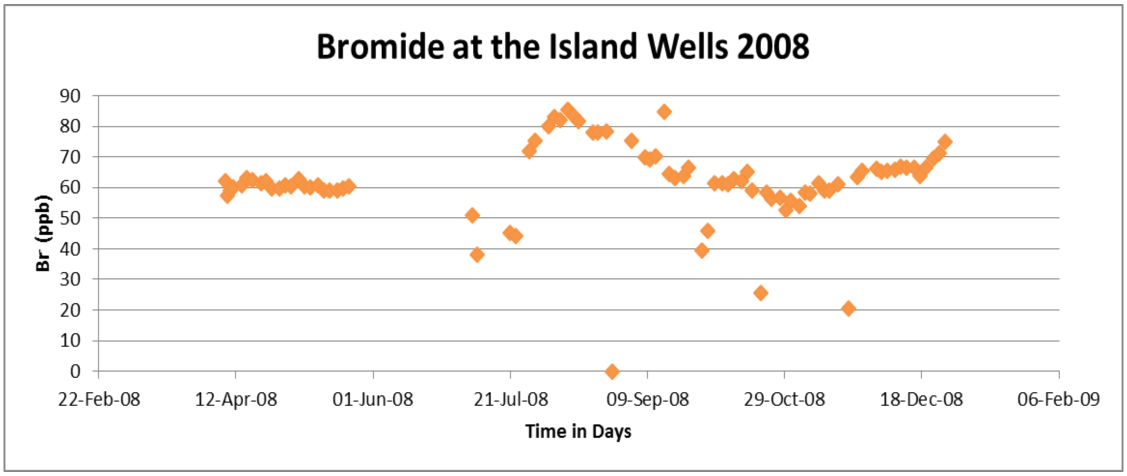

Figure 2.16: Graph representing bromide concentration on a daily basis at the island wells for the year 2008.

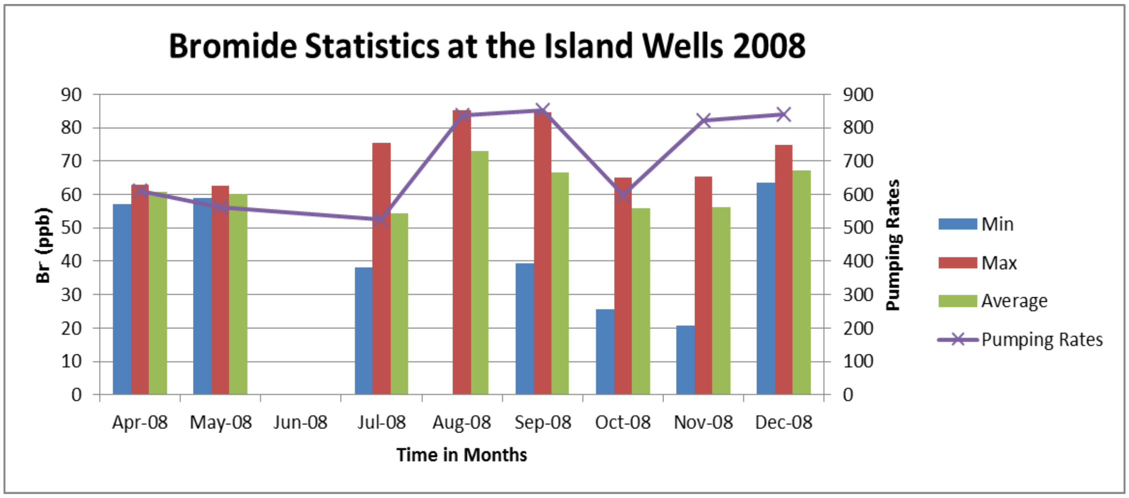

Figure 2.17: Graph representing pumping rates and statistical minimum (MIN), maximum (MAX) and Average values for bromide each month at the island wells in 2008.

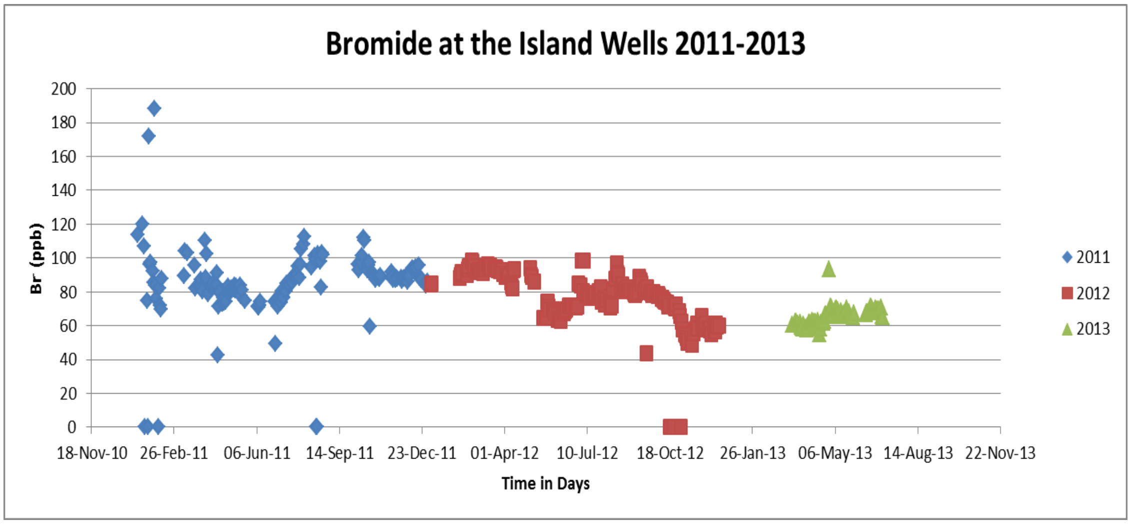

Figure 2.18: Graph showing bromide concentration on a daily basis for the years 2011-2013 at the island wells.

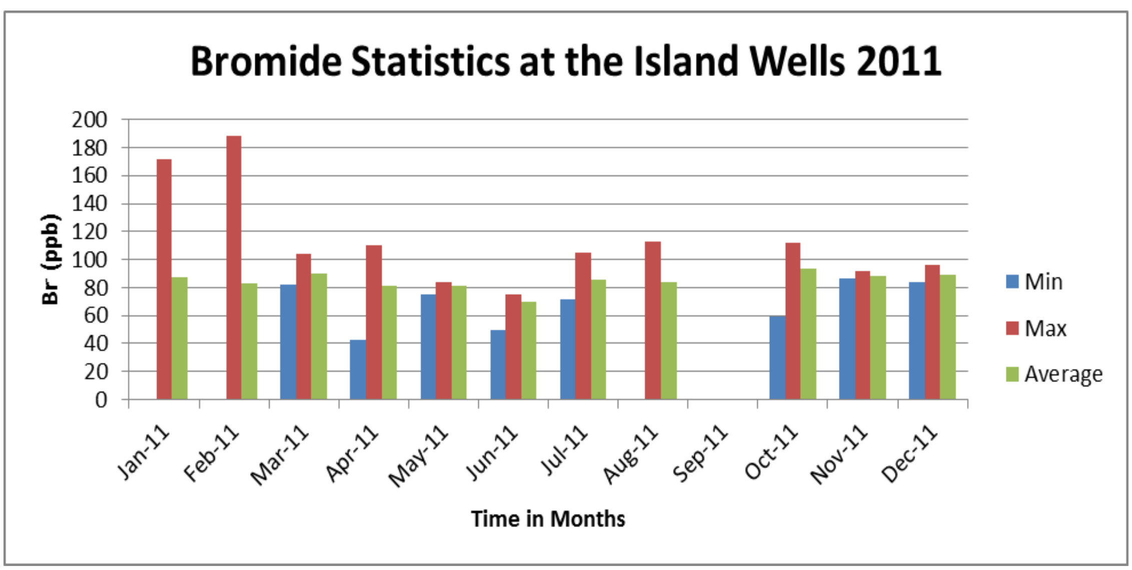

Figure 2.19: Graph representing statistical minimum (MIN), maximum (MAX) and average values for bromide each month at the island wells in 2011.

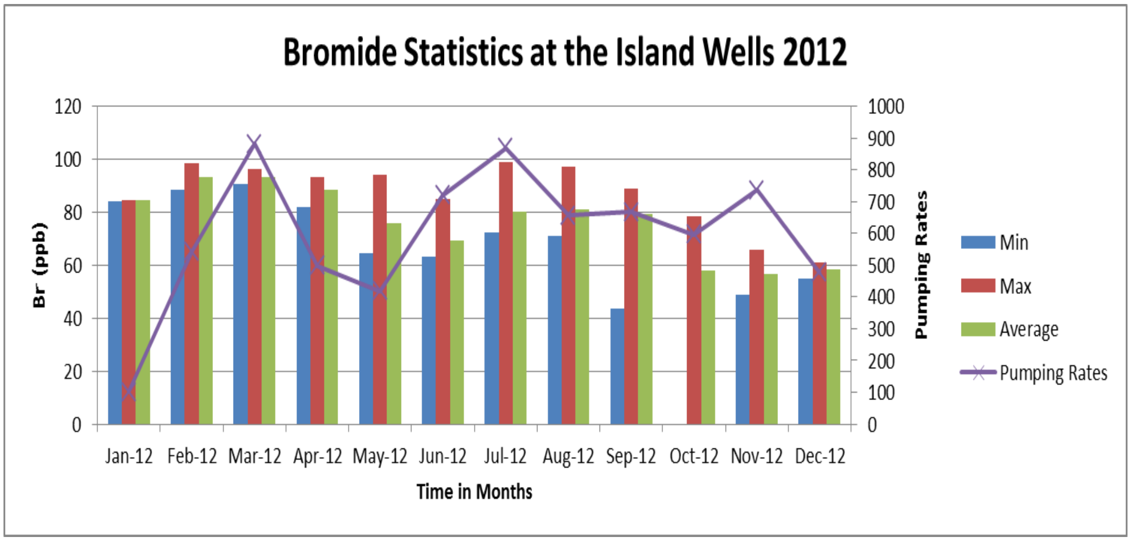

Figure 2.20: Graph representing pumping rates and statistical minimum (MIN), maximum (MAX) and average values for bromide each month at the island wells in 2012.Here the Bromide concentration for November in the MAX Stat. is of 1221 ppb. I took it out in order to see the rest of the statistical values.

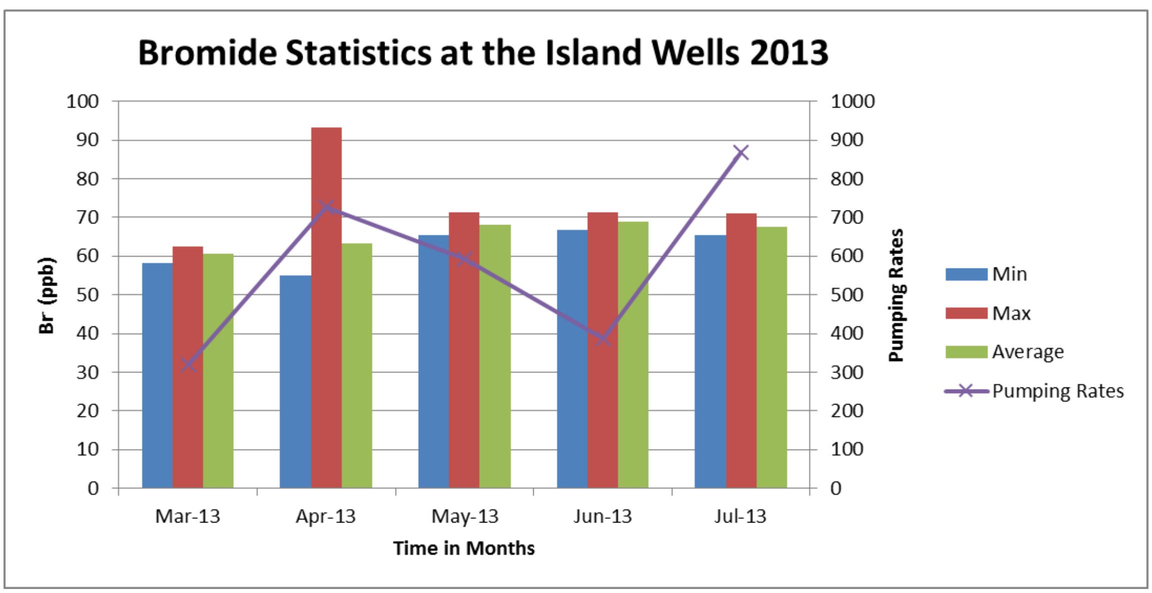

Figure 2.21: Graph representing pumping rates and statistical minimum (MIN), maximum (MAX) and average values for bromide each month at the island wells in 2013.

Fluorite Precipitation Potential in the Lincoln Water Well Field

Fluoride is an important ion for this study and is one ion that is most commonly tested at the Lincoln water well field during water production. Fluoride can be used as a conservative ion if there are no fluoride bearing minerals precipitating in the aquifer (John Gates, Personal Communication). If there are any, then fluoride can't be used as a tracer because any excess amount would be attributed to the minerals solution in water. Hence in order to use fluoride the chance from precipitation of any fluoride bearing mineral needed to be calculated.

In August 19, 2013, I collected six water samples at different wells in the well field for major ion analysis. Using PHREEQC, a geochemical simulation for the alluvial aquifer was recreated in order to study the role of fluorite mineral in the system. Six scenarios were created to simulate the different well's sampled at the Lincoln well field and an additional 2 samples that were taken from a well at the limestone unit at the Fish hatchery in Gretna Nebraska. Table 2.1 shows the Saturation Indices (SI) for Fluorite mineral and shows that the alluvial aquifer is under saturated with respect to fluorite. This is very important because Fluorite is not precipitating in the aquifer and F^- can be used as a conservative ion.

Well ID	Sample Number	Fluorite SI
East Plant	1	-2.32
West Plant	2	-2.04
76-1	3	-1.87
49-7	4	-2.26
32-2A	5	-2.09
37-4A	6	-2.19
54-9	7	-2.12
Limestone well	8	-2.11
Limestone spring	9	-2.18

Table 2.1: Saturation Indices for fluorite at the Lincoln well field and limestone aquifer.

Fluoride Concentration in the North and South Well Field Locations

In 2012, F^- concentrations remained at a constant level in the 400 ppb range throughout the months, see Figure 2.22. In 2012, Fig. 2.23 shows that the monthly average F^- concentration remained relatively constant from August to December, but the well pumping rates decreased from August to November. The maximum values for September and October are relatively higher but it is due to a single day for these months that exceeds the average concentrations, this could be due to triggering pumping in a well where the thickness of the aquifer is thinner such as in the North well field where greater water yields are expected.

In 2013, F^- concentration remained within the 400-500 ppb range from March to July, and increased slightly in July. An unusually high concentration reading in April 29, 2013 that has 1011 ppb is an exception to the almost constant F^- concentration pattern. In 2013, most of the F^- concentration remained constant, but the average concentration increased in April and July where F^- peaked only one day for each of these months, (see Figure 2.24). Pumping rates were lower in April where one of the high F^- concentrations peaked. It is important to notice that during that time period, the river stages were fairly high, and that water could have been indeed being pumped from a thinner section of the aquifer such as in the North well field. It is important to notice that there is only one analyzed sample in July and that concentrations could have varied during that month.

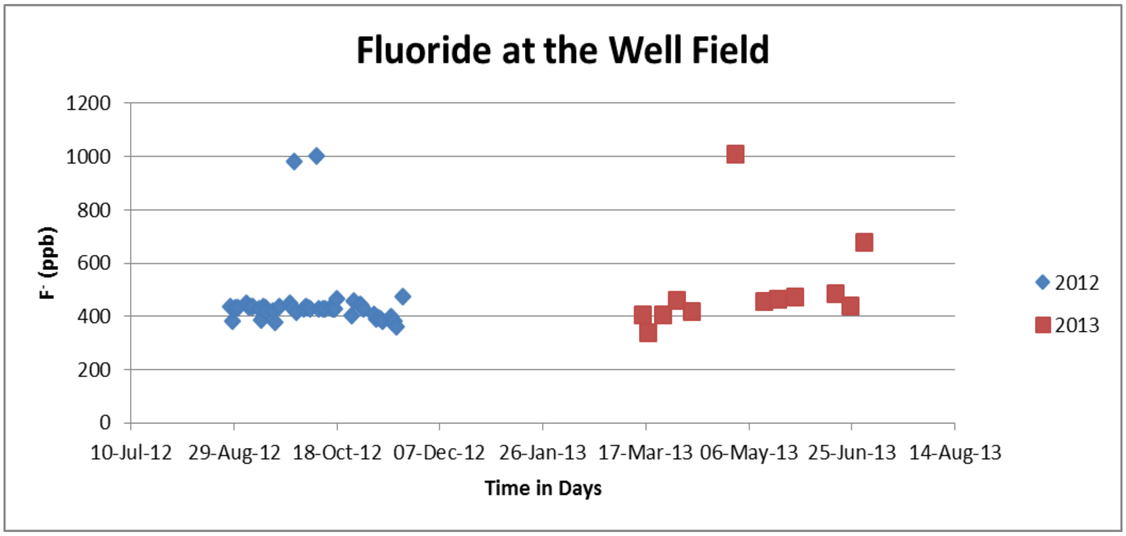

Figure 2.22: Graph showing fluoride concentration in the well field for the years 2012 and 2013.

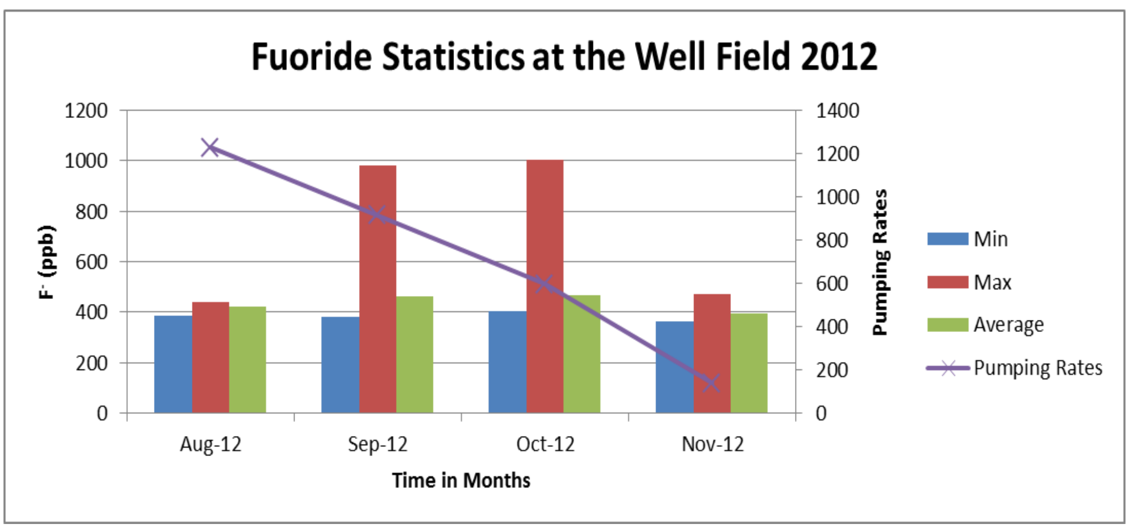

Figure 2.23: Graph representing pumping rates and statistical minimum (MIN), maximum (MAX) and Average values for fluoride each month at the well field in 2012.

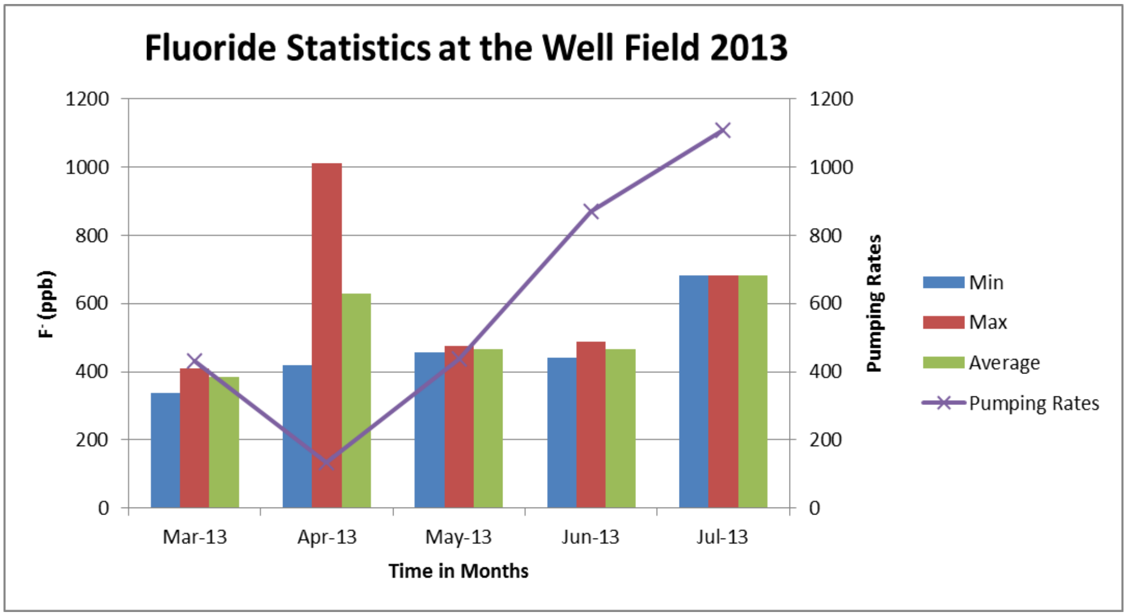

Figure 2.24: Graph representing pumping rates and statistical minimum (MIN), maximum (MAX) and Average values for fluoride each month at the well field in 2013.

Fluoride Concentration in the Island Wells

In 2008, F^- concentration remained relatively constant throughout the year (Figure 2.25). There was one F^- concentration in October that was higher than the rest of the data and one sample in November that was lower than the rest of the F^- concentration data. One sample in October is higher than the rest of the data and gives a high maximum concentration level (Figure 2.26). Pumping rates were high in August and September, and again during November to December, but the monthly average F^- concentration remained fairly constant throughout the year with a slight increase in concentration during October where October had the highest concentration and lowest pumping rate. This reflects a common pattern of delayed groundwater travel time.

In 2011, F^- concentration increased from February to May but then remained fairly constant to the end of the year (Figure 2.27). The monthly average F^- concentration remained relatively constant throughout the year but concentrations were slightly higher from May to August see Figure 2.28.

In 2012, F^- concentration remained fairly constant throughout the year, but minor changes are shown (Fig. 2.27). Large volumes of water were being pumped during March, but F^- concentration was highest in April which shows a groundwater travel time lag in the aquifer (Fig.2.29). This delay in groundwater travel time was also shown by Mn^{+2} and Br^- concentrations. Pumping rates were high during the period of June to July, but F^- concentration remained relatively constant.

In 2013, F^- concentration remained relatively constant throughout the year but had slightly higher concentrations in July (Fig. 2.27). Pumping rates were high during April and July, but the average F^- concentration increased only in July. It is important to note that even though F^- concentration was slightly higher in July, concentrations were not unusually higher from those in previous years.

River water has the same water chemistry as the alluvial aquifer. Davis (1992) mentioned that the Platte River comes into contact with a variety of minerals and rocks along its path and he also mentions that the weathering of the rocks at deeper levels of the river is the primary source of the hydrochemistry of the river and the adjacent groundwater.

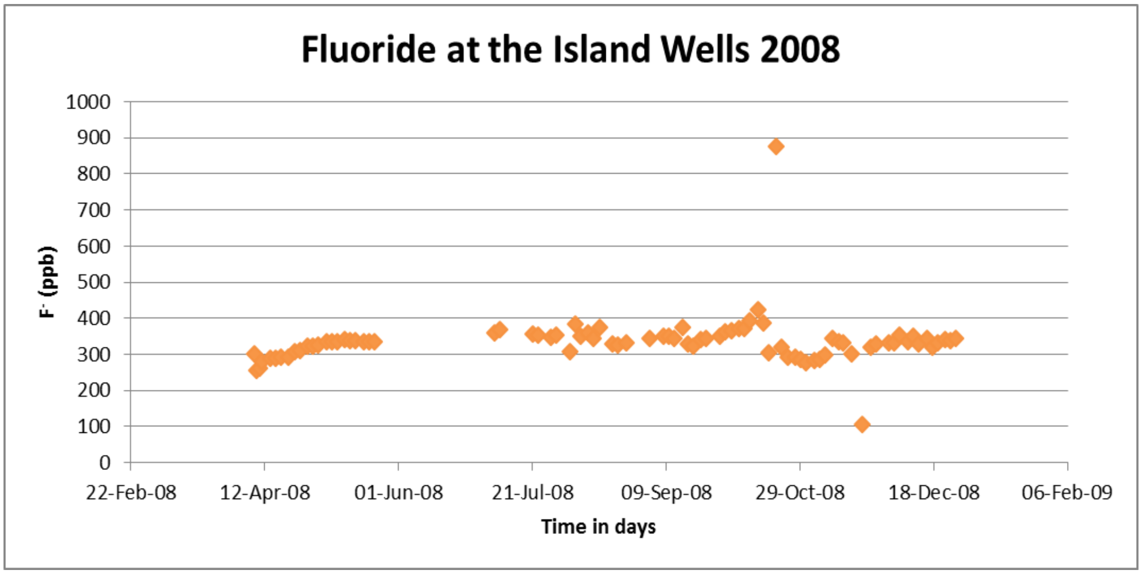

Figure 2.25: Graph showing fluoride concentration in the island wells for the year 2008.

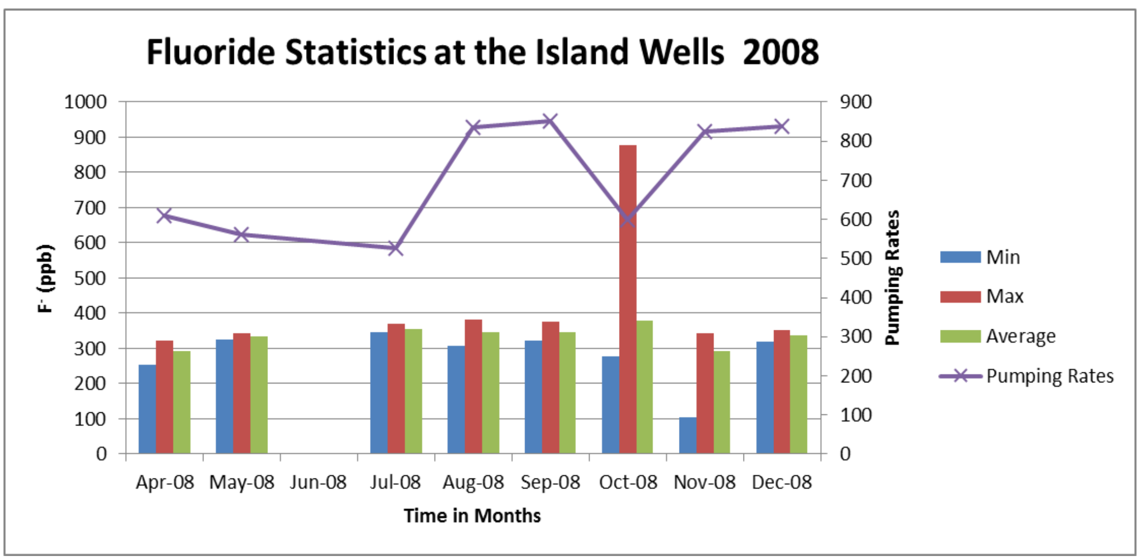

Figure 2.26: Graph representing pumping rates and statistical minimum (MIN), maximum (MAX) and Average values for fluoride each month in the Island wells in 2008.

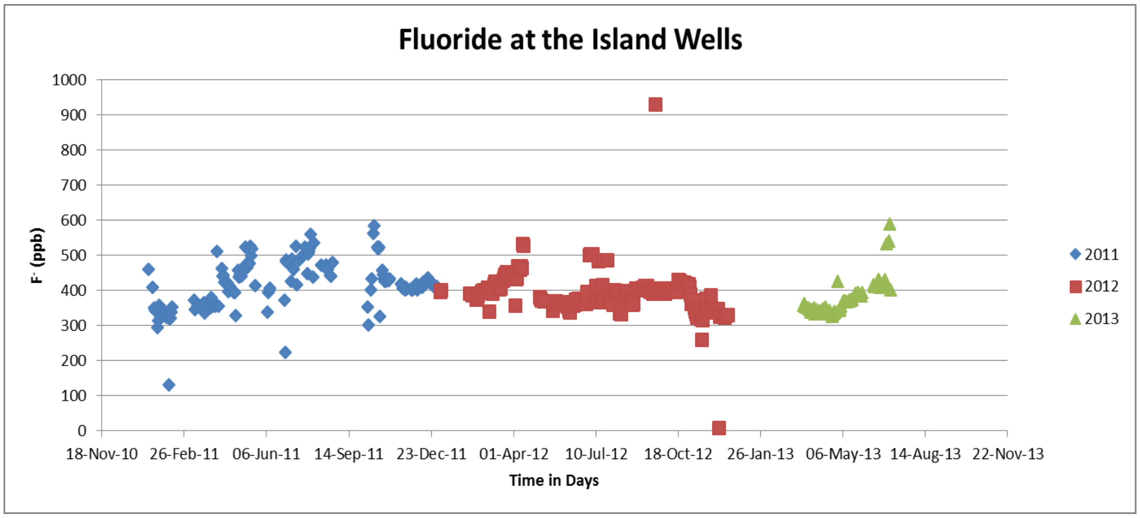

Figure 2.27: Graph showing fluoride concentration in the island wells for the years 2011-2013.

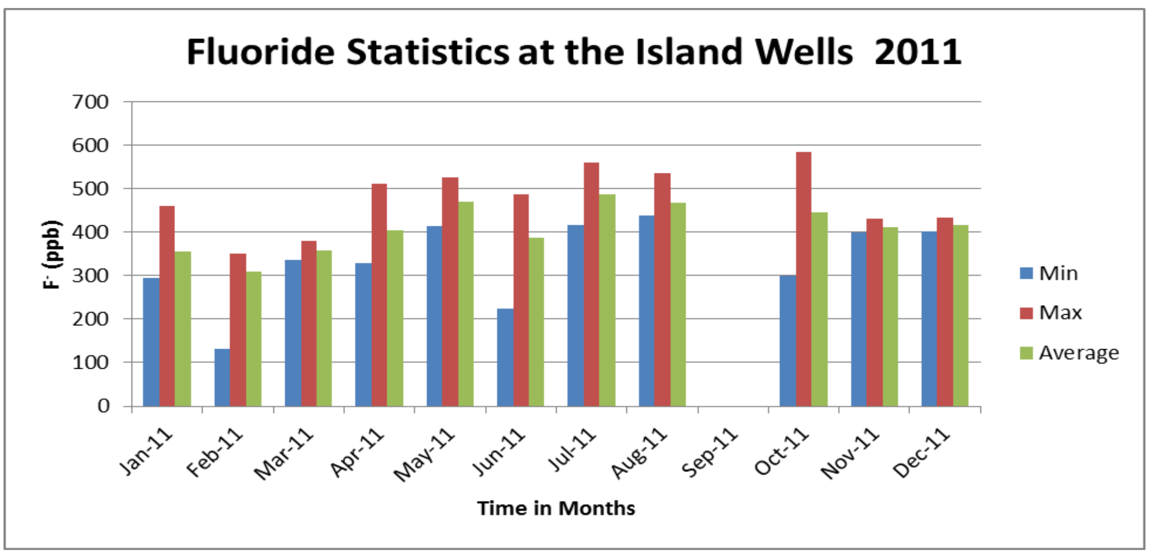

Figure 2.28: Graph representing statistical minimum (Min), maximum (Max) and average values for fluoride each month in the East Treatment Plant in 2011.

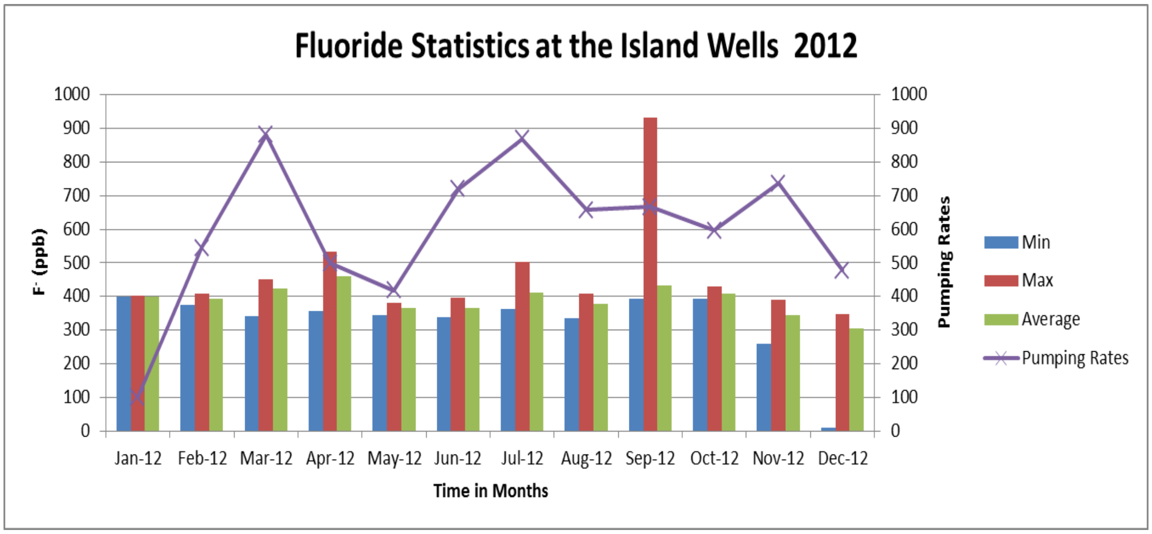

Figure 2.29: Graph representing pumping rates and statistical minimum (Min), maximum (Max) and Average values for fluoride each month in the island wells in 2012.

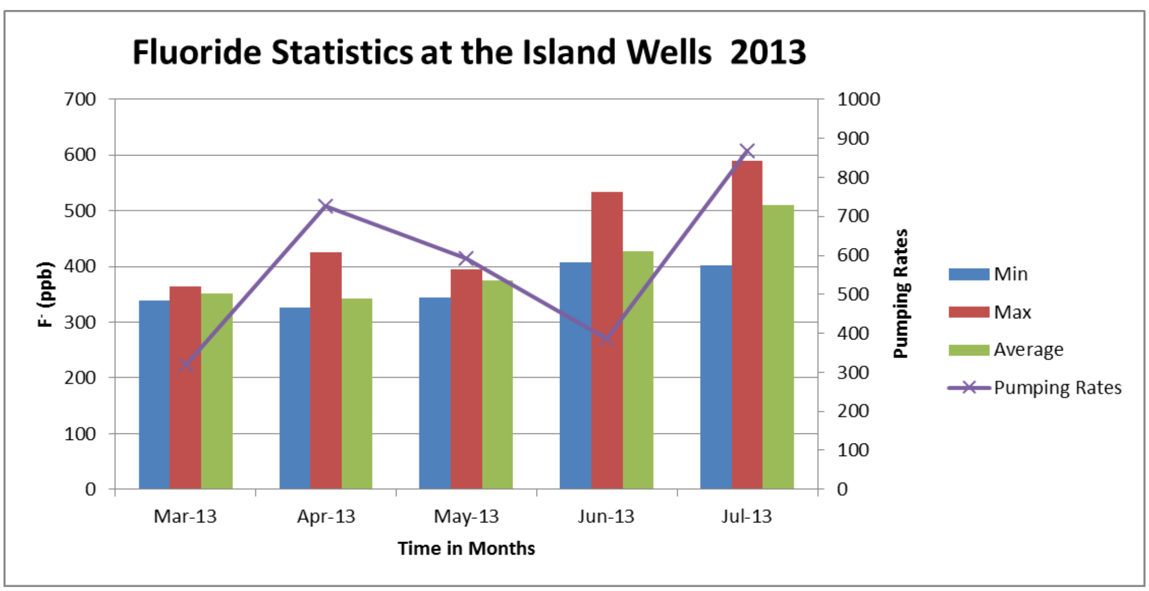

Figure 2.30: Graph representing pumping rates and statistical minimum (Min), maximum (Max) and average values for fluoride each month in the island wells in 2013.

Iron Concentration in the North and South Well Field Locations

Analysis of raw water input to the Lincoln west treatment plant reveals that iron occurs at very low concentrations when compared to Mn^{+2}, Br^{-} and F^{-} in the water. The Lincoln Water System tests for iron a few times per month and because of the low concentrations and it is considered less important in the day to day operation efficiencies (John D. Keith, Personal communication).

The following is a description of iron concentration for the year 2011. Iron concentrations increased briefly in September 2011 and remained fairly low the rest of the year, see Figure 2.31. The average iron concentration remained below 5 ppb most of the year except in September 2011 when the average was above 10 ppb.

In 2012 there was a slight increase in iron concentration during May, July and November, see Fig. 2.31.The monthly iron concentrations increases in May and July, were not to as high as in November 2012, (see Figure 2.33). During May, river stages were fairly high, and pumping rates were high as well but the average iron concentration remained below 20 ppb. The highest pumping rates were in July. At that time river stages were very low, but the average iron concentration increased only slightly during that month. It is important to recognize that there was only one sample analyzed for that month July and there could be an alternate pattern for this time period. In November, pumping rates were lower but the average iron concentration increased.

In May and November 2012, there was higher iron concentration when less volumes of water were being extracted from the aquifer and when the river stages were high. Data suggests that an historic long-term watertable environment is likely to be

encountered when groundwater levels are high. This environment formed before the well field was developed and the water table was more constant. A trench was cut across the river to the wells installed on a river island. A distinct layer, represented in part by iron oxidation/reduction, was present at the likely historic watertable, (Darryll Pederson, Personal Communication). During July 2012, river stages were low and pumping rates were the highest for the year. Iron concentrations increased slightly but not to the point where concentrations deviated from the rest of the samples analyzed. During November, iron concentrations were increasing at the same time river stages were increasing, and water pumping rates were low. This suggests the rising watertable encountered the historic watertable. When groundwater levels drop, oxidation/reduction occurs in the historic watertable zone. When the watertable rise again, the iron in that weathering zone is incorporated in the aquifer water.

During 2013, iron concentrations remained at low concentrations. Figure 2.34 shows that the monthly average iron concentration increased from January to June. Less volumes of water were being pumped out the aquifer during April. Pumpage then increased from May to July. On average, iron concentration was higher in June when pumping rates were high. It is important to note that the river stages were fairly high during that month and that the high iron concentration recorded is still considered low when compared to iron concentration in November 2012. Based on the observed iron data from May and June 2013 where there are greater iron concentrations and river stages are high, it can be said that greater iron concentrations are likely to be found in the historical oxidation/reduction zone.

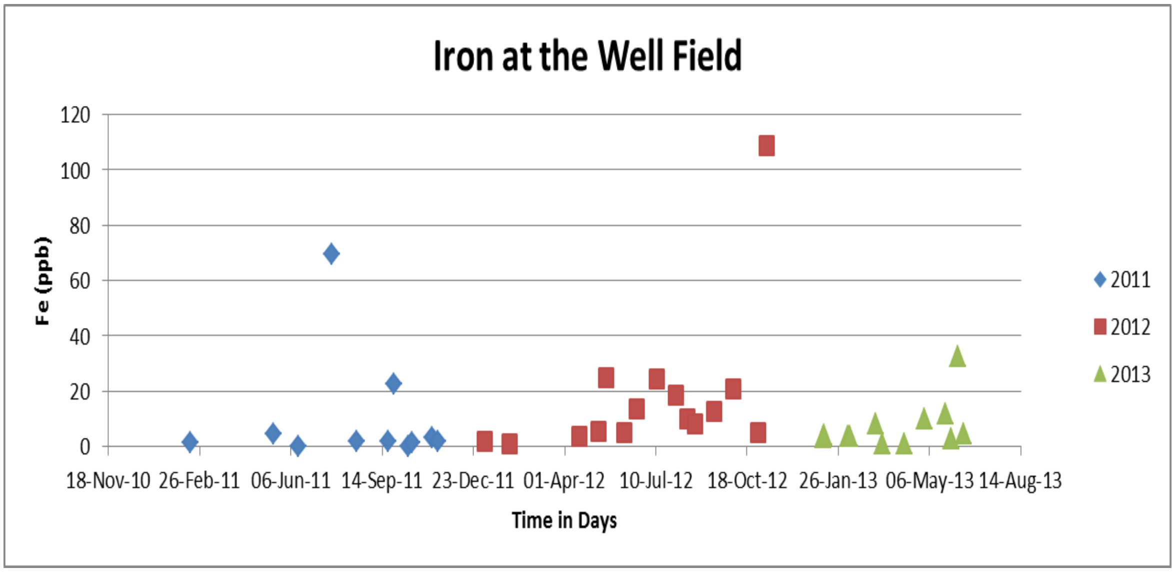

Figure 2.31: Iron concentration in the well field for the years 201, 2012 and 2013.

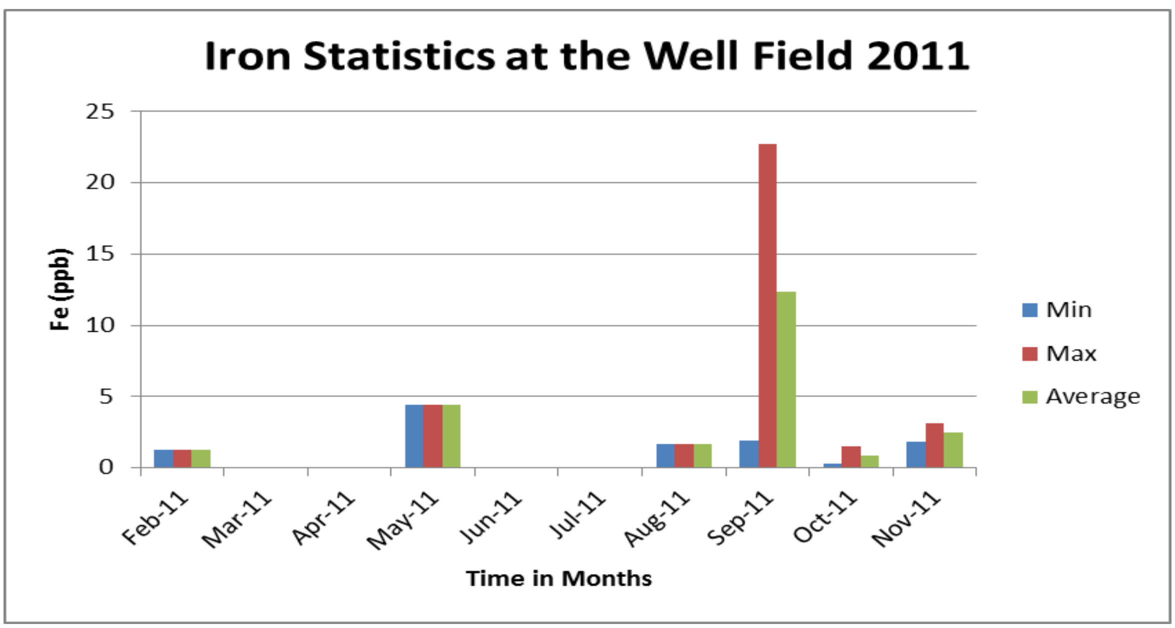

Figure 2.32: Iron concentration in maximum, minimum and average for 2011.

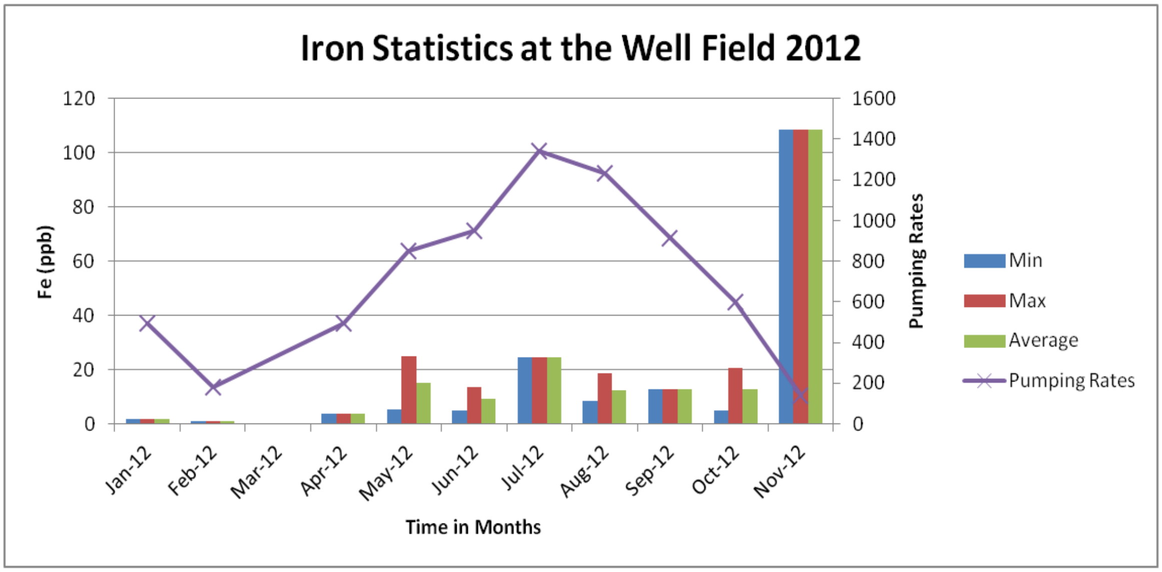

Figure 2.33: Graph representing pumping rates and iron concentration as maximum, minimum and average for 2012 in the well field.

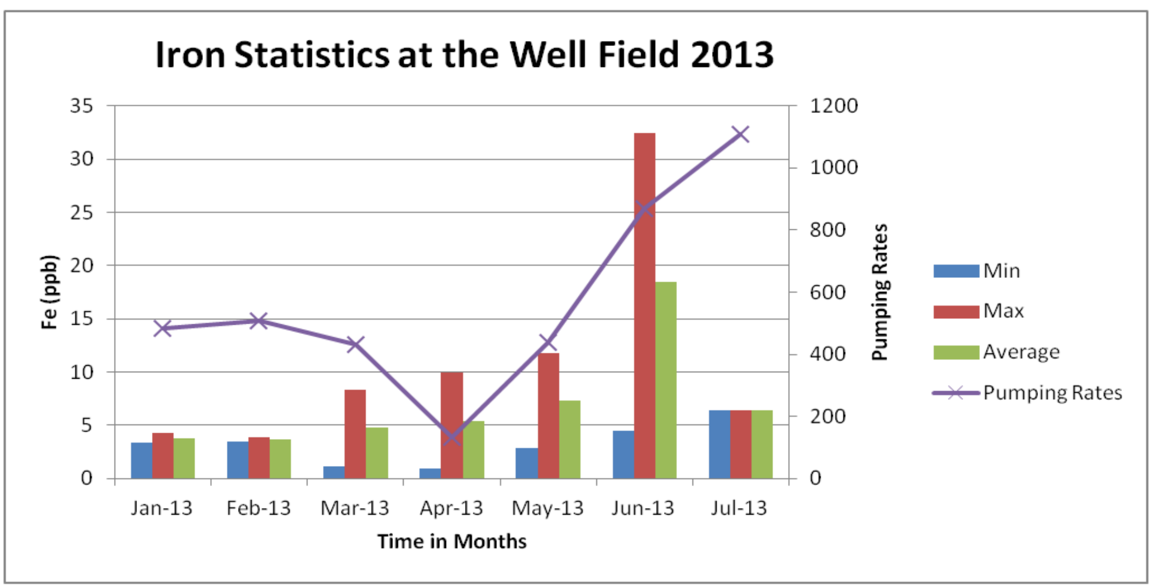

Figure 2.34: Graph representing pumping rates and iron concentration as maximum, minimum and average for 2013 in the well field.

Iron Concentration in the Island Wells

Iron concentration in water analyzed from the island wells in comparison to what mentioned for the North and South well fields occurs at low concentrations and there are only a few samples analyzed per month. There are a few monthly samples in the beginning of 2012 that are higher than the rest of the reported iron concentrations, but these concentrations are still considered low when compared to manganese, bromide and fluoride, (see Figure 2.35).

