Water Systems Engineering, Inc.

Date: September 7, 2018

Lab Report No. 21273

Tom Engelken
Northway Well and Pump
4895 8th Ave.
Marion, Iowa 52302

Project Description: Prairie View Estates, Well No.2, Samples dated 8/15/18
Monitoring Analysis (2)

Test Description:

The Monitoring Analysis is an abridged series of chemical and biological tests used to identify common fouling issues within potable well systems. The tests include a limited number of chemical parameters such as pH, total dissolved solids/conductivity, and the oxidation reduction potential (ORP). The sample is also evaluated for the presence of chlorine, iron, and manganese. Biological testing is performed in an effort to quantify the total bacterial population, assess anaerobic conditions, and identify the presence of iron related bacteria or sulfate reducing organisms.

Testing Procedures:

All laboratory testing procedures are performed according to the guidelines set forth in *Standard Methods for the Examination of Water and Wastewater* as established by the American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF). Corrosion analyses are performed in accordance with the guidelines as set forth by the National Association of Corrosion Engineers (NACE). In general, these methods are approved by both the Environmental Protection Agency (EPA) and AWWA for the reporting of water and/or wastewater data.

Sample collection and shipment is the responsibility of the customer, performed according to protocol and procedures defined by the laboratory in advance of the sampling event with regards to the specific project and nature of the problem.

Disclaimer:

The data and interpretations presented are based on an evaluation of the samples and submitted data. Conclusions reached in this report are based upon the data available at the time of submittal and the accuracy of the report depends upon the validity of information submitted. Any recommendations presented are based on laboratory and field evaluations of similar fouling occurrences within potable water systems. Further investigative efforts, such as efficiency testing, site inspection, video survey, or other evaluation methods may offer additional insight into the system's condition and the degree of fouling present.

Client: Northway Well & Pump
Date: September 7, 2018
Lab Report No. 21273

Re: Prairie View Estates, Well No.2, Samples dated 8/15/18
Monitoring Analysis (2)

ND - Not Detected NA - Not Applicable * as $CaCO_3$	**System** mg/l	**Well (pumping)** mg/l	**Detection Limits**
pH Value	7.24	7.28	NA
Total Dissolved Solids	579	628	1.0 mg/l
Conductivity (µm or µS/cm)	809	872	NA
ORP (mV)	195.0	200.6	NA
Chlorine (as Cl)	ND	ND	0.02 mg/l
Iron (resuspended)	0.86	0.49	0.02 mg/l
Manganese (as Mn)	ND	ND	0.1 mg/l
Total Organic Carbon (C)	0.3	0.5	0.0 mg/l
Plate Count (colonies/ml)	65	14	NA
Anaerobic Growth (%)	10	10	NA
Sulfate Reducing Bacteria	Negative	Negative	NA
Fe/Mn Oxidizing Bacteria	Negative	Negative	NA
ATP (cells per ml) Initial	46,000	45,000	NA

Microscopic Evaluation:

System: Very low visible bacterial activity with very low amount of crystalline debris.

Well: Very low visible bacterial activity, moderate iron oxide with very low iron oxide entrained biomass.

Deposit Sample:

Photographs of sample:

Figure 1: Sample as received

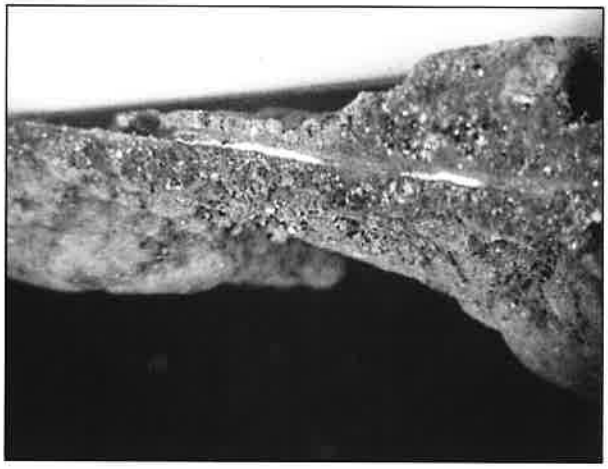

Figure 2: Sample at 30x magnification

Microscopic Evaluation:

Low visible microbial activity, low amount of crystalline debris, heavy iron oxide presence, moderate density and no magnetism.

Moderately strong effervescence reported in response to acid; strong H_2S generation during dissolution.

