Influences on Water Quality of the Wilcox Aquifer in Northwestern Louisiana

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EXTENDED ABSTRACT

Water chemistry within the Wilcox Aquifer has been studied for over 50 years (Page and May, 1964; Rapp, 1996; Carlson and Van Biersel, 2010; Tollett and Seanor, 2011; Carlson and Horn, 2014). Many of these past studies have water samples that have been collected mainly from public supply wells or industrial wells. This study involves collection and analytical analysis of water chemistry for over 20 different ions from 1136 domestic water supply wells within Bossier, Caddo, and DeSoto parishes (Fig. 1). These samples were all collected in 2010 and 2011 thus allowing for a detail spatial view of ion concentrations for a limited time interval thus avoiding combination of samples from over decades that would be the case of when considering pre-existing results noted within the U.S. Geological Survey water quality database of approximately 700 wells as listed in their website for these three parishes. Their dataset will provide information in regards to possible temporal changes of water quality within the Wilcox. With the combination of these two datasets a conceptual model has been developed that explains the variations of water quality that appears in both time and space.

Underlying this aquifer are a number of natural gas fields that appear to be one of the influences on water quality. Each of these fields have a different volume of natural gas within them, both total gas and gas per unit area of the field. These fields appear to impact concentrations of methane (Fig. 2), chloride (Fig. 3) and sodium in the overlying Wilcox. Confidence of significance between two sets of sample results are determined by two techniques a median test and a Mann-Whitney ranks test. For methane and chloride many of these differences are significant as defined by a confidence of difference between concentrations over different gas fields being over 95% (Kirk, 1990; Sprent and Smeeton, 2007). By contrast it appears that the number of Haynesville natural gas play wells (Fig. 4) within a section does not influence the concentration of methane. This appears to be the case regardless which is considered: all oil and gas wells or those associated with development of the Haynesville natural gas play. This indicates that natural gas concentrations in the Wilcox are not typically the results of imperfect construction of oil and gas wells or possible accidents. On the other had they could a result of natural process where gas has seeped up into the overlying Wilcox either through sediments be-

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tween gas plays and the Wilcox or along fractures and/or faults within the rock between the gas plays and the Wilcox.

However, not all variations of water chemistry can be explained by the various gas fields. Other ions for example iron, calcium, sodium appear to vary depending on which of the typically three sands that the Wilcox Aquifer is composed of (Van Biersel and Carlson, 2009). Of these sands the two upper sands are often tapped by domestic wells within the study area. For thus study a select set of wells, approximately 680 about 60% all study wells, have a Louisiana Department of Natural Resources driller log, which includes a recorded of stratigraphy determined from cuttings (Louisiana Department of Natural Resources, 2015). With a significant number of wells in the top sand, approximately 125, and the second sand downwards, approximately 555, it is possible to determine if ion concentration is dependent on which sand is tapped. The upper sand has a higher concentration of iron, nitrate, and silicon (Figs. 5–7). By contrast the concentration methane, sodium, and total dissolved solids (TDS) is higher in the second sand (Figs. 8–10). Some of these differences have been observed previously for Wilcox (Carlson and Van Biersel, 2009, 2010). Carlson and Van Biersel's (2010) study included results where the concentration of iron and manganese are higher within the top sand than the second sand and concentration of chloride and sodium are higher in the second sand.

Concentrations of ions vary in both vertical and lateral directions. There is a general increase in ion concentrations from southwest to the east-northeast towards the Red River in Caddo Parish. In the southwest portion of Caddo Parish concentrations of chloride and sulfate tend to be lower than elsewhere in the parish (Figs. 11 and 12). This region matches well with the potentiometric high region within the Carrizo-Wilcox Aquifer in southwest Caddo Parish (Rapp, 1996, his figure 5). There is a region of higher chloride concentration that is approximately 5 miles south-southeast of downtown Shreveport. This area matches the area covered by a cone of depression in south-southeast portion of Caddo Parish as observed by Rapp (1996). This cone with its radial draw of water towards it causing water to move from the Red River, which is the reverse of the normal flow from west to east across the parish (Rapp, 1996).

There is also the influence of surface water bodies that is apparent. Chloride concentration highs are clustered often near surface water bodies (Van Biersel and Carlson, 2009). The pattern of chloride high clusters noted by Van Biersel and Carlson (2009) appears again for this study. These highs of chloride high concentration cluster throughout the study region (Fig. 11), include ones that Van Biersel and Carlson (2009) noted: Cross Lake (western central Caddo Parish), Gilmer Bayou (southwest Caddo Parish), Red River (border between Caddo and Bossier parishes), and Wallace Lake (border between Caddo and DeSoto parishes). In addition, another cluster near a surface water body occurs near Lake Bistineau in southeast corner of Bossier Parish (Fig. 11). This is an example of the interaction between surface water and groundwater. They are really one water resource (Chow et al., 1988; Domenico and Schwartz, 1990; Fetter, 2001). This interaction is important enough to be included when developing groundwater models (Anderson and Woessner, 1992; Haitjema, 1995) and developing policy and law (Becker and House, 2010; Saxowsky, 2007). Not all areas of high chloride concentration can be explained by surface water groundwater interaction. There is an area south of Barksdale Air Force (southern Bossier Parish) over the Sligo Field that probably reveals the possible influence of water welling up from oil and gas field that turn causes chloride concentrations too differ greatly depending on which field lies under the Wilcox Aquifer. The Wilcox above the Sligo Field has a median concentration of chloride of approximately 100 mg/L, which is three times the median concentration of chloride in the Wilcox for all water sampled in the study. In addition, the difference of chloride concentrations of the over 100 wells over the Sligo Field are almost always higher than chloride concentrations of over 100 wells over the Bethany-Longstreet Field (Fig. 3) and median concentration over Sligo Field is approximately 10 times that over Bethany-Longstreet (Fig. 3). Bethany-Longstreet is under that low chloride concentration region that Rapp (1996) noted.

In addition it appears that water withdrawals appear to impact water quality as a result of causing water to move vertically within the Wilcox Aquifer. These withdrawals are probably enhancing the interaction between the Wilcox and the overlying Red River Alluvial Aquifer in the Red River Valley running between Bossier and Caddo parishes (Fig. 12). This is important because of the cone of depression in south-southeast Caddo

Parish (Rapp, 1996) and the difference of water quality between the two aquifers. This is especially true for nitrate, iron and sulfate concentrations (Figs. 13–15). Nitrate is a health concern as evidenced by a primary U.S. Environmental Protection Agency (U.S. EPA) drinking water standard. Iron and sulfate have only secondary EPA drinking water standards (U.S. EPA, 2012). The combination of these two ions in higher concentrations plus typical bacterial activity will generate hydrogen sulfide yields (Clarke, 1953; Texas A&M University AgriLife Extension, 1999; University of Massachusetts Extension, 2007) water that is unpleasant in terms of odor as reported my numerous well owners during this study. Lastly it appears that water quality is changing through time (Fig. 16). This is not surprising because the Red River has both median chloride concentration which is 326 mg/L, and sulfate which is 58 mg/L concentrations (Garrison, 1997) that are considerably higher than both median chloride concentration in the Wilcox Aquifer which is 35 mg/L, and sulfate median concentration of approximately 30 mg/L in the Red River alluvial and approximately 3 mg/L in the Wilcox Aquifer (Fig. 15).

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