In 2011, iron concentrations remained between 0 to 9 ppb throughout the year with the highest concentrations in December, see Fig. 2.35. The average iron concentration increased during March where the river stages were fairly high. The average iron concentration also increased slightly during July but wasn't as high as the high reported in March (see Figure 2.36). Iron concentration was the highest in December. The river stages were fairly high during that month suggesting that watertable reached the historic weathering environment.

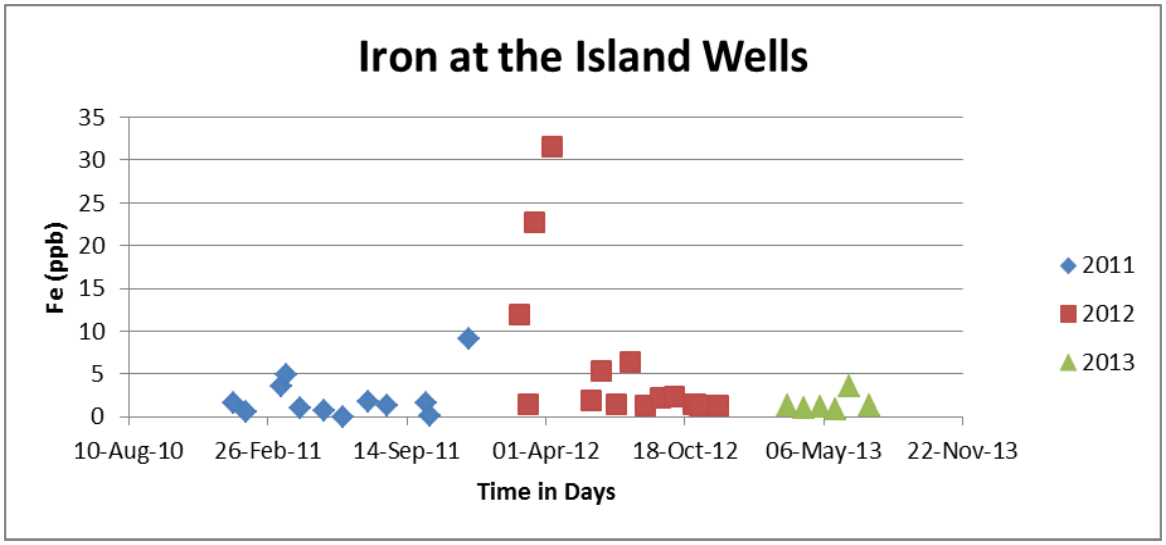

Figure 2.35: Iron concentration in the water from the island wells for 2011, 2012 and 2013.

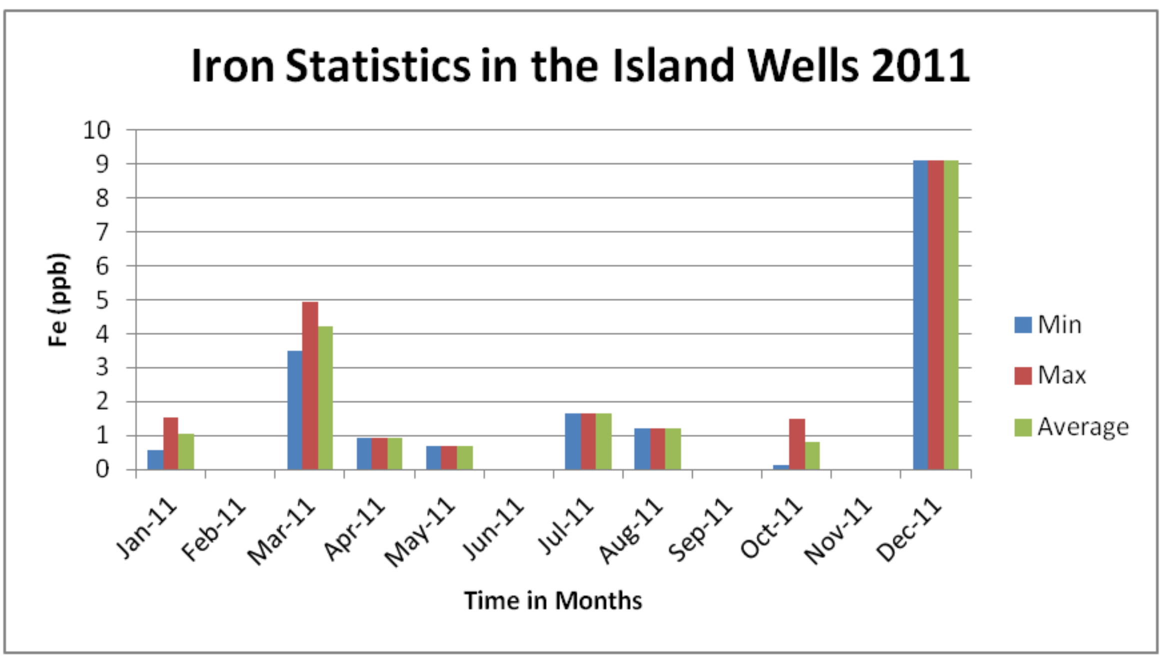

Figure 2.36: Graph representing minimum, maximum and average iron concentrations in water in the island wells in 2011.

In 2012, iron concentration was higher from February to April when compared to the other months during that year. It is important to notice that river stages were higher during January through April. Figure 2.37 shows that well pumping rates were higher in March and during that month high maximum iron concentrations peaked. Even though concentrations were high during March, iron concentration increased in April. Pumping rates were also high during July, but the average iron concentrations didn't increase further until August. Iron data also shows a gap between the time of stress of pumping and arrival of changes in iron concentrations in periodic water samples. This time gap likely represents travel times in the aquifer. There were high pumping rates in November, but the average iron concentrations remained low after August. Groundwater levels were low during that time period.

As shown in Figure 2.38 pumping rates were higher in April 2013 and decreased in June. The average iron concentrations decreased during March to May. There were high pumping rates in July, but the average iron concentration decreased during that month. The river stages were low during July. As the well pumping rates increase and river stages decrease, the groundwater levels in the alluvial aquifer decrease. Iron has an inverse pattern when compared to the other ions in that iron concentrations increase when pumping rates are low and river stages are high. As noted earlier, a likely source of iron is the historic watertable zone and high watertables likely intersect this zone.

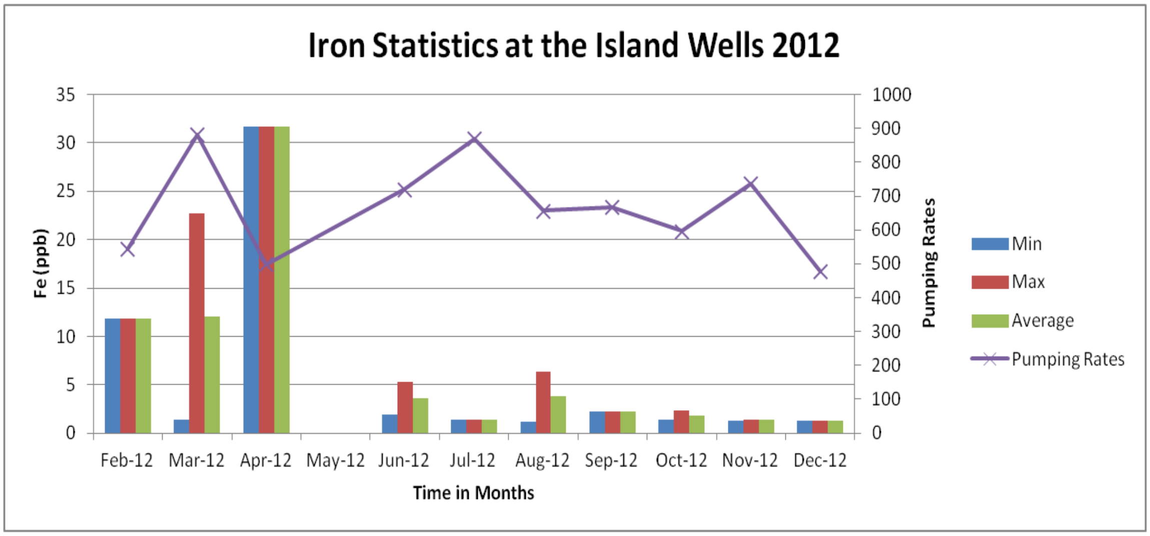

Figure 2.37: Graph representing pumping rates and minimum, maximum and average iron concentrations in water in the island wells in 2012.

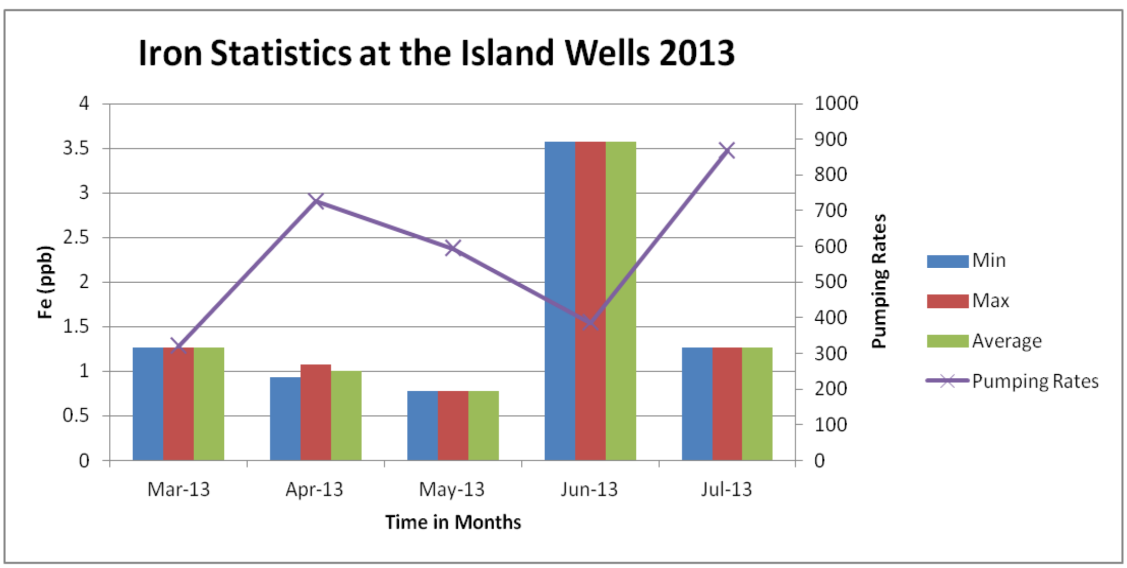

Figure 2.38: Graph representing pumping rates and minimum, maximum and average iron concentrations for the island wells in 2013.

Chapter 3: Ion Ratios

Ion ratios were calculated using fluoride as a conservative ion because its concentration throughout the year is mostly constant when compared to the other ions studied. As mentioned in Chapter 2, there are no fluoride bearing minerals precipitating in the alluvial aquifer and fluoride can be used as a conservative ion for the ion ratios. Ratio concentration values are not as widely spread throughout the months because some daily data did not match fluoride with the other ions for each year and so forth some data sets decreased in content.

Manganese to Fluoride Ratios (Mn^{+2}/F^{-}) in the North and South Well Field Locations

In 2012, Mn^{+2}/F^{-} ratio data are from August to November. Ratios decreased from August to October, but ratios were highest in November (Fig. 3.1). Pumping rates decreased each month until November where considerably higher ratios were present, (Fig. 3.2). River stages were increasing from October to November. As discussed in Chapter 1, increased water viscosity due to decreased water temperature could be the cause for withdrawing more Mn^{+2} from the aquifer, which is indicative that up-coning occurred.

In 2013, Mn^{+2}/F^{-} ratios increased in May and remained fairly high through June and July. As shown in Fig.3.3, pumping rates increased monthly from May to July, but the highest ratios were in May. It is shown that as large volumes of water are being pumped out for water production, while river stages are low, higher Mn^{+2}/F^{-} ratios are present in the water.

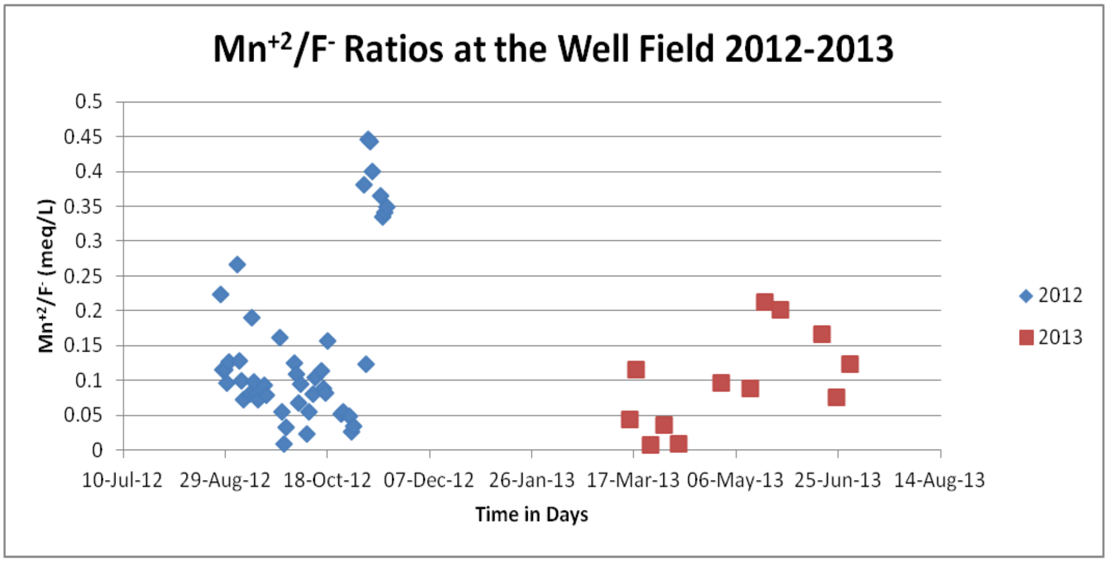

Figure 3.1: Manganese to fluoride ratios (Mn^{+2}/F^{-}) for water in North and South well fields for the years 2012 and 2013.

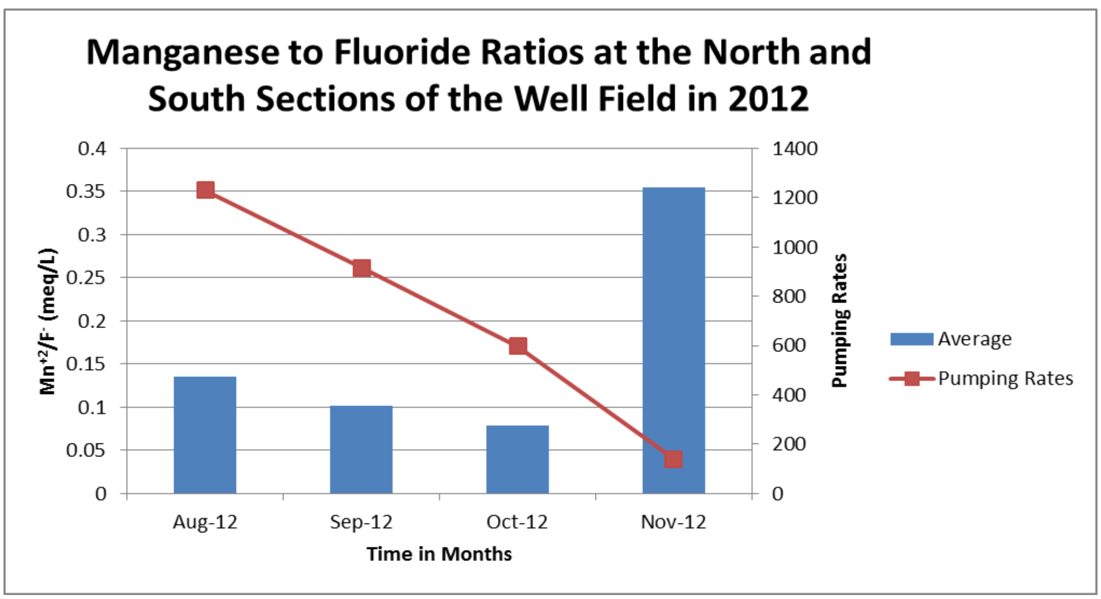

Figure 3.2: Average manganese to fluoride ratios (Mn^{+2}/F^{-}) and well pumping rates in the North and South well fields for the year 2012.

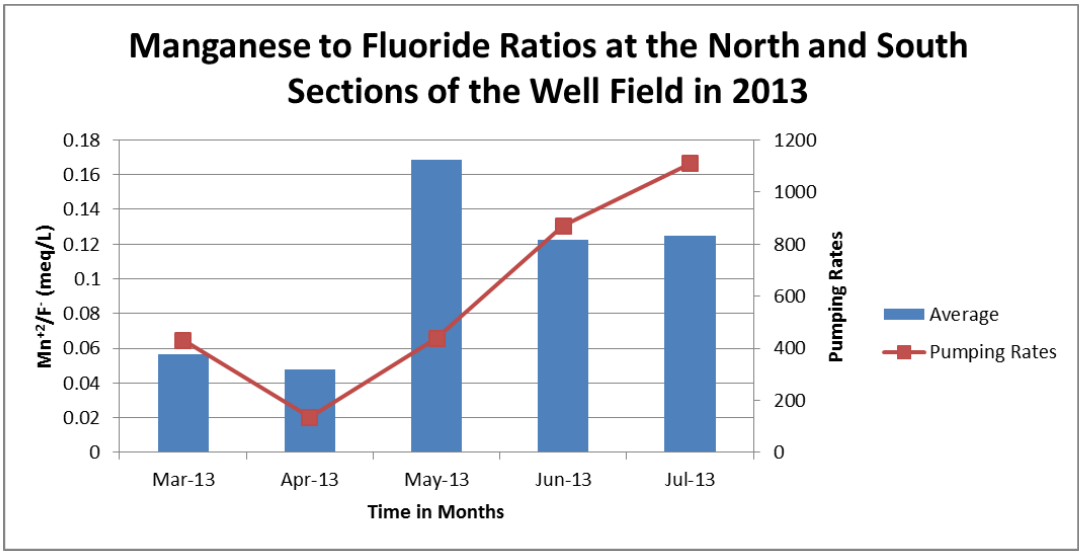

Figure 3.3: Manganese to fluoride ratios (Mn^{+2}/F^{-}) and well pumping rates in the North and South well field for the year 2013.

Manganese to Fluoride ratio (Mn^{+2}/F^{-}) in the Island Wells

In 2008, Mn^{+2}/F^{-} ratios decreased towards May and increased in July (see Figure 3.4). Ratios decreased on average from April to May, as pumping rates were lower in May. During July to September ionic ratios increased with high pumping rates, (see Fig.3.5). River stages were lower from July to September. With low river stages and high pumping rates in August and September, the average Mn^{+2}/F^{-} ratios increased, indeed suggesting that up-coning occurred. Ratios remained high as high pumping rates occurred from August to October. In December, pumping rates were high and the Mn^{+2}/F^{-} ratios increased, but concentration could have been affected by one ratio being higher than the rest of the ratios in December.

In 2012, Mn^{+2}/F^{-} ratios decreased from February to May and increased from July to September where the ratios peaked, see Figure 3.6. The monthly average ratios decreased from February to March, there are a few samples in April that are higher than the rest of the samples analyzed during that month that influence the ratios giving higher averages, (see Fig.3.7). Pumping rates were much higher in March which could be the reason why some analyzed samples were higher in April, product of the delay in groundwater movement. There was an increase in Mn^{+2}/F^{-} ratios from June to September while the pumping rates increased from June to July. Pumping rates remained fairly high from August to October where the Mn^{+2}/F^{-} ratios were higher. The increase in ion ratios from August to October could be attributed a delay in groundwater travel time. It is important to note that manganese concentration is greater in the limestone aquifer due to the aquifers hydrochemical environment, the premise that came from (Hem, 1985) and (John Gates Personal Communication) for Mn^{+2} weathering environment.

In 2013, ratios increased in April and decreased towards July, see Fig.3.6. Notice that even though ratios are high in April, they are still considered low when compared to ratios in the summer of 2012 (Fig.3.6). The monthly average Mn^{+2}/F^{-} ratios increased in April, the pumping rates were high during that month, (see Fig.3.8). Up-coning could have occurred in April as a result of higher water viscosity by decreased water temperature. There was a decrease in Mn^{+2}/F^{-} ratios from May to July, while pumping rates were low. In the well field, Mn^{+2}/F^{-} ratios increased from May to July as the pumping rates increased, while in the island wells the pumping rates and Mn^{+2}/F^{-} ratios decreased from May to July.

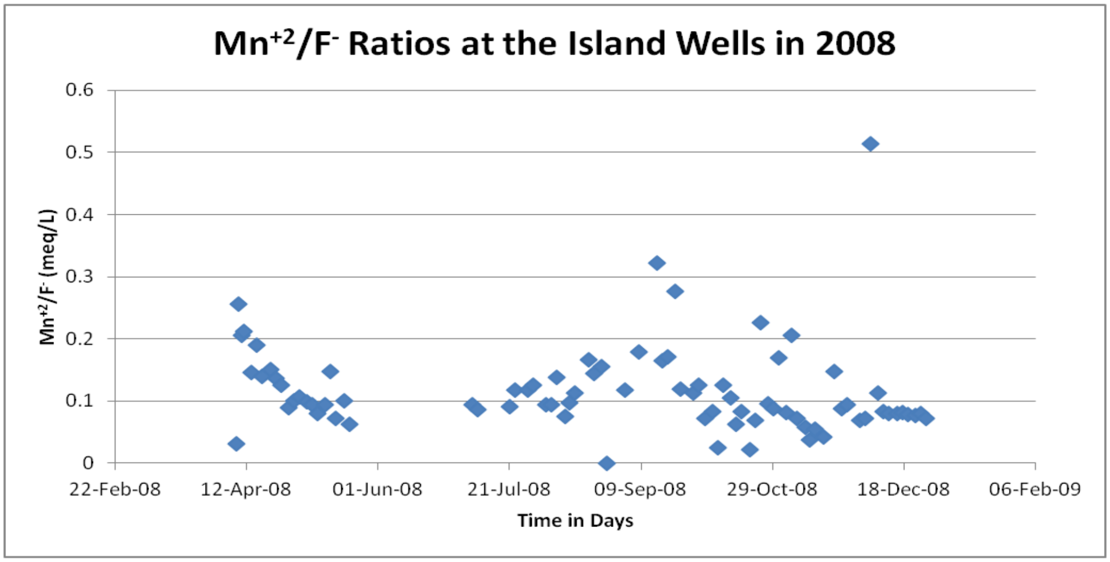

Figure 3.4: Manganese to fluoride ratios (Mn^{+2}/F^{-}) in the island wells in the year 2008.

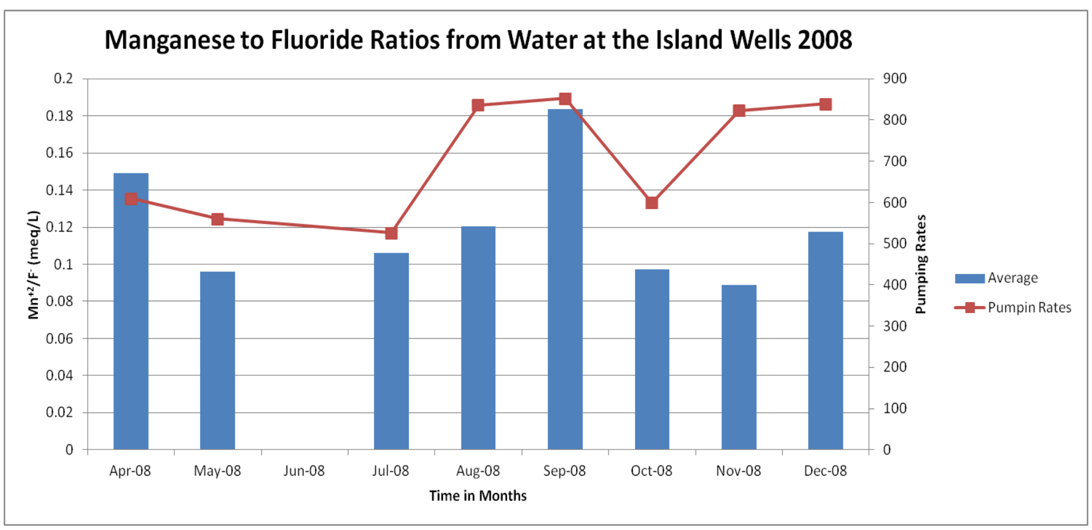

Figure 3.5: Average manganese to fluoride ratios (Mn^{+2}/F^{-}) and well pumping rates in the island wells in the year 2008.

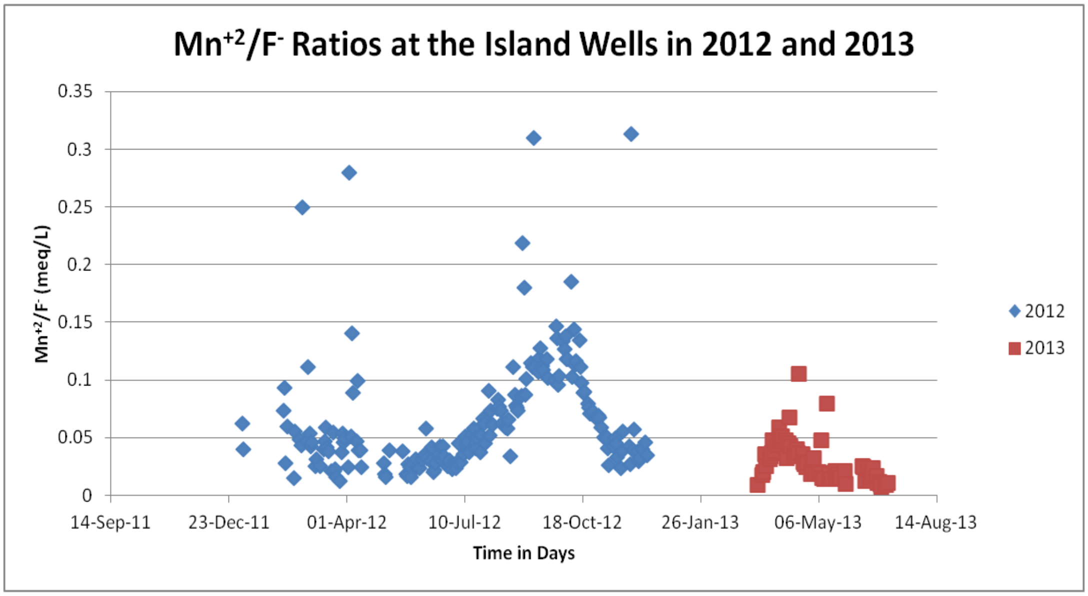

Figure 3.6: Manganese to fluoride ratios (Mn^{+2}/F^{-}) in the island wells for the years 2012 and 2013. Taking the December 6, 2012 Mn^{+2} value of 1.45 out of the graph show's a detailed pattern for the island wells ratios.

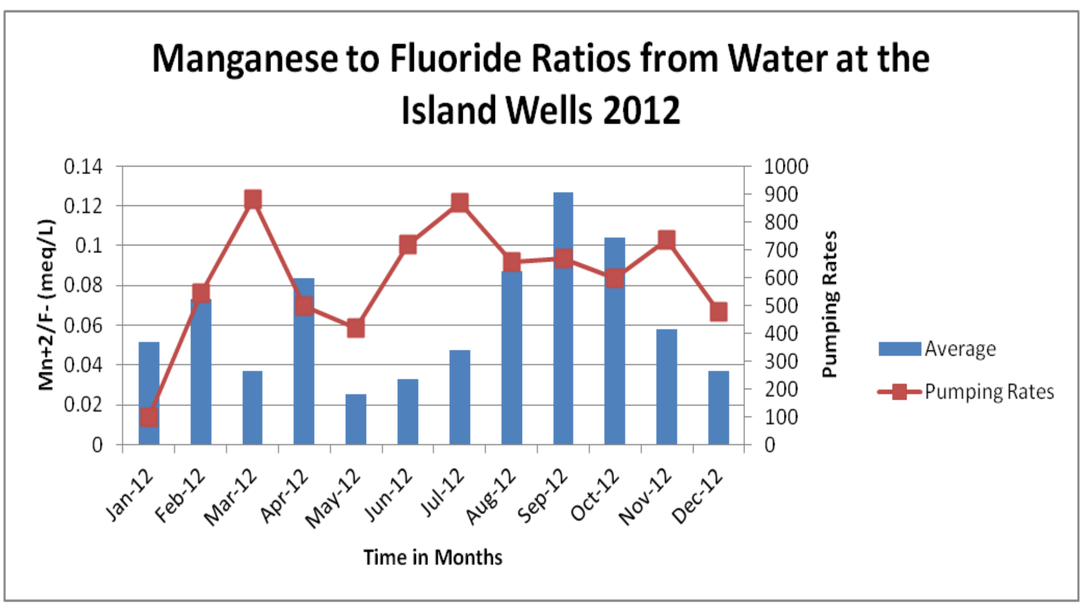

Figure 3.7: Average manganese to fluoride ratios (Mn^{+2}/F^{-}) and well pumping rates in the island wells for the year 2012.

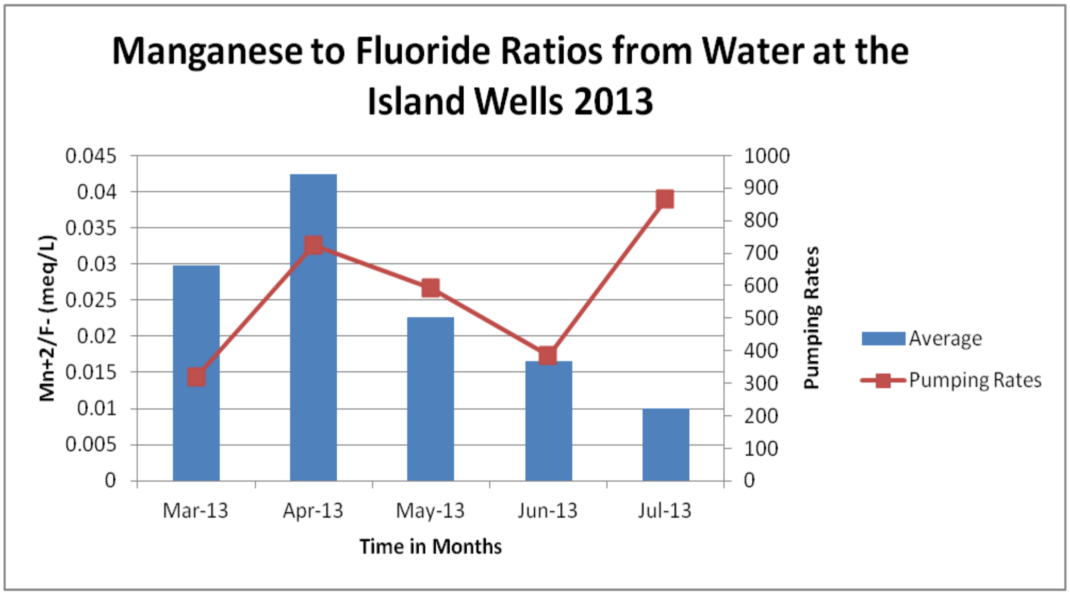

Figure 3.8: Average manganese to fluoride ratios (Mn^{+2}/F^{-}) and well pumping rates in the island wells for the year 2013.

Bromide to Fluoride Ratio (Br-/F-) in the North and South Well Field Locations

In 2012, Br^{-}/F^{-} ratios decreased from August to November, see Fig.3.9. The monthly average Br^{-}/F^{-} ratios also decreased from August to November. Pumping rates decreased each month from August to November respectively, (see Fig.3.10). River stages were low during August but began to increase the following month up to November. The Br^{-}/F^{-} ratios also showed that when pumping rates are high and river stages are low, up-coning is likely to be occurring.

In 2013, Br^-/F^- ratios decreased from March to July, but one sample in April had lower ratios than the rest of the data analyzed throughout the year, which in terms was almost constant (Figure 3.11). As pumping rates decreased from March to April, the Br^-/F^- ratios decreased towards April. In addition as the well pumping rates increased each month from May to July the Br^-/F^- ratios also increased until June, there was a decrease in ratios during the month of July, but it could be a result of having a reduction in samples analyzed when pairing ions for ratios, see Fig.3.12. Bromide-fluoride ratios in 2013 increased when pumping rates were high and decreased when pumping rates were low.

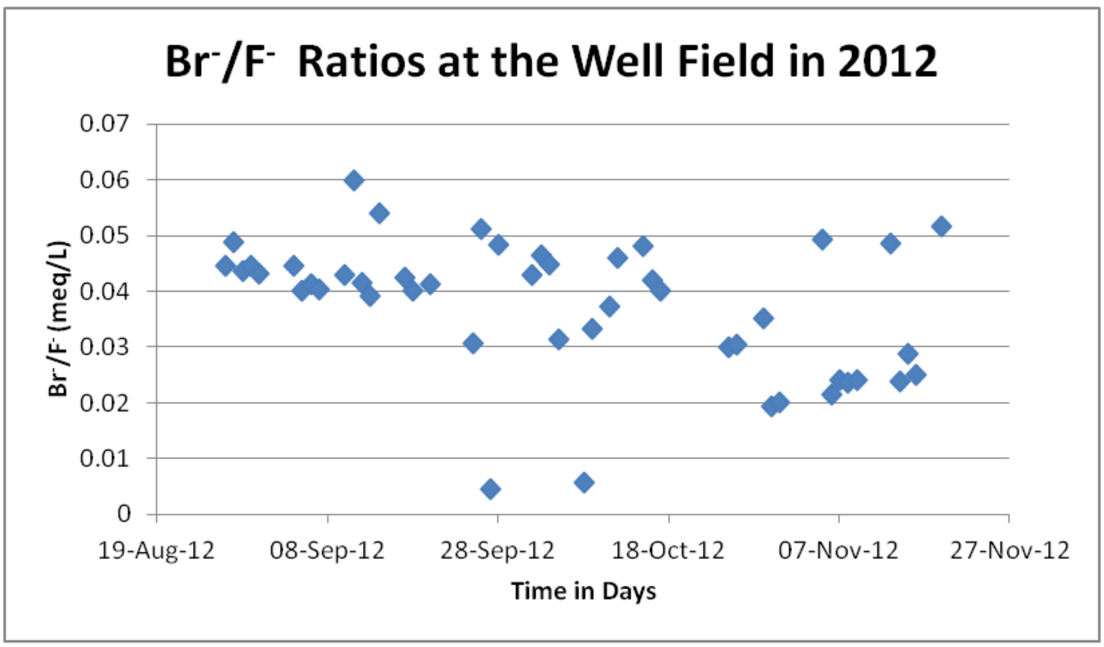

Figure 3.9: Bromide to fluoride ratios (Br^-/F^-) in the North and South well fields for the year 2012.

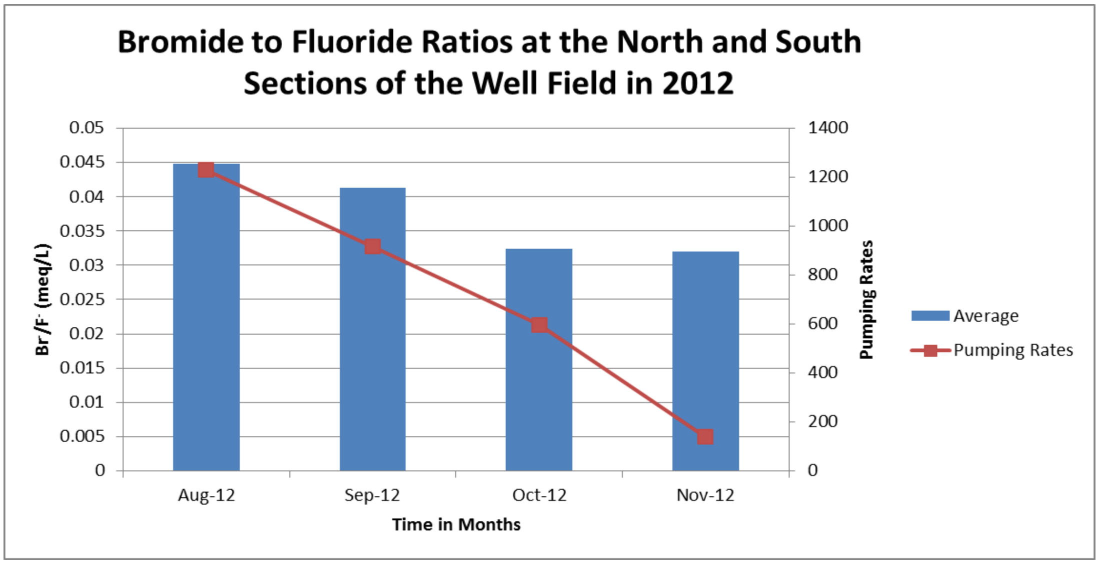

Figure 3.10: Average bromide to fluoride ratios (Br^-/F^-) and pumping rates in the North and South well fields for the year 2012.

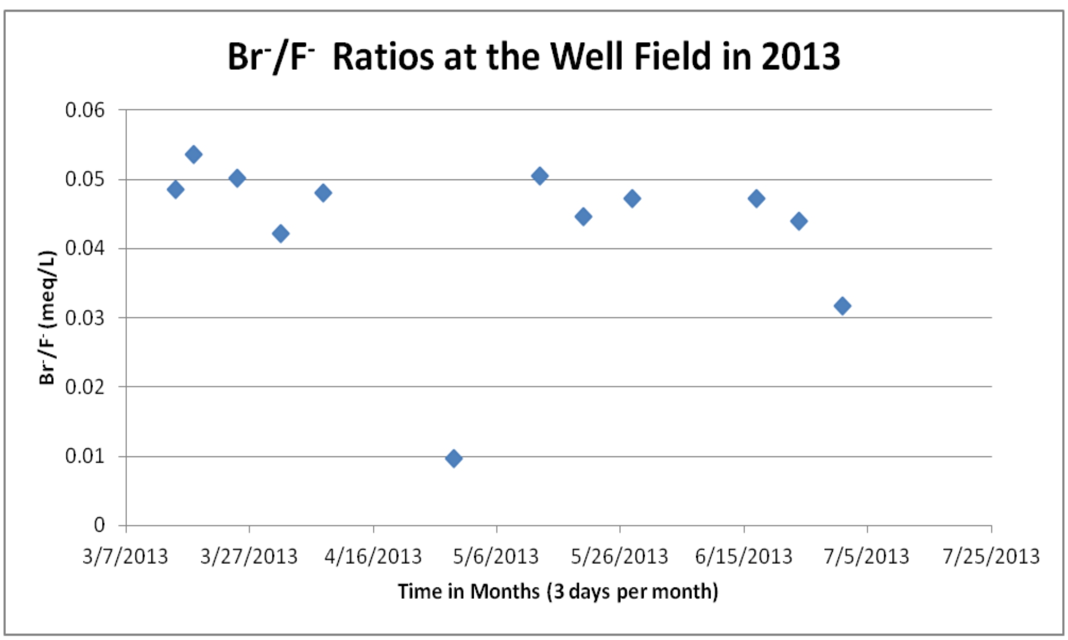

Figure 3.11: Bromide to fluoride ratios (Br^-/F^-) in the North and South well fields for the year 2013.

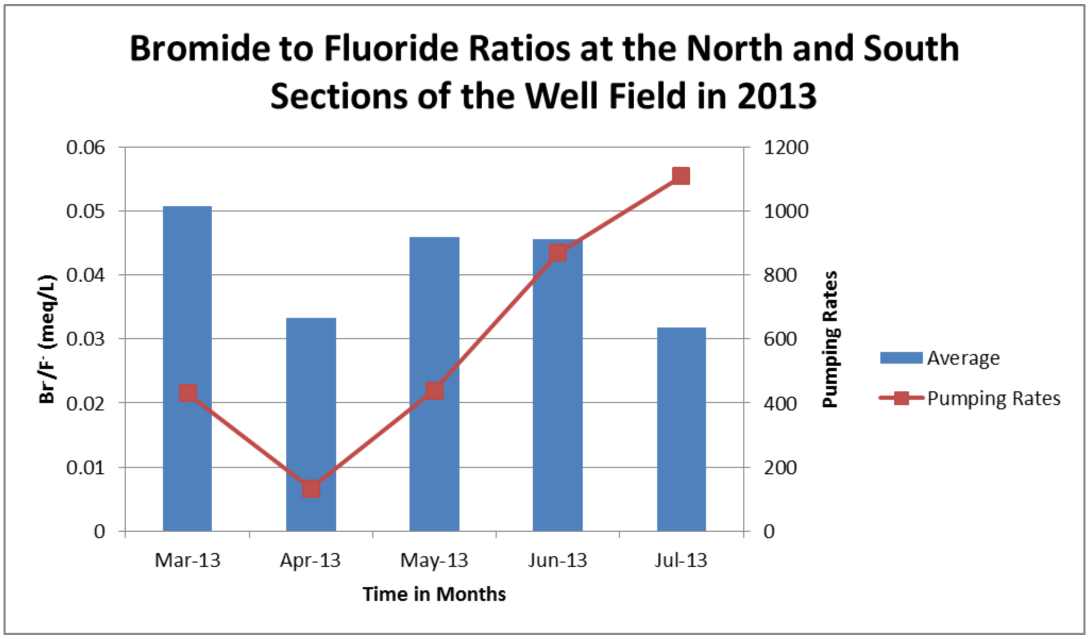

Figure 3.12: Average bromide to fluoride ratios (Br^-/F^-) and pumping in the North and South well fields for the year 2013.

Bromide to Fluoride Ratio (Br-/F-) in the Island Wells

In 2008, Br^-/F^- ratios increased in April and decreased towards May, there is missing data for June. Ratios increased in August and decreased to mid-October which then remained fairly constant to the end of the year, (see Figure 3.13). During the month of August, as the well pumping rates were high, the ionic ratios were high, (see Fig.3.14). In September the pumping rates remained high, but the Br^-/F^- ratios decreased towards October along with decreased pumping rates. As water production increased from November to December, ionic ratios also increased.

In 2012, Br^-/F^- ratios increased from January to February and then decreased towards April (Fig. 3.15). Ionic ratios remained fairly constant from May to July, but there were still some minor changes in ratios. The average Br^-/F^- ratios were higher from January to March, while the pumping rates increased from January to March as shown in Fig.3.16. Pumping rates were fairly high during the period from June to August, while the monthly average ratios also remained fairly high. River stages were low during those months, which is highly possible that up-coning was occurring. Large volumes of water were being extracted from the aquifer during July and November, but Br^-/F^- ratios increased the month after the heavy pumping occurred. This is a common pattern of delay in groundwater movement in the alluvial aquifer.

In 2013, Br^-/F^- ratios remained fairly constant throughout the year, but increased in April and later decreased towards July, (see Figure 3.17). The average Br^-/F^- ratios increased in April, and decreased towards July, notice that pumping rates increased in April and decreased from May to June, (see Fig.3.18). For water produced from the island wells, the high pumping rates in April yielded higher Br^-/F^- ratios. When pumping rates decreased from May to June, ionic ratios decreased June and July. Compared to 2012, Br^-/F^- ratios were higher in 2012 and varied throughout the year but remained at an almost constant average rate unlike in 2013 where the ratios are fairly constant throughout the year.

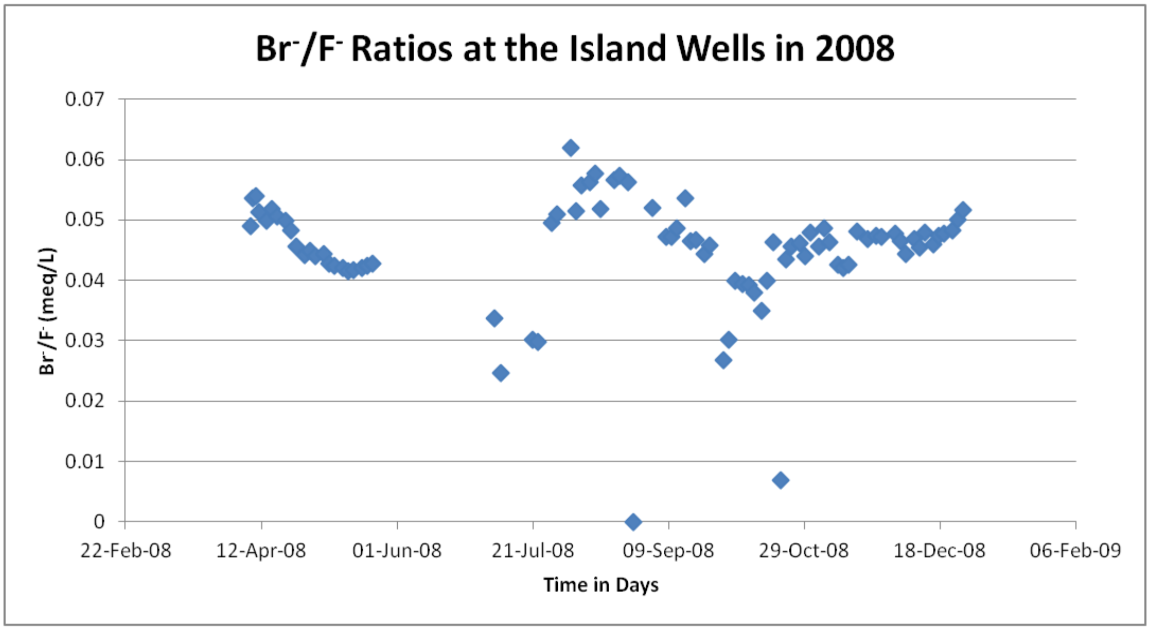

Figure 3.13: Bromide to fluoride ratios (Br^-/F^-) in the island wells for the year 2008.

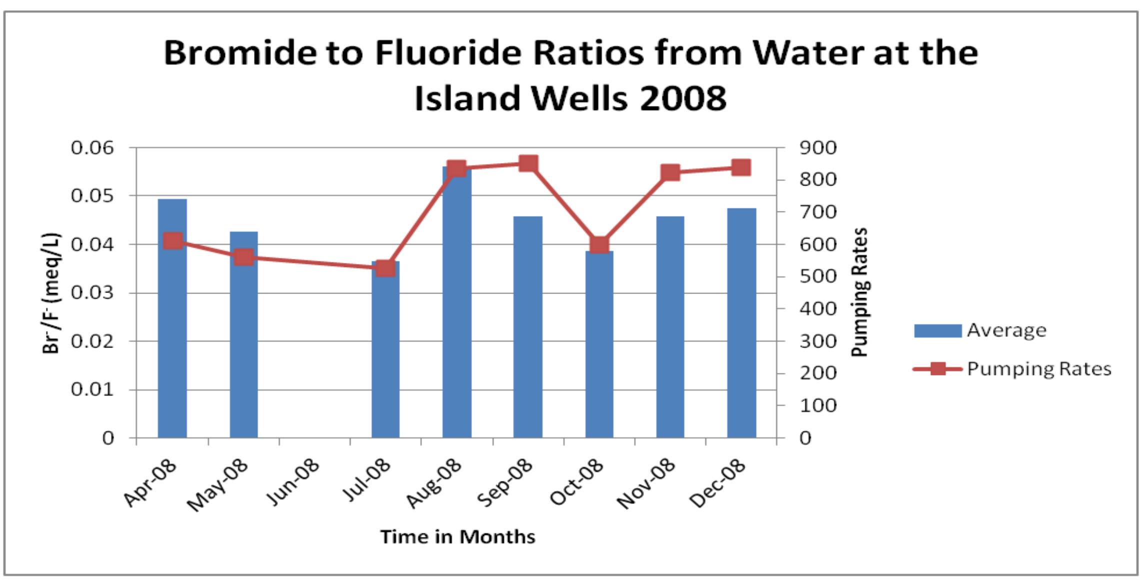

Figure 3.14: Average bromide to fluoride ratios (Br^-/F^-) and pumping rates in the island wells for the year 2008.