Observations:

When received in the lab, each of the samples from the Prairie View Estates water system and well were a light yellow in color. While the system sample was free of sediment, the well sample contained a dark particulate identified as layered iron oxide. The two samples each exhibited a neutral pH value with moderately oxidative oxidation-reduction potentials (ORP).

Total dissolved solids (TDS) and conductivity levels were elevated in each of the samples and exhibited an increase in the well sample. Without additional data, it is difficult to compare the results to historical values, however, the increase with pumping suggests that fall-out of sediment could be occurring within the system. The occurrence of crystalline debris, noted during microscopic evaluation of the sample, further suggests that settling is occurring with the system.

Resuspended iron is a total iron test that accounts for both chemically oxidized and biologically mobilized iron. The values were elevated in the system sample, declining in the well sample. Conversely, visible iron, as noted during microscopic evaluation, was higher in the well samples.

Total organic carbon (TOC) is the amount of carbon bound in an organic compound and is often used as a non-specific indicator of water quality and the potential for bacterial stimulation and

biofouling. Although the TOC levels were not excessive, they were sufficient to expect microbial development within the well and system. In areas of water storage or that have long term, static conditions, could have an increase in bacterial activity.

Biological analysis of the active samples noted very low heterotrophic plate growth. Adenosine triphosphate (ATP) testing, a means of quantifying the microbial population that is not agar dependent, reported average values for both samples. As a point of reference, active well systems typically exhibit an ATP range of 10,000 to 70,000 cells per milliliter (cpm).

Anaerobic growth, reported as a function of the total population, was limited at ten percent in both samples. Testing for the presence of sulfate reducing bacteria was negative. Testing for the presence of iron oxidizing bacteria was negative.

Evaluation of the deposit, representative of debris observed in the discharge from the well, was completed to better identify the fouling that is occurring. The material exhibited characteristics of layered iron oxide and iron sulfide deposition. Although no magnetism was observed, the layering evident in Figure 2 is more suggestive of being a byproduct of corrosion of iron pipe. Hydrogen sulfide was generated during dissolution of the deposit, a characteristic of both iron sulfide presence as well as the occurrence of sulfate reducing bacteria.

Interpretations:

It was reported that the system has been experiencing periodic discharge of black sediment and a fleeting hydrogen sulfide (H_2S) odor. The deposit, representative of the observed sediment, is predominantly iron, including both iron oxide and iron sulfide. The nature of the deposit suggests that the debris is related to corrosion activity. Although the water may not be overly aggressive, overtime, corrosion of the lower portion of the casing could be occurring and mobilizing the iron particulate into the produced water.

Although the water samples were negative for sulfate reducing bacteria (SRB) presence, it is likely that SRB growth could be occurring in the lower extension of the well or in static portions of the piping system. Idle conditions can often result in a surge of anaerobic microbial activity including both SRB occurrence and H_2S development. The recognition of these conditions is often strongest at initial start-up, dissipating as higher production occurs. In addition to the H_2S occurrence, SRB's are an agent of microbiologically influenced corrosion (MIC), creating acidic conditions in the lower extension of the well. Any bends or angles within the piping system, as well as idled sections, could be seeing increased anaerobic activity as well as build-up of the iron and biomass in general.

Recommendations:

Given the reported elevation changes between the well and system, it is advised that a larger pump be temporarily placed into the well and utilized to flush debris from the line. Despite regular pumping (well and lift station), iron typically settles in pipes due to the higher density as well as common entrainment in biomass. The higher velocities provided by the larger pump would be utilized to flush the debris from the supply line. Prior to setting the larger pump, it is advised that the well be airlifted or jetted in a manner to flush out the lower extension of the well to remove any debris which has accumulated downhole. The larger pump should not be used as a permanent replacement for the well.

Once bulk material has been removed, utilization of an acid treatment is recommended to clean

remaining iron and iron oxide entrained biomass from the supply line. Oxalic acid is recommended as a strong organic acid with an affinity for iron and manganese. Oxalic acid is a powdered acid that can be blended and added into the pipeline or metered in as a powder for blending within the pipeline. Usage should not exceed 5% of the pipeline volume. The line should be thoroughly flushed once treatment is completed and disinfected prior to usage.

If you have questions regarding the analysis and the interpretations, please contact our office.

Michael Schnieders, PG, PH-GW
Hydrogeologist