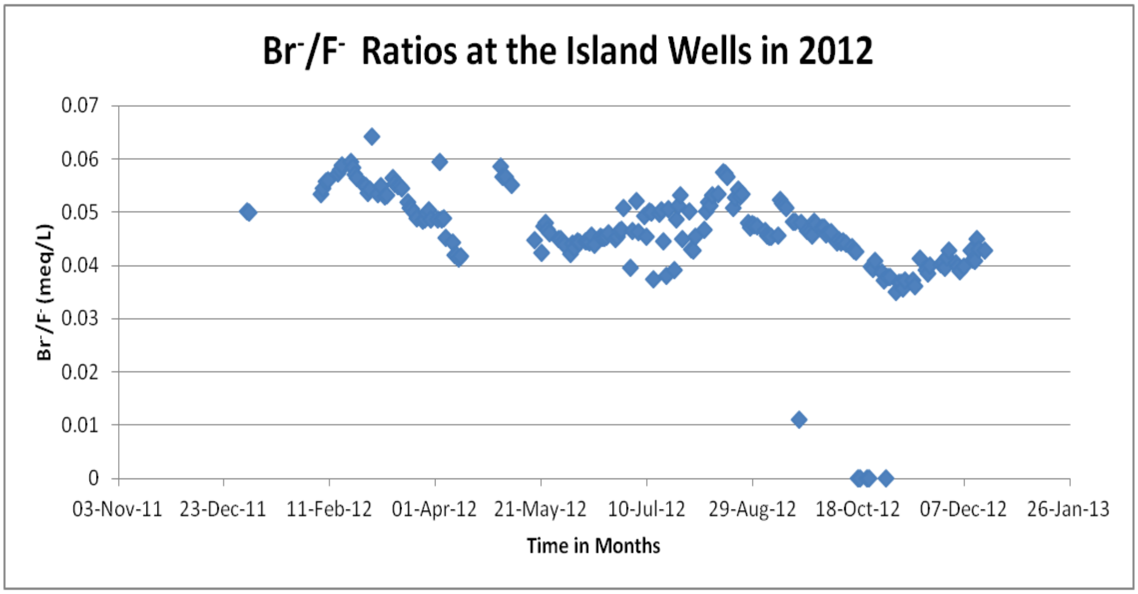

Figure 3.15: Bromide to fluoride ratios (Br^-/F^-) in the island wells in the year 2012.

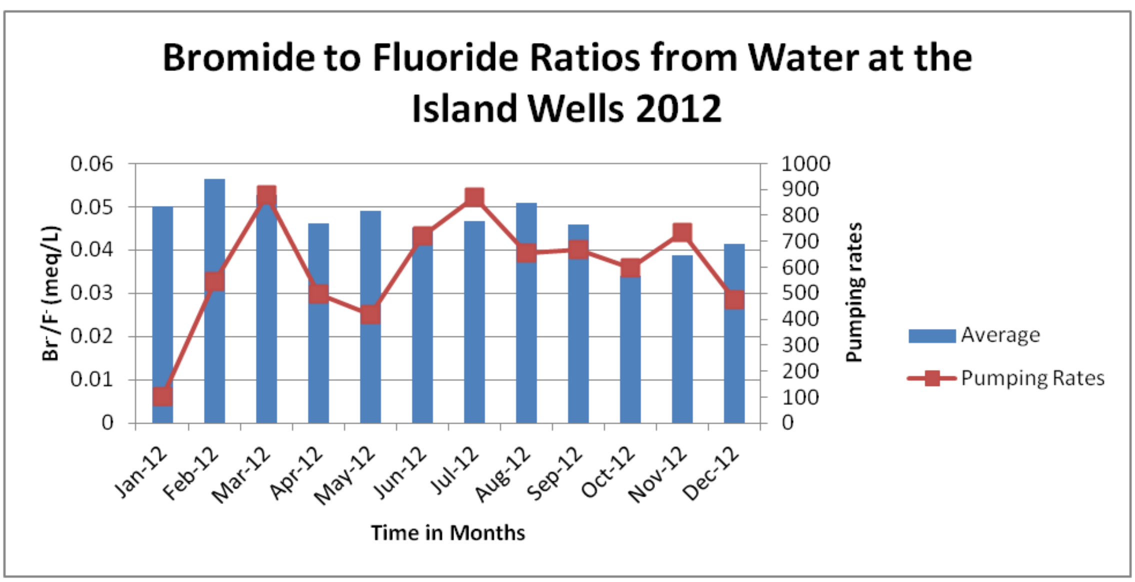

Figure 3.16: Average bromide to fluoride ratios (Br^-/F^-) and pumping rates in the island wells in the year 2012.

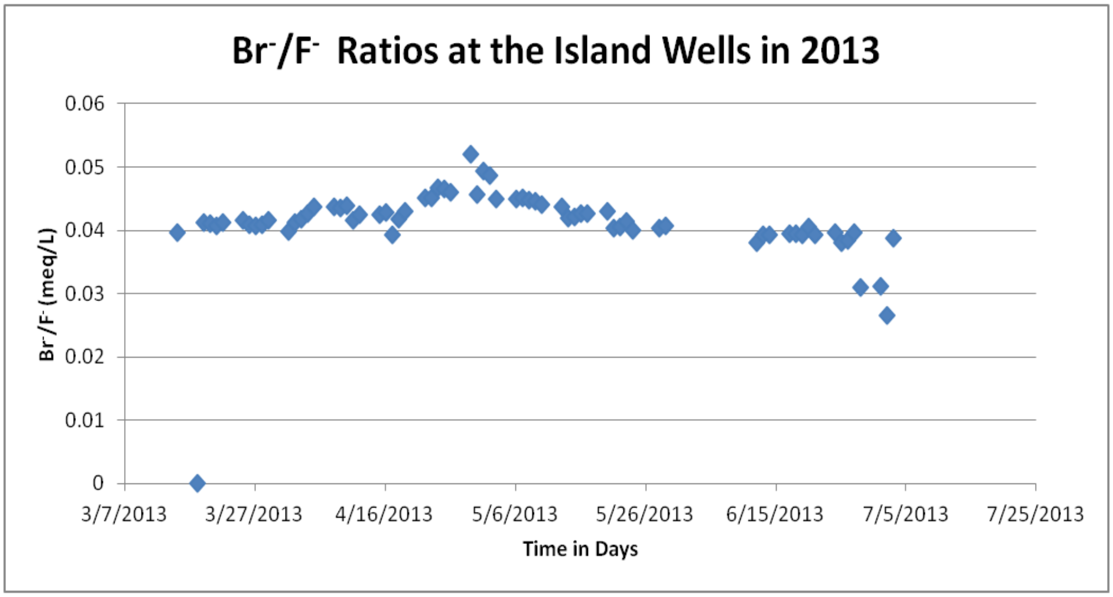

Figure 3.17: Bromide to fluoride ratios (Br^-/F^-) in the island wells for the year 2013.

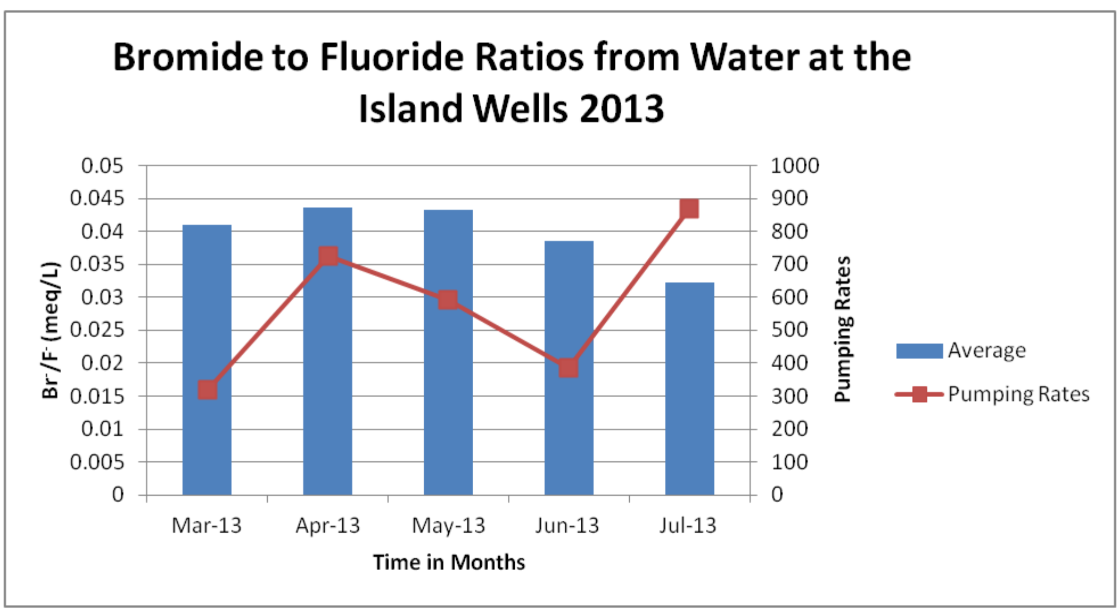

Figure 3.18: Average bromide to fluoride ratios (Br^-/F^-) and pumping rates in the island wells in the year 2013.

Iron to Fluoride Ratios (Fe/F) in the North and South Well Field Locations

In 2012, there are only four available concentration data two of which are in September. The following graphical interpretation is based on these few samples. Iron-fluoride ratios are higher in September and November, see Fig.3.19. The average ratios in September are the same as in October, but note that there is only one sample analyzed available in October, see Fig.3.20. The highest ratio is in November. Pumping rates decreased at a monthly basis from September to November. The river stages increased from September to November. Ionic ratio data also suggests that iron is mostly present in shallower areas of the aquifer based on the Fe/F ratio in November 2012. It is important to consider that there were only a few ion ratios for 2012, but the few samples analyzed showed the common pattern of iron in the alluvial aquifer.

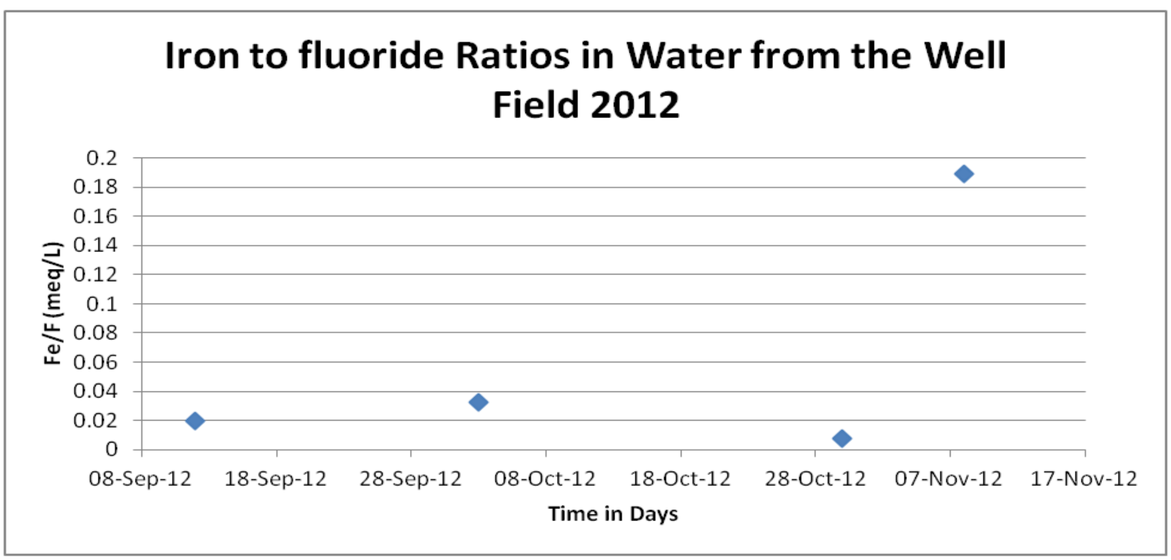

Figure 3.19: Iron to fluoride ratios (Fe/F) in the North and South well fields for the year 2012.

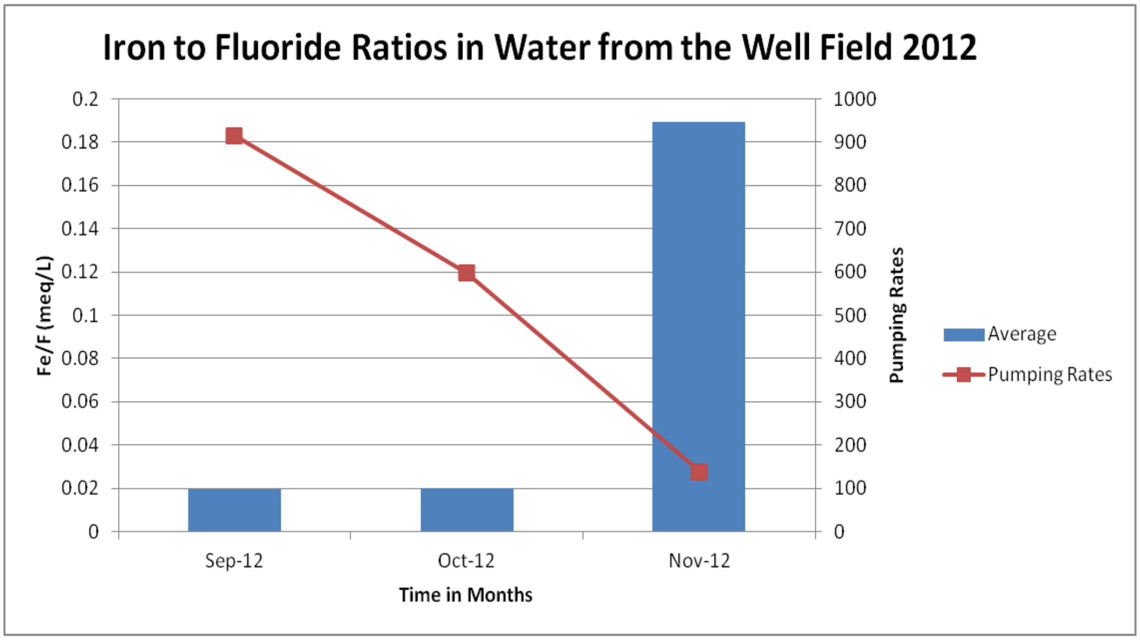

Figure 3.20: Average iron to fluoride ratios (Fe/F) and pumping rates in the North and South well fields for the year 2012.

Iron to Fluoride Ratios (Fe/F) in the Island Wells

In 2012, iron-fluoride ratios are higher in the beginning of the year especially in April (Fig.3.21). The Fe/F ratios are highest in April. Pumping rates were higher during March followed by a decrease during April (Figure 3.22). It is important to note that the river stages were fairly high during the beginning of the year and that a slight increase in river stages occurred during April. Groundwater levels could have been reaching the historic watertable zone in April. Ionic ratios are lower after September. Pumping rates were high during November, but ratios remained low for this month. River stages were also increasing during November.

In 2013, Fe/F ratios are low and remained fairly constant throughout the year, but still increased in June as shown in Fig.3.21. The average Fe/F ratios decreased from March to May. Pumping rates were high during April, but decreased into June, (see Figure 2.23). Taking into account the high pumping rates and low Fe/F ratios in April 2012, and that June 2013 had low well pumping rates and high ratios, the lower groundwater levels the less iron will be present.

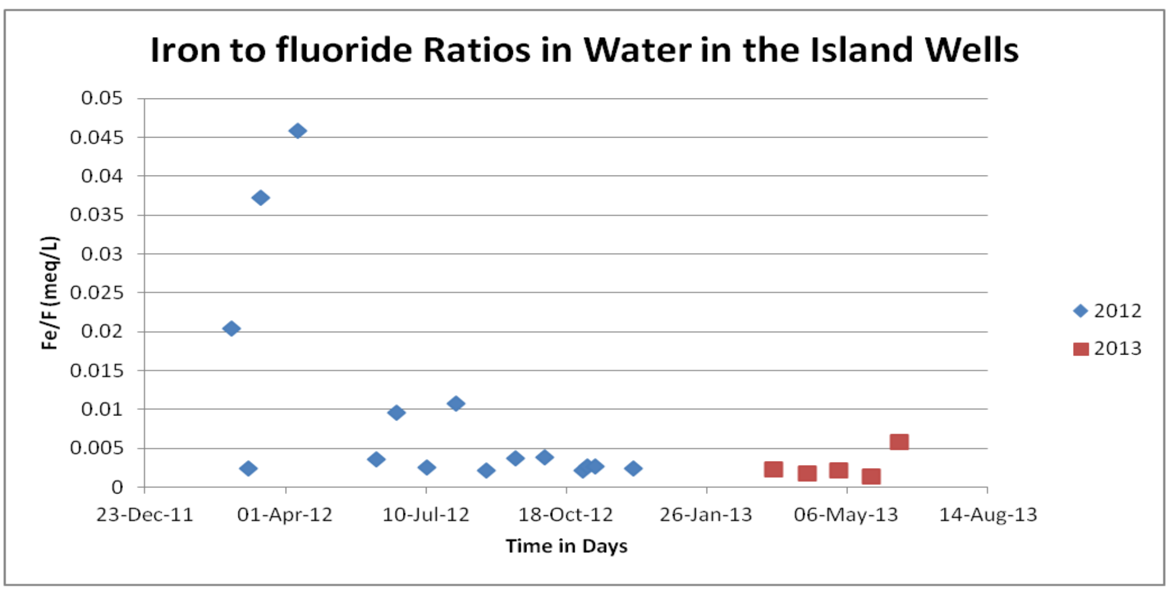

Figure 3.21: Iron to fluoride ratios (Fe/F) in the island wells for the years 2012 and 2013.

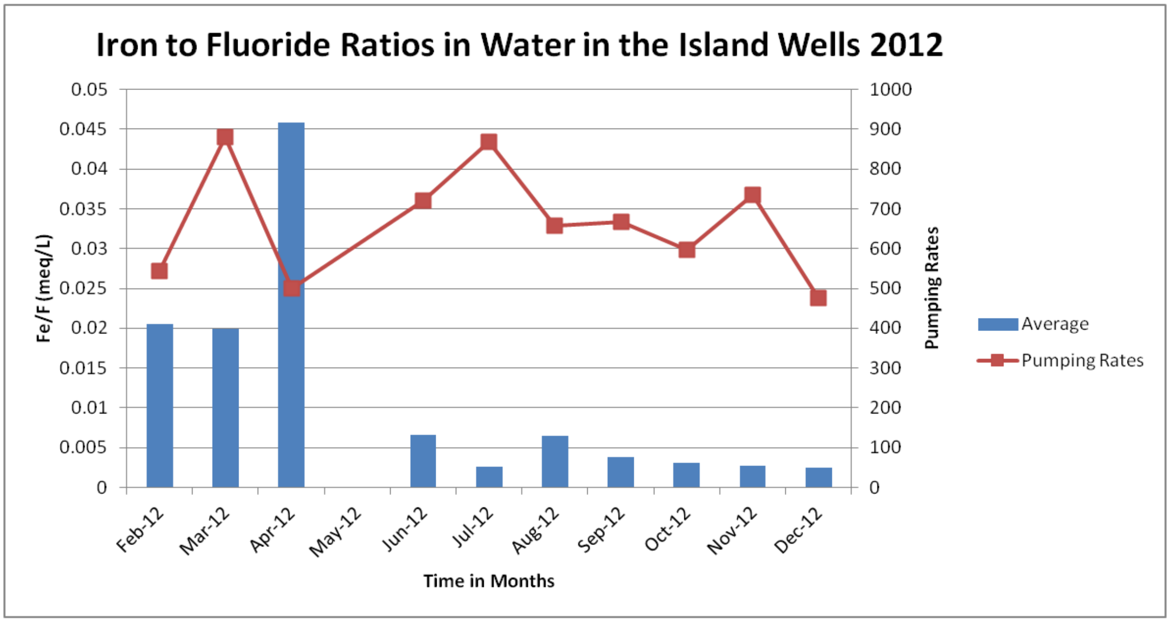

Figure 3.22: Average iron to fluoride ratios (Fe/F) and pumping rates in the island wells for the year 2012.

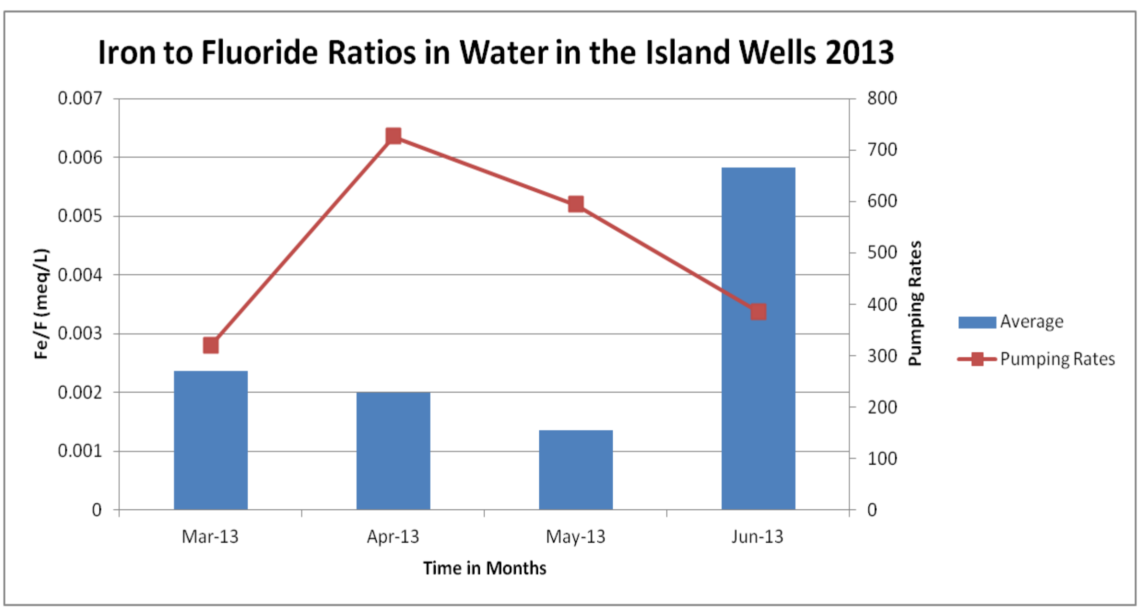

Figure 3.23: Average iron to fluoride ratios (Fe/F) and pumping rates in the island wells for the years 2013.

Chapter 4: Conclusions

A number of distinct ionic patterns of concentrations are occurring in the Lincoln well field that suggest extraction of water from the underlying limestone happens when the aquifer is stressed by heavy pumping and low Platte River levels. The limestone aquifer is the principal source for Mn^{+2} concentration. The patterns that occurred for Mn^{+2} and Br^{-} showed that up-coning was occurring during periods of drought. The ion that was most useful in delineating patterns for up-coning was Mn^{+2}. Increases of Mn^{+2} concentrations during the winter months (from 2012 entering 2013) were also indicative of up-coning. When ion concentrations peaked due to up-coning, higher maximum concentration was present in water analyzed a month after the period of heavy pumping showing that there is also a delay in ion movement through the aquifer. Iron concentration in the aquifer behaves differently and forms an inverse pattern compared to Mn^{+2} and Br^{-} when levels of stress are higher in the aquifer. Fluoride remained fairly constant during the study providing an opportunity for ratio investigation. These ratios also showed that it is likely that up-coning occurred during drought periods.

The pattern that occurred for Mn^{+2} and Br^{-} in the aquifer during periods of drought was that as river stages were low, and pumping rates were high, there was greater stress in the aquifer and higher ionic concentrations were present in the water. The pattern is a good indicator of up-coning as the likely source for these ions would be the underlying limestone. For all three years an increase in Mn^{+2} concentration occurred during the summer, but during the drought summers of 2012 and 2013 Mn^{+2} concentrations were much higher than in 2008 which was considered a wet year.

There is a relationship between Platte River stages and pumping rates during the summer of 2012 and 2013, especially during July. As Platte River stages decreased and large volumes of water were being pumped out the aquifer, groundwater levels dropped dramatically. The lowering of the hydraulic head resulting from dropping of water levels in production well triggers withdrawal from the underlying limestone aquifer, also known as up-coning.

An increase in Mn^{+2} concentration occurred during November 2012 and from January to March 2013. This pattern may have been caused by an increase in water viscosity (lower temperature effect of induced recharge of river water) which could affect flow from the river to the wells. Groundwater movement in shallow depths would be slow because of the increased water viscosity and warmer water at deeper levels would be withdrawn instead. It is likely that the gradient caused by increased water viscosity caused up-coning from the limestone aquifer during the winter of 2012.

Bromide concentration was also affected by changes of aquifer stress. Water analyzed from the North and South well fields showed that in 2012 as the stress levels in the aquifer decreased, the Br^- concentration also decreased. In 2013 Br^- concentration remained fairly constant but increased as pumping rates increased. Ion chemistry data from water at the island wells showed that in periods of higher stress when groundwater levels were low, Br^- concentration also increased. In general, Mn^{+2} and Br^- concentration increased as Platte River stages dropped and pumping rates were high. However, fluoride remained fairly constant and iron had an inverse effect to stress.

Fluoride and iron had individually different patterns than the one observed in Mn^{+2} and Br^-. Fluoride concentrations remained fairly constant throughout the years, but two unexpected highs departed from the other samples analyzed. Those increases in concentration could be from rapidly pumping from a thinner section of the aquifer such as that found in the North well field were greater water yields are expected. On the other hand, iron concentration in the well field was highest when Platte River stages were high and pumping rates were low, this is the inverse pattern.

The pattern that Mn^{+2} and Br^- showed is that as river stages are low and pumping rates are high, up-coning occurs and more of these ions are withdrawn from the limestone aquifer. Iron is the opposite. The pattern formed by iron suggests that iron sources are mostly present at shallow depths of the aquifer where the historic watertable oxidation/reduction environment formed. Iron decreased in concentration with increased depth. Note that iron concentration in the aquifer is much lower than the rest of the ions studied

Ionic ratios also showed changes in water chemistry as stress in the aquifer increases or decreases. Manganese-fluoride ratios showed that during periods of high stress in the alluvial aquifer, the ionic ratios increased representing up-coning. Bromide-fluoride ratios also showed that as groundwater levels decreased, ratios increased. Iron-fluoride ratios showed the inverse pattern, during high periods of stress less iron is present in the water.

A delayed pattern showing travel time through the aquifer occurred for all of the four ions studied. During periods of heavy pumping (high water demand) Mn^{+2} and Br^{-} concentrations would increase on average with increasing pumping rates, but the maximum concentration would usually increase a month later. More Mn^{+2} and Br^{-} ions were being withdrawn from the limestone aquifer.

Ion ratios comparisons were affected by lack of data for fluoride in 2012. Fluoride was used as a conservative ion and there were not enough data for the year to estimate a pattern for the entire year for any of the ions at the well field. Ion ratios are a subject recommended for future study.

Ion data in this study of the Lincoln well field showed that up-coning occurs during periods of high stress such as that caused by the drought in 2012. Ion chemistry data, especially Mn^{+2} served as a good tool in determining if groundwater was being extracted by up-coning from the limestone aquifer. Manganese concentration increasing during winter suggests possible viscosity effects (with seasonal temperature change). This should be a subject for future study. Ion ratios showed that water from the limestone is being withdrawn during stress periods. The boundary between river alluvium and the underlying limestone aquifer is permeable and the Lincoln Water System does produce water from it in stress periods.

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APPENDIX A- MANGANESE DATA-ALL DATA IN PPB

FROM THE WEST TREATMENT PLANT

Param	CollectDate	NumericResult	Site
Manganese, Total	02-Jan-08	31.0644	West Raw (WR)
Manganese, Total	03-Jan-08	33.2381	West Raw (WR)
Manganese, Total	04-Jan-08	24.595	West Raw (WR)
Manganese, Total	07-Jan-08	30.0379	West Raw (WR)
Manganese, Total	08-Jan-08	24.4708	West Raw (WR)
Manganese, Total	09-Jan-08	21.6408	West Raw (WR)
Manganese, Total	10-Jan-08	21.18	West Raw (WR)
Manganese, Total	11-Jan-08	22.93	West Raw (WR)
Manganese, Total	14-Jan-08	20.08	West Raw (WR)
Manganese, Total	15-Jan-08	21.6406	West Raw (WR)
Manganese, Total	16-Jan-08	17.36	West Raw (WR)
Manganese, Total	17-Jan-08	25.28	West Raw (WR)
Manganese, Total	18-Jan-08	19.56	West Raw (WR)
Manganese, Total	22-Jan-08	19.58	West Raw (WR)
Manganese, Total	23-Jan-08	19.95	West Raw (WR)
Manganese, Total	24-Jan-08	17.02	West Raw (WR)
Manganese, Total	25-Jan-08	37.81	West Raw (WR)
Manganese, Total	28-Jan-08	21.54	West Raw (WR)
Manganese, Total	29-Jan-08	24.87	West Raw (WR)
Manganese, Total	30-Jan-08	18	West Raw (WR)
Manganese, Total	31-Jan-08	16.96	West Raw (WR)

Manganese, Total	01-Feb-08	17.95	West Raw (WR)
Manganese, Total	04-Feb-08	17.9408	West Raw (WR)
Manganese, Total	05-Feb-08	20.0787	West Raw (WR)
Manganese, Total	06-Feb-08	17.9291	West Raw (WR)
Manganese, Total	07-Feb-08	16.967	West Raw (WR)
Manganese, Total	08-Feb-08	82.1705	West Raw (WR)
Manganese, Total	11-Feb-08	6.8706	West Raw (WR)
Manganese, Total	12-Feb-08	4.6365	West Raw (WR)
Manganese, Total	13-Feb-08	4.3862	West Raw (WR)
Manganese, Total	14-Feb-08	3.0434	West Raw (WR)
Manganese, Total	15-Feb-08	2.6771	West Raw (WR)
Manganese, Total	19-Feb-08	5.5817	West Raw (WR)
Manganese, Total	20-Feb-08	4.8462	West Raw (WR)
Manganese, Total	21-Feb-08	5.1048	West Raw (WR)
Manganese, Total	22-Feb-08	3.3491	West Raw (WR)
Manganese, Total	25-Feb-08	2.32	West Raw (WR)
Manganese, Total	26-Feb-08	2.6202	West Raw (WR)
Manganese, Total	27-Feb-08	2.0323	West Raw (WR)
Manganese, Total	28-Feb-08	1.7844	West Raw (WR)
Manganese, Total	29-Feb-08	2.5964	West Raw (WR)
Manganese, Total	03-Mar-08	4.09	West Raw (WR)
Manganese, Total	04-Mar-08	2.78	West Raw (WR)
Manganese, Total	05-Mar-08	3.11	West Raw (WR)
Manganese, Total	06-Mar-08	0.17	West Raw (WR)
Manganese, Total	07-Mar-08	0.26	West Raw (WR)

Manganese, Total	10-Mar-08	3.27	West Raw (WR)
Manganese, Total	11-Mar-08	8.36	West Raw (WR)
Manganese, Total	12-Mar-08	8.68	West Raw (WR)
Manganese, Total	13-Mar-08	9.19	West Raw (WR)
Manganese, Total	14-Mar-08	10.03	West Raw (WR)
Manganese, Total	17-Mar-08	7.91	West Raw (WR)
Manganese, Total	18-Mar-08	7.63	West Raw (WR)
Manganese, Total	19-Mar-08	14.7483	West Raw (WR)
Manganese, Total	20-Mar-08	18.1045	West Raw (WR)
Manganese, Total	21-Mar-08	22.8602	West Raw (WR)
Manganese, Total	24-Mar-08	35.32	West Raw (WR)
Manganese, Total	25-Mar-08	37.07	West Raw (WR)
Manganese, Total	26-Mar-08	31.8343	West Raw (WR)
Manganese, Total	27-Mar-08	24.3	West Raw (WR)
Manganese, Total	28-Mar-08	51.11	West Raw (WR)
Manganese, Total	31-Mar-08	34.18	West Raw (WR)
Manganese, Total	01-Apr-08	29.37	West Raw (WR)
Manganese, Total	02-Apr-08	39.65	West Raw (WR)
Manganese, Total	03-Apr-08	28.35	West Raw (WR)
Manganese, Total	04-Apr-08	16	West Raw (WR)
Manganese, Total	07-Apr-08	46.0688	West Raw (WR)
Manganese, Total	08-Apr-08	13.7514	West Raw (WR)
Manganese, Total	09-Apr-08	83.4892	West Raw (WR)
Manganese, Total	10-Apr-08	78.7693	West Raw (WR)
Manganese, Total	11-Apr-08	91.958	West Raw (WR)

Manganese, Total	14-Apr-08	14.3688	West Raw (WR)
Manganese, Total	06-May-08	88.2858	West Raw (WR)
Manganese, Total	07-May-08	97.5835	West Raw (WR)
Manganese, Total	08-May-08	81.0191	West Raw (WR)
Manganese, Total	09-May-08	44.1411	West Raw (WR)
Manganese, Total	16-May-08	68.03	West Raw (WR)
Manganese, Total	19-May-08	78.0248	West Raw (WR)
Manganese, Total	20-May-08	68.87	West Raw (WR)
Manganese, Total	21-May-08	64.2409	West Raw (WR)
Manganese, Total	22-May-08	80.4952	West Raw (WR)
Manganese, Total	23-May-08	99.39	West Raw (WR)
Manganese, Total	27-May-08	50.9625	West Raw (WR)
Manganese, Total	28-May-08	66.1524	West Raw (WR)
Manganese, Total	29-May-08	70.2889	West Raw (WR)
Manganese, Total	30-May-08	69.98	West Raw (WR)
Manganese, Total	02-Jun-08	80.169	West Raw (WR)
Manganese, Total	03-Jun-08	61.8643	West Raw (WR)
Manganese, Total	04-Jun-08	50.9259	West Raw (WR)
Manganese, Total	05-Jun-08	70.3482	West Raw (WR)
Manganese, Total	06-Jun-08	63.05	West Raw (WR)
Manganese, Total	09-Jun-08	49.3239	West Raw (WR)
Manganese, Total	10-Jun-08	39.4383	West Raw (WR)
Manganese, Total	11-Jun-08	50.1667	West Raw (WR)
Manganese, Total	12-Jun-08	37.9646	West Raw (WR)
Manganese, Total	13-Jun-08	39.9536	West Raw (WR)

Manganese, Total	16-Jun-08	63.31	West Raw (WR)
Manganese, Total	17-Jun-08	58.55	West Raw (WR)
Manganese, Total	18-Jun-08	62.45	West Raw (WR)
Manganese, Total	19-Jun-08	53.88	West Raw (WR)
Manganese, Total	20-Jun-08	62.09	West Raw (WR)
Manganese, Total	23-Jun-08	79.43	West Raw (WR)
Manganese, Total	24-Jun-08	71.18	West Raw (WR)
Manganese, Total	25-Jun-08	63.7	West Raw (WR)
Manganese, Total	26-Jun-08	68.85	West Raw (WR)
Manganese, Total	27-Jun-08	63.54	West Raw (WR)
Manganese, Total	30-Jun-08	57.97	West Raw (WR)
Manganese, Total	01-Jul-08	61.68	West Raw (WR)
Manganese, Total	02-Jul-08	56.02	West Raw (WR)
Manganese, Total	03-Jul-08	42.7	West Raw (WR)
Manganese, Total	07-Jul-08	92.54	West Raw (WR)
Manganese, Total	08-Jul-08	52.83	West Raw (WR)
Manganese, Total	09-Jul-08	60.62	West Raw (WR)
Manganese, Total	10-Jul-08	71.14	West Raw (WR)
Manganese, Total	11-Jul-08	40.3	West Raw (WR)
Manganese, Total	14-Jul-08	50.11	West Raw (WR)
Manganese, Total	15-Jul-08	39.16	West Raw (WR)
Manganese, Total	16-Jul-08	52.12	West Raw (WR)
Manganese, Total	17-Jul-08	68.62	West Raw (WR)
Manganese, Total	18-Jul-08	97.05	West Raw (WR)
Manganese, Total	21-Jul-08	38.7333	West Raw (WR)

Manganese, Total	22-Jul-08	65.5486	West Raw (WR)
Manganese, Total	23-Jul-08	70.9812	West Raw (WR)
Manganese, Total	24-Jul-08	46.3071	West Raw (WR)
Manganese, Total	25-Jul-08	40.2175	West Raw (WR)
Manganese, Total	28-Jul-08	64.8305	West Raw (WR)
Manganese, Total	29-Jul-08	68.2389	West Raw (WR)
Manganese, Total	30-Jul-08	54.1231	West Raw (WR)
Manganese, Total	31-Jul-08	49.0077	West Raw (WR)
Manganese, Total	01-Aug-08	49.6268	West Raw (WR)
Manganese, Total	04-Aug-08	37.7394	West Raw (WR)
Manganese, Total	05-Aug-08	33.6448	West Raw (WR)
Manganese, Total	06-Aug-08	36.5176	West Raw (WR)
Manganese, Total	07-Aug-08	48.1777	West Raw (WR)
Manganese, Total	08-Aug-08	46.6191	West Raw (WR)
Manganese, Total	11-Aug-08	43.0216	West Raw (WR)
Manganese, Total	12-Aug-08	43.0896	West Raw (WR)
Manganese, Total	13-Aug-08	18.4449	West Raw (WR)
Manganese, Total	14-Aug-08	19.738	West Raw (WR)
Manganese, Total	15-Aug-08	49.311	West Raw (WR)
Manganese, Total	18-Aug-08	45.8862	West Raw (WR)
Manganese, Total	19-Aug-08	52.5203	West Raw (WR)
Manganese, Total	20-Aug-08	51.022	West Raw (WR)
Manganese, Total	21-Aug-08	66.549	West Raw (WR)
Manganese, Total	22-Aug-08	69.8371	West Raw (WR)
Manganese, Total	25-Aug-08	50.4827	West Raw (WR)

Manganese, Total	26-Aug-08	43.4004	West Raw (WR)
Manganese, Total	27-Aug-08	52.1343	West Raw (WR)
Manganese, Total	28-Aug-08	59.9421	West Raw (WR)
Manganese, Total	29-Aug-08	22.7155	West Raw (WR)
Manganese, Total	02-Sep-08	36.1417	West Raw (WR)
Manganese, Total	04-Sep-08	36.045	West Raw (WR)
Manganese, Total	05-Sep-08	47.0333	West Raw (WR)
Manganese, Total	08-Sep-08	16.8341	West Raw (WR)
Manganese, Total	19-Sep-08	6.2017	West Raw (WR)
Manganese, Total	22-Sep-08	3.2007	West Raw (WR)
Manganese, Total	23-Sep-08	3.3998	West Raw (WR)
Manganese, Total	24-Sep-08	14.811	West Raw (WR)
Manganese, Total	25-Sep-08	10.0215	West Raw (WR)
Manganese, Total	26-Sep-08	15.2271	West Raw (WR)
Manganese, Total	29-Sep-08	4.26	West Raw (WR)
Manganese, Total	30-Sep-08	8.42	West Raw (WR)
Manganese, Total	01-Oct-08	5.04	West Raw (WR)
Manganese, Total	02-Oct-08	7.4672	West Raw (WR)
Manganese, Total	03-Oct-08	8.0874	West Raw (WR)
Manganese, Total	06-Oct-08	9.792	West Raw (WR)
Manganese, Total	07-Oct-08	26.1539	West Raw (WR)
Manganese, Total	08-Oct-08	13.3787	West Raw (WR)
Manganese, Total	09-Oct-08	14.0684	West Raw (WR)
Manganese, Total	10-Oct-08	26.9159	West Raw (WR)
Manganese, Total	13-Oct-08	75.12	West Raw (WR)

Manganese, Total	14-Oct-08	98.64	West Raw (WR)
Manganese, Total	15-Oct-08	74.23	West Raw (WR)
Manganese, Total	16-Oct-08	37.26	West Raw (WR)
Manganese, Total	17-Oct-08	34.54	West Raw (WR)
Manganese, Total	20-Oct-08	28.55	West Raw (WR)
Manganese, Total	21-Oct-08	46.35	West Raw (WR)
Manganese, Total	22-Oct-08	31.88	West Raw (WR)
Manganese, Total	23-Oct-08	31.01	West Raw (WR)
Manganese, Total	24-Oct-08	39.99	West Raw (WR)
Manganese, Total	27-Oct-08	9.1	West Raw (WR)
Manganese, Total	28-Oct-08	13.88	West Raw (WR)

In 2011

Param	CollectDate	Numerical Result	Site
Manganese, Total	15-Feb-11	121.792	West Raw (WR)
Manganese, Total	16-Feb-11	31.4718	West Raw (WR)
Manganese, Total	17-Feb-11	22.9426	West Raw (WR)
Manganese, Total	18-Feb-11	83.4283	West Raw (WR)
Manganese, Total	22-Feb-11	50.69	West Raw (WR)
Manganese, Total	23-Feb-11	50.86	West Raw (WR)
Manganese, Total	24-Feb-11	44.66	West Raw (WR)
Manganese, Total	25-Feb-11	43.81	West Raw (WR)
Manganese, Total	28-Feb-11	28.92	West Raw (WR)
Manganese, Total	01-Mar-11	42.2795	West Raw (WR)
Manganese, Total	02-Mar-11	39.8	West Raw (WR)

Manganese, Total	03-Mar-11	34.26	West Raw (WR)
Manganese, Total	04-Mar-11	33.9322	West Raw (WR)
Manganese, Total	07-Mar-11	32.5676	West Raw (WR)
Manganese, Total	08-Mar-11	35.1414	West Raw (WR)
Manganese, Total	09-Mar-11	33.1603	West Raw (WR)
Manganese, Total	11-May-11	61.0068	West Raw (WR)
Manganese, Total	12-May-11	44.909	West Raw (WR)
Manganese, Total	16-May-11	3.25	West Raw (WR)
Manganese, Total	17-May-11	3.8262	West Raw (WR)
Manganese, Total	18-May-11	19.1972	West Raw (WR)
Manganese, Total	19-May-11	27.7632	West Raw (WR)
Manganese, Total	20-May-11	53.0624	West Raw (WR)
Manganese, Total	23-May-11	75.4415	West Raw (WR)
Manganese, Total	24-May-11	33.8149	West Raw (WR)
Manganese, Total	25-May-11	115.473	West Raw (WR)
Manganese, Total	26-May-11	134.871	West Raw (WR)
Manganese, Total	27-May-11	48.6247	West Raw (WR)
Manganese, Total	31-May-11	55.2445	West Raw (WR)
Manganese, Total	01-Jun-11	59.3816	West Raw (WR)
Manganese, Total	02-Jun-11	38.1314	West Raw (WR)
Manganese, Total	03-Jun-11	38.3529	West Raw (WR)
Manganese, Total	06-Jun-11	75.4385	West Raw (WR)
Manganese, Total	07-Jun-11	25.0123	West Raw (WR)
Manganese, Total	08-Jun-11	26.647	West Raw (WR)
Manganese, Total	09-Jun-11	39.7502	West Raw (WR)

Manganese, Total	10-Jun-11	72.2484	West Raw (WR)
Manganese, Total	13-Jun-11	111.692	West Raw (WR)
Manganese, Total	14-Jun-11	86.8208	West Raw (WR)
Manganese, Total	15-Jun-11	68.8324	West Raw (WR)
Manganese, Total	16-Jun-11	65.32	West Raw (WR)
Manganese, Total	17-Jun-11	46.56	West Raw (WR)
Manganese, Total	20-Jun-11	55.77	West Raw (WR)
Manganese, Total	22-Jun-11	59.6003	West Raw (WR)
Manganese, Total	23-Jun-11	43.98	West Raw (WR)
Manganese, Total	24-Jun-11	30.7996	West Raw (WR)
Manganese, Total	27-Jun-11	85.166	West Raw (WR)
Manganese, Total	28-Jun-11	56.9746	West Raw (WR)
Manganese, Total	29-Jun-11	42.0513	West Raw (WR)
Manganese, Total	30-Jun-11	45.26	West Raw (WR)
Manganese, Total	01-Jul-11	50.2887	West Raw (WR)
Manganese, Total	05-Jul-11	35.8285	West Raw (WR)
Manganese, Total	06-Jul-11	29.1586	West Raw (WR)
Manganese, Total	07-Jul-11	34.4963	West Raw (WR)
Manganese, Total	08-Jul-11	33.2633	West Raw (WR)
Manganese, Total	11-Jul-11	52.8173	West Raw (WR)
Manganese, Total	12-Jul-11	35.0017	West Raw (WR)
Manganese, Total	13-Jul-11	36.8278	West Raw (WR)
Manganese, Total	14-Jul-11	48.07	West Raw (WR)
Manganese, Total	15-Jul-11	29.855	West Raw (WR)
Manganese, Total	18-Jul-11	32.9567	West Raw (WR)

Manganese, Total	19-Jul-11	44.2974	West Raw (WR)
Manganese, Total	20-Jul-11	36.7	West Raw (WR)
Manganese, Total	21-Jul-11	37.3227	West Raw (WR)
Manganese, Total	22-Jul-11	34.2326	West Raw (WR)
Manganese, Total	25-Jul-11	85.7851	West Raw (WR)
Manganese, Total	26-Jul-11	55.3327	West Raw (WR)
Manganese, Total	27-Jul-11	44.1903	West Raw (WR)
Manganese, Total	28-Jul-11	23.2145	West Raw (WR)
Manganese, Total	29-Jul-11	32.4997	West Raw (WR)
Manganese, Total	01-Aug-11	76.8935	West Raw (WR)
Manganese, Total	02-Aug-11	39.1877	West Raw (WR)
Manganese, Total	03-Aug-11	65.8306	West Raw (WR)
Manganese, Total	04-Aug-11	35.49	West Raw (WR)
Manganese, Total	05-Aug-11	42.2344	West Raw (WR)
Manganese, Total	08-Aug-11	39.889	West Raw (WR)
Manganese, Total	09-Aug-11	55.46	West Raw (WR)
Manganese, Total	10-Aug-11	39.9031	West Raw (WR)
Manganese, Total	11-Aug-11	35.42	West Raw (WR)
Manganese, Total	12-Aug-11	32.4937	West Raw (WR)
Manganese, Total	15-Aug-11	17.13	West Raw (WR)
Manganese, Total	16-Aug-11	11.9884	West Raw (WR)
Manganese, Total	17-Aug-11	25.0406	West Raw (WR)
Manganese, Total	18-Aug-11	44.48	West Raw (WR)
Manganese, Total	19-Aug-11	55.9116	West Raw (WR)
Manganese, Total	22-Aug-11	65.5633	West Raw (WR)

Manganese, Total	23-Aug-11	53.12	West Raw (WR)
Manganese, Total	24-Aug-11	89.865	West Raw (WR)
Manganese, Total	25-Aug-11	47.1653	West Raw (WR)
Manganese, Total	26-Aug-11	70.64	West Raw (WR)
Manganese, Total	29-Aug-11	28.6904	West Raw (WR)
Manganese, Total	30-Aug-11	25.9262	West Raw (WR)
Manganese, Total	31-Aug-11	30.1416	West Raw (WR)
Manganese, Total	01-Sep-11	37.8956	West Raw (WR)
Manganese, Total	02-Sep-11	21.9621	West Raw (WR)
Manganese, Total	06-Sep-11	36.09	West Raw (WR)
Manganese, Total	07-Sep-11	44.6	West Raw (WR)
Manganese, Total	08-Sep-11	20.72	West Raw (WR)
Manganese, Total	09-Sep-11	30.56	West Raw (WR)
Manganese, Total	12-Sep-11	37.93	West Raw (WR)
Manganese, Total	13-Sep-11	33.62	West Raw (WR)
Manganese, Total	14-Sep-11	36.93	West Raw (WR)
Manganese, Total	15-Sep-11	51.48	West Raw (WR)
Manganese, Total	16-Sep-11	35.23	West Raw (WR)
Manganese, Total	19-Sep-11	28.11	West Raw (WR)
Manganese, Total	20-Sep-11	38.01	West Raw (WR)
Manganese, Total	21-Sep-11	30.01	West Raw (WR)
Manganese, Total	22-Sep-11	30.29	West Raw (WR)
Manganese, Total	23-Sep-11	26.76	West Raw (WR)
Manganese, Total	26-Sep-11	33.99	West Raw (WR)
Manganese, Total	27-Sep-11	46.71	West Raw (WR)

Manganese, Total	28-Sep-11	72.75	West Raw (WR)
Manganese, Total	29-Sep-11	100.453	West Raw (WR)
Manganese, Total	30-Sep-11	99.0068	West Raw (WR)
Manganese, Total	03-Oct-11	56.6234	West Raw (WR)
Manganese, Total	04-Oct-11	78.3252	West Raw (WR)
Manganese, Total	05-Oct-11	67.5933	West Raw (WR)
Manganese, Total	06-Oct-11	48.2264	West Raw (WR)
Manganese, Total	07-Oct-11	50.96	West Raw (WR)
Manganese, Total	10-Oct-11	27.81	West Raw (WR)
Manganese, Total	11-Oct-11	31.01	West Raw (WR)
Manganese, Total	12-Oct-11	21.88	West Raw (WR)
Manganese, Total	13-Oct-11	9.88	West Raw (WR)
Manganese, Total	14-Oct-11	3.7	West Raw (WR)
Manganese, Total	17-Oct-11	11.25	West Raw (WR)
Manganese, Total	18-Oct-11	16.14	West Raw (WR)
Manganese, Total	19-Oct-11	83.2	West Raw (WR)
Manganese, Total	20-Oct-11	93.85	West Raw (WR)
Manganese, Total	21-Oct-11	62.12	West Raw (WR)
Manganese, Total	24-Oct-11	51.13	West Raw (WR)
Manganese, Total	25-Oct-11	52.76	West Raw (WR)
Manganese, Total	26-Oct-11	63.77	West Raw (WR)
Manganese, Total	27-Oct-11	51.19	West Raw (WR)
Manganese, Total	28-Oct-11	155.32	West Raw (WR)
Manganese, Total	31-Oct-11	49.23	West Raw (WR)
Manganese, Total	01-Nov-11	27.45	West Raw (WR)

Manganese, Total	02-Nov-11	33.9	West Raw (WR)
Manganese, Total	03-Nov-11	32.4715	West Raw (WR)
Manganese, Total	04-Nov-11	32.0262	West Raw (WR)
Manganese, Total	07-Nov-11	41.7488	West Raw (WR)
Manganese, Total	08-Nov-11	36.9582	West Raw (WR)
Manganese, Total	09-Nov-11	49.2341	West Raw (WR)
Manganese, Total	14-Nov-11	51.03	West Raw (WR)
Manganese, Total	18-Nov-11	5.86	West Raw (WR)
Manganese, Total	21-Nov-11	8.01	West Raw (WR)
Manganese, Total	15-Nov-11	49.97	West Raw (WR)
Manganese, Total	16-Nov-11	48.69	West Raw (WR)
Manganese, Total	17-Nov-11	23.66	West Raw (WR)
Manganese, Total	22-Nov-11	7.76	West Raw (WR)
Manganese, Total	23-Nov-11	9.8	West Raw (WR)

In 2012

Param	Collect Date	Numerical Results	Sites
Manganese, Total	05-Jan-12	65.02	West Raw (WR)
Manganese, Total	06-Jan-12	23.16	West Raw (WR)
Manganese, Total	09-Jan-12	10.98	West Raw (WR)
Manganese, Total	10-Jan-12	9.85	West Raw (WR)
Manganese, Total	11-Jan-12	9.77	West Raw (WR)
Manganese, Total	12-Jan-12	12.05	West Raw (WR)
Manganese, Total	13-Jan-12	2.27	West Raw (WR)
Manganese, Total	17-Jan-12	8.2	West Raw (WR)

Manganese, Total	18-Jan-12	5.57	West Raw (WR)
Manganese, Total	19-Jan-12	10.12	West Raw (WR)
Manganese, Total	20-Jan-12	8.7	West Raw (WR)
Manganese, Total	23-Jan-12	23.24	West Raw (WR)
Manganese, Total	24-Jan-12	21.45	West Raw (WR)
Manganese, Total	25-Jan-12	19.48	West Raw (WR)
Manganese, Total	26-Jan-12	16.15	West Raw (WR)
Manganese, Total	27-Jan-12	14.6	West Raw (WR)
Manganese, Total	30-Jan-12	13.61	West Raw (WR)
Manganese, Total	31-Jan-12	11.55	West Raw (WR)
Manganese, Total	01-Feb-12	14.68	West Raw (WR)
Manganese, Total	02-Feb-12	12.16	West Raw (WR)
Manganese, Total	03-Feb-12	9.7	West Raw (WR)
Manganese, Total	06-Feb-12	10.24	West Raw (WR)
Manganese, Total	13-Feb-12	25.11	West Raw (WR)
Manganese, Total	14-Feb-12	31.41	West Raw (WR)
Manganese, Total	15-Feb-12	34.25	West Raw (WR)
Manganese, Total	07-Mar-12	21.74	West Raw (WR)
Manganese, Total	08-Mar-12	21.35	West Raw (WR)
Manganese, Total	13-Apr-12	18.99	West Raw (WR)
Manganese, Total	16-Apr-12	23.03	West Raw (WR)
Manganese, Total	17-Apr-12	23.02	West Raw (WR)
Manganese, Total	18-Apr-12	31.79	West Raw (WR)
Manganese, Total	19-Apr-12	22.44	West Raw (WR)
Manganese, Total	20-Apr-12	1.7299	West Raw (WR)

Manganese, Total	23-Apr-12	55.1	West Raw (WR)
Manganese, Total	24-Apr-12	50.49	West Raw (WR)
Manganese, Total	25-Apr-12	68.018	West Raw (WR)
Manganese, Total	26-Apr-12	56.6615	West Raw (WR)
Manganese, Total	27-Apr-12	70.4043	West Raw (WR)
Manganese, Total	30-Apr-12	64.73	West Raw (WR)
Manganese, Total	01-May-12	71.21	West Raw (WR)
Manganese, Total	02-May-12	53.7208	West Raw (WR)
Manganese, Total	03-May-12	76.2583	West Raw (WR)
Manganese, Total	04-May-12	32.2952	West Raw (WR)
Manganese, Total	07-May-12	39.4575	West Raw (WR)
Manganese, Total	08-May-12	47.2508	West Raw (WR)
Manganese, Total	09-May-12	40.0003	West Raw (WR)
Manganese, Total	10-May-12	92.3844	West Raw (WR)
Manganese, Total	11-May-12	83.0343	West Raw (WR)
Manganese, Total	14-May-12	75.9605	West Raw (WR)
Manganese, Total	15-May-12	79.13	West Raw (WR)
Manganese, Total	16-May-12	88.86	West Raw (WR)
Manganese, Total	17-May-12	96.8316	West Raw (WR)
Manganese, Total	18-May-12	62.053	West Raw (WR)
Manganese, Total	21-May-12	33.5185	West Raw (WR)
Manganese, Total	22-May-12	21.1638	West Raw (WR)
Manganese, Total	23-May-12	18.0703	West Raw (WR)
Manganese, Total	24-May-12	22.09	West Raw (WR)
Manganese, Total	25-May-12	45.27	West Raw (WR)

Manganese, Total	29-May-12	63.24	West Raw (WR)
Manganese, Total	30-May-12	107.01	West Raw (WR)
Manganese, Total	31-May-12	91.292	West Raw (WR)
Manganese, Total	01-Jun-12	85.8607	West Raw (WR)
Manganese, Total	04-Jun-12	126.813	West Raw (WR)
Manganese, Total	05-Jun-12	71.8291	West Raw (WR)
Manganese, Total	06-Jun-12	104.267	West Raw (WR)
Manganese, Total	07-Jun-12	87.7901	West Raw (WR)
Manganese, Total	08-Jun-12	90.6894	West Raw (WR)
Manganese, Total	11-Jun-12	78.4251	West Raw (WR)
Manganese, Total	12-Jun-12	124.18	West Raw (WR)
Manganese, Total	13-Jun-12	91.9988	West Raw (WR)
Manganese, Total	14-Jun-12	97.3602	West Raw (WR)
Manganese, Total	15-Jun-12	98.6353	West Raw (WR)
Manganese, Total	18-Jun-12	210.106	West Raw (WR)
Manganese, Total	19-Jun-12	91.9889	West Raw (WR)
Manganese, Total	20-Jun-12	88.8683	West Raw (WR)
Manganese, Total	21-Jun-12	77.5313	West Raw (WR)
Manganese, Total	22-Jun-12	58.6218	West Raw (WR)
Manganese, Total	25-Jun-12	128.96	West Raw (WR)
Manganese, Total	26-Jun-12	73.83	West Raw (WR)
Manganese, Total	27-Jun-12	73.91	West Raw (WR)
Manganese, Total	28-Jun-12	84.45	West Raw (WR)
Manganese, Total	29-Jun-12	93.5498	West Raw (WR)
Manganese, Total	02-Jul-12	101.16	West Raw (WR)

Manganese, Total	03-Jul-12	78.94	West Raw (WR)
Manganese, Total	05-Jul-12	92.4758	West Raw (WR)
Manganese, Total	06-Jul-12	70.96	West Raw (WR)
Manganese, Total	09-Jul-12	69.13	West Raw (WR)
Manganese, Total	10-Jul-12	71.81	West Raw (WR)
Manganese, Total	11-Jul-12	90.91	West Raw (WR)
Manganese, Total	12-Jul-12	104.81	West Raw (WR)
Manganese, Total	13-Jul-12	58.91	West Raw (WR)
Manganese, Total	16-Jul-12	70.23	West Raw (WR)
Manganese, Total	17-Jul-12	77.79	West Raw (WR)
Manganese, Total	18-Jul-12	131.64	West Raw (WR)
Manganese, Total	19-Jul-12	88.73	West Raw (WR)
Manganese, Total	20-Jul-12	91.07	West Raw (WR)
Manganese, Total	23-Jul-12	99.0402	West Raw (WR)
Manganese, Total	24-Jul-12	97.5931	West Raw (WR)
Manganese, Total	25-Jul-12	105.501	West Raw (WR)
Manganese, Total	26-Jul-12	89.7	West Raw (WR)
Manganese, Total	27-Jul-12	74.09	West Raw (WR)
Manganese, Total	30-Jul-12	84.69	West Raw (WR)
Manganese, Total	31-Jul-12	98.83	West Raw (WR)
Manganese, Total	01-Aug-12	88.11	West Raw (WR)
Manganese, Total	02-Aug-12	96.56	West Raw (WR)
Manganese, Total	03-Aug-12	54.44	West Raw (WR)
Manganese, Total	06-Aug-12	108.24	West Raw (WR)
Manganese, Total	07-Aug-12	45.88	West Raw (WR)

Manganese, Total	08-Aug-12	62.86	West Raw (WR)
Manganese, Total	09-Aug-12	51.59	West Raw (WR)
Manganese, Total	10-Aug-12	75.14	West Raw (WR)
Manganese, Total	13-Aug-12	95.85	West Raw (WR)
Manganese, Total	14-Aug-12	117.39	West Raw (WR)
Manganese, Total	15-Aug-12	104.47	West Raw (WR)
Manganese, Total	16-Aug-12	118.51	West Raw (WR)
Manganese, Total	17-Aug-12	66.01	West Raw (WR)
Manganese, Total	20-Aug-12	156.37	West Raw (WR)
Manganese, Total	21-Aug-12	109.494	West Raw (WR)
Manganese, Total	22-Aug-12	73.43	West Raw (WR)
Manganese, Total	23-Aug-12	74.28	West Raw (WR)
Manganese, Total	24-Aug-12	80.42	West Raw (WR)
Manganese, Total	27-Aug-12	141.893	West Raw (WR)
Manganese, Total	28-Aug-12	64.21	West Raw (WR)
Manganese, Total	29-Aug-12	72.5264	West Raw (WR)
Manganese, Total	30-Aug-12	60.3311	West Raw (WR)
Manganese, Total	31-Aug-12	79.8	West Raw (WR)
Manganese, Total	04-Sep-12	173.611	West Raw (WR)
Manganese, Total	05-Sep-12	81.1722	West Raw (WR)
Manganese, Total	06-Sep-12	63.63	West Raw (WR)
Manganese, Total	07-Sep-12	46.0664	West Raw (WR)
Manganese, Total	10-Sep-12	50.5508	West Raw (WR)
Manganese, Total	11-Sep-12	106.468	West Raw (WR)
Manganese, Total	12-Sep-12	61.6752	West Raw (WR)

Manganese, Total	13-Sep-12	50.2205	West Raw (WR)
Manganese, Total	14-Sep-12	44.4067	West Raw (WR)
Manganese, Total	17-Sep-12	56.6456	West Raw (WR)
Manganese, Total	18-Sep-12	43.3823	West Raw (WR)
Manganese, Total	24-Sep-12	65.9963	West Raw (WR)
Manganese, Total	25-Sep-12	105.397	West Raw (WR)
Manganese, Total	26-Sep-12	34.9768	West Raw (WR)
Manganese, Total	27-Sep-12	13.43	West Raw (WR)
Manganese, Total	28-Sep-12	19.82	West Raw (WR)
Manganese, Total	01-Oct-12	59.11	West Raw (WR)
Manganese, Total	02-Oct-12	78.1677	West Raw (WR)
Manganese, Total	03-Oct-12	69.8609	West Raw (WR)
Manganese, Total	04-Oct-12	42.4948	West Raw (WR)
Manganese, Total	05-Oct-12	59.2952	West Raw (WR)
Manganese, Total	08-Oct-12	35.9275	West Raw (WR)
Manganese, Total	09-Oct-12	34.5616	West Raw (WR)
Manganese, Total	10-Oct-12	67.22	West Raw (WR)
Manganese, Total	11-Oct-12	50.7145	West Raw (WR)
Manganese, Total	12-Oct-12	64.9773	West Raw (WR)
Manganese, Total	15-Oct-12	71.9797	West Raw (WR)
Manganese, Total	16-Oct-12	55.5165	West Raw (WR)
Manganese, Total	17-Oct-12	51.1498	West Raw (WR)
Manganese, Total	18-Oct-12	106.373	West Raw (WR)
Manganese, Total	19-Oct-12	39.24	West Raw (WR)
Manganese, Total	22-Oct-12	89.69	West Raw (WR)

Manganese, Total	23-Oct-12	54.7	West Raw (WR)
Manganese, Total	24-Oct-12	47.23	West Raw (WR)
Manganese, Total	25-Oct-12	31.1545	West Raw (WR)
Manganese, Total	26-Oct-12	37.2005	West Raw (WR)
Manganese, Total	29-Oct-12	31.7626	West Raw (WR)
Manganese, Total	30-Oct-12	16.9672	West Raw (WR)
Manganese, Total	31-Oct-12	22.06	West Raw (WR)
Manganese, Total	05-Nov-12	224.465	West Raw (WR)
Manganese, Total	06-Nov-12	70.29	West Raw (WR)
Manganese, Total	07-Nov-12	255.394	West Raw (WR)
Manganese, Total	08-Nov-12	250.117	West Raw (WR)
Manganese, Total	09-Nov-12	221.36	West Raw (WR)
Manganese, Total	13-Nov-12	210.273	West Raw (WR)
Manganese, Total	14-Nov-12	184.191	West Raw (WR)
Manganese, Total	15-Nov-12	188.063	West Raw (WR)
Manganese, Total	16-Nov-12	183.286	West Raw (WR)
Manganese, Total	18-Dec-12	96.08	West Raw (WR)
Manganese, Total	19-Dec-12	88.6878	West Raw (WR)
Manganese, Total	20-Dec-12	61.7761	West Raw (WR)
Manganese, Total	21-Dec-12	58.7372	West Raw (WR)
Manganese, Total	24-Dec-12	76.2056	West Raw (WR)
Manganese, Total	26-Dec-12	63.5108	West Raw (WR)
Manganese, Total	27-Dec-12	61.1867	West Raw (WR)
Manganese, Total	28-Dec-12	56.9281	West Raw (WR)
Manganese, Total	31-Dec-12	54.0739	West Raw (WR)

In 2013			
Param	CollectDate	NumericResult	Site
Manganese, Total	1/2/2013	53.4265	West Raw (WR)
Manganese, Total	1/3/2013	64.4464	West Raw (WR)
Manganese, Total	1/4/2013	57.0237	West Raw (WR)
Manganese, Total	1/7/2013	62.3809	West Raw (WR)
Manganese, Total	1/8/2013	65.1949	West Raw (WR)
Manganese, Total	1/9/2013	72.3346	West Raw (WR)
Manganese, Total	1/10/2013	73.8596	West Raw (WR)
Manganese, Total	1/11/2013	77.3132	West Raw (WR)
Manganese, Total	1/14/2013	53.5668	West Raw (WR)
Manganese, Total	1/15/2013	51.85	West Raw (WR)
Manganese, Total	1/16/2013	64.2942	West Raw (WR)
Manganese, Total	1/17/2013	68.3682	West Raw (WR)
Manganese, Total	1/18/2013	64.291	West Raw (WR)
Manganese, Total	1/22/2013	141.155	West Raw (WR)
Manganese, Total	1/23/2013	118.485	West Raw (WR)
Manganese, Total	1/24/2013	96.555	West Raw (WR)
Manganese, Total	1/25/2013	97.1356	West Raw (WR)
Manganese, Total	1/28/2013	60.0674	West Raw (WR)
Manganese, Total	1/29/2013	55.3684	West Raw (WR)
Manganese, Total	1/30/2013	58.0005	West Raw (WR)
Manganese, Total	1/31/2013	47.8685	West Raw (WR)
Manganese, Total	2/1/2013	59.7389	West Raw (WR)

Manganese, Total	2/4/2013	78.7946	West Raw (WR)
Manganese, Total	2/5/2013	62.1905	West Raw (WR)
Manganese, Total	2/6/2013	70.7952	West Raw (WR)
Manganese, Total	2/7/2013	66.9215	West Raw (WR)
Manganese, Total	2/8/2013	63.8816	West Raw (WR)
Manganese, Total	2/11/2013	38.253	West Raw (WR)
Manganese, Total	2/12/2013	46.493	West Raw (WR)
Manganese, Total	2/13/2013	38.3416	West Raw (WR)
Manganese, Total	2/14/2013	46.8096	West Raw (WR)
Manganese, Total	2/15/2013	37.1474	West Raw (WR)
Manganese, Total	2/19/2013	66.4663	West Raw (WR)
Manganese, Total	2/20/2013	71.2939	West Raw (WR)
Manganese, Total	2/21/2013	54.3246	West Raw (WR)
Manganese, Total	2/22/2013	68.326	West Raw (WR)
Manganese, Total	2/25/2013	54.0992	West Raw (WR)
Manganese, Total	2/26/2013	48.273	West Raw (WR)
Manganese, Total	2/27/2013	57.3758	West Raw (WR)
Manganese, Total	2/28/2013	50.6213	West Raw (WR)
Manganese, Total	3/1/2013	43.9742	West Raw (WR)
Manganese, Total	3/4/2013	50.9048	West Raw (WR)
Manganese, Total	3/5/2013	47.9101	West Raw (WR)
Manganese, Total	3/6/2013	49.0236	West Raw (WR)
Manganese, Total	3/7/2013	54.9033	West Raw (WR)
Manganese, Total	3/8/2013	53.2515	West Raw (WR)
Manganese, Total	3/11/2013	53.2093	West Raw (WR)

Manganese, Total	3/12/2013	55.6858	West Raw (WR)
Manganese, Total	3/13/2013	54.7847	West Raw (WR)
Manganese, Total	3/14/2013	47.506	West Raw (WR)
Manganese, Total	3/15/2013	26.3742	West Raw (WR)
Manganese, Total	3/18/2013	56.7341	West Raw (WR)
Manganese, Total	3/19/2013	76.4387	West Raw (WR)
Manganese, Total	3/20/2013	80.4665	West Raw (WR)
Manganese, Total	3/21/2013	82.8319	West Raw (WR)
Manganese, Total	3/22/2013	82.0698	West Raw (WR)
Manganese, Total	3/25/2013	4.8796	West Raw (WR)
Manganese, Total	3/26/2013	3.5769	West Raw (WR)
Manganese, Total	3/27/2013	39.6974	West Raw (WR)
Manganese, Total	3/28/2013	46.9886	West Raw (WR)
Manganese, Total	3/29/2013	39.5081	West Raw (WR)
Manganese, Total	4/1/2013	24.605	West Raw (WR)
Manganese, Total	4/2/2013	22.8643	West Raw (WR)
Manganese, Total	4/3/2013	25.0759	West Raw (WR)
Manganese, Total	4/4/2013	23.9274	West Raw (WR)
Manganese, Total	4/5/2013	20.4229	West Raw (WR)
Manganese, Total	4/8/2013	6.1819	West Raw (WR)
Manganese, Total	4/9/2013	5.7618	West Raw (WR)
Manganese, Total	4/26/2013	73.1026	West Raw (WR)
Manganese, Total	4/29/2013	141.492	West Raw (WR)
Manganese, Total	4/30/2013	120.466	West Raw (WR)
Manganese, Total	5/1/2013	128.125	West Raw (WR)

Manganese, Total	5/2/2013	144.954	West Raw (WR)
Manganese, Total	5/3/2013	119.341	West Raw (WR)
Manganese, Total	5/6/2013	90.44	West Raw (WR)
Manganese, Total	5/7/2013	121.69	West Raw (WR)
Manganese, Total	5/8/2013	160.22	West Raw (WR)
Manganese, Total	5/9/2013	133	West Raw (WR)
Manganese, Total	5/10/2013	112.77	West Raw (WR)
Manganese, Total	5/13/2013	59.2323	West Raw (WR)
Manganese, Total	5/14/2013	124.528	West Raw (WR)
Manganese, Total	5/15/2013	172.272	West Raw (WR)
Manganese, Total	5/16/2013	116.753	West Raw (WR)
Manganese, Total	5/17/2013	126.675	West Raw (WR)
Manganese, Total	5/20/2013	144.479	West Raw (WR)
Manganese, Total	5/21/2013	45.8611	West Raw (WR)
Manganese, Total	5/22/2013	208.694	West Raw (WR)
Manganese, Total	5/23/2013	171.814	West Raw (WR)
Manganese, Total	5/24/2013	116.913	West Raw (WR)
Manganese, Total	5/28/2013	139.313	West Raw (WR)
Manganese, Total	5/29/2013	136.111	West Raw (WR)
Manganese, Total	5/30/2013	61.5187	West Raw (WR)
Manganese, Total	5/31/2013	168.24	West Raw (WR)
Manganese, Total	6/3/2013	156.655	West Raw (WR)
Manganese, Total	6/4/2013	69.7263	West Raw (WR)
Manganese, Total	6/5/2013	91.3936	West Raw (WR)
Manganese, Total	6/6/2013	87.4415	West Raw (WR)

Manganese, Total	6/7/2013	100.54	West Raw (WR)
Manganese, Total	6/10/2013	112.924	West Raw (WR)
Manganese, Total	6/11/2013	29.727	West Raw (WR)
Manganese, Total	6/12/2013	109.823	West Raw (WR)
Manganese, Total	6/13/2013	124.124	West Raw (WR)
Manganese, Total	6/14/2013	109.628	West Raw (WR)
Manganese, Total	6/17/2013	118.493	West Raw (WR)
Manganese, Total	6/18/2013	135.474	West Raw (WR)
Manganese, Total	6/19/2013	89.8974	West Raw (WR)
Manganese, Total	6/20/2013	138.391	West Raw (WR)
Manganese, Total	6/21/2013	104.618	West Raw (WR)
Manganese, Total	6/24/2013	49.3994	West Raw (WR)
Manganese, Total	6/25/2013	103.476	West Raw (WR)
Manganese, Total	6/26/2013	73.2397	West Raw (WR)
Manganese, Total	6/27/2013	77.756	West Raw (WR)
Manganese, Total	6/28/2013	103.709	West Raw (WR)
Manganese, Total	7/1/2013	122.597	West Raw (WR)
Manganese, Total	7/2/2013	205.101	West Raw (WR)
Manganese, Total	7/3/2013	101.389	West Raw (WR)
Manganese, Total	7/5/2013	87.0268	West Raw (WR)
Manganese, Total	7/8/2013	146.247	West Raw (WR)
Manganese, Total	7/9/2013	74.63	West Raw (WR)
Manganese, Total	7/10/2013	76.58	West Raw (WR)
Manganese, Total	7/11/2013	49.3347	West Raw (WR)
Manganese, Total	7/12/2013	102.105	West Raw (WR)

Manganese, Total	7/15/2013	108.392	West Raw (WR)
Manganese, Total	7/16/2013	138.029	West Raw (WR)
Manganese, Total	7/17/2013	75.4392	West Raw (WR)
Manganese, Total	7/18/2013	97.6803	West Raw (WR)

FROM THE EAST TREATMENT PLANT

Param	Collect Date	Numeric Result	Site
Manganese, Total	08-Apr-08	13.7449	East Raw (Tap 1) (ER)
Manganese, Total	09-Apr-08	93.9968	East Raw (Tap 1) (ER)
Manganese, Total	10-Apr-08	77.8117	East Raw (Tap 1) (ER)
Manganese, Total	11-Apr-08	85.5185	East Raw (Tap 1) (ER)
Manganese, Total	14-Apr-08	61.7156	East Raw (Tap 1) (ER)
Manganese, Total	15-Apr-08	22.0515	East Raw (Tap 1) (ER)
Manganese, Total	16-Apr-08	79.9119	East Raw (Tap 1) (ER)
Manganese, Total	17-Apr-08	61.2553	East Raw (Tap 1) (ER)
Manganese, Total	18-Apr-08	59.5684	East Raw (Tap 1) (ER)
Manganese, Total	21-Apr-08	63.9922	East Raw (Tap 1) (ER)
Manganese, Total	22-Apr-08	52.9381	East Raw (Tap 1) (ER)
Manganese, Total	23-Apr-08	60.8384	East Raw (Tap 1) (ER)
Manganese, Total	24-Apr-08	67.9357	East Raw (Tap 1) (ER)
Manganese, Total	25-Apr-08	57.129	East Raw (Tap 1) (ER)
Manganese, Total	28-Apr-08	41.499	East Raw (Tap 1) (ER)
Manganese, Total	29-Apr-08	42.9059	East Raw (Tap 1) (ER)
Manganese, Total	30-Apr-08	46.735	East Raw (Tap 1) (ER)
Manganese, Total	01-May-08	34.1154	East Raw (Tap 1) (ER)

Manganese, Total	02-May-08	50.6304	East Raw (Tap 1) (ER)
Manganese, Total	05-May-08	48.4588	East Raw (Tap 1) (ER)
Manganese, Total	06-May-08	45.1493	East Raw (Tap 1) (ER)
Manganese, Total	07-May-08	46.1099	East Raw (Tap 1) (ER)
Manganese, Total	08-May-08	48.5488	East Raw (Tap 1) (ER)
Manganese, Total	09-May-08	39.4664	East Raw (Tap 1) (ER)
Manganese, Total	12-May-08	47.2385	East Raw (Tap 1) (ER)
Manganese, Total	13-May-08	35.4041	East Raw (Tap 1) (ER)
Manganese, Total	14-May-08	72.87	East Raw (Tap 1) (ER)
Manganese, Total	15-May-08	24.2711	East Raw (Tap 1) (ER)
Manganese, Total	16-May-08	35.5855	East Raw (Tap 1) (ER)
Manganese, Total	19-May-08	48.5027	East Raw (Tap 1) (ER)
Manganese, Total	20-May-08	32.41	East Raw (Tap 1) (ER)
Manganese, Total	21-May-08	30.8593	East Raw (Tap 1) (ER)
Manganese, Total	22-May-08	53.8273	East Raw (Tap 1) (ER)
Manganese, Total	07-Jul-08	48.96	East Raw (Tap 1) (ER)
Manganese, Total	08-Jul-08	64.98	East Raw (Tap 1) (ER)
Manganese, Total	09-Jul-08	46.72	East Raw (Tap 1) (ER)
Manganese, Total	10-Jul-08	42.01	East Raw (Tap 1) (ER)
Manganese, Total	11-Jul-08	45.11	East Raw (Tap 1) (ER)
Manganese, Total	14-Jul-08	37.63	East Raw (Tap 1) (ER)
Manganese, Total	15-Jul-08	45.14	East Raw (Tap 1) (ER)
Manganese, Total	16-Jul-08	42.94	East Raw (Tap 1) (ER)
Manganese, Total	17-Jul-08	56.59	East Raw (Tap 1) (ER)
Manganese, Total	18-Jul-08	58.46	East Raw (Tap 1) (ER)

Manganese, Total	21-Jul-08	47.0484	East Raw (Tap 1) (ER)
Manganese, Total	22-Jul-08	52.0892	East Raw (Tap 1) (ER)
Manganese, Total	23-Jul-08	60.2637	East Raw (Tap 1) (ER)
Manganese, Total	24-Jul-08	55.9386	East Raw (Tap 1) (ER)
Manganese, Total	25-Jul-08	57.4784	East Raw (Tap 1) (ER)
Manganese, Total	28-Jul-08	59.3306	East Raw (Tap 1) (ER)
Manganese, Total	29-Jul-08	47.5961	East Raw (Tap 1) (ER)
Manganese, Total	30-Jul-08	64.2447	East Raw (Tap 1) (ER)
Manganese, Total	31-Jul-08	51.2479	East Raw (Tap 1) (ER)
Manganese, Total	01-Aug-08	56.2999	East Raw (Tap 1) (ER)
Manganese, Total	04-Aug-08	41.8738	East Raw (Tap 1) (ER)
Manganese, Total	05-Aug-08	38.2875	East Raw (Tap 1) (ER)
Manganese, Total	06-Aug-08	52.4033	East Raw (Tap 1) (ER)
Manganese, Total	07-Aug-08	62.1613	East Raw (Tap 1) (ER)
Manganese, Total	08-Aug-08	70.4414	East Raw (Tap 1) (ER)
Manganese, Total	11-Aug-08	39.9051	East Raw (Tap 1) (ER)
Manganese, Total	12-Aug-08	58.0103	East Raw (Tap 1) (ER)
Manganese, Total	13-Aug-08	48.4611	East Raw (Tap 1) (ER)
Manganese, Total	14-Aug-08	49.3888	East Raw (Tap 1) (ER)
Manganese, Total	15-Aug-08	61.9465	East Raw (Tap 1) (ER)
Manganese, Total	18-Aug-08	68.9469	East Raw (Tap 1) (ER)
Manganese, Total	19-Aug-08	66.894	East Raw (Tap 1) (ER)
Manganese, Total	20-Aug-08	78.923	East Raw (Tap 1) (ER)
Manganese, Total	21-Aug-08	70.6078	East Raw (Tap 1) (ER)
Manganese, Total	22-Aug-08	68.0411	East Raw (Tap 1) (ER)

Manganese, Total	25-Aug-08	74.5435	East Raw (Tap 1) (ER)
Manganese, Total	26-Aug-08	175.236	East Raw (Tap 1) (ER)
Manganese, Total	27-Aug-08	47.7836	East Raw (Tap 1) (ER)
Manganese, Total	28-Aug-08	59.3775	East Raw (Tap 1) (ER)
Manganese, Total	29-Aug-08	17.1232	East Raw (Tap 1) (ER)
Manganese, Total	02-Sep-08	15.3299	East Raw (Tap 1) (ER)
Manganese, Total	03-Sep-08	58.8467	East Raw (Tap 1) (ER)
Manganese, Total	04-Sep-08	149.59	East Raw (Tap 1) (ER)
Manganese, Total	05-Sep-08	49.6346	East Raw (Tap 1) (ER)
Manganese, Total	08-Sep-08	91.5293	East Raw (Tap 1) (ER)
Manganese, Total	09-Sep-08	60.1439	East Raw (Tap 1) (ER)
Manganese, Total	15-Sep-08	175.409	East Raw (Tap 1) (ER)
Manganese, Total	16-Sep-08	73.3871	East Raw (Tap 1) (ER)
Manganese, Total	17-Sep-08	79.0774	East Raw (Tap 1) (ER)
Manganese, Total	18-Sep-08	45.3659	East Raw (Tap 1) (ER)
Manganese, Total	19-Sep-08	80.0408	East Raw (Tap 1) (ER)
Manganese, Total	22-Sep-08	136.611	East Raw (Tap 1) (ER)
Manganese, Total	23-Sep-08	76.4137	East Raw (Tap 1) (ER)
Manganese, Total	24-Sep-08	60.2672	East Raw (Tap 1) (ER)
Manganese, Total	25-Sep-08	75.0214	East Raw (Tap 1) (ER)
Manganese, Total	26-Sep-08	49.0073	East Raw (Tap 1) (ER)
Manganese, Total	29-Sep-08	57.66	East Raw (Tap 1) (ER)
Manganese, Total	30-Sep-08	39.82	East Raw (Tap 1) (ER)
Manganese, Total	01-Oct-08	66.27	East Raw (Tap 1) (ER)

Manganese, Total	02-Oct-08	94.7741	East Raw (Tap 1) (ER)
Manganese, Total	03-Oct-08	38.343	East Raw (Tap 1) (ER)
Manganese, Total	06-Oct-08	45.0567	East Raw (Tap 1) (ER)
Manganese, Total	07-Oct-08	50.3831	East Raw (Tap 1) (ER)
Manganese, Total	08-Oct-08	13.7426	East Raw (Tap 1) (ER)
Manganese, Total	09-Oct-08	10.4814	East Raw (Tap 1) (ER)
Manganese, Total	10-Oct-08	72.1821	East Raw (Tap 1) (ER)
Manganese, Total	13-Oct-08	64.42	East Raw (Tap 1) (ER)
Manganese, Total	14-Oct-08	47.38	East Raw (Tap 1) (ER)
Manganese, Total	15-Oct-08	35.23	East Raw (Tap 1) (ER)
Manganese, Total	16-Oct-08	37.36	East Raw (Tap 1) (ER)
Manganese, Total	17-Oct-08	36.45	East Raw (Tap 1) (ER)
Manganese, Total	20-Oct-08	29.08	East Raw (Tap 1) (ER)
Manganese, Total	21-Oct-08	35.4	East Raw (Tap 1) (ER)
Manganese, Total	22-Oct-08	32.16	East Raw (Tap 1) (ER)
Manganese, Total	23-Oct-08	33.16	East Raw (Tap 1) (ER)
Manganese, Total	24-Oct-08	95.65	East Raw (Tap 1) (ER)
Manganese, Total	27-Oct-08	41.07	East Raw (Tap 1) (ER)
Manganese, Total	28-Oct-08	36.29	East Raw (Tap 1) (ER)
Manganese, Total	29-Oct-08	36.69	East Raw (Tap 1) (ER)
Manganese, Total	30-Oct-08	47.92	East Raw (Tap 1) (ER)
Manganese, Total	31-Oct-08	67.89	East Raw (Tap 1) (ER)
Manganese, Total	03-Nov-08	33.14	East Raw (Tap 1) (ER)
Manganese, Total	04-Nov-08	54.51	East Raw (Tap 1) (ER)
Manganese, Total	05-Nov-08	85.05	East Raw (Tap 1) (ER)

Manganese, Total	06-Nov-08	35.0682	East Raw (Tap 1) (ER)
Manganese, Total	07-Nov-08	31.59	East Raw (Tap 1) (ER)
Manganese, Total	10-Nov-08	29.3	East Raw (Tap 1) (ER)
Manganese, Total	12-Nov-08	18.67	East Raw (Tap 1) (ER)
Manganese, Total	13-Nov-08	26.19	East Raw (Tap 1) (ER)
Manganese, Total	14-Nov-08	26.77	East Raw (Tap 1) (ER)
Manganese, Total	17-Nov-08	18.5736	East Raw (Tap 1) (ER)
Manganese, Total	18-Nov-08	19.9009	East Raw (Tap 1) (ER)
Manganese, Total	19-Nov-08	16.76	East Raw (Tap 1) (ER)
Manganese, Total	20-Nov-08	17.4457	East Raw (Tap 1) (ER)
Manganese, Total	21-Nov-08	22.4953	East Raw (Tap 1) (ER)
Manganese, Total	24-Nov-08	41.0602	East Raw (Tap 1) (ER)
Manganese, Total	25-Nov-08	44.1625	East Raw (Tap 1) (ER)
Manganese, Total	26-Nov-08	44.9335	East Raw (Tap 1) (ER)
Manganese, Total	01-Dec-08	33.4213	East Raw (Tap 1) (ER)
Manganese, Total	02-Dec-08	340.506	East Raw (Tap 1) (ER)
Manganese, Total	03-Dec-08	35.0722	East Raw (Tap 1) (ER)
Manganese, Total	04-Dec-08	43.8266	East Raw (Tap 1) (ER)
Manganese, Total	05-Dec-08	262.049	East Raw (Tap 1) (ER)
Manganese, Total	08-Dec-08	54.8725	East Raw (Tap 1) (ER)
Manganese, Total	09-Dec-08	44.5788	East Raw (Tap 1) (ER)
Manganese, Total	10-Dec-08	42.2079	East Raw (Tap 1) (ER)
Manganese, Total	11-Dec-08	37.3214	East Raw (Tap 1) (ER)
Manganese, Total	12-Dec-08	38.0129	East Raw (Tap 1) (ER)
Manganese, Total	15-Dec-08	39.5979	East Raw (Tap 1) (ER)

Manganese, Total	16-Dec-08	39.3058	East Raw (Tap 1) (ER)
Manganese, Total	17-Dec-08	38.1398	East Raw (Tap 1) (ER)
Manganese, Total	18-Dec-08	43.8986	East Raw (Tap 1) (ER)
Manganese, Total	19-Dec-08	38.0049	East Raw (Tap 1) (ER)
Manganese, Total	22-Dec-08	38.4293	East Raw (Tap 1) (ER)
Manganese, Total	23-Dec-08	36.0984	East Raw (Tap 1) (ER)
Manganese, Total	24-Dec-08	39.5154	East Raw (Tap 1) (ER)
Manganese, Total	26-Dec-08	36.2761	East Raw (Tap 1) (ER)
Manganese, Total	29-Dec-08	35.4343	East Raw (Tap 1) (ER)
Manganese, Total	30-Dec-08	33.1102	East Raw (Tap 1) (ER)

In 2011

Param	Collect Date	Numerical Result	Site
Manganese, Total	03-Jan-11	27.6408	East Raw (Tap 1) (ER)
Manganese, Total	04-Jan-11	57.9392	East Raw (Tap 1) (ER)
Manganese, Total	05-Jan-11	65.5714	East Raw (Tap 1) (ER)
Manganese, Total	06-Jan-11	31.9615	East Raw (Tap 1) (ER)
Manganese, Total	07-Jan-11	101.582	East Raw (Tap 1) (ER)
Manganese, Total	10-Jan-11	69.5524	East Raw (Tap 1) (ER)
Manganese, Total	11-Jan-11	21.8232	East Raw (Tap 1) (ER)
Manganese, Total	12-Jan-11	29.1945	East Raw (Tap 1) (ER)
Manganese, Total	13-Jan-11	38.8103	East Raw (Tap 1) (ER)
Manganese, Total	14-Jan-11	35.0921	East Raw (Tap 1) (ER)

Manganese, Total	18-Jan-11	16.9161	East Raw (Tap 1) (ER)
Manganese, Total	19-Jan-11	22.7322	East Raw (Tap 1) (ER)
Manganese, Total	20-Jan-11	25.3152	East Raw (Tap 1) (ER)
Manganese, Total	21-Jan-11	39.4534	East Raw (Tap 1) (ER)
Manganese, Total	24-Jan-11	74.8585	East Raw (Tap 1) (ER)
Manganese, Total	25-Jan-11	33.9164	East Raw (Tap 1) (ER)
Manganese, Total	26-Jan-11	38.2883	East Raw (Tap 1) (ER)
Manganese, Total	27-Jan-11	113.853	East Raw (Tap 1) (ER)
Manganese, Total	28-Jan-11	38.8285	East Raw (Tap 1) (ER)
Manganese, Total	31-Jan-11	18.9218	East Raw (Tap 1) (ER)
Manganese, Total	01-Feb-11	34.6365	East Raw (Tap 1) (ER)
Manganese, Total	02-Feb-11	20.877	East Raw (Tap 1) (ER)
Manganese, Total	03-Feb-11	38.2475	East Raw (Tap 1) (ER)
Manganese, Total	04-Feb-11	97.9009	East Raw (Tap 1) (ER)
Manganese, Total	07-Feb-11	23.484	East Raw (Tap 1) (ER)
Manganese, Total	08-Feb-11	215.929	East Raw (Tap 1) (ER)
Manganese, Total	09-Feb-11	27.969	East Raw (Tap 1) (ER)
Manganese, Total	10-Feb-11	35.1351	East Raw (Tap 1) (ER)
Manganese, Total	11-Feb-11	107.079	East Raw (Tap 1) (ER)
Manganese, Total	14-Feb-11	35.4296	East Raw (Tap 1) (ER)
Manganese, Total	10-Mar-11	301.513	East Raw (Tap 1) (ER)
Manganese, Total	11-Mar-11	39.6079	East Raw (Tap 1) (ER)
Manganese, Total	14-Mar-11	36.5884	East Raw (Tap 1) (ER)
Manganese, Total	15-Mar-11	42.52	East Raw (Tap 1) (ER)
Manganese, Total	16-Mar-11	136.655	East Raw (Tap 1) (ER)

Manganese, Total	17-Mar-11	130.741	East Raw (Tap 1) (ER)
Manganese, Total	18-Mar-11	62.4407	East Raw (Tap 1) (ER)
Manganese, Total	21-Mar-11	33.1898	East Raw (Tap 1) (ER)
Manganese, Total	22-Mar-11	28.6773	East Raw (Tap 1) (ER)
Manganese, Total	23-Mar-11	35.2869	East Raw (Tap 1) (ER)
Manganese, Total	24-Mar-11	31.6007	East Raw (Tap 1) (ER)
Manganese, Total	25-Mar-11	23.1389	East Raw (Tap 1) (ER)
Manganese, Total	28-Mar-11	19.6775	East Raw (Tap 1) (ER)
Manganese, Total	29-Mar-11	17.0521	East Raw (Tap 1) (ER)
Manganese, Total	30-Mar-11	18.7403	East Raw (Tap 1) (ER)
Manganese, Total	31-Mar-11	23.1925	East Raw (Tap 1) (ER)
Manganese, Total	01-Apr-11	23.5153	East Raw (Tap 1) (ER)
Manganese, Total	04-Apr-11	17.4146	East Raw (Tap 1) (ER)
Manganese, Total	05-Apr-11	17.3661	East Raw (Tap 1) (ER)
Manganese, Total	06-Apr-11	16.6635	East Raw (Tap 1) (ER)
Manganese, Total	07-Apr-11	18.7695	East Raw (Tap 1) (ER)
Manganese, Total	08-Apr-11	13.299	East Raw (Tap 1) (ER)
Manganese, Total	11-Apr-11	14.8131	East Raw (Tap 1) (ER)
Manganese, Total	12-Apr-11	18.1776	East Raw (Tap 1) (ER)
Manganese, Total	13-Apr-11	18.3416	East Raw (Tap 1) (ER)
Manganese, Total	14-Apr-11	12.12	East Raw (Tap 1) (ER)
Manganese, Total	15-Apr-11	12.0875	East Raw (Tap 1) (ER)
Manganese, Total	18-Apr-11	17.3139	East Raw (Tap 1) (ER)
Manganese, Total	19-Apr-11	14.6681	East Raw (Tap 1) (ER)
Manganese, Total	20-Apr-11	14.3826	East Raw (Tap 1) (ER)

Manganese, Total	21-Apr-11	32.3326	East Raw (Tap 1) (ER)
Manganese, Total	22-Apr-11	18.9743	East Raw (Tap 1) (ER)
Manganese, Total	25-Apr-11	6.7148	East Raw (Tap 1) (ER)
Manganese, Total	26-Apr-11	11.1727	East Raw (Tap 1) (ER)
Manganese, Total	27-Apr-11	55.0451	East Raw (Tap 1) (ER)
Manganese, Total	29-Apr-11	15.511	East Raw (Tap 1) (ER)
Manganese, Total	02-May-11	32.8304	East Raw (Tap 1) (ER)
Manganese, Total	03-May-11	22.6106	East Raw (Tap 1) (ER)
Manganese, Total	04-May-11	30.6526	East Raw (Tap 1) (ER)
Manganese, Total	05-May-11	15.2179	East Raw (Tap 1) (ER)
Manganese, Total	06-May-11	20.6731	East Raw (Tap 1) (ER)
Manganese, Total	09-May-11	34.0564	East Raw (Tap 1) (ER)
Manganese, Total	10-May-11	3.0941	East Raw (Tap 1) (ER)
Manganese, Total	11-May-11	33.9406	East Raw (Tap 1) (ER)
Manganese, Total	12-May-11	21.4704	East Raw (Tap 1) (ER)
Manganese, Total	13-May-11	7.6406	East Raw (Tap 1) (ER)
Manganese, Total	03-Jan-11	17.25448853	East Raw (Tap 1) (ER)
Manganese, Total	04-Jan-11	16.63962562	East Raw (Tap 1) (ER)
Manganese, Total	05-Jan-11	16.02476271	East Raw (Tap 1) (ER)
Manganese, Total	06-Jan-11	15.4098998	East Raw (Tap 1) (ER)
Manganese, Total	07-Jan-11	14.79503689	East Raw (Tap 1) (ER)
Manganese, Total	10-Jan-11	14.18017398	East Raw (Tap 1) (ER)
Manganese, Total	11-Jan-11	13.56531107	East Raw (Tap 1) (ER)
Manganese, Total	02-Jun-11	14.9805	East Raw (Tap 1) (ER)
Manganese, Total	03-Jun-11	37.2964	East Raw (Tap 1) (ER)

Manganese, Total	06-Jun-11	31.0804	East Raw (Tap 1) (ER)
Manganese, Total	07-Jun-11	24.2634	East Raw (Tap 1) (ER)
Manganese, Total	08-Jun-11	24.0713	East Raw (Tap 1) (ER)
Manganese, Total	09-Jun-11	23.3679	East Raw (Tap 1) (ER)
Manganese, Total	10-Jun-11	24.2308	East Raw (Tap 1) (ER)
Manganese, Total	13-Jun-11	24.1676	East Raw (Tap 1) (ER)
Manganese, Total	14-Jun-11	26.1341	East Raw (Tap 1) (ER)
Manganese, Total	15-Jun-11	29.3578	East Raw (Tap 1) (ER)
Manganese, Total	22-Jun-11	32.8533	East Raw (Tap 1) (ER)
Manganese, Total	23-Jun-11	27.3	East Raw (Tap 1) (ER)
Manganese, Total	24-Jun-11	15.6358	East Raw (Tap 1) (ER)
Manganese, Total	27-Jun-11	45.3034	East Raw (Tap 1) (ER)
Manganese, Total	28-Jun-11	38.1539	East Raw (Tap 1) (ER)
Manganese, Total	29-Jun-11	25.0537	East Raw (Tap 1) (ER)
Manganese, Total	30-Jun-11	21.43	East Raw (Tap 1) (ER)
Manganese, Total	01-Jul-11	22.6878	East Raw (Tap 1) (ER)
Manganese, Total	05-Jul-11	32.9772	East Raw (Tap 1) (ER)
Manganese, Total	06-Jul-11	32.6308	East Raw (Tap 1) (ER)
Manganese, Total	07-Jul-11	29.0713	East Raw (Tap 1) (ER)
Manganese, Total	08-Jul-11	25.9622	East Raw (Tap 1) (ER)
Manganese, Total	11-Jul-11	32.9374	East Raw (Tap 1) (ER)
Manganese, Total	12-Jul-11	25.9971	East Raw (Tap 1) (ER)
Manganese, Total	13-Jul-11	18.9333	East Raw (Tap 1) (ER)
Manganese, Total	14-Jul-11	13.76	East Raw (Tap 1) (ER)
Manganese, Total	15-Jul-11	22.293	East Raw (Tap 1) (ER)

Manganese, Total	18-Jul-11	23.7498	East Raw (Tap 1) (ER)
Manganese, Total	19-Jul-11	29.4714	East Raw (Tap 1) (ER)
Manganese, Total	20-Jul-11	32.69	East Raw (Tap 1) (ER)
Manganese, Total	21-Jul-11	23.8258	East Raw (Tap 1) (ER)
Manganese, Total	22-Jul-11	17.3734	East Raw (Tap 1) (ER)
Manganese, Total	25-Jul-11	23.917	East Raw (Tap 1) (ER)
Manganese, Total	26-Jul-11	59.7699	East Raw (Tap 1) (ER)
Manganese, Total	27-Jul-11	16.7023	East Raw (Tap 1) (ER)
Manganese, Total	28-Jul-11	10.6084	East Raw (Tap 1) (ER)
Manganese, Total	29-Jul-11	18.4104	East Raw (Tap 1) (ER)
Manganese, Total	01-Aug-11	21.4291	East Raw (Tap 1) (ER)
Manganese, Total	02-Aug-11	21.8581	East Raw (Tap 1) (ER)
Manganese, Total	03-Aug-11	34.2395	East Raw (Tap 1) (ER)
Manganese, Total	04-Aug-11	35.92	East Raw (Tap 1) (ER)
Manganese, Total	05-Aug-11	36.409	East Raw (Tap 1) (ER)
Manganese, Total	08-Aug-11	37.2577	East Raw (Tap 1) (ER)
Manganese, Total	09-Aug-11	37.56	East Raw (Tap 1) (ER)
Manganese, Total	10-Aug-11	53.5812	East Raw (Tap 1) (ER)
Manganese, Total	11-Aug-11	45.77	East Raw (Tap 1) (ER)
Manganese, Total	12-Aug-11	49.3041	East Raw (Tap 1) (ER)
Manganese, Total	15-Aug-11	27.43	East Raw (Tap 1) (ER)
Manganese, Total	16-Aug-11	12.6997	East Raw (Tap 1) (ER)
Manganese, Total	17-Aug-11	35.5411	East Raw (Tap 1) (ER)
Manganese, Total	18-Aug-11	25.3	East Raw (Tap 1) (ER)
Manganese, Total	19-Aug-11	24.0262	East Raw (Tap 1) (ER)

Manganese, Total	22-Aug-11	25.1026	East Raw (Tap 1) (ER)
Manganese, Total	23-Aug-11	25.35	East Raw (Tap 1) (ER)
Manganese, Total	24-Aug-11	32.6736	East Raw (Tap 1) (ER)
Manganese, Total	25-Aug-11	26.3586	East Raw (Tap 1) (ER)
Manganese, Total	26-Aug-11	24.24	East Raw (Tap 1) (ER)
Manganese, Total	29-Aug-11	31.7834	East Raw (Tap 1) (ER)
Manganese, Total	30-Aug-11	29.9157	East Raw (Tap 1) (ER)
Manganese, Total	31-Aug-11	30.8045	East Raw (Tap 1) (ER)
Manganese, Total	01-Sep-11	44.4173	East Raw (Tap 1) (ER)
Manganese, Total	02-Sep-11	24.6808	East Raw (Tap 1) (ER)
Manganese, Total	06-Oct-11	86.4531	East Raw (Tap 1) (ER)
Manganese, Total	07-Oct-11	57.12	East Raw (Tap 1) (ER)
Manganese, Total	10-Oct-11	49.34	East Raw (Tap 1) (ER)
Manganese, Total	11-Oct-11	48.91	East Raw (Tap 1) (ER)
Manganese, Total	12-Oct-11	32.44	East Raw (Tap 1) (ER)
Manganese, Total	13-Oct-11	34.6	East Raw (Tap 1) (ER)
Manganese, Total	14-Oct-11	34.69	East Raw (Tap 1) (ER)
Manganese, Total	17-Oct-11	31.85	East Raw (Tap 1) (ER)
Manganese, Total	18-Oct-11	34.12	East Raw (Tap 1) (ER)
Manganese, Total	19-Oct-11	31.26	East Raw (Tap 1) (ER)
Manganese, Total	20-Oct-11	31.98	East Raw (Tap 1) (ER)
Manganese, Total	21-Oct-11	28.06	East Raw (Tap 1) (ER)
Manganese, Total	24-Oct-11	32.72	East Raw (Tap 1) (ER)
Manganese, Total	25-Oct-11	335.6	East Raw (Tap 1) (ER)
Manganese, Total	26-Oct-11	30.44	East Raw (Tap 1) (ER)

Manganese, Total	27-Oct-11	27.52	East Raw (Tap 1) (ER)
Manganese, Total	28-Oct-11	25.06	East Raw (Tap 1) (ER)
Manganese, Total	31-Oct-11	19.73	East Raw (Tap 1) (ER)
Manganese, Total	01-Nov-11	17.63	East Raw (Tap 1) (ER)
Manganese, Total	02-Nov-11	19.1	East Raw (Tap 1) (ER)
Manganese, Total	18-Nov-11	23.13	East Raw (Tap 1) (ER)
Manganese, Total	21-Nov-11	22.64	East Raw (Tap 1) (ER)
Manganese, Total	16-Nov-11	19.9	East Raw (Tap 1) (ER)
Manganese, Total	17-Nov-11	17.79	East Raw (Tap 1) (ER)
Manganese, Total	22-Nov-11	13.69	East Raw (Tap 1) (ER)
Manganese, Total	23-Nov-11	17.34	East Raw (Tap 1) (ER)
Manganese, Total	28-Nov-11	24.13	East Raw (Tap 1) (ER)
Manganese, Total	29-Nov-11	22.08	East Raw (Tap 1) (ER)
Manganese, Total	30-Nov-11	33.56	East Raw (Tap 1) (ER)
Manganese, Total	01-Dec-11	33.37	East Raw (Tap 1) (ER)
Manganese, Total	02-Dec-11	15.5	East Raw (Tap 1) (ER)
Manganese, Total	05-Dec-11	25.4	East Raw (Tap 1) (ER)
Manganese, Total	06-Dec-11	30.81	East Raw (Tap 1) (ER)
Manganese, Total	07-Dec-11	22.83	East Raw (Tap 1) (ER)
Manganese, Total	08-Dec-11	24.8438	East Raw (Tap 1) (ER)
Manganese, Total	09-Dec-11	42.1706	East Raw (Tap 1) (ER)
Manganese, Total	12-Dec-11	64.1	East Raw (Tap 1) (ER)
Manganese, Total	13-Dec-11	17.83	East Raw (Tap 1) (ER)
Manganese, Total	14-Dec-11	25.3535	East Raw (Tap 1) (ER)
Manganese, Total	15-Dec-11	32.44	East Raw (Tap 1) (ER)

Manganese, Total	16-Dec-11	35.48	East Raw (Tap 1) (ER)
Manganese, Total	19-Dec-11	35.36	East Raw (Tap 1) (ER)
Manganese, Total	20-Dec-11	57.5403	East Raw (Tap 1) (ER)
Manganese, Total	21-Dec-11	44.1932	East Raw (Tap 1) (ER)
Manganese, Total	22-Dec-11	72.52	East Raw (Tap 1) (ER)
Manganese, Total	23-Dec-11	27.5281	East Raw (Tap 1) (ER)
Manganese, Total	27-Dec-11	22.8444	East Raw (Tap 1) (ER)
Manganese, Total	28-Dec-11	29.5872	East Raw (Tap 1) (ER)
Manganese, Total	29-Dec-11	17.7068	East Raw (Tap 1) (ER)
Manganese, Total	30-Dec-11	47.664	East Raw (Tap 1) (ER)

In 2012

Param	Collect Date	Numerical Results	Sites
Manganese, Total	03-Jan-12	36.12	East Raw (Tap 1) (ER)
Manganese, Total	04-Jan-12	23.61	East Raw (Tap 1) (ER)
Manganese, Total	07-Feb-12	41.88	East Raw (Tap 1) (ER)
Manganese, Total	08-Feb-12	52.78	East Raw (Tap 1) (ER)
Manganese, Total	09-Feb-12	16.08	East Raw (Tap 1) (ER)
Manganese, Total	10-Feb-12	33.33	East Raw (Tap 1) (ER)
Manganese, Total	16-Feb-12	8.5	East Raw (Tap 1) (ER)
Manganese, Total	17-Feb-12	30.88	East Raw (Tap 1) (ER)
Manganese, Total	21-Feb-12	27.64	East Raw (Tap 1) (ER)
Manganese, Total	22-Feb-12	24.99	East Raw (Tap 1) (ER)
Manganese, Total	23-Feb-12	142.34	East Raw (Tap 1) (ER)
Manganese, Total	27-Feb-12	26.97	East Raw (Tap 1) (ER)

Manganese, Total	28-Feb-12	63.74	East Raw (Tap 1) (ER)
Manganese, Total	29-Feb-12	31.72	East Raw (Tap 1) (ER)
Manganese, Total	01-Mar-12	25.29	East Raw (Tap 1) (ER)
Manganese, Total	02-Mar-12	22.9	East Raw (Tap 1) (ER)
Manganese, Total	05-Mar-12	15.09	East Raw (Tap 1) (ER)
Manganese, Total	06-Mar-12	17.95	East Raw (Tap 1) (ER)
Manganese, Total	09-Mar-12	15.98	East Raw (Tap 1) (ER)
Manganese, Total	12-Mar-12	23.68	East Raw (Tap 1) (ER)
Manganese, Total	13-Mar-12	27.9	East Raw (Tap 1) (ER)
Manganese, Total	14-Mar-12	34.51	East Raw (Tap 1) (ER)
Manganese, Total	15-Mar-12	24.95	East Raw (Tap 1) (ER)
Manganese, Total	16-Mar-12	22.91	East Raw (Tap 1) (ER)
Manganese, Total	19-Mar-12	13.02	East Raw (Tap 1) (ER)
Manganese, Total	20-Mar-12	34.55	East Raw (Tap 1) (ER)
Manganese, Total	21-Mar-12	13.55	East Raw (Tap 1) (ER)
Manganese, Total	22-Mar-12	14.73	East Raw (Tap 1) (ER)
Manganese, Total	23-Mar-12	10.3688	East Raw (Tap 1) (ER)
Manganese, Total	26-Mar-12	8.13	East Raw (Tap 1) (ER)
Manganese, Total	27-Mar-12	24.48	East Raw (Tap 1) (ER)
Manganese, Total	28-Mar-12	34.12	East Raw (Tap 1) (ER)
Manganese, Total	29-Mar-12	29.49	East Raw (Tap 1) (ER)
Manganese, Total	30-Mar-12	31.85	East Raw (Tap 1) (ER)
Manganese, Total	02-Apr-12	15.4	East Raw (Tap 1) (ER)
Manganese, Total	03-Apr-12	144.99	East Raw (Tap 1) (ER)
Manganese, Total	04-Apr-12	32.03	East Raw (Tap 1) (ER)

Manganese, Total	05-Apr-12	88.79	East Raw (Tap 1) (ER)
Manganese, Total	06-Apr-12	60.8	East Raw (Tap 1) (ER)
Manganese, Total	09-Apr-12	31.37	East Raw (Tap 1) (ER)
Manganese, Total	10-Apr-12	67.82	East Raw (Tap 1) (ER)
Manganese, Total	11-Apr-12	26.67	East Raw (Tap 1) (ER)
Manganese, Total	12-Apr-12	30.36	East Raw (Tap 1) (ER)
Manganese, Total	13-Apr-12	19.18	East Raw (Tap 1) (ER)
Manganese, Total	02-May-12	15.667	East Raw (Tap 1) (ER)
Manganese, Total	03-May-12	10.0948	East Raw (Tap 1) (ER)
Manganese, Total	04-May-12	8.6466	East Raw (Tap 1) (ER)
Manganese, Total	07-May-12	21.2708	East Raw (Tap 1) (ER)
Manganese, Total	18-May-12	19.1434	East Raw (Tap 1) (ER)
Manganese, Total	21-May-12	9.5172	East Raw (Tap 1) (ER)
Manganese, Total	22-May-12	9.1095	East Raw (Tap 1) (ER)
Manganese, Total	23-May-12	14.6454	East Raw (Tap 1) (ER)
Manganese, Total	24-May-12	12.96	East Raw (Tap 1) (ER)
Manganese, Total	25-May-12	8.4	East Raw (Tap 1) (ER)
Manganese, Total	29-May-12	16.9	East Raw (Tap 1) (ER)
Manganese, Total	30-May-12	12.99	East Raw (Tap 1) (ER)
Manganese, Total	31-May-12	13.3581	East Raw (Tap 1) (ER)
Manganese, Total	01-Jun-12	12.5558	East Raw (Tap 1) (ER)
Manganese, Total	04-Jun-12	16.5039	East Raw (Tap 1) (ER)
Manganese, Total	05-Jun-12	18.133	East Raw (Tap 1) (ER)
Manganese, Total	06-Jun-12	17.9443	East Raw (Tap 1) (ER)
Manganese, Total	07-Jun-12	28.9674	East Raw (Tap 1) (ER)

Manganese, Total	08-Jun-12	15.9405	East Raw (Tap 1) (ER)
Manganese, Total	11-Jun-12	15.7369	East Raw (Tap 1) (ER)
Manganese, Total	12-Jun-12	21.7066	East Raw (Tap 1) (ER)
Manganese, Total	13-Jun-12	10.7593	East Raw (Tap 1) (ER)
Manganese, Total	14-Jun-12	11.7932	East Raw (Tap 1) (ER)
Manganese, Total	15-Jun-12	15.4185	East Raw (Tap 1) (ER)
Manganese, Total	18-Jun-12	19.7943	East Raw (Tap 1) (ER)
Manganese, Total	19-Jun-12	23.3506	East Raw (Tap 1) (ER)
Manganese, Total	20-Jun-12	16.6326	East Raw (Tap 1) (ER)
Manganese, Total	21-Jun-12	23.0998	East Raw (Tap 1) (ER)
Manganese, Total	22-Jun-12	18.2505	East Raw (Tap 1) (ER)
Manganese, Total	25-Jun-12	13.74	East Raw (Tap 1) (ER)
Manganese, Total	26-Jun-12	13.8	East Raw (Tap 1) (ER)
Manganese, Total	27-Jun-12	16.38	East Raw (Tap 1) (ER)
Manganese, Total	28-Jun-12	13.94	East Raw (Tap 1) (ER)
Manganese, Total	29-Jun-12	13.4503	East Raw (Tap 1) (ER)
Manganese, Total	02-Jul-12	17.15	East Raw (Tap 1) (ER)
Manganese, Total	03-Jul-12	20.9	East Raw (Tap 1) (ER)
Manganese, Total	05-Jul-12	24.2177	East Raw (Tap 1) (ER)
Manganese, Total	06-Jul-12	21.28	East Raw (Tap 1) (ER)
Manganese, Total	09-Jul-12	19.29	East Raw (Tap 1) (ER)
Manganese, Total	10-Jul-12	30.68	East Raw (Tap 1) (ER)
Manganese, Total	11-Jul-12	23.45	East Raw (Tap 1) (ER)
Manganese, Total	12-Jul-12	25.22	East Raw (Tap 1) (ER)
Manganese, Total	13-Jul-12	26.31	East Raw (Tap 1) (ER)

Manganese, Total	16-Jul-12	28.24	East Raw (Tap 1) (ER)
Manganese, Total	17-Jul-12	30.69	East Raw (Tap 1) (ER)
Manganese, Total	18-Jul-12	26.49	East Raw (Tap 1) (ER)
Manganese, Total	19-Jul-12	28.68	East Raw (Tap 1) (ER)
Manganese, Total	20-Jul-12	27.14	East Raw (Tap 1) (ER)
Manganese, Total	23-Jul-12	26.6448	East Raw (Tap 1) (ER)
Manganese, Total	24-Jul-12	29.2811	East Raw (Tap 1) (ER)
Manganese, Total	25-Jul-12	35.5451	East Raw (Tap 1) (ER)
Manganese, Total	26-Jul-12	33.26	East Raw (Tap 1) (ER)
Manganese, Total	27-Jul-12	25.66	East Raw (Tap 1) (ER)
Manganese, Total	30-Jul-12	47.54	East Raw (Tap 1) (ER)
Manganese, Total	31-Jul-12	30.2	East Raw (Tap 1) (ER)
Manganese, Total	01-Aug-12	42.54	East Raw (Tap 1) (ER)
Manganese, Total	02-Aug-12	35.36	East Raw (Tap 1) (ER)
Manganese, Total	03-Aug-12	33.04	East Raw (Tap 1) (ER)
Manganese, Total	06-Aug-12	42.79	East Raw (Tap 1) (ER)
Manganese, Total	07-Aug-12	40.56	East Raw (Tap 1) (ER)
Manganese, Total	08-Aug-12	37.84	East Raw (Tap 1) (ER)
Manganese, Total	09-Aug-12	35.45	East Raw (Tap 1) (ER)
Manganese, Total	10-Aug-12	32.56	East Raw (Tap 1) (ER)
Manganese, Total	13-Aug-12	33.24	East Raw (Tap 1) (ER)
Manganese, Total	15-Aug-12	33.59	East Raw (Tap 1) (ER)
Manganese, Total	16-Aug-12	36.19	East Raw (Tap 1) (ER)
Manganese, Total	17-Aug-12	18.87	East Raw (Tap 1) (ER)
Manganese, Total	20-Aug-12	60.56	East Raw (Tap 1) (ER)

Manganese, Total	21-Aug-12	46.8251	East Raw (Tap 1) (ER)
Manganese, Total	22-Aug-12	41.6	East Raw (Tap 1) (ER)
Manganese, Total	23-Aug-12	39.81	East Raw (Tap 1) (ER)
Manganese, Total	24-Aug-12	38.73	East Raw (Tap 1) (ER)
Manganese, Total	27-Aug-12	50.9501	East Raw (Tap 1) (ER)
Manganese, Total	28-Aug-12	128.31	East Raw (Tap 1) (ER)
Manganese, Total	29-Aug-12	105.227	East Raw (Tap 1) (ER)
Manganese, Total	30-Aug-12	51.021	East Raw (Tap 1) (ER)
Manganese, Total	31-Aug-12	59.38	East Raw (Tap 1) (ER)
Manganese, Total	04-Sep-12	68.0632	East Raw (Tap 1) (ER)
Manganese, Total	05-Sep-12	65.9448	East Raw (Tap 1) (ER)
Manganese, Total	06-Sep-12	183.207	East Raw (Tap 1) (ER)
Manganese, Total	07-Sep-12	66.7832	East Raw (Tap 1) (ER)
Manganese, Total	10-Sep-12	64.0374	East Raw (Tap 1) (ER)
Manganese, Total	11-Sep-12	69.6408	East Raw (Tap 1) (ER)
Manganese, Total	12-Sep-12	73.9524	East Raw (Tap 1) (ER)
Manganese, Total	13-Sep-12	65.1363	East Raw (Tap 1) (ER)
Manganese, Total	14-Sep-12	62.5108	East Raw (Tap 1) (ER)
Manganese, Total	17-Sep-12	67.1342	East Raw (Tap 1) (ER)
Manganese, Total	18-Sep-12	59.1288	East Raw (Tap 1) (ER)
Manganese, Total	24-Sep-12	58.2535	East Raw (Tap 1) (ER)
Manganese, Total	25-Sep-12	86.1546	East Raw (Tap 1) (ER)
Manganese, Total	26-Sep-12	79.6715	East Raw (Tap 1) (ER)
Manganese, Total	27-Sep-12	54.97	East Raw (Tap 1) (ER)
Manganese, Total	28-Sep-12	59.85	East Raw (Tap 1) (ER)

Manganese, Total	01-Oct-12	76.03	East Raw (Tap 1) (ER)
Manganese, Total	02-Oct-12	72.4027	East Raw (Tap 1) (ER)
Manganese, Total	03-Oct-12	79.9275	East Raw (Tap 1) (ER)
Manganese, Total	04-Oct-12	69.4485	East Raw (Tap 1) (ER)
Manganese, Total	05-Oct-12	67.889	East Raw (Tap 1) (ER)
Manganese, Total	08-Oct-12	109.02	East Raw (Tap 1) (ER)
Manganese, Total	09-Oct-12	60.0656	East Raw (Tap 1) (ER)
Manganese, Total	10-Oct-12	84.47	East Raw (Tap 1) (ER)
Manganese, Total	11-Oct-12	65.1233	East Raw (Tap 1) (ER)
Manganese, Total	12-Oct-12	67.2049	East Raw (Tap 1) (ER)
Manganese, Total	15-Oct-12	78.8877	East Raw (Tap 1) (ER)
Manganese, Total	16-Oct-12	64.0545	East Raw (Tap 1) (ER)
Manganese, Total	17-Oct-12	56.571	East Raw (Tap 1) (ER)
Manganese, Total	18-Oct-12	55.4762	East Raw (Tap 1) (ER)
Manganese, Total	19-Oct-12	55.86	East Raw (Tap 1) (ER)
Manganese, Total	22-Oct-12	48.66	East Raw (Tap 1) (ER)
Manganese, Total	23-Oct-12	46.48	East Raw (Tap 1) (ER)
Manganese, Total	24-Oct-12	43.48	East Raw (Tap 1) (ER)
Manganese, Total	25-Oct-12	43.1723	East Raw (Tap 1) (ER)
Manganese, Total	26-Oct-12	44.3908	East Raw (Tap 1) (ER)
Manganese, Total	29-Oct-12	40.903	East Raw (Tap 1) (ER)
Manganese, Total	30-Oct-12	41.0473	East Raw (Tap 1) (ER)
Manganese, Total	31-Oct-12	41.3813	East Raw (Tap 1) (ER)
Manganese, Total	01-Nov-12	38.1782	East Raw (Tap 1) (ER)
Manganese, Total	02-Nov-12	31.1233	East Raw (Tap 1) (ER)

Manganese, Total	05-Nov-12	27.3179	East Raw (Tap 1) (ER)
Manganese, Total	06-Nov-12	26.2614	East Raw (Tap 1) (ER)
Manganese, Total	07-Nov-12	24.8287	East Raw (Tap 1) (ER)
Manganese, Total	08-Nov-12	19.9494	East Raw (Tap 1) (ER)
Manganese, Total	09-Nov-12	12.476	East Raw (Tap 1) (ER)
Manganese, Total	13-Nov-12	20.7818	East Raw (Tap 1) (ER)
Manganese, Total	14-Nov-12	22.935	East Raw (Tap 1) (ER)
Manganese, Total	15-Nov-12	17.0447	East Raw (Tap 1) (ER)
Manganese, Total	16-Nov-12	15.3751	East Raw (Tap 1) (ER)
Manganese, Total	19-Nov-12	12.4606	East Raw (Tap 1) (ER)
Manganese, Total	20-Nov-12	21.13	East Raw (Tap 1) (ER)
Manganese, Total	21-Nov-12	27.74	East Raw (Tap 1) (ER)
Manganese, Total	26-Nov-12	23.8062	East Raw (Tap 1) (ER)
Manganese, Total	27-Nov-12	13.9528	East Raw (Tap 1) (ER)
Manganese, Total	28-Nov-12	157.06	East Raw (Tap 1) (ER)
Manganese, Total	29-Nov-12	19.2593	East Raw (Tap 1) (ER)
Manganese, Total	30-Nov-12	27.9781	East Raw (Tap 1) (ER)
Manganese, Total	03-Dec-12	19.1995	East Raw (Tap 1) (ER)
Manganese, Total	04-Dec-12	14.9388	East Raw (Tap 1) (ER)
Manganese, Total	05-Dec-12	16.3202	East Raw (Tap 1) (ER)
Manganese, Total	06-Dec-12	18.8127	East Raw (Tap 1) (ER)
Manganese, Total	07-Dec-12	19.0571	East Raw (Tap 1) (ER)
Manganese, Total	10-Dec-12	22.1589	East Raw (Tap 1) (ER)
Manganese, Total	11-Dec-12	16.858	East Raw (Tap 1) (ER)
Manganese, Total	12-Dec-12	16.8524	East Raw (Tap 1) (ER)

Manganese, Total	13-Dec-12	17.6141	East Raw (Tap 1) (ER)
Manganese, Total	14-Dec-12	21.8563	East Raw (Tap 1) (ER)
Manganese, Total	17-Dec-12	18.9946	East Raw (Tap 1) (ER)

In 2013

Param	Collect Date	Numeric Result	Site
Manganese, Total	3/15/2013	4.6855	East Raw (Tap 1) (ER)
Manganese, Total	3/18/2013	8.1275	East Raw (Tap 1) (ER)
Manganese, Total	3/19/2013	9.2346	East Raw (Tap 1) (ER)
Manganese, Total	3/20/2013	10.7523	East Raw (Tap 1) (ER)
Manganese, Total	3/21/2013	18.33	East Raw (Tap 1) (ER)
Manganese, Total	3/22/2013	12.8706	East Raw (Tap 1) (ER)
Manganese, Total	3/25/2013	16.222	East Raw (Tap 1) (ER)
Manganese, Total	3/26/2013	17.1019	East Raw (Tap 1) (ER)
Manganese, Total	3/27/2013	18.5077	East Raw (Tap 1) (ER)
Manganese, Total	3/28/2013	23.3931	East Raw (Tap 1) (ER)
Manganese, Total	3/29/2013	19.2994	East Raw (Tap 1) (ER)
Manganese, Total	4/1/2013	22.1671	East Raw (Tap 1) (ER)
Manganese, Total	4/2/2013	28.6216	East Raw (Tap 1) (ER)
Manganese, Total	4/3/2013	23.1255	East Raw (Tap 1) (ER)
Manganese, Total	4/4/2013	24.1759	East Raw (Tap 1) (ER)
Manganese, Total	4/5/2013	25.0319	East Raw (Tap 1) (ER)
Manganese, Total	4/8/2013	23.9758	East Raw (Tap 1) (ER)
Manganese, Total	4/9/2013	16.0153	East Raw (Tap 1) (ER)

Manganese, Total	4/10/2013	22.0425	East Raw (Tap 1) (ER)
Manganese, Total	4/11/2013	33.1025	East Raw (Tap 1) (ER)
Manganese, Total	4/12/2013	21.726	East Raw (Tap 1) (ER)
Manganese, Total	4/15/2013	17.7694	East Raw (Tap 1) (ER)
Manganese, Total	4/16/2013	16.9142	East Raw (Tap 1) (ER)
Manganese, Total	4/17/2013	19.2908	East Raw (Tap 1) (ER)
Manganese, Total	4/18/2013	17.6535	East Raw (Tap 1) (ER)
Manganese, Total	4/19/2013	52.3754	East Raw (Tap 1) (ER)
Manganese, Total	4/22/2013	16.9137	East Raw (Tap 1) (ER)
Manganese, Total	4/23/2013	13.8698	East Raw (Tap 1) (ER)
Manganese, Total	4/24/2013	13.2747	East Raw (Tap 1) (ER)
Manganese, Total	4/25/2013	12.3957	East Raw (Tap 1) (ER)
Manganese, Total	4/26/2013	13.7964	East Raw (Tap 1) (ER)
Manganese, Total	4/29/2013	11.6525	East Raw (Tap 1) (ER)
Manganese, Total	4/30/2013	14.3039	East Raw (Tap 1) (ER)
Manganese, Total	5/1/2013	11.6417	East Raw (Tap 1) (ER)
Manganese, Total	5/2/2013	16.1682	East Raw (Tap 1) (ER)
Manganese, Total	5/3/2013	10.1983	East Raw (Tap 1) (ER)
Manganese, Total	5/6/2013	10.72	East Raw (Tap 1) (ER)
Manganese, Total	5/7/2013	10.26	East Raw (Tap 1) (ER)
Manganese, Total	5/8/2013	25.88	East Raw (Tap 1) (ER)
Manganese, Total	5/9/2013	8.21	East Raw (Tap 1) (ER)
Manganese, Total	5/10/2013	7.73	East Raw (Tap 1) (ER)
Manganese, Total	5/13/2013	43.0852	East Raw (Tap 1) (ER)
Manganese, Total	5/14/2013	10.1798	East Raw (Tap 1) (ER)

Manganese, Total	5/15/2013	7.9944	East Raw (Tap 1) (ER)
Manganese, Total	5/16/2013	8.0088	East Raw (Tap 1) (ER)
Manganese, Total	5/17/2013	7.871	East Raw (Tap 1) (ER)
Manganese, Total	5/20/2013	11.9071	East Raw (Tap 1) (ER)
Manganese, Total	5/21/2013	8.8602	East Raw (Tap 1) (ER)
Manganese, Total	5/22/2013	10.7481	East Raw (Tap 1) (ER)
Manganese, Total	5/23/2013	8.8233	East Raw (Tap 1) (ER)
Manganese, Total	5/24/2013	8.578	East Raw (Tap 1) (ER)
Manganese, Total	5/28/2013	11.6566	East Raw (Tap 1) (ER)
Manganese, Total	5/29/2013	5.7916	East Raw (Tap 1) (ER)
Manganese, Total	6/12/2013	15.5483	East Raw (Tap 1) (ER)
Manganese, Total	6/13/2013	14.9564	East Raw (Tap 1) (ER)
Manganese, Total	6/14/2013	7.3728	East Raw (Tap 1) (ER)
Manganese, Total	6/17/2013	14.0294	East Raw (Tap 1) (ER)
Manganese, Total	6/18/2013	7.6466	East Raw (Tap 1) (ER)
Manganese, Total	6/19/2013	9.8471	East Raw (Tap 1) (ER)
Manganese, Total	6/20/2013	11.2746	East Raw (Tap 1) (ER)
Manganese, Total	6/21/2013	14.3174	East Raw (Tap 1) (ER)
Manganese, Total	6/24/2013	10.1726	East Raw (Tap 1) (ER)
Manganese, Total	6/25/2013	6.7267	East Raw (Tap 1) (ER)
Manganese, Total	6/26/2013	7.4205	East Raw (Tap 1) (ER)
Manganese, Total	6/27/2013	6.0654	East Raw (Tap 1) (ER)
Manganese, Total	6/28/2013	5.6983	East Raw (Tap 1) (ER)
Manganese, Total	7/1/2013	8.0175	East Raw (Tap 1) (ER)
Manganese, Total	7/2/2013	7.6626	East Raw (Tap 1) (ER)

Manganese, Total	7/3/2013	6.3972	East Raw (Tap 1) (ER)
Manganese, Total	7/5/2013	7.6005	East Raw (Tap 1) (ER)
Manganese, Total	7/8/2013	7.3955	East Raw (Tap 1) (ER)
Manganese, Total	7/9/2013	7.72	East Raw (Tap 1) (ER)
Manganese, Total	7/10/2013	6.41	East Raw (Tap 1) (ER)
Manganese, Total	7/11/2013	19.4787	East Raw (Tap 1) (ER)
Manganese, Total	7/12/2013	8.3754	East Raw (Tap 1) (ER)
Manganese, Total	7/15/2013	11.0881	East Raw (Tap 1) (ER)
Manganese, Total	7/16/2013	13.5072	East Raw (Tap 1) (ER)
Manganese, Total	7/17/2013	14.2325	East Raw (Tap 1) (ER)
Manganese, Total	7/18/2013	13.822	East Raw (Tap 1) (ER)

APPENDIX B- BROMIDE DATA- ALL DATA IN PPB

FROM THE WEST TREATMENT PLANT

Param	Collect Date	Numeric Result	Site
Bromide	07-May-08	69.288	West Raw (WR)
Bromide	24-Sep-08	75.281	West Raw (WR)
Bromide	29-Sep-08	66.19	West Raw (WR)
Bromide	01-Oct-08	72.224	West Raw (WR)
Bromide	03-Oct-08	73.292	West Raw (WR)
Bromide	06-Oct-08	73.133	West Raw (WR)
Bromide	08-Oct-08	76.125	West Raw (WR)

In 2012			
Param	Collect Date	Numerical Results	Sites
Bromide	27-Aug-12	82.072	West Raw (WR)
Bromide	28-Aug-12	78.57	West Raw (WR)
Bromide	29-Aug-12	78.697	West Raw (WR)
Bromide	30-Aug-12	80.8	West Raw (WR)
Bromide	31-Aug-12	78.912	West Raw (WR)
Bromide	04-Sep-12	83.982	West Raw (WR)
Bromide	05-Sep-12	73.578	West Raw (WR)
Bromide	06-Sep-12	75.992	West Raw (WR)
Bromide	07-Sep-12	73.963	West Raw (WR)
Bromide	10-Sep-12	77.405	West Raw (WR)
Bromide	11-Sep-12	96.609	West Raw (WR)
Bromide	12-Sep-12	76.078	West Raw (WR)
Bromide	13-Sep-12	71.252	West Raw (WR)
Bromide	14-Sep-12	94.301	West Raw (WR)
Bromide	17-Sep-12	74.923	West Raw (WR)
Bromide	18-Sep-12	64.074	West Raw (WR)
Bromide	20-Sep-12	75.709	West Raw (WR)
Bromide	25-Sep-12	58.067	West Raw (WR)
Bromide	26-Sep-12	92.977	West Raw (WR)
Bromide	27-Sep-12	17.955	West Raw (WR)
Bromide	28-Sep-12	84.83	West Raw (WR)
Bromide	02-Oct-12	77.273	West Raw (WR)

Bromide	03-Oct-12	85.061	West Raw (WR)
Bromide	04-Oct-12	81.284	West Raw (WR)
Bromide	05-Oct-12	56.371	West Raw (WR)
Bromide	08-Oct-12	23.347	West Raw (WR)
Bromide	09-Oct-12	60.158	West Raw (WR)
Bromide	11-Oct-12	66.907	West Raw (WR)
Bromide	12-Oct-12	82.224	West Raw (WR)
Bromide	15-Oct-12	87.398	West Raw (WR)
Bromide	16-Oct-12	75.655	West Raw (WR)
Bromide	17-Oct-12	72.302	West Raw (WR)
Bromide	18-Oct-12	0	West Raw (WR)
Bromide	25-Oct-12	50.894	West Raw (WR)
Bromide	26-Oct-12	58.304	West Raw (WR)
Bromide	29-Oct-12	65.818	West Raw (WR)
Bromide	30-Oct-12	35.847	West Raw (WR)
Bromide	31-Oct-12	36.016	West Raw (WR)
Bromide	05-Nov-12	84.195	West Raw (WR)
Bromide	06-Nov-12	35.059	West Raw (WR)
Bromide	07-Nov-12	39.76	West Raw (WR)
Bromide	08-Nov-12	38.515 W	est Raw (WR)
Bromide	09-Nov-12	38.514	West Raw (WR)
Bromide	13-Nov-12	81.279	West Raw (WR)
Bromide	14-Nov-12	37.732	West Raw (WR)
Bromide	15-Nov-12	46.076	West Raw (WR)
Bromide	16-Nov-12	38.108	West Raw (WR)

Bromide	19-Nov-12	102.676	West Raw (WR)

In 2013

Param	Collect Date	Numeric Result	Site
Bromide	3/15/2013	83.431	West Raw (WR)
Bromide	3/18/2013	76.492	West Raw (WR)
Bromide	3/25/2013	85.442	West Raw (WR)
Bromide	4/1/2013	81.555	West Raw (WR)
Bromide	4/8/2013	84.856	West Raw (WR)
Bromide	4/29/2013	41.428	West Raw (WR)
Bromide	5/13/2013	97.007	West Raw (WR)
Bromide	5/20/2013	87.708	West Raw (WR)
Bromide	5/28/2013	94.554	West Raw (WR)
Bromide	6/17/2013	97.136	West Raw (WR)
Bromide	6/24/2013	81.883	West Raw (WR)
Bromide	7/1/2013	90.965	West Raw (WR)

FROM THE EAST TREATMENT PLANT

Param	Collect Date	Numeric Result	Site
Bromide	08-Apr-08	62.21	East Raw (Tap 1) (ER)
Bromide	09-Apr-08	57.282	East Raw (Tap 1) (ER)
Bromide	10-Apr-08	59.234	East Raw (Tap 1) (ER)
Bromide	11-Apr-08	60.09	East Raw (Tap 1) (ER)
Bromide	14-Apr-08	60.785	East Raw (Tap 1) (ER)

Bromide	16-Apr-08	63.081	East Raw (Tap 1) (ER)
Bromide	18-Apr-08	62.354	East Raw (Tap 1) (ER)
Bromide	21-Apr-08	61.512	East Raw (Tap 1) (ER)
Bromide	23-Apr-08	62.128	East Raw (Tap 1) (ER)
Bromide	25-Apr-08	59.819	East Raw (Tap 1) (ER)
Bromide	28-Apr-08	59.66	East Raw (Tap 1) (ER)
Bromide	30-Apr-08	60.728	East Raw (Tap 1) (ER)
Bromide	02-May-08	60.38	East Raw (Tap 1) (ER)
Bromide	05-May-08	62.647	East Raw (Tap 1) (ER)
Bromide	07-May-08	60.324	East Raw (Tap 1) (ER)
Bromide	09-May-08	60.002	East Raw (Tap 1) (ER)
Bromide	12-May-08	60.644	East Raw (Tap 1) (ER)
Bromide	14-May-08	59.227	East Raw (Tap 1) (ER)
Bromide	16-May-08	59.075	East Raw (Tap 1) (ER)
Bromide	19-May-08	59.089	East Raw (Tap 1) (ER)
Bromide	21-May-08	59.595	East Raw (Tap 1) (ER)
Bromide	23-May-08	60.265	East Raw (Tap 1) (ER)
Bromide	07-Jul-08	51.062	East Raw (Tap 1) (ER)
Bromide	09-Jul-08	38.24	East Raw (Tap 1) (ER)
Bromide	21-Jul-08	45.146	East Raw (Tap 1) (ER)
Bromide	23-Jul-08	44.328	East Raw (Tap 1) (ER)
Bromide	28-Jul-08	72.019	East Raw (Tap 1) (ER)
Bromide	30-Jul-08	75.425	East Raw (Tap 1) (ER)
Bromide	04-Aug-08	80.193	East Raw (Tap 1) (ER)
Bromide	06-Aug-08	83.026	East Raw (Tap 1) (ER)

Bromide	08-Aug-08	81.938	East Raw (Tap 1) (ER)
Bromide	11-Aug-08	85.396	East Raw (Tap 1) (ER)
Bromide	13-Aug-08	83.467	East Raw (Tap 1) (ER)
Bromide	15-Aug-08	81.861	East Raw (Tap 1) (ER)
Bromide	20-Aug-08	78.179	East Raw (Tap 1) (ER)
Bromide	22-Aug-08	78.188	East Raw (Tap 1) (ER)
Bromide	25-Aug-08	78.27	East Raw (Tap 1) (ER)
Bromide	27-Aug-08	0	East Raw (Tap 1) (ER)
Bromide	03-Sep-08	75.211	East Raw (Tap 1) (ER)
Bromide	08-Sep-08	69.773	East Raw (Tap 1) (ER)
Bromide	10-Sep-08	69.225	East Raw (Tap 1) (ER)
Bromide	12-Sep-08	70.267	East Raw (Tap 1) (ER)
Bromide	15-Sep-08	84.717	East Raw (Tap 1) (ER)
Bromide	17-Sep-08	64.63	East Raw (Tap 1) (ER)
Bromide	19-Sep-08	63.211	East Raw (Tap 1) (ER)
Bromide	22-Sep-08	63.654	East Raw (Tap 1) (ER)
Bromide	24-Sep-08	66.473	East Raw (Tap 1) (ER)
Bromide	29-Sep-08	39.495	East Raw (Tap 1) (ER)
Bromide	01-Oct-08	45.802	East Raw (Tap 1) (ER)
Bromide	03-Oct-08	61.584	East Raw (Tap 1) (ER)
Bromide	06-Oct-08	61.471	East Raw (Tap 1) (ER)
Bromide	08-Oct-08	61.115	East Raw (Tap 1) (ER)
Bromide	10-Oct-08	62.738	East Raw (Tap 1) (ER)
Bromide	13-Oct-08	62.065	East Raw (Tap 1) (ER)
Bromide	15-Oct-08	65.15	East Raw (Tap 1) (ER)

Bromide	17-Oct-08	59.185	East Raw (Tap 1) (ER)
Bromide	20-Oct-08	25.633	East Raw (Tap 1) (ER)
Bromide	22-Oct-08	58.442	East Raw (Tap 1) (ER)
Bromide	24-Oct-08	56.232	East Raw (Tap 1) (ER)
Bromide	27-Oct-08	56.698	East Raw (Tap 1) (ER)
Bromide	29-Oct-08	52.689	East Raw (Tap 1) (ER)
Bromide	31-Oct-08	55.744	East Raw (Tap 1) (ER)
Bromide	03-Nov-08	53.945	East Raw (Tap 1) (ER)
Bromide	05-Nov-08	58.547	East Raw (Tap 1) (ER)
Bromide	07-Nov-08	58.165	East Raw (Tap 1) (ER)
Bromide	10-Nov-08	61.477	East Raw (Tap 1) (ER)
Bromide	12-Nov-08	59.176	East Raw (Tap 1) (ER)
Bromide	14-Nov-08	59.135	East Raw (Tap 1) (ER)
Bromide	17-Nov-08	61.088	East Raw (Tap 1) (ER)
Bromide	21-Nov-08	20.634	East Raw (Tap 1) (ER)
Bromide	24-Nov-08	63.631	East Raw (Tap 1) (ER)
Bromide	26-Nov-08	65.344	East Raw (Tap 1) (ER)
Bromide	01-Dec-08	66.295	East Raw (Tap 1) (ER)
Bromide	03-Dec-08	65.085	East Raw (Tap 1) (ER)
Bromide	05-Dec-08	65.657	East Raw (Tap 1) (ER)
Bromide	08-Dec-08	65.815	East Raw (Tap 1) (ER)
Bromide	10-Dec-08	66.911	East Raw (Tap 1) (ER)
Bromide	12-Dec-08	66.389	East Raw (Tap 1) (ER)
Bromide	15-Dec-08	66.366	East Raw (Tap 1) (ER)
Bromide	17-Dec-08	63.642	East Raw (Tap 1) (ER)

Bromide	19-Dec-08	66.429	East Raw (Tap 1) (ER)
Bromide	22-Dec-08	69.401	East Raw (Tap 1) (ER)
Bromide	24-Dec-08	71.23	East Raw (Tap 1) (ER)
Bromide	26-Dec-08	75.004	East Raw (Tap 1) (ER)

In 2011

Param	Collect Date	Numerical Result	Site
Bromide	13-Jan-11	113.918	East Raw (Tap 1) (ER)
Bromide	18-Jan-11	120.076	East Raw (Tap 1) (ER)
Bromide	20-Jan-11	106.77	East Raw (Tap 1) (ER)
Bromide	21-Jan-11	0	East Raw (Tap 1) (ER)
Bromide	24-Jan-11	74.926	East Raw (Tap 1) (ER)
Bromide	25-Jan-11	0	East Raw (Tap 1) (ER)
Bromide	26-Jan-11	171.809	East Raw (Tap 1) (ER)
Bromide	27-Jan-11	96.112	East Raw (Tap 1) (ER)
Bromide	28-Jan-11	97.242	East Raw (Tap 1) (ER)
Bromide	31-Jan-11	92.45	East Raw (Tap 1) (ER)
Bromide	01-Feb-11	85.699	East Raw (Tap 1) (ER)
Bromide	02-Feb-11	188.06	East Raw (Tap 1) (ER)
Bromide	03-Feb-11	84.018	East Raw (Tap 1) (ER)
Bromide	04-Feb-11	75.873	East Raw (Tap 1) (ER)
Bromide	07-Feb-11	0	East Raw (Tap 1) (ER)
Bromide	08-Feb-11	82.169	East Raw (Tap 1) (ER)

Bromide	09-Feb-11	71.895	East Raw (Tap 1) (ER)
Bromide	10-Feb-11	69.579	East Raw (Tap 1) (ER)
Bromide	11-Feb-11	87.951	East Raw (Tap 1) (ER)
Bromide	10-Mar-11	89.642	East Raw (Tap 1) (ER)
Bromide	11-Mar-11	104.345	East Raw (Tap 1) (ER)
Bromide	14-Mar-11	102.707	East Raw (Tap 1) (ER)
Bromide	22-Mar-11	95.832	East Raw (Tap 1) (ER)
Bromide	23-Mar-11	82.298	East Raw (Tap 1) (ER)
Bromide	28-Mar-11	83.174	East Raw (Tap 1) (ER)
Bromide	29-Mar-11	83.278	East Raw (Tap 1) (ER)
Bromide	30-Mar-11	86.914	East Raw (Tap 1) (ER)
Bromide	31-Mar-11	82.332	East Raw (Tap 1) (ER)
Bromide	01-Apr-11	80.533	East Raw (Tap 1) (ER)
Bromide	04-Apr-11	110.446	East Raw (Tap 1) (ER)
Bromide	05-Apr-11	88.218	East Raw (Tap 1) (ER)
Bromide	06-Apr-11	102.405	East Raw (Tap 1) (ER)
Bromide	08-Apr-11	78.923	East Raw (Tap 1) (ER)
Bromide	12-Apr-11	83.697	East Raw (Tap 1) (ER)
Bromide	13-Apr-11	82.082	East Raw (Tap 1) (ER)
Bromide	14-Apr-11	83.255	East Raw (Tap 1) (ER)
Bromide	15-Apr-11	85.203	East Raw (Tap 1) (ER)
Bromide	18-Apr-11	84.261	East Raw (Tap 1) (ER)
Bromide	19-Apr-11	91.379	East Raw (Tap 1) (ER)
Bromide	20-Apr-11	42.73	East Raw (Tap 1) (ER)
Bromide	21-Apr-11	71.308	East Raw (Tap 1) (ER)

Bromide	22-Apr-11	80.061	East Raw (Tap 1) (ER)
Bromide	25-Apr-11	73.181	East Raw (Tap 1) (ER)
Bromide	26-Apr-11	76.596	East Raw (Tap 1) (ER)
Bromide	27-Apr-11	73.859	East Raw (Tap 1) (ER)
Bromide	28-Apr-11	76.412	East Raw (Tap 1) (ER)
Bromide	29-Apr-11	74.03	East Raw (Tap 1) (ER)
Bromide	02-May-11	83.365	East Raw (Tap 1) (ER)
Bromide	03-May-11	79.177	East Raw (Tap 1) (ER)
Bromide	04-May-11	79.531	East Raw (Tap 1) (ER)
Bromide	05-May-11	81.107	East Raw (Tap 1) (ER)
Bromide	06-May-11	81.918	East Raw (Tap 1) (ER)
Bromide	09-May-11	81.685	East Raw (Tap 1) (ER)
Bromide	10-May-11	83.9	East Raw (Tap 1) (ER)
Bromide	11-May-11	81.099	East Raw (Tap 1) (ER)
Bromide	12-May-11	82.98	East Raw (Tap 1) (ER)
Bromide	13-May-11	81.376	East Raw (Tap 1) (ER)
Bromide	16-May-11	82.213	East Raw (Tap 1) (ER)
Bromide	17-May-11	83.584	East Raw (Tap 1) (ER)
Bromide	18-May-11	77.84	East Raw (Tap 1) (ER)
Bromide	19-May-11	80.839	East Raw (Tap 1) (ER)
Bromide	23-May-11	74.796	East Raw (Tap 1) (ER)
Bromide	07-Jun-11	71.152	East Raw (Tap 1) (ER)
Bromide	08-Jun-11	70.901	East Raw (Tap 1) (ER)
Bromide	09-Jun-11	72.188	East Raw (Tap 1) (ER)
Bromide	10-Jun-11	74.037	East Raw (Tap 1) (ER)

Bromide	27-Jun-11	74.243	East Raw (Tap 1) (ER)
Bromide	28-Jun-11	49.328	East Raw (Tap 1) (ER)
Bromide	29-Jun-11	74.712	East Raw (Tap 1) (ER)
Bromide	30-Jun-11	72.803	East Raw (Tap 1) (ER)
Bromide	01-Jul-11	71.301	East Raw (Tap 1) (ER)
Bromide	05-Jul-11	73.587	East Raw (Tap 1) (ER)
Bromide	06-Jul-11	80.144	East Raw (Tap 1) (ER)
Bromide	07-Jul-11	77.013	East Raw (Tap 1) (ER)
Bromide	08-Jul-11	76.72	East Raw (Tap 1) (ER)
Bromide	11-Jul-11	80.668	East Raw (Tap 1) (ER)
Bromide	12-Jul-11	85.101	East Raw (Tap 1) (ER)
Bromide	15-Jul-11	84.267	East Raw (Tap 1) (ER)
Bromide	19-Jul-11	85.624	East Raw (Tap 1) (ER)
Bromide	20-Jul-11	89.152	East Raw (Tap 1) (ER)
Bromide	22-Jul-11	89.545	East Raw (Tap 1) (ER)
Bromide	25-Jul-11	89.777	East Raw (Tap 1) (ER)
Bromide	26-Jul-11	94.935	East Raw (Tap 1) (ER)
Bromide	27-Jul-11	88.2	East Raw (Tap 1) (ER)
Bromide	28-Jul-11	96.267	East Raw (Tap 1) (ER)
Bromide	29-Jul-11	104.962	East Raw (Tap 1) (ER)
Bromide	01-Aug-11	107.962	East Raw (Tap 1) (ER)
Bromide	02-Aug-11	112.811	East Raw (Tap 1) (ER)
Bromide	11-Aug-11	94.545	East Raw (Tap 1) (ER)
Bromide	15-Aug-11	101.151	East Raw (Tap 1) (ER)
Bromide	16-Aug-11	99.193	East Raw (Tap 1) (ER)

Bromide	17-Aug-11	0	East Raw (Tap 1) (ER)
Bromide	18-Aug-11	0	East Raw (Tap 1) (ER)
Bromide	19-Aug-11	102.576	East Raw (Tap 1) (ER)
Bromide	22-Aug-11	97.858	East Raw (Tap 1) (ER)
Bromide	23-Aug-11	82.847	East Raw (Tap 1) (ER)
Bromide	24-Aug-11	102.817	East Raw (Tap 1) (ER)
Bromide	25-Aug-11	101.88	East Raw (Tap 1) (ER)
Bromide	06-Oct-11	96.142	East Raw (Tap 1) (ER)
Bromide	07-Oct-11	92.833	East Raw (Tap 1) (ER)
Bromide	10-Oct-11	97.329	East Raw (Tap 1) (ER)
Bromide	11-Oct-11	101.431	East Raw (Tap 1) (ER)
Bromide	13-Oct-11	112.09	East Raw (Tap 1) (ER)
Bromide	14-Oct-11	110.431	East Raw (Tap 1) (ER)
Bromide	18-Oct-11	92.833	East Raw (Tap 1) (ER)
Bromide	19-Oct-11	95.699	East Raw (Tap 1) (ER)
Bromide	20-Oct-11	97.162	East Raw (Tap 1) (ER)
Bromide	21-Oct-11	59.592	East Raw (Tap 1) (ER)
Bromide	24-Oct-11	90.909	East Raw (Tap 1) (ER)
Bromide	25-Oct-11	89.384	East Raw (Tap 1) (ER)
Bromide	26-Oct-11	90.233	East Raw (Tap 1) (ER)
Bromide	27-Oct-11	88.997	East Raw (Tap 1) (ER)
Bromide	28-Oct-11	87.025	East Raw (Tap 1) (ER)
Bromide	31-Oct-11	88.084	East Raw (Tap 1) (ER)
Bromide	01-Nov-11	87.588	East Raw (Tap 1) (ER)
Bromide	02-Nov-11	89.481	East Raw (Tap 1) (ER)

Bromide	18-Nov-11	87.08	East Raw (Tap 1) (ER)
Bromide	21-Nov-11	86.922	East Raw (Tap 1) (ER)
Bromide	16-Nov-11	91.428	East Raw (Tap 1) (ER)
Bromide	17-Nov-11	89.011	East Raw (Tap 1) (ER)
Bromide	22-Nov-11	88.564	East Raw (Tap 1) (ER)
Bromide	23-Nov-11	88.023	East Raw (Tap 1) (ER)
Bromide	28-Nov-11	88.332	East Raw (Tap 1) (ER)
Bromide	29-Nov-11	86.701	East Raw (Tap 1) (ER)
Bromide	30-Nov-11	87.551	East Raw (Tap 1) (ER)
Bromide	01-Dec-11	87.787	East Raw (Tap 1) (ER)
Bromide	02-Dec-11	88.371	East Raw (Tap 1) (ER)
Bromide	05-Dec-11	89.673	East Raw (Tap 1) (ER)
Bromide	06-Dec-11	86.083	East Raw (Tap 1) (ER)
Bromide	07-Dec-11	88.699	East Raw (Tap 1) (ER)
Bromide	08-Dec-11	89.426	East Raw (Tap 1) (ER)
Bromide	12-Dec-11	93.746	East Raw (Tap 1) (ER)
Bromide	13-Dec-11	93.269	East Raw (Tap 1) (ER)
Bromide	14-Dec-11	93.478	East Raw (Tap 1) (ER)
Bromide	15-Dec-11	94.587	East Raw (Tap 1) (ER)
Bromide	19-Dec-11	95.867	East Raw (Tap 1) (ER)
Bromide	20-Dec-11	88.581	East Raw (Tap 1) (ER)
Bromide	21-Dec-11	88.072	East Raw (Tap 1) (ER)
Bromide	22-Dec-11	87.458	East Raw (Tap 1) (ER)
Bromide	23-Dec-11	87.034	East Raw (Tap 1) (ER)
Bromide	27-Dec-11	85.007	East Raw (Tap 1) (ER)

Bromide	28-Dec-11	83.845 East Raw (Tap 1) (ER)	
Bromide	29-Dec-11	85.411 East Raw (Tap 1) (ER)	
Bromide	30-Dec-11	86.151 East Raw (Tap 1) (ER)	

In 2012

Param	Collect Date	Numerical Results	Sites
Bromide	03-Jan-12	84.107 E	ast Raw (Tap 1) (ER)
Bromide	04-Jan-12	84.765	East Raw (Tap 1) (ER)
Bromide	07-Feb-12	88.437	East Raw (Tap 1) (ER)
Bromide	08-Feb-12	89.764	East Raw (Tap 1) (ER)
Bromide	09-Feb-12	91.888	East Raw (Tap 1) (ER)
Bromide	10-Feb-12	91.169	East Raw (Tap 1) (ER)
Bromide	15-Feb-12	90.228	East Raw (Tap 1) (ER)
Bromide	16-Feb-12	93.341	East Raw (Tap 1) (ER)
Bromide	17-Feb-12	95.183	East Raw (Tap 1) (ER)
Bromide	21-Feb-12	98.48	East Raw (Tap 1) (ER)
Bromide	22-Feb-12	98.144	East Raw (Tap 1) (ER)
Bromide	23-Feb-12	94.702	East Raw (Tap 1) (ER)
Bromide	24-Feb-12	95.128	East Raw (Tap 1) (ER)
Bromide	27-Feb-12	92.518	East Raw (Tap 1) (ER)
Bromide	28-Feb-12	91.533	East Raw (Tap 1) (ER)
Bromide	29-Feb-12	92.285	East Raw (Tap 1) (ER)
Bromide	01-Mar-12	92.899	East Raw (Tap 1) (ER)
Bromide	02-Mar-12	92.151	East Raw (Tap 1) (ER)
Bromide	05-Mar-12	91.767	East Raw (Tap 1) (ER)

Bromide	06-Mar-12	91.065	East Raw (Tap 1) (ER)
Bromide	08-Mar-12	93.539	East Raw (Tap 1) (ER)
Bromide	09-Mar-12	95.289	East Raw (Tap 1) (ER)
Bromide	12-Mar-12	96.379	East Raw (Tap 1) (ER)
Bromide	13-Mar-12	95.518	East Raw (Tap 1) (ER)
Bromide	14-Mar-12	93.556	East Raw (Tap 1) (ER)
Bromide	15-Mar-12	95.578	East Raw (Tap 1) (ER)
Bromide	16-Mar-12	93.793	East Raw (Tap 1) (ER)
Bromide	19-Mar-12	93.636	East Raw (Tap 1) (ER)
Bromide	20-Mar-12	93.273	East Raw (Tap 1) (ER)
Bromide	21-Mar-12	94.711	East Raw (Tap 1) (ER)
Bromide	22-Mar-12	94.135	East Raw (Tap 1) (ER)
Bromide	23-Mar-12	93	East Raw (Tap 1) (ER)
Bromide	26-Mar-12	92.443	East Raw (Tap 1) (ER)
Bromide	27-Mar-12	92.693	East Raw (Tap 1) (ER)
Bromide	28-Mar-12	92.332	East Raw (Tap 1) (ER)
Bromide	29-Mar-12	93.065	East Raw (Tap 1) (ER)
Bromide	30-Mar-12	90.798	East Raw (Tap 1) (ER)
Bromide	02-Apr-12	88.597	East Raw (Tap 1) (ER)
Bromide	03-Apr-12	89.505	East Raw (Tap 1) (ER)
Bromide	04-Apr-12	88.891	East Raw (Tap 1) (ER)
Bromide	05-Apr-12	89.777	East Raw (Tap 1) (ER)
Bromide	06-Apr-12	89.459	East Raw (Tap 1) (ER)
Bromide	09-Apr-12	85.705	East Raw (Tap 1) (ER)
Bromide	10-Apr-12	82.967	East Raw (Tap 1) (ER)

Bromide	11-Apr-12	82.069	East Raw (Tap 1) (ER)
Bromide	12-Apr-12	92.885	East Raw (Tap 1) (ER)
Bromide	13-Apr-12	93.221	East Raw (Tap 1) (ER)
Bromide	02-May-12	94.212	East Raw (Tap 1) (ER)
Bromide	03-May-12	89.985	East Raw (Tap 1) (ER)
Bromide	04-May-12	88.72	East Raw (Tap 1) (ER)
Bromide	07-May-12	86.207	East Raw (Tap 1) (ER)
Bromide	18-May-12	64.714	East Raw (Tap 1) (ER)
Bromide	21-May-12	64.353	East Raw (Tap 1) (ER)
Bromide	22-May-12	73.916	East Raw (Tap 1) (ER)
Bromide	23-May-12	73.924	East Raw (Tap 1) (ER)
Bromide	24-May-12	71.495	East Raw (Tap 1) (ER)
Bromide	25-May-12	69.775	East Raw (Tap 1) (ER)
Bromide	29-May-12	69.439	East Raw (Tap 1) (ER)
Bromide	30-May-12	69.467	East Raw (Tap 1) (ER)
Bromide	31-May-12	68.456	East Raw (Tap 1) (ER)
Bromide	01-Jun-12	67.503	East Raw (Tap 1) (ER)
Bromide	04-Jun-12	63.724	East Raw (Tap 1) (ER)
Bromide	05-Jun-12	66.115	East Raw (Tap 1) (ER)
Bromide	06-Jun-12	64.49	East Raw (Tap 1) (ER)
Bromide	07-Jun-12	64.373	East Raw (Tap 1) (ER)
Bromide	08-Jun-12	63.15	East Raw (Tap 1) (ER)
Bromide	11-Jun-12	67.312	East Raw (Tap 1) (ER)
Bromide	12-Jun-12	67.272	East Raw (Tap 1) (ER)
Bromide	13-Jun-12	68.819	East Raw (Tap 1) (ER)

Bromide	14-Jun-12	69.382	East Raw (Tap 1) (ER)
Bromide	15-Jun-12	69.641	East Raw (Tap 1) (ER)
Bromide	18-Jun-12	72.144	East Raw (Tap 1) (ER)
Bromide	19-Jun-12	72.089	East Raw (Tap 1) (ER)
Bromide	20-Jun-12	71.531	East Raw (Tap 1) (ER)
Bromide	21-Jun-12	71.317	East Raw (Tap 1) (ER)
Bromide	22-Jun-12	71.339	East Raw (Tap 1) (ER)
Bromide	25-Jun-12	70.59	East Raw (Tap 1) (ER)
Bromide	26-Jun-12	70.634	East Raw (Tap 1) (ER)
Bromide	27-Jun-12	71.814	East Raw (Tap 1) (ER)
Bromide	28-Jun-12	71.418	East Raw (Tap 1) (ER)
Bromide	29-Jun-12	84.942	East Raw (Tap 1) (ER)
Bromide	02-Jul-12	83.743	East Raw (Tap 1) (ER)
Bromide	03-Jul-12	98.748	East Raw (Tap 1) (ER)
Bromide	05-Jul-12	80.542	East Raw (Tap 1) (ER)
Bromide	06-Jul-12	98.435	East Raw (Tap 1) (ER)
Bromide	09-Jul-12	77.984	East Raw (Tap 1) (ER)
Bromide	10-Jul-12	79.357	East Raw (Tap 1) (ER)
Bromide	11-Jul-12	78.829	East Raw (Tap 1) (ER)
Bromide	12-Jul-12	78.26	East Raw (Tap 1) (ER)
Bromide	13-Jul-12	76.729	East Raw (Tap 1) (ER)
Bromide	16-Jul-12	77.384	East Raw (Tap 1) (ER)
Bromide	17-Jul-12	77.868	East Raw (Tap 1) (ER)
Bromide	18-Jul-12	77.918	East Raw (Tap 1) (ER)
Bromide	19-Jul-12	78.213	East Raw (Tap 1) (ER)

Bromide	20-Jul-12	78.697	East Raw (Tap 1) (ER)
Bromide	23-Jul-12	80.532	East Raw (Tap 1) (ER)
Bromide	24-Jul-12	79.408	East Raw (Tap 1) (ER)
Bromide	25-Jul-12	79.7	East Raw (Tap 1) (ER)
Bromide	26-Jul-12	82.404	East Raw (Tap 1) (ER)
Bromide	27-Jul-12	74.365	East Raw (Tap 1) (ER)
Bromide	30-Jul-12	76.366	East Raw (Tap 1) (ER)
Bromide	31-Jul-12	72.351	East Raw (Tap 1) (ER)
Bromide	01-Aug-12	72.22	East Raw (Tap 1) (ER)
Bromide	02-Aug-12	75.56	East Raw (Tap 1) (ER)
Bromide	06-Aug-12	77.097	East Raw (Tap 1) (ER)
Bromide	07-Aug-12	70.92	East Raw (Tap 1) (ER)
Bromide	08-Aug-12	74.494	East Raw (Tap 1) (ER)
Bromide	09-Aug-12	72.113	East Raw (Tap 1) (ER)
Bromide	10-Aug-12	81.327	East Raw (Tap 1) (ER)
Bromide	13-Aug-12	87.668	East Raw (Tap 1) (ER)
Bromide	15-Aug-12	97.013	East Raw (Tap 1) (ER)
Bromide	16-Aug-12	91.266	East Raw (Tap 1) (ER)
Bromide	17-Aug-12	90.135	East Raw (Tap 1) (ER)
Bromide	20-Aug-12	80.617	East Raw (Tap 1) (ER)
Bromide	21-Aug-12	81.848	East Raw (Tap 1) (ER)
Bromide	22-Aug-12	84.557	East Raw (Tap 1) (ER)
Bromide	23-Aug-12	80.611	East Raw (Tap 1) (ER)
Bromide	24-Aug-12	81.702	East Raw (Tap 1) (ER)
Bromide	27-Aug-12	82.435	East Raw (Tap 1) (ER)

Bromide	28-Aug-12	80.663	ast Raw (Tap 1) (ER)
Bromide	29-Aug-12	81.033	East Raw (Tap 1) (ER)
Bromide	30-Aug-12	80.663	East Raw (Tap 1) (ER)
Bromide	31-Aug-12	80.781	East Raw (Tap 1) (ER)
Bromide	04-Sep-12	80.066	East Raw (Tap 1) (ER)
Bromide	05-Sep-12	78.468	East Raw (Tap 1) (ER)
Bromide	06-Sep-12	78.419	East Raw (Tap 1) (ER)
Bromide	07-Sep-12	79.237	East Raw (Tap 1) (ER)
Bromide	10-Sep-12	79.727	East Raw (Tap 1) (ER)
Bromide	11-Sep-12	88.795	East Raw (Tap 1) (ER)
Bromide	12-Sep-12	87.216	East Raw (Tap 1) (ER)
Bromide	13-Sep-12	86.346	East Raw (Tap 1) (ER)
Bromide	14-Sep-12	85.083	East Raw (Tap 1) (ER)
Bromide	17-Sep-12	79.967	East Raw (Tap 1) (ER)
Bromide	18-Sep-12	81.295	East Raw (Tap 1) (ER)
Bromide	20-Sep-12	43.668	East Raw (Tap 1) (ER)
Bromide	21-Sep-12	82.544	East Raw (Tap 1) (ER)
Bromide	24-Sep-12	79.628	East Raw (Tap 1) (ER)
Bromide	25-Sep-12	79.258	East Raw (Tap 1) (ER)
Bromide	26-Sep-12	77.928	East Raw (Tap 1) (ER)
Bromide	27-Sep-12	79.942	East Raw (Tap 1) (ER)
Bromide	28-Sep-12	80.11	East Raw (Tap 1) (ER)
Bromide	01-Oct-12	78.262	East Raw (Tap 1) (ER)
Bromide	02-Oct-12	78.128	East Raw (Tap 1) (ER)
Bromide	03-Oct-12	77.53	East Raw (Tap 1) (ER)

Bromide	04-Oct-12	78.578	East Raw (Tap 1) (ER)
Bromide	05-Oct-12	77.341	East Raw (Tap 1) (ER)
Bromide	08-Oct-12	75.852	East Raw (Tap 1) (ER)
Bromide	09-Oct-12	76.327	East Raw (Tap 1) (ER)
Bromide	10-Oct-12	75.477	East Raw (Tap 1) (ER)
Bromide	11-Oct-12	74.615	East Raw (Tap 1) (ER)
Bromide	12-Oct-12	73.954	East Raw (Tap 1) (ER)
Bromide	15-Oct-12	73.87	East Raw (Tap 1) (ER)
Bromide	16-Oct-12	71.551	East Raw (Tap 1) (ER)
Bromide	17-Oct-12	71.786	East Raw (Tap 1) (ER)
Bromide	18-Oct-12	0	East Raw (Tap 1) (ER)
Bromide	19-Oct-12	0	East Raw (Tap 1) (ER)
Bromide	22-Oct-12	0	East Raw (Tap 1) (ER)
Bromide	23-Oct-12	0	East Raw (Tap 1) (ER)
Bromide	24-Oct-12	70.884	East Raw (Tap 1) (ER)
Bromide	25-Oct-12	70.06	East Raw (Tap 1) (ER)
Bromide	26-Oct-12	72.351	East Raw (Tap 1) (ER)
Bromide	29-Oct-12	68.456	East Raw (Tap 1) (ER)
Bromide	30-Oct-12	65.803	East Raw (Tap 1) (ER)
Bromide	31-Oct-12	0	East Raw (Tap 1) (ER)
Bromide	01-Nov-12	62.389	East Raw (Tap 1) (ER)
Bromide	02-Nov-12	57.889	East Raw (Tap 1) (ER)
Bromide	05-Nov-12	55.142	East Raw (Tap 1) (ER)
Bromide	06-Nov-12	54.327	East Raw (Tap 1) (ER)
Bromide	07-Nov-12	52.771	East Raw (Tap 1) (ER)

Bromide	08-Nov-12	50.022	East Raw (Tap 1) (ER)
Bromide	09-Nov-12	50.818	East Raw (Tap 1) (ER)
Bromide	13-Nov-12	52.478	East Raw (Tap 1) (ER)
Bromide	14-Nov-12	48.752	East Raw (Tap 1) (ER)
Bromide	16-Nov-12	55.305	East Raw (Tap 1) (ER)
Bromide	19-Nov-12	58.572	East Raw (Tap 1) (ER)
Bromide	20-Nov-12	61.213	East Raw (Tap 1) (ER)
Bromide	21-Nov-12	58.194	East Raw (Tap 1) (ER)
Bromide	26-Nov-12	65.743	East Raw (Tap 1) (ER)
Bromide	27-Nov-12	60.231	East Raw (Tap 1) (ER)
Bromide	28-Nov-12	57.79	East Raw (Tap 1) (ER)
Bromide	29-Nov-12	59.794	East Raw (Tap 1) (ER)
Bromide	30-Nov-12	61.062	East Raw (Tap 1) (ER)
Bromide	03-Dec-12	58.335	East Raw (Tap 1) (ER)
Bromide	04-Dec-12	58.395	East Raw (Tap 1) (ER)
Bromide	05-Dec-12	57.168	East Raw (Tap 1) (ER)
Bromide	06-Dec-12	58.633	East Raw (Tap 1) (ER)
Bromide	07-Dec-12	54.786	East Raw (Tap 1) (ER)
Bromide	10-Dec-12	59.432	East Raw (Tap 1) (ER)
Bromide	11-Dec-12	57.37	East Raw (Tap 1) (ER)
Bromide	12-Dec-12	56.568	East Raw (Tap 1) (ER)
Bromide	13-Dec-12	61.149	East Raw (Tap 1) (ER)
Bromide	14-Dec-12	59.539	East Raw (Tap 1) (ER)
Bromide	17-Dec-12	59.805	East Raw (Tap 1) (ER)

In 2013			
Param	Collect Date	Numeric Result	Site
Bromide	3/15/2013	60.527	East Raw (Tap 1) (ER)
Bromide	3/19/2013	62.125	East Raw (Tap 1) (ER)
Bromide	3/20/2013	62.516	East Raw (Tap 1) (ER)
Bromide	3/21/2013	60.702	East Raw (Tap 1) (ER)
Bromide	3/22/2013	61.076	East Raw (Tap 1) (ER)
Bromide	3/25/2013	61.523	East Raw (Tap 1) (ER)
Bromide	3/26/2013	59.787	East Raw (Tap 1) (ER)
Bromide	3/27/2013	59.011	East Raw (Tap 1) (ER)
Bromide	3/28/2013	58.188	East Raw (Tap 1) (ER)
Bromide	3/29/2013	60.423	East Raw (Tap 1) (ER)
Bromide	4/1/2013	58.783	East Raw (Tap 1) (ER)
Bromide	4/2/2013	57.924	East Raw (Tap 1) (ER)
Bromide	4/3/2013	59.479	East Raw (Tap 1) (ER)
Bromide	4/4/2013	61.725	East Raw (Tap 1) (ER)
Bromide	4/5/2013	61.982	East Raw (Tap 1) (ER)
Bromide	4/8/2013	62.992	East Raw (Tap 1) (ER)
Bromide	4/9/2013	61.837	East Raw (Tap 1) (ER)
Bromide	4/10/2013	62.172	East Raw (Tap 1) (ER)
Bromide	4/11/2013	59.202	East Raw (Tap 1) (ER)
Bromide	4/12/2013	62.156	East Raw (Tap 1) (ER)
Bromide	4/15/2013	62.939	East Raw (Tap 1) (ER)
Bromide	4/16/2013	60.986	East Raw (Tap 1) (ER)
Bromide	4/17/2013	54.963	East Raw (Tap 1) (ER)

Bromide	4/18/2013	58.455	East Raw (Tap 1) (ER)
Bromide	4/19/2013	61.99	East Raw (Tap 1) (ER)
Bromide	4/22/2013	61.98	East Raw (Tap 1) (ER)
Bromide	4/23/2013	62.901	East Raw (Tap 1) (ER)
Bromide	4/24/2013	66.276	East Raw (Tap 1) (ER)
Bromide	4/25/2013	66.747	East Raw (Tap 1) (ER)
Bromide	4/26/2013	65.637	East Raw (Tap 1) (ER)
Bromide	4/29/2013	93.246	East Raw (Tap 1) (ER)
Bromide	4/30/2013	65.795	East Raw (Tap 1) (ER)
Bromide	5/1/2013	71.365	East Raw (Tap 1) (ER)
Bromide	5/2/2013	70.899	East Raw (Tap 1) (ER)
Bromide	5/3/2013	67.059	East Raw (Tap 1) (ER)
Bromide	5/6/2013	69.928	East Raw (Tap 1) (ER)
Bromide	5/7/2013	70.262	East Raw (Tap 1) (ER)
Bromide	5/8/2013	69.863	East Raw (Tap 1) (ER)
Bromide	5/9/2013	68.956	East Raw (Tap 1) (ER)
Bromide	5/10/2013	67.988	East Raw (Tap 1) (ER)
Bromide	5/13/2013	68.505	East Raw (Tap 1) (ER)
Bromide	5/14/2013	65.449	East Raw (Tap 1) (ER)
Bromide	5/15/2013	66.113	East Raw (Tap 1) (ER)
Bromide	5/16/2013	67.004	East Raw (Tap 1) (ER)
Bromide	5/17/2013	67.142	East Raw (Tap 1) (ER)
Bromide	5/20/2013	70.096	East Raw (Tap 1) (ER)
Bromide	5/21/2013	66.455	East Raw (Tap 1) (ER)
Bromide	5/22/2013	66.866	East Raw (Tap 1) (ER)

Bromide	5/23/2013	67.812	East Raw (Tap 1) (ER)
Bromide	5/24/2013	66.431	East Raw (Tap 1) (ER)
Bromide	5/28/2013	65.298	East Raw (Tap 1) (ER)
Bromide	5/29/2013	67.4	East Raw (Tap 1) (ER)
Bromide	6/12/2013	66.635	East Raw (Tap 1) (ER)
Bromide	6/13/2013	68.056	East Raw (Tap 1) (ER)
Bromide	6/14/2013	67.853	East Raw (Tap 1) (ER)
Bromide	6/17/2013	68.837	East Raw (Tap 1) (ER)
Bromide	6/18/2013	71.337	East Raw (Tap 1) (ER)
Bromide	6/19/2013	70.791	East Raw (Tap 1) (ER)
Bromide	6/20/2013	69.615	East Raw (Tap 1) (ER)
Bromide	6/21/2013	67.834	East Raw (Tap 1) (ER)
Bromide	6/24/2013	69.971	East Raw (Tap 1) (ER)
Bromide	6/25/2013	67.989	East Raw (Tap 1) (ER)
Bromide	6/26/2013	69.557	East Raw (Tap 1) (ER)
Bromide	6/27/2013	69.12	East Raw (Tap 1) (ER)
Bromide	6/28/2013	69.399	East Raw (Tap 1) (ER)
Bromide	7/1/2013	71.05	East Raw (Tap 1) (ER)
Bromide	7/2/2013	65.91	East Raw (Tap 1) (ER)
Bromide	7/3/2013	65.388	East Raw (Tap 1) (ER)

APPENDIX C- FLUORIDE DATA- ALL DATA IN PPB

FROM THE WEST TREATMENT PLANT

Param	Collect Date	Numeric Result	Site
Fluoride	07-May-08	347.24	West Raw (WR)
Fluoride	24-Sep-08	379.117	West Raw (WR)
Fluoride	29-Sep-08	368.484	West Raw (WR)
Fluoride	01-Oct-08	381.408	West Raw (WR)
Fluoride	03-Oct-08	398.583	West Raw (WR)
Fluoride	06-Oct-08	406.23	West Raw (WR)
Fluoride	08-Oct-08	398.927	West Raw (WR)

In 2012

Param	Collect Date	Numerical Results	Sites
Fluoride	27-Aug-12	438.459	West Raw (WR)
Fluoride	28-Aug-12	384.128	West Raw (WR)
Fluoride	29-Aug-12	430.19	West Raw (WR)
Fluoride	30-Aug-12	432.676	West Raw (WR)
Fluoride	31-Aug-12	434.48	West Raw (WR)
Fluoride	04-Sep-12	449.488	West Raw (WR)
Fluoride	05-Sep-12	437.974	West Raw (WR)
Fluoride	06-Sep-12	437.445	West Raw (WR)
Fluoride	07-Sep-12	437.593	West Raw (WR)
Fluoride	10-Sep-12	430.217	West Raw (WR)
Fluoride	11-Sep-12	384.706	West Raw (WR)

Fluoride	12-Sep-12	435.401	West Raw (WR)
Fluoride	13-Sep-12	433.953	West Raw (WR)
Fluoride	14-Sep-12	416.233	West Raw (WR)
Fluoride	17-Sep-12	420.365	West Raw (WR)
Fluoride	18-Sep-12	379.981	West Raw (WR)
Fluoride	20-Sep-12	436.269	West Raw (WR)
Fluoride	25-Sep-12	450.385	West Raw (WR)
Fluoride	26-Sep-12	433.133	West Raw (WR)
Fluoride	27-Sep-12	982.603	West Raw (WR)
Fluoride	28-Sep-12	417.61	West Raw (WR)
Fluoride	02-Oct-12	427.768	West Raw (WR)
Fluoride	03-Oct-12	436.695	West Raw (WR)
Fluoride	04-Oct-12	431.75	West Raw (WR)
Fluoride	05-Oct-12	429.242	West Raw (WR)
Fluoride	08-Oct-12	1003.369	West Raw (WR)
Fluoride	09-Oct-12	430.309	West Raw (WR)
Fluoride	11-Oct-12	428.814	West Raw (WR)
Fluoride	12-Oct-12	426.673	West Raw (WR)
Fluoride	15-Oct-12	432.999	West Raw (WR)
Fluoride	16-Oct-12	429.43	West Raw (WR)
Fluoride	17-Oct-12	429.574	West Raw (WR)
Fluoride	18-Oct-12	467.171	West Raw (WR)
Fluoride	25-Oct-12	403.906	West Raw (WR)
Fluoride	26-Oct-12	456.936	West Raw (WR)
Fluoride	29-Oct-12	445.244	West Raw (WR)

Fluoride	30-Oct-12	440.586	West Raw (WR)
Fluoride	31-Oct-12	427.541	West Raw (WR)
Fluoride	05-Nov-12	407.328	West Raw (WR)
Fluoride	06-Nov-12	390.546	West Raw (WR)
Fluoride	07-Nov-12	395.052	West Raw (WR)
Fluoride	08-Nov-12	390.098	West Raw (WR)
Fluoride	09-Nov-12	381.242	West Raw (WR)
Fluoride	13-Nov-12	398.108	West Raw (WR)
Fluoride	14-Nov-12	378.54	West Raw (WR)
Fluoride	15-Nov-12	381.007	West Raw (WR)
Fluoride	16-Nov-12	362.187	West Raw (WR)
Fluoride	19-Nov-12	473.393	West Raw (WR)

In 2013

Param	Collect Date	Numeric Result	Site
Fluoride	3/15/2013	408.488	West Raw (WR)
Fluoride	3/18/2013	338.836	West Raw (WR)
Fluoride	3/25/2013	405.574	West Raw (WR)
Fluoride	4/1/2013	459.89	West Raw (WR)
Fluoride	4/8/2013	419.997	West Raw (WR)
Fluoride	4/29/2013	1011.171	West Raw (WR)
Fluoride	5/13/2013	456.166	West Raw (WR)
Fluoride	5/20/2013	467.908	West Raw (WR)
Fluoride	5/28/2013	475.666	West Raw (WR)
Fluoride	6/17/2013	488.199	West Raw (WR)

Fluoride	6/24/2013	442.345	West Raw (WR)
Fluoride	7/1/2013	680.707	West Raw (WR)

FROM THE EAST TREATMENT PLANT

Param	Collec tDate	Numeric Result	Site
Fluoride	08-Apr-08	301.512	East Raw (Tap 1) (ER)
Fluoride	09-Apr-08	253.938	East Raw (Tap 1) (ER)
Fluoride	10-Apr-08	261.292	East Raw (Tap 1) (ER)
Fluoride	11-Apr-08	278.736	East Raw (Tap 1) (ER)
Fluoride	14-Apr-08	290.082	East Raw (Tap 1) (ER)
Fluoride	16-Apr-08	289.294	East Raw (Tap 1) (ER)
Fluoride	18-Apr-08	293.35	East Raw (Tap 1) (ER)
Fluoride	21-Apr-08	293.378	East Raw (Tap 1) (ER)
Fluoride	23-Apr-08	306.187	East Raw (Tap 1) (ER)
Fluoride	25-Apr-08	311.439	East Raw (Tap 1) (ER)
Fluoride	28-Apr-08	321.502	East Raw (Tap 1) (ER)
Fluoride	30-Apr-08	322.054	East Raw (Tap 1) (ER)
Fluoride	02-May-08	325.788	East Raw (Tap 1) (ER)
Fluoride	05-May-08	336.09	East Raw (Tap 1) (ER)
Fluoride	07-May-08	335.136	East Raw (Tap 1) (ER)
Fluoride	09-May-08	335.577	East Raw (Tap 1) (ER)
Fluoride	12-May-08	342.335	East Raw (Tap 1) (ER)
Fluoride	14-May-08	338.995	East Raw (Tap 1) (ER)
Fluoride	16-May-08	337.209	East Raw (Tap 1) (ER)
Fluoride	19-May-08	334.418	East Raw (Tap 1) (ER)

Fluoride	21-May-08	334.088	East Raw (Tap 1) (ER)
Fluoride	23-May-08	334.557	East Raw (Tap 1) (ER)
Fluoride	07-Jul-08	359.225	East Raw (Tap 1) (ER)
Fluoride	09-Jul-08	368.684	East Raw (Tap 1) (ER)
Fluoride	21-Jul-08	356.173	East Raw (Tap 1) (ER)
Fluoride	23-Jul-08	353.532	East Raw (Tap 1) (ER)
Fluoride	28-Jul-08	345.607	East Raw (Tap 1) (ER)
Fluoride	30-Jul-08	352.41	East Raw (Tap 1) (ER)
Fluoride	04-Aug-08	307.996	East Raw (Tap 1) (ER)
Fluoride	06-Aug-08	382.831	East Raw (Tap 1) (ER)
Fluoride	08-Aug-08	349.898	East Raw (Tap 1) (ER)
Fluoride	11-Aug-08	360.567	East Raw (Tap 1) (ER)
Fluoride	13-Aug-08	343.857	East Raw (Tap 1) (ER)
Fluoride	15-Aug-08	374.901	East Raw (Tap 1) (ER)
Fluoride	20-Aug-08	327.83	East Raw (Tap 1) (ER)
Fluoride	22-Aug-08	324.385	East Raw (Tap 1) (ER)
Fluoride	25-Aug-08	330.549	East Raw (Tap 1) (ER)
Fluoride	03-Sep-08	344.066	East Raw (Tap 1) (ER)
Fluoride	08-Sep-08	351.442	East Raw (Tap 1) (ER)
Fluoride	10-Sep-08	349.177	East Raw (Tap 1) (ER)
Fluoride	12-Sep-08	344.02	East Raw (Tap 1) (ER)
Fluoride	15-Sep-08	375.796	East Raw (Tap 1) (ER)
Fluoride	17-Sep-08	329.784	East Raw (Tap 1) (ER)
Fluoride	19-Sep-08	321.434	East Raw (Tap 1) (ER)
Fluoride	22-Sep-08	340.916	East Raw (Tap 1) (ER)

Fluoride	24-Sep-08	345.533	East Raw (Tap 1) (ER)
Fluoride	29-Sep-08	351	East Raw (Tap 1) (ER)
Fluoride	01-Oct-08	361.404	East Raw (Tap 1) (ER)
Fluoride	03-Oct-08	366.888	East Raw (Tap 1) (ER)
Fluoride	06-Oct-08	370.884	East Raw (Tap 1) (ER)
Fluoride	08-Oct-08	370.633	East Raw (Tap 1) (ER)
Fluoride	10-Oct-08	393.597	East Raw (Tap 1) (ER)
Fluoride	13-Oct-08	422.65	East Raw (Tap 1) (ER)
Fluoride	15-Oct-08	387.242	East Raw (Tap 1) (ER)
Fluoride	17-Oct-08	303.224	East Raw (Tap 1) (ER)
Fluoride	20-Oct-08	876.216	East Raw (Tap 1) (ER)
Fluoride	22-Oct-08	319.94	East Raw (Tap 1) (ER)
Fluoride	24-Oct-08	292.507	East Raw (Tap 1) (ER)
Fluoride	27-Oct-08	292.508	East Raw (Tap 1) (ER)
Fluoride	29-Oct-08	284.557	East Raw (Tap 1) (ER)
Fluoride	31-Oct-08	276.6	East Raw (Tap 1) (ER)
Fluoride	03-Nov-08	281.535	East Raw (Tap 1) (ER)
Fluoride	05-Nov-08	285.991	East Raw (Tap 1) (ER)
Fluoride	07-Nov-08	298.039	East Raw (Tap 1) (ER)
Fluoride	10-Nov-08	343.787	East Raw (Tap 1) (ER)
Fluoride	12-Nov-08	334.266	East Raw (Tap 1) (ER)
Fluoride	14-Nov-08	330.427	East Raw (Tap 1) (ER)
Fluoride	17-Nov-08	301.863	East Raw (Tap 1) (ER)
Fluoride	21-Nov-08	104.577	East Raw (Tap 1) (ER)
Fluoride	24-Nov-08	318.883	East Raw (Tap 1) (ER)

Fluoride	26-Nov-08	329.338	East Raw (Tap 1) (ER)
Fluoride	01-Dec-08	330.631	East Raw (Tap 1) (ER)
Fluoride	03-Dec-08	332.777	East Raw (Tap 1) (ER)
Fluoride	05-Dec-08	352.051	East Raw (Tap 1) (ER)
Fluoride	08-Dec-08	333.935	East Raw (Tap 1) (ER)
Fluoride	10-Dec-08	349.817	East Raw (Tap 1) (ER)
Fluoride	12-Dec-08	329.286	East Raw (Tap 1) (ER)
Fluoride	15-Dec-08	342.71	East Raw (Tap 1) (ER)
Fluoride	17-Dec-08	319.023	East Raw (Tap 1) (ER)
Fluoride	19-Dec-08	330.429	East Raw (Tap 1) (ER)
Fluoride	22-Dec-08	342.323	East Raw (Tap 1) (ER)
Fluoride	24-Dec-08	338.725	East Raw (Tap 1) (ER)
Fluoride	26-Dec-08	345.215	East Raw (Tap 1) (ER)

In 2011

Param	Collect Date	Numerical Result	Site
Fluoride	13-Jan-11	460.232	East Raw (Tap 1) (ER)
Fluoride	18-Jan-11	409.449	East Raw (Tap 1) (ER)
Fluoride	20-Jan-11	349.595	East Raw (Tap 1) (ER)
Fluoride	21-Jan-11	342.155	East Raw (Tap 1) (ER)
Fluoride	24-Jan-11	295.032	East Raw (Tap 1) (ER)
Fluoride	25-Jan-11	313.103	East Raw (Tap 1) (ER)
Fluoride	26-Jan-11	357.491	East Raw (Tap 1) (ER)
Fluoride	27-Jan-11	347.253	East Raw (Tap 1) (ER)
Fluoride	28-Jan-11	332.787	East Raw (Tap 1) (ER)

Fluoride	31-Jan-11	345.531	East Raw (Tap 1) (ER)
Fluoride	01-Feb-11	334.48	East Raw (Tap 1) (ER)
Fluoride	02-Feb-11	339.281	East Raw (Tap 1) (ER)
Fluoride	03-Feb-11	331.419	East Raw (Tap 1) (ER)
Fluoride	04-Feb-11	322.939	East Raw (Tap 1) (ER)
Fluoride	07-Feb-11	130.892	East Raw (Tap 1) (ER)
Fluoride	08-Feb-11	319.83	East Raw (Tap 1) (ER)
Fluoride	09-Feb-11	320.165	East Raw (Tap 1) (ER)
Fluoride	10-Feb-11	337.561	East Raw (Tap 1) (ER)
Fluoride	11-Feb-11	351.943	East Raw (Tap 1) (ER)
Fluoride	10-Mar-11	371.927	East Raw (Tap 1) (ER)
Fluoride	11-Mar-11	346.446	East Raw (Tap 1) (ER)
Fluoride	14-Mar-11	355.589	East Raw (Tap 1) (ER)
Fluoride	22-Mar-11	365.171	East Raw (Tap 1) (ER)
Fluoride	23-Mar-11	336.934	East Raw (Tap 1) (ER)
Fluoride	28-Mar-11	362.103	East Raw (Tap 1) (ER)
Fluoride	29-Mar-11	350.637	East Raw (Tap 1) (ER)
Fluoride	30-Mar-11	379.644	East Raw (Tap 1) (ER)
Fluoride	31-Mar-11	361.125	East Raw (Tap 1) (ER)
Fluoride	01-Apr-11	355.371	East Raw (Tap 1) (ER)
Fluoride	04-Apr-11	354.092	East Raw (Tap 1) (ER)
Fluoride	05-Apr-11	360.332	East Raw (Tap 1) (ER)
Fluoride	06-Apr-11	512.525	East Raw (Tap 1) (ER)
Fluoride	08-Apr-11	354.246	East Raw (Tap 1) (ER)
Fluoride	12-Apr-11	462.178	East Raw (Tap 1) (ER)

Fluoride	13-Apr-11	440.502	East Raw (Tap 1) (ER)
Fluoride	14-Apr-11	443.112	East Raw (Tap 1) (ER)
Fluoride	15-Apr-11	423.837	East Raw (Tap 1) (ER)
Fluoride	18-Apr-11	422.427	East Raw (Tap 1) (ER)
Fluoride	19-Apr-11	420.486	East Raw (Tap 1) (ER)
Fluoride	20-Apr-11	397.311	East Raw (Tap 1) (ER)
Fluoride	21-Apr-11	414.638	East Raw (Tap 1) (ER)
Fluoride	22-Apr-11	410.277	East Raw (Tap 1) (ER)
Fluoride	25-Apr-11	399.893	East Raw (Tap 1) (ER)
Fluoride	26-Apr-11	398.842	East Raw (Tap 1) (ER)
Fluoride	27-Apr-11	394.363	East Raw (Tap 1) (ER)
Fluoride	28-Apr-11	393.668	East Raw (Tap 1) (ER)
Fluoride	29-Apr-11	329.551	East Raw (Tap 1) (ER)
Fluoride	02-May-11	457.208	East Raw (Tap 1) (ER)
Fluoride	03-May-11	439.301	East Raw (Tap 1) (ER)
Fluoride	04-May-11	442.045	East Raw (Tap 1) (ER)
Fluoride	05-May-11	451.085	East Raw (Tap 1) (ER)
Fluoride	06-May-11	440.335	East Raw (Tap 1) (ER)
Fluoride	09-May-11	465.241	East Raw (Tap 1) (ER)
Fluoride	10-May-11	464.833	East Raw (Tap 1) (ER)
Fluoride	11-May-11	523.008	East Raw (Tap 1) (ER)
Fluoride	12-May-11	475.979	East Raw (Tap 1) (ER)
Fluoride	13-May-11	464.695	East Raw (Tap 1) (ER)
Fluoride	16-May-11	476.564	East Raw (Tap 1) (ER)
Fluoride	17-May-11	526.343	East Raw (Tap 1) (ER)

Fluoride	18-May-11	498.966	East Raw (Tap 1) (ER)
Fluoride	19-May-11	519.961	East Raw (Tap 1) (ER)
Fluoride	23-May-11	413.687	East Raw (Tap 1) (ER)
Fluoride	07-Jun-11	337.463	East Raw (Tap 1) (ER)
Fluoride	08-Jun-11	395.249	East Raw (Tap 1) (ER)
Fluoride	09-Jun-11	399.295	East Raw (Tap 1) (ER)
Fluoride	10-Jun-11	406.585	East Raw (Tap 1) (ER)
Fluoride	27-Jun-11	373.03	East Raw (Tap 1) (ER)
Fluoride	28-Jun-11	223.671	East Raw (Tap 1) (ER)
Fluoride	29-Jun-11	487.382	East Raw (Tap 1) (ER)
Fluoride	30-Jun-11	483.418	East Raw (Tap 1) (ER)
Fluoride	01-Jul-11	480.312	East Raw (Tap 1) (ER)
Fluoride	05-Jul-11	425.006	East Raw (Tap 1) (ER)
Fluoride	06-Jul-11	489.926	East Raw (Tap 1) (ER)
Fluoride	07-Jul-11	464.974	East Raw (Tap 1) (ER)
Fluoride	08-Jul-11	460.358	East Raw (Tap 1) (ER)
Fluoride	11-Jul-11	525.416	East Raw (Tap 1) (ER)
Fluoride	12-Jul-11	417.44	East Raw (Tap 1) (ER)
Fluoride	15-Jul-11	486.521	East Raw (Tap 1) (ER)
Fluoride	19-Jul-11	498.001	East Raw (Tap 1) (ER)
Fluoride	20-Jul-11	501.96	East Raw (Tap 1) (ER)
Fluoride	22-Jul-11	524.083	East Raw (Tap 1) (ER)
Fluoride	25-Jul-11	448.343	East Raw (Tap 1) (ER)
Fluoride	26-Jul-11	504.51	East Raw (Tap 1) (ER)
Fluoride	27-Jul-11	511.29	East Raw (Tap 1) (ER)

Fluoride	28-Jul-11	521.246	East Raw (Tap 1) (ER)
Fluoride	29-Jul-11	561.477	East Raw (Tap 1) (ER)
Fluoride	01-Aug-11	438.705	East Raw (Tap 1) (ER)
Fluoride	02-Aug-11	535.325	East Raw (Tap 1) (ER)
Fluoride	11-Aug-11	472.149	East Raw (Tap 1) (ER)
Fluoride	15-Aug-11	466.482	East Raw (Tap 1) (ER)
Fluoride	16-Aug-11	468.095	East Raw (Tap 1) (ER)
Fluoride	17-Aug-11	473.284	East Raw (Tap 1) (ER)
Fluoride	18-Aug-11	465.835	East Raw (Tap 1) (ER)
Fluoride	19-Aug-11	460.143	East Raw (Tap 1) (ER)
Fluoride	22-Aug-11	442.366	East Raw (Tap 1) (ER)
Fluoride	23-Aug-11	439.714	East Raw (Tap 1) (ER)
Fluoride	24-Aug-11	478.102	East Raw (Tap 1) (ER)
Fluoride	25-Aug-11	478.815	East Raw (Tap 1) (ER)
Fluoride	06-Oct-11	352.854	East Raw (Tap 1) (ER)
Fluoride	07-Oct-11	300.515	East Raw (Tap 1) (ER)
Fluoride	10-Oct-11	401.801	East Raw (Tap 1) (ER)
Fluoride	11-Oct-11	432.722	East Raw (Tap 1) (ER)
Fluoride	13-Oct-11	562.58	East Raw (Tap 1) (ER)
Fluoride	14-Oct-11	585.046	East Raw (Tap 1) (ER)
Fluoride	18-Oct-11	524.56	East Raw (Tap 1) (ER)
Fluoride	19-Oct-11	519.612	East Raw (Tap 1) (ER)
Fluoride	20-Oct-11	523.332	East Raw (Tap 1) (ER)
Fluoride	21-Oct-11	325.008	East Raw (Tap 1) (ER)
Fluoride	24-Oct-11	456.679	East Raw (Tap 1) (ER)

Fluoride	25-Oct-11	446.623	East Raw (Tap 1) (ER)
Fluoride	26-Oct-11	432.619	East Raw (Tap 1) (ER)
Fluoride	27-Oct-11	424.997	East Raw (Tap 1) (ER)
Fluoride	28-Oct-11	425.006	East Raw (Tap 1) (ER)
Fluoride	31-Oct-11	429.603	East Raw (Tap 1) (ER)
Fluoride	01-Nov-11	428.117	East Raw (Tap 1) (ER)
Fluoride	02-Nov-11	432.522	East Raw (Tap 1) (ER)
Fluoride	18-Nov-11	407.614	East Raw (Tap 1) (ER)
Fluoride	21-Nov-11	402.17	East Raw (Tap 1) (ER)
Fluoride	16-Nov-11	418.963	East Raw (Tap 1) (ER)
Fluoride	17-Nov-11	415.435	East Raw (Tap 1) (ER)
Fluoride	22-Nov-11	407.854	East Raw (Tap 1) (ER)
Fluoride	23-Nov-11	402.939	East Raw (Tap 1) (ER)
Fluoride	28-Nov-11	404.608	East Raw (Tap 1) (ER)
Fluoride	29-Nov-11	400.547	East Raw (Tap 1) (ER)
Fluoride	30-Nov-11	401.276	East Raw (Tap 1) (ER)
Fluoride	01-Dec-11	405.255	East Raw (Tap 1) (ER)
Fluoride	02-Dec-11	411.437	East Raw (Tap 1) (ER)
Fluoride	05-Dec-11	418.165	East Raw (Tap 1) (ER)
Fluoride	06-Dec-11	401.358	East Raw (Tap 1) (ER)
Fluoride	07-Dec-11	408.15	East Raw (Tap 1) (ER)
Fluoride	08-Dec-11	409.556	East Raw (Tap 1) (ER)
Fluoride	12-Dec-11	407.973	East Raw (Tap 1) (ER)
Fluoride	13-Dec-11	423.005	East Raw (Tap 1) (ER)
Fluoride	14-Dec-11	421.34	East Raw (Tap 1) (ER)

Fluoride	15-Dec-11	425.015	East Raw (Tap 1) (ER)
Fluoride	19-Dec-11	434.743	East Raw (Tap 1) (ER)
Fluoride	20-Dec-11	423.204	East Raw (Tap 1) (ER)
Fluoride	21-Dec-11	427.033	East Raw (Tap 1) (ER)
Fluoride	22-Dec-11	426.345	East Raw (Tap 1) (ER)
Fluoride	23-Dec-11	422.91	East Raw (Tap 1) (ER)
Fluoride	27-Dec-11	413.345	East Raw (Tap 1) (ER)
Fluoride	28-Dec-11	407.074	East Raw (Tap 1) (ER)
Fluoride	29-Dec-11	411.318	East Raw (Tap 1) (ER)
Fluoride	30-Dec-11	412.385	East Raw (Tap 1) (ER)

In 2012

Param	Collect Date	Numerical Results	Sites
Fluoride	03-Jan-12	397.85	East Raw (Tap 1) (ER)
Fluoride	04-Jan-12	402.087	East Raw (Tap 1) (ER)
Fluoride	07-Feb-12	393.089	East Raw (Tap 1) (ER)
Fluoride	08-Feb-12	391.247	East Raw (Tap 1) (ER)
Fluoride	09-Feb-12	391.003	East Raw (Tap 1) (ER)
Fluoride	10-Feb-12	386.322	East Raw (Tap 1) (ER)
Fluoride	15-Feb-12	374.378	East Raw (Tap 1) (ER)
Fluoride	16-Feb-12	382.85	East Raw (Tap 1) (ER)
Fluoride	17-Feb-12	384.032	East Raw (Tap 1) (ER)
Fluoride	21-Feb-12	393.401	East Raw (Tap 1) (ER)
Fluoride	22-Feb-12	398.915	East Raw (Tap 1) (ER)
Fluoride	23-Feb-12	394.278	East Raw (Tap 1) (ER)

Fluoride	24-Feb-12	400.672	East Raw (Tap 1) (ER)
Fluoride	27-Feb-12	397.902	East Raw (Tap 1) (ER)
Fluoride	28-Feb-12	396.109	East Raw (Tap 1) (ER)
Fluoride	29-Feb-12	407.869	East Raw (Tap 1) (ER)
Fluoride	01-Mar-12	406.656	East Raw (Tap 1) (ER)
Fluoride	02-Mar-12	341.109	East Raw (Tap 1) (ER)
Fluoride	05-Mar-12	408.049	East Raw (Tap 1) (ER)
Fluoride	06-Mar-12	393.008	East Raw (Tap 1) (ER)
Fluoride	08-Mar-12	419.73	East Raw (Tap 1) (ER)
Fluoride	09-Mar-12	425.029	East Raw (Tap 1) (ER)
Fluoride	12-Mar-12	405.123	East Raw (Tap 1) (ER)
Fluoride	13-Mar-12	409.161	East Raw (Tap 1) (ER)
Fluoride	14-Mar-12	405.004	East Raw (Tap 1) (ER)
Fluoride	15-Mar-12	413.116	East Raw (Tap 1) (ER)
Fluoride	16-Mar-12	407.692	East Raw (Tap 1) (ER)
Fluoride	19-Mar-12	427.365	East Raw (Tap 1) (ER)
Fluoride	20-Mar-12	436.194	East Raw (Tap 1) (ER)
Fluoride	21-Mar-12	444.757	East Raw (Tap 1) (ER)
Fluoride	22-Mar-12	446.699	East Raw (Tap 1) (ER)
Fluoride	23-Mar-12	452.321	East Raw (Tap 1) (ER)
Fluoride	26-Mar-12	451.877	East Raw (Tap 1) (ER)
Fluoride	27-Mar-12	451.226	East Raw (Tap 1) (ER)
Fluoride	28-Mar-12	439.903	East Raw (Tap 1) (ER)
Fluoride	29-Mar-12	438.831	East Raw (Tap 1) (ER)
Fluoride	30-Mar-12	442.596	East Raw (Tap 1) (ER)

Fluoride	02-Apr-12	432.97	East Raw (Tap 1) (ER)
Fluoride	03-Apr-12	357.719	East Raw (Tap 1) (ER)
Fluoride	04-Apr-12	433.164	East Raw (Tap 1) (ER)
Fluoride	05-Apr-12	435.392	East Raw (Tap 1) (ER)
Fluoride	06-Apr-12	469.2	East Raw (Tap 1) (ER)
Fluoride	09-Apr-12	459.558	East Raw (Tap 1) (ER)
Fluoride	10-Apr-12	469.247	East Raw (Tap 1) (ER)
Fluoride	11-Apr-12	464.951	East Raw (Tap 1) (ER)
Fluoride	12-Apr-12	534.13	East Raw (Tap 1) (ER)
Fluoride	13-Apr-12	529.542	East Raw (Tap 1) (ER)
Fluoride	02-May-12	381.443	East Raw (Tap 1) (ER)
Fluoride	03-May-12	376.879	East Raw (Tap 1) (ER)
Fluoride	04-May-12	371.809	East Raw (Tap 1) (ER)
Fluoride	07-May-12	370.675	East Raw (Tap 1) (ER)
Fluoride	18-May-12	343.435	East Raw (Tap 1) (ER)
Fluoride	21-May-12	359.39	East Raw (Tap 1) (ER)
Fluoride	22-May-12	370.212	East Raw (Tap 1) (ER)
Fluoride	23-May-12	366.057	East Raw (Tap 1) (ER)
Fluoride	24-May-12	363.51	East Raw (Tap 1) (ER)
Fluoride	25-May-12	359.405	East Raw (Tap 1) (ER)
Fluoride	29-May-12	365.348	East Raw (Tap 1) (ER)
Fluoride	30-May-12	366.507	East Raw (Tap 1) (ER)
Fluoride	31-May-12	366.678	East Raw (Tap 1) (ER)
Fluoride	01-Jun-12	364.4	East Raw (Tap 1) (ER)
Fluoride	04-Jun-12	358.633	East Raw (Tap 1) (ER)

Fluoride	05-Jun-12	354.897	East Raw (Tap 1) (ER)
Fluoride	06-Jun-12	354.059	East Raw (Tap 1) (ER)
Fluoride	07-Jun-12	343.23	East Raw (Tap 1) (ER)
Fluoride	08-Jun-12	337.866	East Raw (Tap 1) (ER)
Fluoride	11-Jun-12	359.257	East Raw (Tap 1) (ER)
Fluoride	12-Jun-12	358.035	East Raw (Tap 1) (ER)
Fluoride	13-Jun-12	368.598	East Raw (Tap 1) (ER)
Fluoride	14-Jun-12	361.014	East Raw (Tap 1) (ER)
Fluoride	15-Jun-12	376.006	East Raw (Tap 1) (ER)
Fluoride	18-Jun-12	376.946	East Raw (Tap 1) (ER)
Fluoride	19-Jun-12	377.583	East Raw (Tap 1) (ER)
Fluoride	20-Jun-12	376.185	East Raw (Tap 1) (ER)
Fluoride	21-Jun-12	372.252	East Raw (Tap 1) (ER)
Fluoride	22-Jun-12	367.523	East Raw (Tap 1) (ER)
Fluoride	25-Jun-12	371.751	East Raw (Tap 1) (ER)
Fluoride	26-Jun-12	368.786	East Raw (Tap 1) (ER)
Fluoride	27-Jun-12	365.965	East Raw (Tap 1) (ER)
Fluoride	28-Jun-12	363.42	East Raw (Tap 1) (ER)
Fluoride	29-Jun-12	397.25	East Raw (Tap 1) (ER)
Fluoride	02-Jul-12	501.008	East Raw (Tap 1) (ER)
Fluoride	03-Jul-12	503.867	East Raw (Tap 1) (ER)
Fluoride	05-Jul-12	367.368	East Raw (Tap 1) (ER)
Fluoride	06-Jul-12	504.005	East Raw (Tap 1) (ER)
Fluoride	09-Jul-12	374.571	East Raw (Tap 1) (ER)
Fluoride	10-Jul-12	414.056	East Raw (Tap 1) (ER)

Fluoride	11-Jul-12	373.111	East Raw (Tap 1) (ER)
Fluoride	12-Jul-12	371.087	East Raw (Tap 1) (ER)
Fluoride	13-Jul-12	485.41	East Raw (Tap 1) (ER)
Fluoride	16-Jul-12	369.793	East Raw (Tap 1) (ER)
Fluoride	17-Jul-12	366.685	East Raw (Tap 1) (ER)
Fluoride	18-Jul-12	415.409	East Raw (Tap 1) (ER)
Fluoride	19-Jul-12	487.403	East Raw (Tap 1) (ER)
Fluoride	20-Jul-12	368.899	East Raw (Tap 1) (ER)
Fluoride	23-Jul-12	487.316	East Raw (Tap 1) (ER)
Fluoride	24-Jul-12	386.634	East Raw (Tap 1) (ER)
Fluoride	25-Jul-12	369.778	East Raw (Tap 1) (ER)
Fluoride	26-Jul-12	367.818	East Raw (Tap 1) (ER)
Fluoride	27-Jul-12	393.031	East Raw (Tap 1) (ER)
Fluoride	30-Jul-12	361.175	East Raw (Tap 1) (ER)
Fluoride	31-Jul-12	399.779	East Raw (Tap 1) (ER)
Fluoride	01-Aug-12	400.796	East Raw (Tap 1) (ER)
Fluoride	02-Aug-12	394.954	East Raw (Tap 1) (ER)
Fluoride	06-Aug-12	391.86	East Raw (Tap 1) (ER)
Fluoride	07-Aug-12	335.355	East Raw (Tap 1) (ER)
Fluoride	08-Aug-12	340.879	East Raw (Tap 1) (ER)
Fluoride	09-Aug-12	333.805	East Raw (Tap 1) (ER)
Fluoride	10-Aug-12	362.203	East Raw (Tap 1) (ER)
Fluoride	13-Aug-12	388.918	East Raw (Tap 1) (ER)
Fluoride	15-Aug-12	400.289	East Raw (Tap 1) (ER)
Fluoride	16-Aug-12	378.477	East Raw (Tap 1) (ER)

Fluoride	17-Aug-12	377.343	East Raw (Tap 1) (ER)
Fluoride	20-Aug-12	375.776	East Raw (Tap 1) (ER)
Fluoride	21-Aug-12	368.369	East Raw (Tap 1) (ER)
Fluoride	22-Aug-12	370.407	East Raw (Tap 1) (ER)
Fluoride	23-Aug-12	360.981	East Raw (Tap 1) (ER)
Fluoride	24-Aug-12	363.697	East Raw (Tap 1) (ER)
Fluoride	27-Aug-12	406.94	East Raw (Tap 1) (ER)
Fluoride	28-Aug-12	405.738	East Raw (Tap 1) (ER)
Fluoride	29-Aug-12	402.543	East Raw (Tap 1) (ER)
Fluoride	30-Aug-12	402.42	East Raw (Tap 1) (ER)
Fluoride	31-Aug-12	405.083	East Raw (Tap 1) (ER)
Fluoride	04-Sep-12	408.088	East Raw (Tap 1) (ER)
Fluoride	05-Sep-12	407.896	East Raw (Tap 1) (ER)
Fluoride	06-Sep-12	408.964	East Raw (Tap 1) (ER)
Fluoride	07-Sep-12	413.024	East Raw (Tap 1) (ER)
Fluoride	10-Sep-12	414.313	East Raw (Tap 1) (ER)
Fluoride	11-Sep-12	402.508	East Raw (Tap 1) (ER)
Fluoride	12-Sep-12	400.711	East Raw (Tap 1) (ER)
Fluoride	13-Sep-12	399.359	East Raw (Tap 1) (ER)
Fluoride	14-Sep-12	397.009	East Raw (Tap 1) (ER)
Fluoride	17-Sep-12	393.053	East Raw (Tap 1) (ER)
Fluoride	18-Sep-12	400.293	East Raw (Tap 1) (ER)
Fluoride	20-Sep-12	931.515	East Raw (Tap 1) (ER)
Fluoride	21-Sep-12	407.505	East Raw (Tap 1) (ER)
Fluoride	24-Sep-12	406.142	East Raw (Tap 1) (ER)

Fluoride	25-Sep-12	406.014	East Raw (Tap 1) (ER)
Fluoride	26-Sep-12	404.818	East Raw (Tap 1) (ER)
Fluoride	27-Sep-12	394.172	East Raw (Tap 1) (ER)
Fluoride	28-Sep-12	398.45	East Raw (Tap 1) (ER)
Fluoride	01-Oct-12	393.268	East Raw (Tap 1) (ER)
Fluoride	02-Oct-12	392.743	East Raw (Tap 1) (ER)
Fluoride	03-Oct-12	400.747	East Raw (Tap 1) (ER)
Fluoride	04-Oct-12	404.907	East Raw (Tap 1) (ER)
Fluoride	05-Oct-12	396.911	East Raw (Tap 1) (ER)
Fluoride	08-Oct-12	406.875	East Raw (Tap 1) (ER)
Fluoride	09-Oct-12	403.673	East Raw (Tap 1) (ER)
Fluoride	10-Oct-12	404.38	East Raw (Tap 1) (ER)
Fluoride	11-Oct-12	398.135	East Raw (Tap 1) (ER)
Fluoride	12-Oct-12	398.364	East Raw (Tap 1) (ER)
Fluoride	15-Oct-12	403.918	East Raw (Tap 1) (ER)
Fluoride	16-Oct-12	397.228	East Raw (Tap 1) (ER)
Fluoride	17-Oct-12	400.515	East Raw (Tap 1) (ER)
Fluoride	18-Oct-12	430.309	East Raw (Tap 1) (ER)
Fluoride	19-Oct-12	428.843	East Raw (Tap 1) (ER)
Fluoride	22-Oct-12	421.97	East Raw (Tap 1) (ER)
Fluoride	23-Oct-12	420.595	East Raw (Tap 1) (ER)
Fluoride	24-Oct-12	422.563	East Raw (Tap 1) (ER)
Fluoride	25-Oct-12	421.159	East Raw (Tap 1) (ER)
Fluoride	26-Oct-12	420.791	East Raw (Tap 1) (ER)
Fluoride	29-Oct-12	419.898	East Raw (Tap 1) (ER)

Fluoride	30-Oct-12	419.869	East Raw (Tap 1) (ER)
Fluoride	31-Oct-12	412.475	East Raw (Tap 1) (ER)
Fluoride	01-Nov-12	390.221	East Raw (Tap 1) (ER)
Fluoride	02-Nov-12	362.569	East Raw (Tap 1) (ER)
Fluoride	05-Nov-12	372.911	East Raw (Tap 1) (ER)
Fluoride	06-Nov-12	350.682	East Raw (Tap 1) (ER)
Fluoride	07-Nov-12	340.719	East Raw (Tap 1) (ER)
Fluoride	08-Nov-12	332.583	East Raw (Tap 1) (ER)
Fluoride	09-Nov-12	324.681	East Raw (Tap 1) (ER)
Fluoride	13-Nov-12	333.723	East Raw (Tap 1) (ER)
Fluoride	14-Nov-12	319.47	East Raw (Tap 1) (ER)
Fluoride	15-Nov-12	259.017	East Raw (Tap 1) (ER)
Fluoride	16-Nov-12	316.829	East Raw (Tap 1) (ER)
Fluoride	19-Nov-12	354.757	East Raw (Tap 1) (ER)
Fluoride	20-Nov-12	376.522	East Raw (Tap 1) (ER)
Fluoride	21-Nov-12	345.742	East Raw (Tap 1) (ER)
Fluoride	26-Nov-12	388.037	East Raw (Tap 1) (ER)
Fluoride	27-Nov-12	350.81	East Raw (Tap 1) (ER)
Fluoride	28-Nov-12	346.587	East Raw (Tap 1) (ER)
Fluoride	29-Nov-12	341.935	East Raw (Tap 1) (ER)
Fluoride	30-Nov-12	338.793	East Raw (Tap 1) (ER)
Fluoride	03-Dec-12	343.037	East Raw (Tap 1) (ER)
Fluoride	04-Dec-12	347.281	East Raw (Tap 1) (ER)
Fluoride	05-Dec-12	347.507	East Raw (Tap 1) (ER)
Fluoride	06-Dec-12	8.918	East Raw (Tap 1) (ER)

Fluoride	07-Dec-12	327.15	East Raw (Tap 1) (ER)
Fluoride	10-Dec-12	329.963	East Raw (Tap 1) (ER)
Fluoride	11-Dec-12	331.812	East Raw (Tap 1) (ER)
Fluoride	12-Dec-12	328.814	East Raw (Tap 1) (ER)
Fluoride	13-Dec-12	323.172	East Raw (Tap 1) (ER)
Fluoride	14-Dec-12	328.575	East Raw (Tap 1) (ER)
Fluoride	17-Dec-12	331.54	East Raw (Tap 1) (ER)

In 2013

Param	Collect Date	Numeric Result	Site
Fluoride	3/15/2013	363.91	East Raw (Tap 1) (ER)
Fluoride	3/19/2013	357.662	East Raw (Tap 1) (ER)
Fluoride	3/20/2013	362.878	East Raw (Tap 1) (ER)
Fluoride	3/21/2013	354.938	East Raw (Tap 1) (ER)
Fluoride	3/22/2013	351.919	East Raw (Tap 1) (ER)
Fluoride	3/25/2013	351.566	East Raw (Tap 1) (ER)
Fluoride	3/26/2013	347.683	East Raw (Tap 1) (ER)
Fluoride	3/27/2013	344.708	East Raw (Tap 1) (ER)
Fluoride	3/28/2013	338.757	East Raw (Tap 1) (ER)
Fluoride	3/29/2013	345.341	East Raw (Tap 1) (ER)
Fluoride	4/1/2013	351.054	East Raw (Tap 1) (ER)
Fluoride	4/2/2013	333.654	East Raw (Tap 1) (ER)
Fluoride	4/3/2013	338.66	East Raw (Tap 1) (ER)
Fluoride	4/4/2013	344.539	East Raw (Tap 1) (ER)
Fluoride	4/5/2013	337.881	East Raw (Tap 1) (ER)

Fluoride	4/8/2013	343.361	East Raw (Tap 1) (ER)
Fluoride	4/9/2013	337.896	East Raw (Tap 1) (ER)
Fluoride	4/10/2013	336.45	East Raw (Tap 1) (ER)
Fluoride	4/11/2013	339.181	East Raw (Tap 1) (ER)
Fluoride	4/12/2013	348.331	East Raw (Tap 1) (ER)
Fluoride	4/15/2013	352.727	East Raw (Tap 1) (ER)
Fluoride	4/16/2013	338.431	East Raw (Tap 1) (ER)
Fluoride	4/17/2013	332.636	East Raw (Tap 1) (ER)
Fluoride	4/18/2013	333.21	East Raw (Tap 1) (ER)
Fluoride	4/19/2013	342.502	East Raw (Tap 1) (ER)
Fluoride	4/22/2013	326.816	East Raw (Tap 1) (ER)
Fluoride	4/23/2013	331.044	East Raw (Tap 1) (ER)
Fluoride	4/24/2013	336.834	East Raw (Tap 1) (ER)
Fluoride	4/25/2013	341.766	East Raw (Tap 1) (ER)
Fluoride	4/26/2013	338.924	East Raw (Tap 1) (ER)
Fluoride	4/29/2013	426.043	East Raw (Tap 1) (ER)
Fluoride	4/30/2013	342.341	East Raw (Tap 1) (ER)
Fluoride	5/1/2013	343.985	East Raw (Tap 1) (ER)
Fluoride	5/2/2013	346.403	East Raw (Tap 1) (ER)
Fluoride	5/3/2013	355.101	East Raw (Tap 1) (ER)
Fluoride	5/6/2013	369.611	East Raw (Tap 1) (ER)
Fluoride	5/7/2013	370.154	East Raw (Tap 1) (ER)
Fluoride	5/8/2013	370.484	East Raw (Tap 1) (ER)
Fluoride	5/9/2013	368.411	East Raw (Tap 1) (ER)
Fluoride	5/10/2013	367.707	East Raw (Tap 1) (ER)

Fluoride	5/13/2013	372.438	East Raw (Tap 1) (ER)
Fluoride	5/14/2013	371.04	East Raw (Tap 1) (ER)
Fluoride	5/15/2013	373.312	East Raw (Tap 1) (ER)
Fluoride	5/16/2013	374.416	East Raw (Tap 1) (ER)
Fluoride	5/17/2013	375.117	East Raw (Tap 1) (ER)
Fluoride	5/20/2013	387.437	East Raw (Tap 1) (ER)
Fluoride	5/21/2013	391.16	East Raw (Tap 1) (ER)
Fluoride	5/22/2013	391.842	East Raw (Tap 1) (ER)
Fluoride	5/23/2013	390.293	East Raw (Tap 1) (ER)
Fluoride	5/24/2013	394.434	East Raw (Tap 1) (ER)
Fluoride	5/28/2013	384.394	East Raw (Tap 1) (ER)
Fluoride	5/29/2013	393.225	East Raw (Tap 1) (ER)
Fluoride	6/12/2013	415.934	East Raw (Tap 1) (ER)
Fluoride	6/13/2013	412.221	East Raw (Tap 1) (ER)
Fluoride	6/14/2013	410.855	East Raw (Tap 1) (ER)
Fluoride	6/17/2013	415.366	East Raw (Tap 1) (ER)
Fluoride	6/18/2013	430.635	East Raw (Tap 1) (ER)
Fluoride	6/19/2013	428.391	East Raw (Tap 1) (ER)
Fluoride	6/20/2013	408.133	East Raw (Tap 1) (ER)
Fluoride	6/21/2013	411.499	East Raw (Tap 1) (ER)
Fluoride	6/24/2013	419.387	East Raw (Tap 1) (ER)
Fluoride	6/25/2013	424.442	East Raw (Tap 1) (ER)
Fluoride	6/26/2013	430.275	East Raw (Tap 1) (ER)
Fluoride	6/27/2013	414.211	East Raw (Tap 1) (ER)
Fluoride	6/28/2013	534.269	East Raw (Tap 1) (ER)

Fluoride	7/1/2013	541.236	East Raw (Tap 1) (ER)
Fluoride	7/2/2013	589.3	East Raw (Tap 1) (ER)
Fluoride	7/3/2013	401.552	East Raw (Tap 1) (ER)

APPENDIX D-IRON DATA-ALL DATA IN PPB

FROM THE WEST TREATMENT PLANT

Param	Collect Date	Numerical Result	Sites
Iron	15-Feb-11	1.2983	West Raw (WR)
Iron	18-May-11	4.4	West Raw (WR)
Iron	14-Jun-11	0	West Raw (WR)
Iron	20-Jul-11	69.42	West Raw (WR)
Iron	17-Aug-11	1.7	West Raw (WR)
Iron	20-Sep-11	1.93	West Raw (WR)
Iron	27-Sep-11	22.7	West Raw (WR)
Iron	12-Oct-11	0.27	West Raw (WR)
Iron	17-Oct-11	1.51	West Raw (WR)
Iron	07-Nov-11	3.16	West Raw (WR)
Iron	14-Nov-11	1.8	West Raw (WR)

In 2012

Param	Collect Date	Numerical Results	Sites
Iron	05-Jan-12	1.9321	West Raw (WR)

Iron	01-Feb-12	0.88	West Raw (WR)
Iron	17-Apr-12	3.83	West Raw (WR)
Iron	08-May-12	5.4496	West Raw (WR)
Iron	17-May-12	24.9138	West Raw (WR)
Iron	05-Jun-12	4.9066	West Raw (WR)
Iron	19-Jun-12	13.7359	West Raw (WR)
Iron	11-Jul-12	24.45	West Raw (WR)
Iron	01-Aug-12	18.61	West Raw (WR)
Iron	14-Aug-12	10.03	West Raw (WR)
Iron	22-Aug-12	8.3605	West Raw (WR)
Iron	12-Sep-12	12.6428	West Raw (WR)
Iron	03-Oct-12	20.6301	West Raw (WR)
Iron	30-Oct-12	4.9768	West Raw (WR)
Iron	08-Nov-12	108.605	West Raw (WR)

In 2013

Param	Collect Date	Numeric Result	Site
Iron	1/9/2013	3.3516	West Raw (WR)
Iron	1/10/2013	4.285	West Raw (WR)
Iron	2/6/2013	3.8741	West Raw (WR)
Iron	2/8/2013	3.4541	West Raw (WR)
Iron	3/8/2013	8.3662	West Raw (WR)
Iron	3/15/2013	1.1252	West Raw (WR)
Iron	4/8/2013	0.9512	West Raw (WR)
Iron	4/30/2013	9.9366	West Raw (WR)

Iron	5/23/2013	11.8127	West Raw (WR)
Iron	5/30/2013	2.903	West Raw (WR)
Iron	6/6/2013	32.4468	West Raw (WR)
Iron	6/12/2013	4.5208	West Raw (WR)
Iron	7/11/2013	6.4218	West Raw (WR)

FROM THE EAST TREATEMENT PLANT

Param	Collect Date	Numerical Result	Sites
Iron	07-Jan-11	1.5363	East Raw (Tap 1) (ER)
Iron	26-Jan-11	0.5657	East Raw (Tap 1) (ER)
Iron	18-Mar-11	3.49	East Raw (Tap 1) (ER)
Iron	24-Mar-11	4.93	East Raw (Tap 1) (ER)
Iron	13-Apr-11	0.91	East Raw (Tap 1) (ER)
Iron	18-May-11	0.7	East Raw (Tap 1) (ER)
Iron	14-Jun-11	0	East Raw (Tap 1) (ER)
Iron	20-Jul-11	1.66	East Raw (Tap 1) (ER)
Iron	17-Aug-11	1.22	East Raw (Tap 1) (ER)
Iron	12-Oct-11	1.51	East Raw (Tap 1) (ER)
Iron	17-Oct-11	0.14	East Raw (Tap 1) (ER)
Iron	13-Dec-11	9.0861	East Raw (Tap 1) (ER)

In 2012

Param	Collect Date	Numerical Results	Sites
Iron	23-Feb-12	11.88	ast Raw (Tap 1) (ER)
Iron	06-Mar-12	1.43	East Raw (Tap 1) (ER)

Iron	15-Mar-12	22.66	East Raw (Tap 1) (ER)
Iron	10-Apr-12	31.64	East Raw (Tap 1) (ER)
Iron	05-Jun-12	1.8621	East Raw (Tap 1) (ER)
Iron	19-Jun-12	5.3218	East Raw (Tap 1) (ER)
Iron	11-Jul-12	1.43	East Raw (Tap 1) (ER)
Iron	01-Aug-12	6.34	East Raw (Tap 1) (ER)
Iron	22-Aug-12	1.2171	East Raw (Tap 1) (ER)
Iron	12-Sep-12	2.2167	East Raw (Tap 1) (ER)
Iron	03-Oct-12	2.3083	East Raw (Tap 1) (ER)
Iron	30-Oct-12	1.3841	East Raw (Tap 1) (ER)
Iron	02-Nov-12	1.4144	East Raw (Tap 1) (ER)
Iron	08-Nov-12	1.3102	East Raw (Tap 1) (ER)
Iron	05-Dec-12	1.282	East Raw (Tap 1) (ER)

In 2013

Param	Collect Date	Numeric Result	Site
Iron	3/15/2013	1.2666	East Raw (Tap 1) (ER)
Iron	4/8/2013	0.9365	East Raw (Tap 1) (ER)
Iron	4/30/2013	1.0741	East Raw (Tap 1) (ER)
Iron	5/23/2013	0.7818	East Raw (Tap 1) (ER)
Iron	6/12/2013	3.5681	East Raw (Tap 1) (ER)
Iron	7/11/2013	1.2674	East Raw (Tap 1) (ER)

APPENDIX E-PUMPING RATE DATA-ALL DATA IN MILLY GALONS (MG)

The following is the total pumping rates for each month. Groups A and B are from North and South well fields.

Months	Pump Rate Group A (MG)	Group B (MG)	Sum A+B	Island wells (MG)
Jan-08	516.49	633.42	1149.91	0
Feb-08	373.24	899.95	1273.19	0
Mar-08	338.97	976.29	1315.26	31.6
Apr-08	168.33	93.48	261.81	609.82
May-08	327.72	117.98	445.7	560.75
Jun-08	763.09	278.73	1041.82	0
Jul-08	654.41	370.45	1024.86	525.86
Aug-08	605.5	401.09	1006.59	836.19
Sep-08	115.91	272.95	388.86	852.39
Oct-08	227.37	296.74	524.11	599.24
Nov-08	0.02	0	0.02	823.32
Dec-08	0.54	0.01	0.55	839.13

Months	Pump Rate Group A (MG)	Group B (MG)	Sum A+B	Island wells (MG)
Jan-12	419.59	76.11	495.7	100.01
Feb-12	138.61	40.88	179.49	544.43
Mar-12	26.94	16.56	43.5	880.91
Apr-12	254.51	237.74	492.25	498.96
May-12	504.42	348	852.42	418.59
Jun-12	658.28	290.08	948.36	719.76
Jul-12	916.26	423.74	1340	868.34
Aug-12	941.48	288.23	1229.71	656.69
Sep-12	638.43	276.69	915.12	666.65
Oct-12	465.37	132.09	597.46	596.29
Nov-12	130.13	8.77	138.9	735.71
Dec-12	189.85	53.52	243.37	477.04

Months	Pump Rate Group A (MG)	Group B (MG)	Sum A+B	Island wells (MG)
Jan-13	454.19	30.51	484.7	12.67
Feb-13	495.3	11.63	506.93	21.04
Mar-13	382.63	47.65	430.28	319.96
Apr-13	98.26	35.5	133.76	725.89
May-13	355.11	83.54	438.65	593.28
Jun-13	601.35	268.96	870.31	385.51
Jul-13	751.8	356.985	1108.785	868.02
Aug-13	718.61	169.83	888.44	822.9
Sep-13	691.33	138.24	829.57	767.78
Oct-13	411.93	153.63	565.56	611.35
Nov-13	14.68	1.21	15.89	844.08
Dec-13	221.95	7.64	229.59	554.34

APPENDIX F-MAJOR INORGANIC ION DATA-FIELD SAMPLES-ALL DATA IN (mg/L)

Sample ID	Aquifer	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	$HCO3^{-}$	$SO4^{2-}$	Cl^{-}
East Plant	alluvial	45.5	13	29.4	8.97	174.02	61.1	14.9
West Plant	alluvial	47.4	13.4	35	10	184.19	70.1	14.3
76-1	alluvial	59	16.1	37.6	11.3	186.45	54	14.5
49-7	alluvial	59	15.8	39.1	13.8	201.14	113.5	20.7
32-2A	alluvial	45.5	13.9	36.9	9.38	180.8	82.7	15.5
37-4A	alluvial	41.6	11.8	51.8	11.3	179.67	55.4	14.2
54-9A	alluvial	45.5	12.5	23.4	10	174.02	58.3	14.5
Shramm Park	limestone	103.5	27.3	72	10.6	463.3	31.5	22.5
Limestone Spring	limestone	59	15.7	70.5	5	282.5	15.8	6.6

APPENDIX G-PHREEQC OUTPUT FILES FOR FLUORITE SATURATION INDICIES

Sample 1: East treatment plant

Input file: C:\Users\Juanita\AppData\Local\Temp\phrq0000.tmp

Output file: C:\Users\Juanita\Desktop\thesis phreeqc\Fluorite in the lincoln well field\sampleone.out

Database file: C:\Program Files (x86)\Phreeqc\Databases\Phreeqc.dat

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Reading data base.

SOLUTION_MASTER_SPECIES

SOLUTION_SPECIES

PHASES

EXCHANGE_MASTER_SPECIES

EXCHANGE_SPECIES

SURFACE_MASTER_SPECIES

SURFACE_SPECIES

RATES

END

Reading input data for simulation 1.

TITLE Fluorite precipitation program, Sample 1:East Treatment Plant-Raw

SOLUTION 1

units ppm

temp 25

Ca 45.5

Mg 13

K 8.97

Na 29.4

Cl 14.9 charge

F 0.27

S(6) 61.1

Alkalinity 174.02 as HCO3-

END

TITLE

Fluorite precipitation program, Sample 1:East Treatment Plant-Raw

----

Beginning of initial solution calculations.

Initial solution 1.

-----------------------------Solution composition------------------------------

Elements	Molality	Moles	
Alkalinity	2.853e-03	2.853e-03	
Ca	1.136e-03	1.136e-03	
Cl	7.102e-04	7.102e-04	Charge balance
F	1.422e-05	1.422e-05	
K	2.295e-04	2.295e-04	
Mg	5.349e-04	5.349e-04	
Na	1.279e-03	1.279e-03	
S(6)	6.363e-04	6.363e-04	

----------------------------Description of solution----------------------------

pH = 7.000

pe = 4.000

Specific Conductance (uS/cm, 25 oC) = 477

Density (g/cm3) = 0.99734 (Millero)

Activity of water = 1.000

Ionic strength = 6.708e-03

Mass of water (kg) = 1.000e+00

Total carbon (mol/kg) = 3.428e-03

Total CO2 (mol/kg) = 3.428e-03

Temperature (deg C) = 25.000

Electrical balance (eq) = -7.809e-13

Percent error, 100*(Cat-|An|)/(Cat+|An|) = -0.00

Iterations = 9

Total H = 1.110153e+02

Total O = 5.551847e+01

----------------------------Distribution of species----------------------------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
OH-	1.093e-07	1.001e-07	-6.961	-7.000	-0.038
H+	1.080e-07	1.000e-07	-6.966	-7.000	-0.034
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000
C(4)	3.428e-03				
HCO3-	2.805e-03	2.580e-03	-2.552	-2.588	-0.036
CO2	5.792e-04	5.801e-04	-3.237	-3.236	0.001
CaHCO3+	2.684e-05	2.468e-05	-4.571	-4.608	-0.036
MgHCO3+	1.159e-05	1.063e-05	-4.936	-4.973	-0.038
NaHCO3	1.695e-06	1.698e-06	-5.771	-5.770	0.001
CO3-2	1.692e-06	1.210e-06	-5.772	-5.917	-0.146
CaCO3	1.522e-06	1.524e-06	-5.818	-5.817	0.001
MgCO3	4.060e-07	4.066e-07	-6.392	-6.391	0.001
NaCO3-	2.875e-08	2.637e-08	-7.541	-7.579	-0.038
Ca	1.136e-03				
Ca+2	1.049e-03	7.498e-04	-2.979	-3.125	-0.146
CaSO4	5.782e-05	5.791e-05	-4.238	-4.237	0.001
CaHCO3+	2.684e-05	2.468e-05	-4.571	-4.608	-0.036
CaCO3	1.522e-06	1.524e-06	-5.818	-5.817	0.001
CaF+	8.997e-08	8.252e-08	-7.046	-7.083	-0.038
CaOH+	1.357e-09	1.244e-09	-8.868	-8.905	-0.038
CaHSO4+	3.699e-11	3.392e-11	-10.432	-10.469	-0.038
Cl	7.102e-04				
Cl-	7.102e-04	6.507e-04	-3.149	-3.187	-0.038
F	1.422e-05				
F-	1.380e-05	1.264e-05	-4.860	-4.898	-0.038
MgF+	3.206e-07	2.940e-07	-6.494	-6.532	-0.038

CaF+	8.997e-08	8.252e-08	-7.046	-7.083	-0.038
NaF	8.498e-09	8.511e-09	-8.071	-8.070	0.001
HF	1.892e-09	1.895e-09	-8.723	-8.722	0.001
HF2-	1.002e-13	9.188e-14	-12.999	-13.037	-0.038
H(0)	1.414e-25				
H2	7.069e-26	7.079e-26	-25.151	-25.150	0.001
K	2.295e-04				
K+	2.289e-04	2.097e-04	-3.640	-3.678	-0.038
KSO4-	6.217e-07	5.703e-07	-6.206	-6.244	-0.038
KOH	7.258e-12	7.269e-12	-11.139	-11.139	0.001
Mg	5.349e-04				
Mg+2	4.907e-04	3.522e-04	-3.309	-3.453	-0.144
MgSO4	3.191e-05	3.196e-05	-4.496	-4.495	0.001
MgHCO3+	1.159e-05	1.063e-05	-4.936	-4.973	-0.038
MgCO3	4.060e-07	4.066e-07	-6.392	-6.391	0.001
MgF+	3.206e-07	2.940e-07	-6.494	-6.532	-0.038
MgOH+	1.394e-08	1.279e-08	-7.856	-7.893	-0.038
Na	1.279e-03				
Na+	1.275e-03	1.171e-03	-2.894	-2.932	-0.037
NaSO4-	2.476e-06	2.271e-06	-5.606	-5.644	-0.038
NaHCO3	1.695e-06	1.698e-06	-5.771	-5.770	0.001
NaCO3-	2.875e-08	2.637e-08	-7.541	-7.579	-0.038
NaF	8.498e-09	8.511e-09	-8.071	-8.070	0.001
NaOH	7.720e-11	7.732e-11	-10.112	-10.112	0.001
O(0)	0.000e+00				
O2	0.000e+00	0.000e+00	-42.081	-42.080	0.001
S(6)	6.363e-04				
SO4-2	5.434e-04	3.871e-04	-3.265	-3.412	-0.147
CaSO4	5.782e-05	5.791e-05	-4.238	-4.237	0.001
MgSO4	3.191e-05	3.196e-05	-4.496	-4.495	0.001
NaSO4-	2.476e-06	2.271e-06	-5.606	-5.644	-0.038
KSO4-	6.217e-07	5.703e-07	-6.206	-6.244	-0.038
HSO4-	4.103e-09	3.763e-09	-8.387	-8.424	-0.038
CaHSO4+	3.699e-11	3.392e-11	-10.432	-10.469	-0.038

------------------------------Saturation indices-------------------------------

Phase	SI	log IAP	log KT	
Anhydrite	-2.18	-6.54	-4.36	CaSO4
Aragonite	-0.71	-9.04	-8.34	CaCO3
Calcite	-0.56	-9.04	-8.48	CaCO3
CO2(g)	-1.77	-3.24	-1.47	CO2
Dolomite	-1.32	-18.41	-17.09	CaMg(CO3)2
Fluorite	-2.32	-12.92	-10.60	CaF2
Gypsum	-1.96	-6.54	-4.58	CaSO4:2H2O
H2(g)	-22.00	-25.15	-3.15	H2
H2O(g)	-1.51	-0.00	1.51	H2O
Halite	-7.70	-6.12	1.58	NaCl
O2(g)	-39.19	-42.08	-2.89	O2

End of simulation.

Reading input data for simulation 2.

End of run.

Sample 2: west treatment plant

Input file: C:\Users\1436\AppData\Local\Temp\phrq0001.tmp

Output file: D:\thesis phreeqc\Fluorite in the lincoln well field\Fluorite SI\sample2.out

Database file: C:\Program Files (x86)\Phreeqc\Databases\Phreeqc.dat

----

Reading data base.

SOLUTION_MASTER_SPECIES

SOLUTION_SPECIES

PHASES

EXCHANGE_MASTER_SPECIES

EXCHANGE_SPECIES

SURFACE_MASTER_SPECIES

SURFACE_SPECIES

RATES

END

Reading input data for simulation 1.

TITLE Fluorite precipitation program, Sample 2:West Treatment Plant-Raw

SOLUTION 1

units ppm

temp 25

Ca 47.4

Mg 13.4

K 10

Na 35

Cl 14.3 charge

F 0.37

S(6) 70.1

Alkalinity 184.19 as HCO3-

END

TITLE

Fluorite precipitation program, Sample 2:West Treatment Plant-Raw

----

Beginning of initial solution calculations.

Initial solution 1.

-----------------------------Solution composition------------------------------

Elements	Molality	Moles	
Alkalinity	3.020e-03	3.020e-03	
Ca	1.183e-03	1.183e-03	
Cl	7.486e-04	7.486e-04	Charge balance
F	1.948e-05	1.948e-05	
K	2.558e-04	2.558e-04	
Mg	5.514e-04	5.514e-04	
Na	1.523e-03	1.523e-03	
S(6)	7.300e-04	7.300e-04	

----------------------------Description of solution----------------------------

pH = 7.000

pe = 4.000

Specific Conductance (uS/cm, 25 oC) = 515

Density (g/cm3) = 0.99737 (Millero)

Activity of water = 1.000

Ionic strength = 7.199e-03

Mass of water (kg) = 1.000e+00

Total carbon (mol/kg) = 3.627e-03

Total CO2 (mol/kg) = 3.627e-03

Temperature (deg C) = 25.000

Electrical balance (eq) = -6.273e-12

Percent error, 100*(Cat-|An|)/(Cat+|An|) = -0.00

Iterations = 9

Total H = 1.110154e+02

Total O = 5.551941e+01

----------------------------Distribution of species----------------------------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
OH-	1.096e-07	1.001e-07	-6.960	-7.000	-0.039
H+	1.083e-07	1.000e-07	-6.965	-7.000	-0.035
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000

C(4) 3.627e-03

HCO3-	2.968e-03	2.722e-03	-2.527	-2.565	-0.038
CO2	6.111e-04	6.122e-04	-3.214	-3.213	0.001
CaHCO3+	2.906e-05	2.665e-05	-4.537	-4.574	-0.038
MgHCO3+	1.241e-05	1.135e-05	-4.906	-4.945	-0.039
NaHCO3	2.123e-06	2.127e-06	-5.673	-5.672	0.001
CO3-2	1.804e-06	1.277e-06	-5.744	-5.894	-0.150
CaCO3	1.643e-06	1.646e-06	-5.784	-5.784	0.001
MgCO3	4.334e-07	4.341e-07	-6.363	-6.362	0.001
NaCO3-	3.611e-08	3.303e-08	-7.442	-7.481	-0.039
Ca	1.183e-03				
Ca+2	1.085e-03	7.673e-04	-2.964	-3.115	-0.151
CaSO4	6.703e-05	6.714e-05	-4.174	-4.173	0.001
CaHCO3+	2.906e-05	2.665e-05	-4.537	-4.574	-0.038
CaCO3	1.643e-06	1.646e-06	-5.784	-5.784	0.001
CaF+	1.261e-07	1.153e-07	-6.899	-6.938	-0.039
CaOH+	1.392e-09	1.273e-09	-8.856	-8.895	-0.039
CaHSO4+	4.300e-11	3.933e-11	-10.367	-10.405	-0.039
Cl	7.486e-04				
Cl-	7.486e-04	6.838e-04	-3.126	-3.165	-0.039
F	1.948e-05				
F-	1.890e-05	1.726e-05	-4.724	-4.763	-0.039
MgF+	4.442e-07	4.063e-07	-6.352	-6.391	-0.039
CaF+	1.261e-07	1.153e-07	-6.899	-6.938	-0.039
NaF	1.377e-08	1.380e-08	-7.861	-7.860	0.001
HF	2.584e-09	2.588e-09	-8.588	-8.587	0.001
HF2-	1.874e-13	1.714e-13	-12.727	-12.766	-0.039
H(0)	1.414e-25				
H2	7.068e-26	7.079e-26	-25.151	-25.150	0.001
K	2.558e-04				
K+	2.551e-04	2.330e-04	-3.593	-3.633	-0.039
KSO4-	7.849e-07	7.179e-07	-6.105	-6.144	-0.039
KOH	8.065e-12	8.078e-12	-11.093	-11.093	0.001
Mg	5.514e-04				
Mg+2	5.015e-04	3.563e-04	-3.300	-3.448	-0.148

MgSO4	3.657e-05	3.663e-05	-4.437	-4.436	0.001
MgHCO3+	1.241e-05	1.135e-05	-4.906	-4.945	-0.039
MgF+	4.442e-07	4.063e-07	-6.352	-6.391	-0.039
MgCO3	4.334e-07	4.341e-07	-6.363	-6.362	0.001
MgOH+	1.414e-08	1.294e-08	-7.849	-7.888	-0.039
Na	1.523e-03				
Na+	1.517e-03	1.389e-03	-2.819	-2.857	-0.038
NaSO4-	3.338e-06	3.053e-06	-5.477	-5.515	-0.039
NaHCO3	2.123e-06	2.127e-06	-5.673	-5.672	0.001
NaCO3-	3.611e-08	3.303e-08	-7.442	-7.481	-0.039
NaF	1.377e-08	1.380e-08	-7.861	-7.860	0.001
NaOH	9.162e-11	9.177e-11	-10.038	-10.037	0.001
O(0)	0.000e+00				
O2	0.000e+00	0.000e+00	-42.081	-42.080	0.001
S(6)	7.300e-04				
SO4-2	6.223e-04	4.385e-04	-3.206	-3.358	-0.152
CaSO4	6.703e-05	6.714e-05	-4.174	-4.173	0.001
MgSO4	3.657e-05	3.663e-05	-4.437	-4.436	0.001
NaSO4-	3.338e-06	3.053e-06	-5.477	-5.515	-0.039
KSO4-	7.849e-07	7.179e-07	-6.105	-6.144	-0.039
HSO4-	4.661e-09	4.263e-09	-8.332	-8.370	-0.039
CaHSO4+	4.300e-11	3.933e-11	-10.367	-10.405	-0.039

------------------------------Saturation indices-------------------------------

Phase	SI	log IAP	log KT	
Anhydrite	-2.11	-6.47	-4.36	CaSO4
Aragonite	-0.67	-9.01	-8.34	CaCO3
Calcite	-0.53	-9.01	-8.48	CaCO3
CO2(g)	-1.75	-3.21	-1.47	CO2
Dolomite	-1.26	-18.35	-17.09	CaMg(CO3)2
Fluorite	-2.04	-12.64	-10.60	CaF2
Gypsum	-1.89	-6.47	-4.58	CaSO4:2H2O
H2(g)	-22.00	-25.15	-3.15	H2
H2O(g)	-1.51	-0.00	1.51	H2O
Halite	-7.60	-6.02	1.58	NaCl

O2(g) -39.19 -42.08 -2.89 O2

End of simulation.

Reading input data for simulation 2.

End of run.

Sample 3: Well 76-1

Input file: C:\Users\1436\AppData\Local\Temp\phrq0001.tmp

Output file: D:\thesis phreeqc\Fluorite in the lincoln well field\Fluorite SI\sample3.out

Database file: C:\Program Files (x86)\Phreeqc\Databases\Phreeqc.dat

----

Reading data base.

SOLUTION_MASTER_SPECIES

SOLUTION_SPECIES

PHASES

EXCHANGE_MASTER_SPECIES

EXCHANGE_SPECIES

SURFACE_MASTER_SPECIES

SURFACE_SPECIES

RATES

END

Reading input data for simulation 1.

TITLE Fluorite precipitation program, Sample 3:Well 76-1

SOLUTION 1

units ppm

temp 25

Ca 59

Mg 16.1

K 11.3

Na 37.6

Cl 14.5 charge

F 0.41

S(6) 54

Alkalinity 186.45 as HCO3-

END

TITLE

Fluorite precipitation program, Sample 3:Well 76-1

Beginning of initial solution calculations.

Initial solution 1.

-----------------------------Solution composition------------------------------

Elements	Molality	Moles	
Alkalinity	3.057e-03	3.057e-03	
Ca	1.473e-03	1.473e-03	
Cl	1.992e-03	1.992e-03	Charge balance
F	2.159e-05	2.159e-05	
K	2.891e-04	2.891e-04	
Mg	6.625e-04	6.625e-04	
Na	1.636e-03	1.636e-03	
S(6)	5.623e-04	5.623e-04	

----------------------------Description of solution----------------------------

pH = 7.000

pe = 4.000

Specific Conductance (uS/cm, 25 oC) = 628

Density (g/cm3) = 0.99740 (Millero)

Activity of water = 1.000

Ionic strength = 8.404e-03

Mass of water (kg) = 1.000e+00

Total carbon (mol/kg) = 3.665e-03

Total CO2 (mol/kg) = 3.665e-03

Temperature (deg C) = 25.000

Electrical balance (eq) = 1.536e-12

Percent error, 100*(Cat-|An|)/(Cat+|An|) = 0.00

Iterations = 8

Total H = 1.110155e+02

Total O = 5.551885e+01

----------------------------Distribution of species----------------------------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
OH-	1.103e-07	1.001e-07	-6.957	-7.000	-0.042
H+	1.088e-07	1.000e-07	-6.963	-7.000	-0.037
H2O	5.551e+01	9.998e-01	1.744	-0.000	0.000
C(4)	3.665e-03				
HCO3-	2.994e-03	2.730e-03	-2.524	-2.564	-0.040
CO2	6.127e-04	6.139e-04	-3.213	-3.212	0.001
CaHCO3+	3.623e-05	3.303e-05	-4.441	-4.481	-0.040
MgHCO3+	1.499e-05	1.362e-05	-4.824	-4.866	-0.041
NaHCO3	2.274e-06	2.278e-06	-5.643	-5.642	0.001
CaCO3	2.035e-06	2.039e-06	-5.691	-5.691	0.001
CO3-2	1.853e-06	1.280e-06	-5.732	-5.893	-0.161
MgCO3	5.200e-07	5.210e-07	-6.284	-6.283	0.001
NaCO3-	3.893e-08	3.538e-08	-7.410	-7.451	-0.041
Ca	1.473e-03				
Ca+2	1.374e-03	9.482e-04	-2.862	-3.023	-0.161
CaSO4	6.057e-05	6.069e-05	-4.218	-4.217	0.001
CaHCO3+	3.623e-05	3.303e-05	-4.441	-4.481	-0.040
CaCO3	2.035e-06	2.039e-06	-5.691	-5.691	0.001
CaF+	1.716e-07	1.560e-07	-6.765	-6.807	-0.041
CaOH+	1.731e-09	1.573e-09	-8.762	-8.803	-0.041
CaHSO4+	3.912e-11	3.555e-11	-10.408	-10.449	-0.041
Cl	1.992e-03				

Cl-	1.992e-03	1.808e-03	-2.701	-2.743	-0.042
F	2.159e-05				
F-	2.081e-05	1.888e-05	-4.682	-4.724	-0.042
MgF+	5.854e-07	5.321e-07	-6.233	-6.274	-0.041
CaF+	1.716e-07	1.560e-07	-6.765	-6.807	-0.041
NaF	1.610e-08	1.613e-08	-7.793	-7.792	0.001
HF	2.827e-09	2.832e-09	-8.549	-8.548	0.001
HF2-	2.258e-13	2.052e-13	-12.646	-12.688	-0.041
H(0)	1.413e-25				
H2	7.066e-26	7.079e-26	-25.151	-25.150	0.001
K	2.891e-04				
K+	2.884e-04	2.618e-04	-3.540	-3.582	-0.042
KSO4-	6.492e-07	5.900e-07	-6.188	-6.229	-0.041
KOH	9.058e-12	9.076e-12	-11.043	-11.042	0.001
Mg	6.625e-04				
Mg+2	6.144e-04	4.265e-04	-3.212	-3.370	-0.159
MgSO4	3.200e-05	3.207e-05	-4.495	-4.494	0.001
MgHCO3+	1.499e-05	1.362e-05	-4.824	-4.866	-0.041
MgF+	5.854e-07	5.321e-07	-6.233	-6.274	-0.041
MgCO3	5.200e-07	5.210e-07	-6.284	-6.283	0.001
MgOH+	1.703e-08	1.548e-08	-7.769	-7.810	-0.041
Na	1.636e-03				
Na+	1.631e-03	1.484e-03	-2.787	-2.829	-0.041
NaSO4-	2.625e-06	2.386e-06	-5.581	-5.622	-0.041
NaHCO3	2.274e-06	2.278e-06	-5.643	-5.642	0.001
NaCO3-	3.893e-08	3.538e-08	-7.410	-7.451	-0.041
NaF	1.610e-08	1.613e-08	-7.793	-7.792	0.001
NaOH	9.785e-11	9.804e-11	-10.009	-10.009	0.001
O(0)	0.000e+00				
O2	0.000e+00	0.000e+00	-42.081	-42.080	0.001
S(6)	5.623e-04				
SO4-2	4.665e-04	3.208e-04	-3.331	-3.494	-0.163
CaSO4	6.057e-05	6.069e-05	-4.218	-4.217	0.001
MgSO4	3.200e-05	3.207e-05	-4.495	-4.494	0.001

NaSO4- 2.625e-06 2.386e-06 -5.581 -5.622 -0.041

KSO4- 6.492e-07 5.900e-07 -6.188 -6.229 -0.041

HSO4- 3.431e-09 3.119e-09 -8.465 -8.506 -0.041

CaHSO4+ 3.912e-11 3.555e-11 -10.408 -10.449 -0.041

------------------------------Saturation indices-------------------------------

Phase	SI	log IAP	log KT	
Anhydrite	-2.16	-6.52	-4.36	CaSO4
Aragonite	-0.58	-8.92	-8.34	CaCO3
Calcite	-0.44	-8.92	-8.48	CaCO3
CO2(g)	-1.74	-3.21	-1.47	CO2
Dolomite	-1.09	-18.18	-17.09	CaMg(CO3)2
Fluorite	-1.87	-12.47	-10.60	CaF2
Gypsum	-1.94	-6.52	-4.58	CaSO4:2H2O
H2(g)	-22.00	-25.15	-3.15	H2
H2O(g)	-1.51	-0.00	1.51	H2O
Halite	-7.15	-5.57	1.58	NaCl
O2(g)	-39.19	-42.08	-2.89	O2

End of simulation.

Reading input data for simulation 2.

End of run.

Sample 4: Well 49-7

Input file: C:\Users\Juanita\AppData\Local\Temp\phrq0000.tmp

Output file: C:\Users\Juanita\Desktop\thesis phreeqc\Fluorite in the lincoln well field\sample4.out

Database file: C:\Program Files (x86)\Phreeqc\Databases\Phreeqc.dat

----

Reading data base.

SOLUTION_MASTER_SPECIES

SOLUTION_SPECIES

PHASES

EXCHANGE_MASTER_SPECIES

EXCHANGE_SPECIES

SURFACE_MASTER_SPECIES

SURFACE_SPECIES

RATES

END

Reading input data for simulation 1.

TITLE Fluorite precipitation program, Sample 4:Well 49-7

SOLUTION 1

units ppm

temp 25

Ca 59

Mg 15.8

K 13.8

Na 39.1

Cl 20.7 charge

F 0.27

S(6) 113.5

Alkalinity 201.14 as HCO3-

END

TITLE

Fluorite precipitation program, Sample 4:Well 49-7

Beginning of initial solution calculations.

Initial solution 1.

-----------------------------Solution composition------------------------------

Elements	Molality	Moles	
Alkalinity	3.298e-03	3.298e-03	
Ca	1.473e-03	1.473e-03	
Cl	6.243e-04	6.243e-04	Charge balance
F	1.422e-05	1.422e-05	
K	3.531e-04	3.531e-04	
Mg	6.502e-04	6.502e-04	
Na	1.702e-03	1.702e-03	
S(6)	1.182e-03	1.182e-03	

----------------------------Description of solution----------------------------

pH = 7.000

pe = 4.000

Specific Conductance (uS/cm, 25 oC) = 608

Density (g/cm3) = 0.99744 (Millero)

Activity of water = 1.000

Ionic strength = 8.742e-03

Mass of water (kg) = 1.000e+00

Total carbon (mol/kg) = 3.954e-03

Total CO2 (mol/kg) = 3.954e-03

Temperature (deg C) = 25.000

Electrical balance (eq) = -1.950e-13

Percent error, 100*(Cat-|An|)/(Cat+|An|) = -0.00

Iterations = 9

Total H = 1.110157e+02

Total O = 5.552215e+01

----------------------------Distribution of species----------------------------

			Log	Log	Log
Species	Molality	Activity	Molality	Activity	Gamma
OH-	1.105e-07	1.001e-07	-6.957	-7.000	-0.043
H+	1.090e-07	1.000e-07	-6.963	-7.000	-0.037
H2O	5.551e+01	9.998e-01	1.744	-0.000	0.000
C(4)	3.954e-03				
HCO3-	3.234e-03	2.944e-03	-2.490	-2.531	-0.041

CO2	6.606e-04	6.619e-04	-3.180	-3.179	0.001
CaHCO3+	3.714e-05	3.380e-05	-4.430	-4.471	-0.041
MgHCO3+	1.498e-05	1.359e-05	-4.825	-4.867	-0.042
NaHCO3	2.541e-06	2.546e-06	-5.595	-5.594	0.001
CaCO3	2.083e-06	2.087e-06	-5.681	-5.680	0.001
CO3-2	2.011e-06	1.380e-06	-5.697	-5.860	-0.163
MgCO3	5.186e-07	5.197e-07	-6.285	-6.284	0.001
NaCO3-	4.357e-08	3.953e-08	-7.361	-7.403	-0.042
Ca	1.473e-03				
Ca+2	1.312e-03	9.001e-04	-2.882	-3.046	-0.164
CaSO4	1.213e-04	1.216e-04	-3.916	-3.915	0.001
CaHCO3+	3.714e-05	3.380e-05	-4.430	-4.471	-0.041
CaCO3	2.083e-06	2.087e-06	-5.681	-5.680	0.001
CaF+	1.075e-07	9.756e-08	-6.969	-7.011	-0.042
CaOH+	1.646e-09	1.493e-09	-8.784	-8.826	-0.042
CaHSO4+	7.848e-11	7.121e-11	-10.105	-10.147	-0.042
Cl	6.243e-04				
Cl-	6.243e-04	5.656e-04	-3.205	-3.247	-0.043
F	1.422e-05				
F-	1.374e-05	1.245e-05	-4.862	-4.905	-0.043
MgF+	3.575e-07	3.244e-07	-6.447	-6.489	-0.042
CaF+	1.075e-07	9.756e-08	-6.969	-7.011	-0.042
NaF	1.099e-08	1.101e-08	-7.959	-7.958	0.001
HF	1.863e-09	1.866e-09	-8.730	-8.729	0.001
HF2-	9.822e-14	8.913e-14	-13.008	-13.050	-0.042
H(0)	1.413e-25				
H2	7.065e-26	7.079e-26	-25.151	-25.150	0.001
K	3.531e-04				
K+	3.514e-04	3.184e-04	-3.454	-3.497	-0.043
KSO4-	1.669e-06	1.514e-06	-5.778	-5.820	-0.042
KOH	1.102e-11	1.104e-11	-10.958	-10.957	0.001
Mg	6.502e-04				
Mg+2	5.718e-04	3.945e-04	-3.243	-3.404	-0.161
MgSO4	6.248e-05	6.260e-05	-4.204	-4.203	0.001

MgHCO3+ 1.498e-05 1.359e-05 -4.825 -4.867 -0.042

MgCO3 5.186e-07 5.197e-07 -6.285 -6.284 0.001

MgF+ 3.575e-07 3.244e-07 -6.447 -6.489 -0.042

MgOH+ 1.578e-08 1.432e-08 -7.802 -7.844 -0.042

Na 1.702e-03

Na+ 1.693e-03 1.538e-03 -2.771 -2.813 -0.042

NaSO4- 5.750e-06 5.218e-06 -5.240 -5.283 -0.042

NaHCO3 2.541e-06 2.546e-06 -5.595 -5.594 0.001

NaCO3- 4.357e-08 3.953e-08 -7.361 -7.403 -0.042

NaF 1.099e-08 1.101e-08 -7.959 -7.958 0.001

NaOH 1.014e-10 1.016e-10 -9.994 -9.993 0.001

O(0) 0.000e+00

O2 0.000e+00 0.000e+00 -42.081 -42.080 0.001

S(6) 1.182e-03

SO4-2 9.908e-04 6.769e-04 -3.004 -3.169 -0.165

CaSO4 1.213e-04 1.216e-04 -3.916 -3.915 0.001

MgSO4 6.248e-05 6.260e-05 -4.204 -4.203 0.001

NaSO4- 5.750e-06 5.218e-06 -5.240 -5.283 -0.042

KSO4- 1.669e-06 1.514e-06 -5.778 -5.820 -0.042

HSO4- 7.253e-09 6.581e-09 -8.139 -8.182 -0.042

CaHSO4+ 7.848e-11 7.121e-11 -10.105 -10.147 -0.042

------------------------------Saturation indices-------------------------------

Phase SI log IAP log KT

Anhydrite -1.85 -6.22 -4.36 CaSO4

Aragonite -0.57 -8.91 -8.34 CaCO3

Calcite -0.43 -8.91 -8.48 CaCO3

CO2(g) -1.71 -3.18 -1.47 CO2

Dolomite -1.08 -18.17 -17.09 CaMg(CO3)2

Fluorite -2.26 -12.86 -10.60 CaF2

Gypsum -1.63 -6.22 -4.58 CaSO4:2H2O

H2(g) -22.00 -25.15 -3.15 H2

H2O(g) -1.51 -0.00 1.51 H2O

Halite -7.64 -6.06 1.58 NaCl

O2(g) -39.19 -42.08 -2.89 O2

End of simulation.

Reading input data for simulation 2.

End of run.

Sample 5: Well 32-2A

Input file: C:\Users\Juanita\AppData\Local\Temp\phrq0000.tmp

Output file: C:\Users\Juanita\Desktop\thesis phreeqc\Fluorite in the lincoln well field\sample5.out

Database file: C:\Program Files (x86)\Phreeqc\Databases\Phreeqc.dat

----

Reading data base.

SOLUTION_MASTER_SPECIES

SOLUTION_SPECIES

PHASES

EXCHANGE_MASTER_SPECIES

EXCHANGE_SPECIES

SURFACE_MASTER_SPECIES

SURFACE_SPECIES

RATES

END

Reading input data for simulation 1.

TITLE Fluorite precipitation program, Sample 5:Well 32-2A

SOLUTION 1

units ppm

temp 25

Ca 45.5

Mg 13.9

K 9.38

Na 36.9

Cl 15.5 charge

F 0.36

S(6) 82.7

Alkalinity 180.8 as HCO3-

END

TITLE

Fluorite precipitation program, Sample 5:Well 32-2A

Beginning of initial solution calculations.

Initial solution 1.

-----------------------------Solution composition------------------------------

Elements	Molality	Moles	
Alkalinity	2.964e-03	2.964e-03	
Ca	1.136e-03	1.136e-03	
Cl	5.554e-04	5.554e-04	Charge balance
F	1.896e-05	1.896e-05	
K	2.400e-04	2.400e-04	
Mg	5.720e-04	5.720e-04	
Na	1.606e-03	1.606e-03	
S(6)	8.612e-04	8.612e-04	

----------------------------Description of solution----------------------------

pH = 7.000

pe = 4.000

Specific Conductance (uS/cm, 25 oC) = 513

Density (g/cm3) = 0.99737 (Millero)

Activity of water = 1.000

Ionic strength = 7.255e-03

Mass of water (kg) = 1.000e+00

Total carbon (mol/kg) = 3.560e-03

Total CO2 (mol/kg) = 3.560e-03

Temperature (deg C) = 25.000

Electrical balance (eq) = -2.634e-13

Percent error, 100*(Cat-|An|)/(Cat+|An|) = -0.00

Iterations = 9

Total H = 1.110154e+02

Total O = 5.551974e+01

----------------------------Distribution of species----------------------------

			Log	Log	Log
Species	Molality	Activity	Molality	Activity	Gamma
OH-	1.096e-07	1.001e-07	-6.960	-7.000	-0.040
H+	1.083e-07	1.000e-07	-6.965	-7.000	-0.035
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000
C(4)	3.560e-03				
HCO3-	2.915e-03	2.673e-03	-2.535	-2.573	-0.038
CO2	6.000e-04	6.010e-04	-3.222	-3.221	0.001
CaHCO3+	2.710e-05	2.484e-05	-4.567	-4.605	-0.038
MgHCO3+	1.248e-05	1.141e-05	-4.904	-4.943	-0.039
NaHCO3	2.196e-06	2.200e-06	-5.658	-5.658	0.001
CO3-2	1.773e-06	1.253e-06	-5.751	-5.902	-0.151
CaCO3	1.532e-06	1.534e-06	-5.815	-5.814	0.001
MgCO3	4.358e-07	4.365e-07	-6.361	-6.360	0.001
NaCO3-	3.736e-08	3.416e-08	-7.428	-7.466	-0.039
Ca	1.136e-03				
Ca+2	1.032e-03	7.286e-04	-2.986	-3.137	-0.151
CaSO4	7.525e-05	7.538e-05	-4.123	-4.123	0.001
CaHCO3+	2.710e-05	2.484e-05	-4.567	-4.605	-0.038
CaCO3	1.532e-06	1.534e-06	-5.815	-5.814	0.001

CaF+	1.165e-07	1.065e-07	-6.934	-6.973	-0.039
CaOH+	1.322e-09	1.209e-09	-8.879	-8.918	-0.039
CaHSO4+	4.829e-11	4.416e-11	-10.316	-10.355	-0.039
Cl	5.554e-04				
Cl-	5.554e-04	5.072e-04	-3.255	-3.295	-0.039
F	1.896e-05				
F-	1.838e-05	1.678e-05	-4.736	-4.775	-0.040
MgF+	4.426e-07	4.047e-07	-6.354	-6.393	-0.039
CaF+	1.165e-07	1.065e-07	-6.934	-6.973	-0.039
NaF	1.411e-08	1.414e-08	-7.850	-7.850	0.001
HF	2.513e-09	2.517e-09	-8.600	-8.599	0.001
HF2-	1.772e-13	1.621e-13	-12.751	-12.790	-0.039
H(0)	1.414e-25				
H2	7.068e-26	7.079e-26	-25.151	-25.150	0.001
K	2.400e-04				
K+	2.391e-04	2.184e-04	-3.621	-3.661	-0.039
KSO4-	8.700e-07	7.955e-07	-6.060	-6.099	-0.039
KOH	7.558e-12	7.571e-12	-11.122	-11.121	0.001
Mg	5.720e-04				
Mg+2	5.143e-04	3.650e-04	-3.289	-3.438	-0.149
MgSO4	4.429e-05	4.436e-05	-4.354	-4.353	0.001
MgHCO3+	1.248e-05	1.141e-05	-4.904	-4.943	-0.039
MgF+	4.426e-07	4.047e-07	-6.354	-6.393	-0.039
MgCO3	4.358e-07	4.365e-07	-6.361	-6.360	0.001
MgOH+	1.449e-08	1.325e-08	-7.839	-7.878	-0.039
Na	1.606e-03				
Na+	1.599e-03	1.464e-03	-2.796	-2.835	-0.038
NaSO4-	4.160e-06	3.803e-06	-5.381	-5.420	-0.039
NaHCO3	2.196e-06	2.200e-06	-5.658	-5.658	0.001
NaCO3-	3.736e-08	3.416e-08	-7.428	-7.466	-0.039
NaF	1.411e-08	1.414e-08	-7.850	-7.850	0.001
NaOH	9.653e-11	9.669e-11	-10.015	-10.015	0.001

```
O(0)          0.000e+00
  O2              0.000e+00   0.000e+00   -42.081   -42.080    0.001
S(6)          8.612e-04
  SO4-2           7.366e-04   5.185e-04    -3.133    -3.285   -0.153
  CaSO4           7.525e-05   7.538e-05    -4.123    -4.123    0.001
  MgSO4           4.429e-05   4.436e-05    -4.354    -4.353    0.001
  NaSO4-          4.160e-06   3.803e-06    -5.381    -5.420   -0.039
  KSO4-           8.700e-07   7.955e-07    -6.060    -6.099   -0.039
  HSO4-           5.513e-09   5.041e-09    -8.259    -8.297   -0.039
  CaHSO4+         4.829e-11   4.416e-11   -10.316   -10.355   -0.039
------------------------------Saturation indices-------------------------------
          Phase             SI log IAP  log KT
          Anhydrite       -2.06   -6.42   -4.36  CaSO4
          Aragonite       -0.70   -9.04   -8.34  CaCO3
          Calcite         -0.56   -9.04   -8.48  CaCO3
          CO2(g)          -1.75   -3.22   -1.47  CO2
          Dolomite        -1.29  -18.38  -17.09  CaMg(CO3)2
          Fluorite        -2.09  -12.69  -10.60  CaF2
          Gypsum          -1.84   -6.42   -4.58  CaSO4:2H2O
          H2(g)          -22.00  -25.15   -3.15  H2
          H2O(g)          -1.51   -0.00    1.51  H2O
          Halite          -7.71   -6.13    1.58  NaCl
          O2(g)          -39.19  -42.08   -2.89  O2
------------------
End of simulation.
------------------
------------------------------------
Reading input data for simulation 2.
------------------------------------
-----------
End of run.
-----------
```

Sample 6: Well 37-4A

Input file: C:\Users\Juanita\AppData\Local\Temp\phrq0000.tmp

Output file: C:\Users\Juanita\Desktop\thesis phreeqc\Fluorite in the lincoln well field\sample6.out

Database file: C:\Program Files (x86)\Phreeqc\Databases\Phreeqc.dat

----

Reading data base.

```
SOLUTION_MASTER_SPECIES
SOLUTION_SPECIES
PHASES
EXCHANGE_MASTER_SPECIES
EXCHANGE_SPECIES
SURFACE_MASTER_SPECIES
SURFACE_SPECIES
RATES
END
```

Reading input data for simulation 1.

```
TITLE Fluorite precipitation program, Sample 6:Well 37-4A
SOLUTION 1
units ppm
temp 25
Ca   41.6
Mg   11.8
K    11.3
Na   51.8
Cl   14.2 charge
F    0.33
S(6) 55.4
Alkalinity 179.67 as HCO3-
END
```

TITLE

Fluorite precipitation program, Sample 6:Well 37-4A

Beginning of initial solution calculations.

Initial solution 1.

-----------------------------Solution composition------------------------------

Elements	Molality	Moles	
Alkalinity	2.946e-03	2.946e-03	
Ca	1.038e-03	1.038e-03	
Cl	1.474e-03	1.474e-03	Charge balance
F	1.738e-05	1.738e-05	
K	2.891e-04	2.891e-04	
Mg	4.855e-04	4.855e-04	
Na	2.254e-03	2.254e-03	
S(6)	5.769e-04	5.769e-04	

----------------------------Description of solution----------------------------

pH = 7.000

pe = 4.000

Specific Conductance (uS/cm, 25 oC) = 566

Density (g/cm3) = 0.99737 (Millero)

Activity of water = 1.000

Ionic strength = 7.308e-03

Mass of water (kg) = 1.000e+00

Total carbon (mol/kg) = 3.539e-03

Total CO2 (mol/kg) = 3.539e-03

Temperature (deg C) = 25.000

Electrical balance (eq) = 3.692e-13

Percent error, 100*(Cat-|An|)/(Cat+|An|) = 0.00

Iterations = 8

Total H = 1.110154e+02

Total O = 5.551854e+01

----------------------------Distribution of species----------------------------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
OH-	1.097e-07	1.001e-07	-6.960	-7.000	-0.040
H+	1.083e-07	1.000e-07	-6.965	-7.000	-0.035
H2O	5.551e+01	9.998e-01	1.744	-0.000	0.000
C(4)	3.539e-03				
HCO3-	2.899e-03	2.658e-03	-2.538	-2.576	-0.038
CO2	5.966e-04	5.976e-04	-3.224	-3.224	0.001
CaHCO3+	2.516e-05	2.306e-05	-4.599	-4.637	-0.038
MgHCO3+	1.080e-05	9.874e-06	-4.967	-5.005	-0.039
NaHCO3	3.067e-06	3.072e-06	-5.513	-5.513	0.001
CO3-2	1.765e-06	1.246e-06	-5.753	-5.904	-0.151
CaCO3	1.422e-06	1.424e-06	-5.847	-5.846	0.001
MgCO3	3.770e-07	3.777e-07	-6.424	-6.423	0.001
NaCO3-	5.219e-08	4.771e-08	-7.282	-7.321	-0.039
Ca	1.038e-03				
Ca+2	9.641e-04	6.802e-04	-3.016	-3.167	-0.152
CaSO4	4.750e-05	4.758e-05	-4.323	-4.323	0.001
CaHCO3+	2.516e-05	2.306e-05	-4.599	-4.637	-0.038
CaCO3	1.422e-06	1.424e-06	-5.847	-5.846	0.001
CaF+	9.997e-08	9.139e-08	-7.000	-7.039	-0.039
CaOH+	1.235e-09	1.129e-09	-8.908	-8.947	-0.039
CaHSO4+	3.049e-11	2.787e-11	-10.516	-10.555	-0.039
Cl	1.474e-03				
Cl-	1.474e-03	1.346e-03	-2.832	-2.871	-0.040
F	1.738e-05				
F-	1.690e-05	1.543e-05	-4.772	-4.812	-0.040
MgF+	3.541e-07	3.237e-07	-6.451	-6.490	-0.039
CaF+	9.997e-08	9.139e-08	-7.000	-7.039	-0.039
NaF	1.822e-08	1.825e-08	-7.739	-7.739	0.001
HF	2.310e-09	2.314e-09	-8.636	-8.636	0.001
HF2-	1.498e-13	1.370e-13	-12.824	-12.863	-0.039

H(0)	1.414e-25				
H2	7.068e-26	7.079e-26	-25.151	-25.150	0.001
K	2.891e-04				
K+	2.884e-04	2.633e-04	-3.540	-3.580	-0.040
KSO4-	7.095e-07	6.486e-07	-6.149	-6.188	-0.039
KOH	9.112e-12	9.128e-12	-11.040	-11.040	0.001
Mg	4.855e-04				
Mg+2	4.479e-04	3.175e-04	-3.349	-3.498	-0.149
MgSO4	2.605e-05	2.610e-05	-4.584	-4.583	0.001
MgHCO3+	1.080e-05	9.874e-06	-4.967	-5.005	-0.039
MgCO3	3.770e-07	3.777e-07	-6.424	-6.423	0.001
MgF+	3.541e-07	3.237e-07	-6.451	-6.490	-0.039
MgOH+	1.261e-08	1.153e-08	-7.899	-7.938	-0.039
Na	2.254e-03				
Na+	2.247e-03	2.056e-03	-2.648	-2.687	-0.039
NaSO4-	3.952e-06	3.612e-06	-5.403	-5.442	-0.039
NaHCO3	3.067e-06	3.072e-06	-5.513	-5.513	0.001
NaCO3-	5.219e-08	4.771e-08	-7.282	-7.321	-0.039
NaF	1.822e-08	1.825e-08	-7.739	-7.739	0.001
NaOH	1.356e-10	1.358e-10	-9.868	-9.867	0.001
O(0)	0.000e+00				
O2	0.000e+00	0.000e+00	-42.081	-42.080	0.001
S(6)	5.769e-04				
SO4-2	4.987e-04	3.506e-04	-3.302	-3.455	-0.153
CaSO4	4.750e-05	4.758e-05	-4.323	-4.323	0.001
MgSO4	2.605e-05	2.610e-05	-4.584	-4.583	0.001
NaSO4-	3.952e-06	3.612e-06	-5.403	-5.442	-0.039
KSO4-	7.095e-07	6.486e-07	-6.149	-6.188	-0.039
HSO4-	3.729e-09	3.409e-09	-8.428	-8.467	-0.039
CaHSO4+	3.049e-11	2.787e-11	-10.516	-10.555	-0.039

------------------------------Saturation indices-------------------------------

Phase	SI	log IAP	log KT	
Anhydrite	-2.26	-6.62	-4.36	CaSO4
Aragonite	-0.74	-9.07	-8.34	CaCO3

Calcite -0.59 -9.07 -8.48 CaCO3

CO2(g) -1.76 -3.22 -1.47 CO2

Dolomite -1.38 -18.47 -17.09 CaMg(CO3)2

Fluorite -2.19 -12.79 -10.60 CaF2

Gypsum -2.04 -6.62 -4.58 CaSO4:2H2O

H2(g) -22.00 -25.15 -3.15 H2

H2O(g) -1.51 -0.00 1.51 H2O

Halite -7.14 -5.56 1.58 NaCl

O2(g) -39.19 -42.08 -2.89 O2

End of simulation.

Reading input data for simulation 2.

End of run.

Sample 7: Well 54-9

Input file: C:\Users\Juanita\AppData\Local\Temp\phrq0000.tmp

Output file: C:\Users\Juanita\Desktop\thesis phreeqc\Fluorite in the lincoln well field\sample7.out

Database file: C:\Program Files (x86)\Phreeqc\Databases\Phreeqc.dat

----

Reading data base.

SOLUTION_MASTER_SPECIES

SOLUTION_SPECIES

PHASES

EXCHANGE_MASTER_SPECIES

EXCHANGE_SPECIES

SURFACE_MASTER_SPECIES

SURFACE_SPECIES

```
RATES
END
------------------------------------
Reading input data for simulation 1.
------------------------------------
TITLE Fluorite precipitation program, Sample 7:Well 54-9
SOLUTION 1
units ppm
temp 25
Ca   45.5
Mg   12.5
K    10
Na   23.4
Cl   14.5 charge
F    0.34
S(6) 58.3
Alkalinity 174.02 as HCO3-
END
-----
TITLE
-----
 Fluorite precipitation program, Sample 7:Well 54-9
-------------------------------------------
Beginning of initial solution calculations.
-------------------------------------------
Initial solution 1.
-----------------------------Solution composition------------------------------
Elements          Molality       Moles
Alkalinity       2.853e-03   2.853e-03
Ca               1.136e-03   1.136e-03
Cl               4.889e-04   4.889e-04  Charge balance
F                1.790e-05   1.790e-05
```

K	2.558e-04	2.558e-04
Mg	5.143e-04	5.143e-04
Na	1.018e-03	1.018e-03
S(6)	6.071e-04	6.071e-04

----------------------------Description of solution----------------------------

pH = 7.000

pe = 4.000

Specific Conductance (uS/cm, 25 oC) = 447

Density (g/cm3) = 0.99733 (Millero)

Activity of water = 1.000

Ionic strength = 6.400e-03

Mass of water (kg) = 1.000e+00

Total carbon (mol/kg) = 3.430e-03

Total CO2 (mol/kg) = 3.430e-03

Temperature (deg C) = 25.000

Electrical balance (eq) = -8.776e-14

Percent error, 100*(Cat-|An|)/(Cat+|An|) = -0.00

Iterations = 9

Total H = 1.110153e+02

Total O = 5.551835e+01

----------------------------Distribution of species----------------------------

			Log	Log	Log
Species	Molality	Activity	Molality	Activity	Gamma
OH-	1.091e-07	1.001e-07	-6.962	-7.000	-0.037
H+	1.079e-07	1.000e-07	-6.967	-7.000	-0.033
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000
C(4)	3.430e-03				
HCO3-	2.806e-03	2.585e-03	-2.552	-2.588	-0.036
CO2	5.803e-04	5.812e-04	-3.236	-3.236	0.001
CaHCO3+	2.707e-05	2.493e-05	-4.568	-4.603	-0.036
MgHCO3+	1.124e-05	1.033e-05	-4.949	-4.986	-0.037
CO3-2	1.684e-06	1.212e-06	-5.774	-5.916	-0.143

CaCO3	1.537e-06	1.539e-06	-5.813	-5.813	0.001
NaHCO3	1.355e-06	1.357e-06	-5.868	-5.868	0.001
MgCO3	3.943e-07	3.949e-07	-6.404	-6.403	0.001
NaCO3-	2.293e-08	2.107e-08	-7.640	-7.676	-0.037
Ca	1.136e-03				
Ca+2	1.051e-03	7.560e-04	-2.978	-3.121	-0.143
CaSO4	5.605e-05	5.613e-05	-4.251	-4.251	0.001
CaHCO3+	2.707e-05	2.493e-05	-4.568	-4.603	-0.036
CaCO3	1.537e-06	1.539e-06	-5.813	-5.813	0.001
CaF+	1.143e-07	1.051e-07	-6.942	-6.979	-0.037
CaOH+	1.365e-09	1.255e-09	-8.865	-8.902	-0.037
CaHSO4+	3.579e-11	3.288e-11	-10.446	-10.483	-0.037
Cl	4.889e-04				
Cl-	4.889e-04	4.488e-04	-3.311	-3.348	-0.037
F	1.790e-05				
F-	1.739e-05	1.595e-05	-4.760	-4.797	-0.037
MgF+	3.917e-07	3.599e-07	-6.407	-6.444	-0.037
CaF+	1.143e-07	1.051e-07	-6.942	-6.979	-0.037
NaF	8.556e-09	8.569e-09	-8.068	-8.067	0.001
HF	2.389e-09	2.393e-09	-8.622	-8.621	0.001
HF2-	1.594e-13	1.465e-13	-12.798	-12.834	-0.037
H(0)	1.414e-25				
H2	7.069e-26	7.079e-26	-25.151	-25.150	0.001
K	2.558e-04				
K+	2.552e-04	2.342e-04	-3.593	-3.630	-0.037
KSO4-	6.664e-07	6.123e-07	-6.176	-6.213	-0.037
KOH	8.108e-12	8.120e-12	-11.091	-11.090	0.001
Mg	5.143e-04				
Mg+2	4.725e-04	3.414e-04	-3.326	-3.467	-0.141
MgSO4	2.974e-05	2.978e-05	-4.527	-4.526	0.001
MgHCO3+	1.124e-05	1.033e-05	-4.949	-4.986	-0.037
MgCO3	3.943e-07	3.949e-07	-6.404	-6.403	0.001

MgF+ 3.917e-07 3.599e-07 -6.407 -6.444 -0.037

MgOH+ 1.349e-08 1.240e-08 -7.870 -7.907 -0.037

Na 1.018e-03

Na+ 1.015e-03 9.333e-04 -2.994 -3.030 -0.036

NaSO4- 1.894e-06 1.741e-06 -5.723 -5.759 -0.037

NaHCO3 1.355e-06 1.357e-06 -5.868 -5.868 0.001

NaCO3- 2.293e-08 2.107e-08 -7.640 -7.676 -0.037

NaF 8.556e-09 8.569e-09 -8.068 -8.067 0.001

NaOH 6.157e-11 6.166e-11 -10.211 -10.210 0.001

O(0) 0.000e+00

O2 0.000e+00 0.000e+00 -42.081 -42.080 0.001

S(6) 6.071e-04

SO4-2 5.187e-04 3.721e-04 -3.285 -3.429 -0.144

CaSO4 5.605e-05 5.613e-05 -4.251 -4.251 0.001

MgSO4 2.974e-05 2.978e-05 -4.527 -4.526 0.001

NaSO4- 1.894e-06 1.741e-06 -5.723 -5.759 -0.037

KSO4- 6.664e-07 6.123e-07 -6.176 -6.213 -0.037

HSO4- 3.937e-09 3.618e-09 -8.405 -8.442 -0.037

CaHSO4+ 3.579e-11 3.288e-11 -10.446 -10.483 -0.037

------------------------------Saturation indices-------------------------------

Phase SI log IAP log KT

Anhydrite -2.19 -6.55 -4.36 CaSO4

Aragonite -0.70 -9.04 -8.34 CaCO3

Calcite -0.56 -9.04 -8.48 CaCO3

CO2(g) -1.77 -3.24 -1.47 CO2

Dolomite -1.33 -18.42 -17.09 CaMg(CO3)2

Fluorite -2.12 -12.72 -10.60 CaF2

Gypsum -1.97 -6.55 -4.58 CaSO4:2H2O

H2(g) -22.00 -25.15 -3.15 H2

H2O(g) -1.51 -0.00 1.51 H2O

Halite -7.96 -6.38 1.58 NaCl

O2(g) -39.19 -42.08 -2.89 O2

End of simulation.

Reading input data for simulation 2.

End of run.

Sample 8: Limestone well at fish hatchery

Input file: C:\Users\Juanita\AppData\Local\Temp\phrq0000.tmp

Output file: C:\Users\Juanita\Desktop\thesis phreeqc\Fluorite in the lincoln well field\sample8.out

Database file: C:\Program Files (x86)\Phreeqc\Databases\Phreeqc.dat

----

Reading data base.

SOLUTION_MASTER_SPECIES

SOLUTION_SPECIES

PHASES

EXCHANGE_MASTER_SPECIES

EXCHANGE_SPECIES

SURFACE_MASTER_SPECIES

SURFACE_SPECIES

RATES

END

Reading input data for simulation 1.

TITLE Fluorite precipitation program, Sample 8:Limestone well at Fish hatchery

SOLUTION 1

units ppm

temp 25

Ca 103.5

Mg 27.3

K 10.6

Na 72

Cl 22.5 charge

F 0.26

S(6) 31.5

Alkalinity 463.3 as HCO3-

END

TITLE

Fluorite precipitation program, Sample 8:Limestone well at Fish hatchery

----

Beginning of initial solution calculations.

Initial solution 1.

-----------------------------Solution composition------------------------------

Elements	Molality	Moles	
Alkalinity	7.598e-03	7.598e-03	
Ca	2.584e-03	2.584e-03	
Cl	2.553e-03	2.553e-03	Charge balance
F	1.370e-05	1.370e-05	
K	2.713e-04	2.713e-04	
Mg	1.124e-03	1.124e-03	
Na	3.134e-03	3.134e-03	
S(6)	3.281e-04	3.281e-04	

----------------------------Description of solution----------------------------

pH = 7.000

pe = 4.000

Specific Conductance (uS/cm, 25 oC) = 1015

Density (g/cm3) = 0.99768 (Millero)

Activity of water = 1.000

Ionic strength = 1.413e-02

Mass of water (kg) = 1.000e+00

Total carbon (mol/kg) = 9.054e-03

Total CO2 (mol/kg) = 9.054e-03

Temperature (deg C) = 25.000

Electrical balance (eq) = -1.292e-12

Percent error, 100*(Cat-|An|)/(Cat+|An|) = -0.00

Iterations = 9

Total H = 1.110200e+02

Total O = 5.553322e+01

----------------------------Distribution of species----------------------------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
OH-	1.131e-07	1.001e-07	-6.946	-7.000	-0.053
H+	1.109e-07	1.000e-07	-6.955	-7.000	-0.045
H2O	5.551e+01	9.997e-01	1.744	-0.000	0.000
C(4)	9.054e-03				
HCO3-	7.360e-03	6.560e-03	-2.133	-2.183	-0.050
CO2	1.470e-03	1.475e-03	-2.833	-2.831	0.001
CaHCO3+	1.414e-04	1.260e-04	-3.850	-3.900	-0.050
MgHCO3+	5.719e-05	5.074e-05	-4.243	-4.295	-0.052
NaHCO3	1.020e-05	1.023e-05	-4.992	-4.990	0.001
CaCO3	7.754e-06	7.779e-06	-5.110	-5.109	0.001
CO3-2	4.876e-06	3.076e-06	-5.312	-5.512	-0.200
MgCO3	1.934e-06	1.941e-06	-5.713	-5.712	0.001
NaCO3-	1.791e-07	1.589e-07	-6.747	-6.799	-0.052
Ca	2.584e-03				
Ca+2	2.387e-03	1.505e-03	-2.622	-2.822	-0.200
CaHCO3+	1.414e-04	1.260e-04	-3.850	-3.900	-0.050
CaSO4	4.750e-05	4.766e-05	-4.323	-4.322	0.001
CaCO3	7.754e-06	7.779e-06	-5.110	-5.109	0.001
CaF+	1.692e-07	1.501e-07	-6.772	-6.824	-0.052
CaOH+	2.815e-09	2.497e-09	-8.551	-8.603	-0.052
CaHSO4+	3.147e-11	2.792e-11	-10.502	-10.554	-0.052

Cl	2.553e-03				
Cl-	2.553e-03	2.259e-03	-2.593	-2.646	-0.053
F	1.370e-05				
F-	1.294e-05	1.145e-05	-4.888	-4.941	-0.053
MgF+	5.636e-07	5.001e-07	-6.249	-6.301	-0.052
CaF+	1.692e-07	1.501e-07	-6.772	-6.824	-0.052
NaF	1.821e-08	1.827e-08	-7.740	-7.738	0.001
HF	1.711e-09	1.717e-09	-8.767	-8.765	0.001
HF2-	8.501e-14	7.542e-14	-13.071	-13.122	-0.052
H(0)	1.411e-25				
H2	7.056e-26	7.079e-26	-25.151	-25.150	0.001
K	2.713e-04				
K+	2.710e-04	2.398e-04	-3.567	-3.620	-0.053
KSO4-	3.014e-07	2.674e-07	-6.521	-6.573	-0.052
KOH	8.286e-12	8.313e-12	-11.082	-11.080	0.001
Mg	1.124e-03				
Mg+2	1.039e-03	6.611e-04	-2.983	-3.180	-0.197
MgHCO3+	5.719e-05	5.074e-05	-4.243	-4.295	-0.052
MgSO4	2.451e-05	2.459e-05	-4.611	-4.609	0.001
MgCO3	1.934e-06	1.941e-06	-5.713	-5.712	0.001
MgF+	5.636e-07	5.001e-07	-6.249	-6.301	-0.052
MgOH+	2.705e-08	2.400e-08	-7.568	-7.620	-0.052
Na	3.134e-03				
Na+	3.121e-03	2.773e-03	-2.506	-2.557	-0.051
NaHCO3	1.020e-05	1.023e-05	-4.992	-4.990	0.001
NaSO4-	2.486e-06	2.206e-06	-5.605	-5.656	-0.052
NaCO3-	1.791e-07	1.589e-07	-6.747	-6.799	-0.052
NaF	1.821e-08	1.827e-08	-7.740	-7.738	0.001
NaOH	1.826e-10	1.832e-10	-9.739	-9.737	0.001
O(0)	0.000e+00				
O2	0.000e+00	0.000e+00	-42.082	-42.080	0.001
S(6)	3.281e-04				
SO4-2	2.533e-04	1.587e-04	-3.596	-3.799	-0.203
CaSO4	4.750e-05	4.766e-05	-4.323	-4.322	0.001

MgSO4 2.451e-05 2.459e-05 -4.611 -4.609 0.001

NaSO4- 2.486e-06 2.206e-06 -5.605 -5.656 -0.052

KSO4- 3.014e-07 2.674e-07 -6.521 -6.573 -0.052

HSO4- 1.739e-09 1.543e-09 -8.760 -8.812 -0.052

CaHSO4+ 3.147e-11 2.792e-11 -10.502 -10.554 -0.052

------------------------------Saturation indices-------------------------------

Phase SI log IAP log KT

Anhydrite -2.26 -6.62 -4.36 CaSO4

Aragonite 0.00 -8.33 -8.34 CaCO3

Calcite 0.15 -8.33 -8.48 CaCO3

CO2(g) -1.36 -2.83 -1.47 CO2

Dolomite 0.06 -17.03 -17.09 CaMg(CO3)2

Fluorite -2.11 -12.70 -10.60 CaF2

Gypsum -2.04 -6.62 -4.58 CaSO4:2H2O

H2(g) -22.00 -25.15 -3.15 H2

H2O(g) -1.51 -0.00 1.51 H2O

Halite -6.78 -5.20 1.58 NaCl

O2(g) -39.19 -42.08 -2.89 O2

End of simulation.

Reading input data for simulation 2.

End of run.

Sample 9: Limestone spring at the fish hatchery

Input file: C:\Users\Juanita\AppData\Local\Temp\phrq0000.tmp

Output file: C:\Users\Juanita\Desktop\thesis phreeqc\Fluorite in the lincoln well field\sample9.out

Database file: C:\Program Files (x86)\Phreeqc\Databases\Phreeqc.dat

----

Reading data base.

SOLUTION_MASTER_SPECIES

SOLUTION_SPECIES

PHASES

EXCHANGE_MASTER_SPECIES

EXCHANGE_SPECIES

SURFACE_MASTER_SPECIES

SURFACE_SPECIES

RATES

END

Reading input data for simulation 1.

TITLE Fluorite precipitation program, Sample 9:Limestone spring at Fish hatchery

SOLUTION 1

units ppm

temp 25

Ca 59

Mg 15.7

K 5

Na 70.5

Cl 6.60 charge

F 0.29

S(6) 15.8

Alkalinity 282.5 as HCO3-

END

TITLE

Fluorite precipitation program, Sample 9:Limestone spring at Fish hatchery

----

Beginning of initial solution calculations.

Initial solution 1.

-----------------------------Solution composition------------------------------

Elements	Molality	Moles	
Alkalinity	4.632e-03	4.632e-03	
Ca	1.473e-03	1.473e-03	
Cl	2.457e-03	2.457e-03	Charge balance
F	1.527e-05	1.527e-05	
K	1.279e-04	1.279e-04	
Mg	6.461e-04	6.461e-04	
Na	3.068e-03	3.068e-03	
S(6)	1.645e-04	1.645e-04	

----------------------------Description of solution----------------------------

pH = 7.000

pe = 4.000

Specific Conductance (uS/cm, 25 oC) = 737

Density (g/cm3) = 0.99746 (Millero)

Activity of water = 1.000

Ionic strength = 9.438e-03

Mass of water (kg) = 1.000e+00

Total carbon (mol/kg) = 5.548e-03

Total CO2 (mol/kg) = 5.548e-03

Temperature (deg C) = 25.000

Electrical balance (eq) = 2.732e-17

Percent error, 100*(Cat-|An|)/(Cat+|An|) = 0.00

Iterations = 10

Total H = 1.110171e+02

Total O = 5.552260e+01

----------------------------Distribution of species----------------------------

Species	Molality	Activity	Log Molality	Log Activity	Gamma
OH-	1.109e-07	1.001e-07	-6.955	-7.000	-0.045
H+	1.093e-07	1.000e-07	-6.962	-7.000	-0.038
H2O	5.551e+01	9.998e-01	1.744	-0.000	0.000
C(4)	5.548e-03				
HCO3-	4.535e-03	4.115e-03	-2.343	-2.386	-0.042
CO2	9.234e-04	9.254e-04	-3.035	-3.034	0.001
CaHCO3+	5.477e-05	4.970e-05	-4.261	-4.304	-0.042
MgHCO3+	2.226e-05	2.014e-05	-4.652	-4.696	-0.044
NaHCO3	6.397e-06	6.411e-06	-5.194	-5.193	0.001
CaCO3	3.062e-06	3.069e-06	-5.514	-5.513	0.001
CO3-2	2.847e-06	1.930e-06	-5.546	-5.715	-0.169
MgCO3	7.684e-07	7.701e-07	-6.114	-6.113	0.001
NaCO3-	1.101e-07	9.955e-08	-6.958	-7.002	-0.044
Ca	1.473e-03				
Ca+2	1.397e-03	9.466e-04	-2.855	-3.024	-0.169
CaHCO3+	5.477e-05	4.970e-05	-4.261	-4.304	-0.042
CaSO4	1.737e-05	1.741e-05	-4.760	-4.759	0.001
CaCO3	3.062e-06	3.069e-06	-5.514	-5.513	0.001
CaF+	1.211e-07	1.096e-07	-6.917	-6.960	-0.044
CaOH+	1.737e-09	1.571e-09	-8.760	-8.804	-0.044
CaHSO4+	1.128e-11	1.020e-11	-10.948	-10.991	-0.044
Cl	2.457e-03				
Cl-	2.457e-03	2.219e-03	-2.610	-2.654	-0.044
F	1.527e-05				
F-	1.472e-05	1.329e-05	-4.832	-4.877	-0.045
MgF+	4.060e-07	3.671e-07	-6.392	-6.435	-0.044
CaF+	1.211e-07	1.096e-07	-6.917	-6.960	-0.044
NaF	2.114e-08	2.118e-08	-7.675	-7.674	0.001
HF	1.988e-09	1.993e-09	-8.701	-8.701	0.001
HF2-	1.123e-13	1.016e-13	-12.949	-12.993	-0.044

H(0) 1.413e-25

H2 7.064e-26 7.079e-26 -25.151 -25.150 0.001

K 1.279e-04

K+ 1.278e-04 1.154e-04 -3.893 -3.938 -0.044

KSO4- 8.266e-08 7.475e-08 -7.083 -7.126 -0.044

KOH 3.993e-12 4.001e-12 -11.399 -11.398 0.001

Mg 6.461e-04

Mg+2 6.136e-04 4.182e-04 -3.212 -3.379 -0.166

MgHCO3+ 2.226e-05 2.014e-05 -4.652 -4.696 -0.044

MgSO4 9.016e-06 9.036e-06 -5.045 -5.044 0.001

MgCO3 7.684e-07 7.701e-07 -6.114 -6.113 0.001

MgF+ 4.060e-07 3.671e-07 -6.392 -6.435 -0.044

MgOH+ 1.679e-08 1.518e-08 -7.775 -7.819 -0.044

Na 3.068e-03

Na+ 3.060e-03 2.770e-03 -2.514 -2.557 -0.043

NaHCO3 6.397e-06 6.411e-06 -5.194 -5.193 0.001

NaSO4- 1.415e-06 1.280e-06 -5.849 -5.893 -0.044

NaCO3- 1.101e-07 9.955e-08 -6.958 -7.002 -0.044

NaF 2.114e-08 2.118e-08 -7.675 -7.674 0.001

NaOH 1.826e-10 1.830e-10 -9.738 -9.738 0.001

O(0) 0.000e+00

O2 0.000e+00 0.000e+00 -42.081 -42.080 0.001

S(6) 1.645e-04

SO4-2 1.367e-04 9.217e-05 -3.864 -4.035 -0.171

CaSO4 1.737e-05 1.741e-05 -4.760 -4.759 0.001

MgSO4 9.016e-06 9.036e-06 -5.045 -5.044 0.001

NaSO4- 1.415e-06 1.280e-06 -5.849 -5.893 -0.044

KSO4- 8.266e-08 7.475e-08 -7.083 -7.126 -0.044

HSO4- 9.909e-10 8.961e-10 -9.004 -9.048 -0.044

CaHSO4+ 1.128e-11 1.020e-11 -10.948 -10.991 -0.044

------------------------------Saturation indices-------------------------------

Phase SI log IAP log KT

Anhydrite -2.70 -7.06 -4.36 CaSO4

Aragonite -0.40 -8.74 -8.34 CaCO3

Calcite	-0.26	-8.74	-8.48	CaCO3
CO2(g)	-1.57	-3.03	-1.47	CO2
Dolomite	-0.74	-17.83	-17.09	CaMg(CO3)2
Fluorite	-2.18	-12.78	-10.60	CaF2
Gypsum	-2.48	-7.06	-4.58	CaSO4:2H2O
H2(g)	-22.00	-25.15	-3.15	H2
H2O(g)	-1.51	-0.00	1.51	H2O
Halite	-6.79	-5.21	1.58	NaCl
O2(g)	-39.19	-42.08	-2.89	O2

End of simulation.

Reading input data for simulation 2.

End of run.
