

# **APPENDIX L**

## **Brine Line Foulant Analysis**

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## Foulant Analysis Report

To: Eastern Municipal Water District

From: Avista Technologies Lab

Avista WO#: 081618-5

### Summary

Eastern Municipal Water District provided one foulant sample to Avista Technologies for analysis. The following is a summary of the results.

- The foulant sample provided was gray-colored and granular in texture. Despite being immersed in water, the wet foulant sample was identical to the dried sample; thus, the dried sample was chosen for further analysis.
- Acid testing performed on the foulant sample produced slight effervescing indicating the presence of carbonates in the sample. No color change was noted.
- Microscope analysis performed on the foulant sample identified primarily translucent crystals and particles with lesser amounts of amorphous inorganic material.
- Fourier Transform Infrared (FT-IR) spectrum of the foulant sample detected one strong sharp peak at about  $1000\text{ cm}^{-1}$  which is associated with the presence of calcium phosphate. The smaller peak present around  $1700\text{ cm}^{-1}$  is indicative of colloidal sulfur.
- Energy Dispersive Spectroscopy (EDS) analysis of the foulant material determined the dominant inorganic element in the membrane foulant material was calcium. Lesser amounts of phosphorous and magnesium with trace amounts ( $<0.50\%$ ) of silicon and sulfur were also detected. The carbon weight percentage is contributed by the carbon tape used to mount the sample during analysis but may also be contributed by the presence of foreign organics.
- Scanning Electron Microscope (SEM) imaging portrayed the foulant sample as granular material. Close-up SEM imaging (5000x) revealed the granular foulant varied in size from 1-50  $\mu\text{m}$ .
- Chromatic Element Imaging<sup>SM</sup> (CEI<sup>SM</sup>) confirmed the granular foulant material as calcium phosphate. A small amount of calcium carbonate was also observed scattered throughout the granular material. The carbon tape was visible beneath the foulant material.

Based on the foulant analysis, the foulant sample was determined to be primarily calcium phosphate. Trace amounts of calcium carbonate were also identified.



## Visual Inspection

The foulant sample provided was gray-colored and granular in texture. Despite being immersed in water, the wet foulant sample was identical to the dried sample; thus, the dried sample was chosen for further analysis.



Image of the foulant sample enclosed in the packaging provided



Close-up images of the dried and wet foulant material

## Foulant Analysis

### **Acid Testing**

Acid testing is used to determine the presence of carbonates and metals in the foulant sample. In this test, dilute hydrochloric acid is applied to the foulant. Effervescing indicates the presence of carbonates while a color change (yellow) is associated with the presence of metals.

Acid testing performed on the foulant sample produced slight effervescing indicating the presence of carbonates in the sample. No color change was noted.

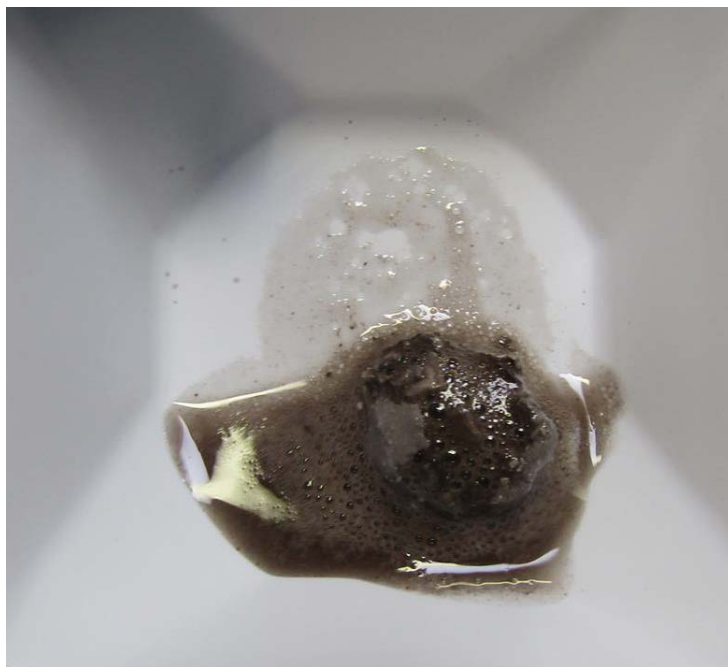
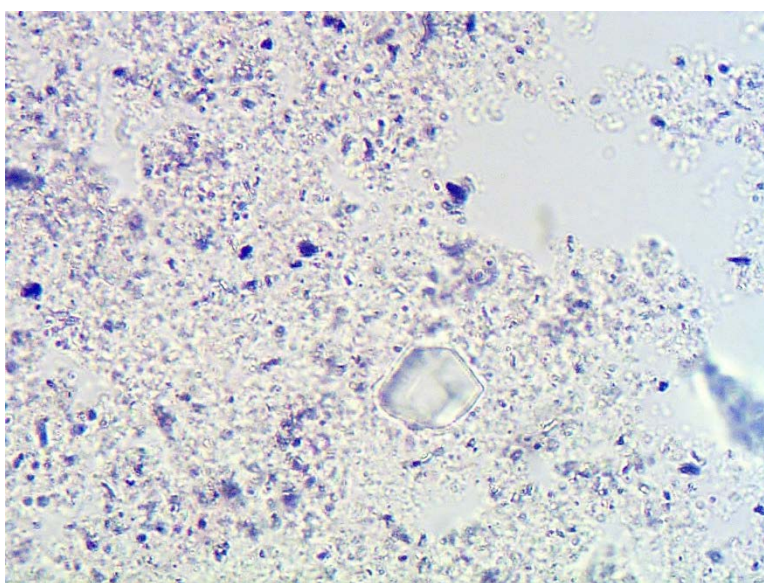
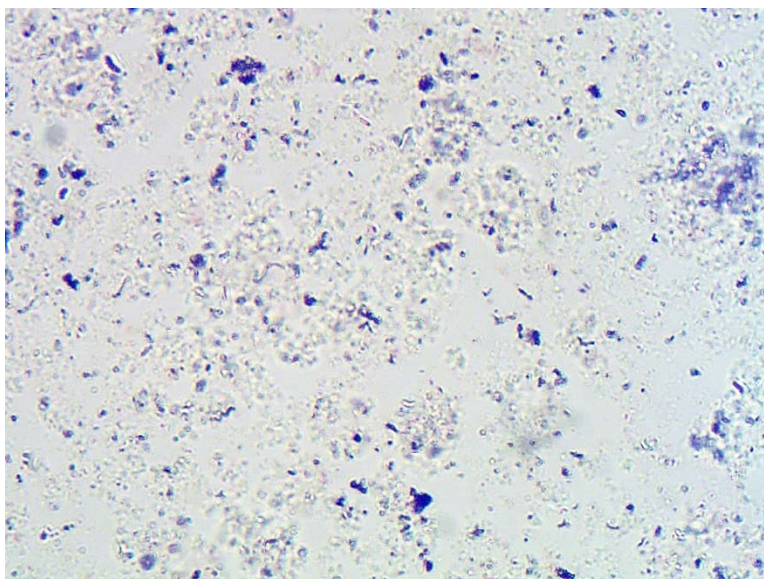


Image of addition of dilute hydrochloric acid to sample

## Microbiological Analysis

This analysis is performed to identify the biological activity of the foulant sample. Foulant samples are stained and examined with a light microscope at 1000x using an oil immersion lens. Gram positive bacteria are stained purple while Gram negative bacteria are stained pink.

Microscope analysis performed on the foulant sample identified primarily translucent crystals particles with lesser amounts of amorphous inorganic material.



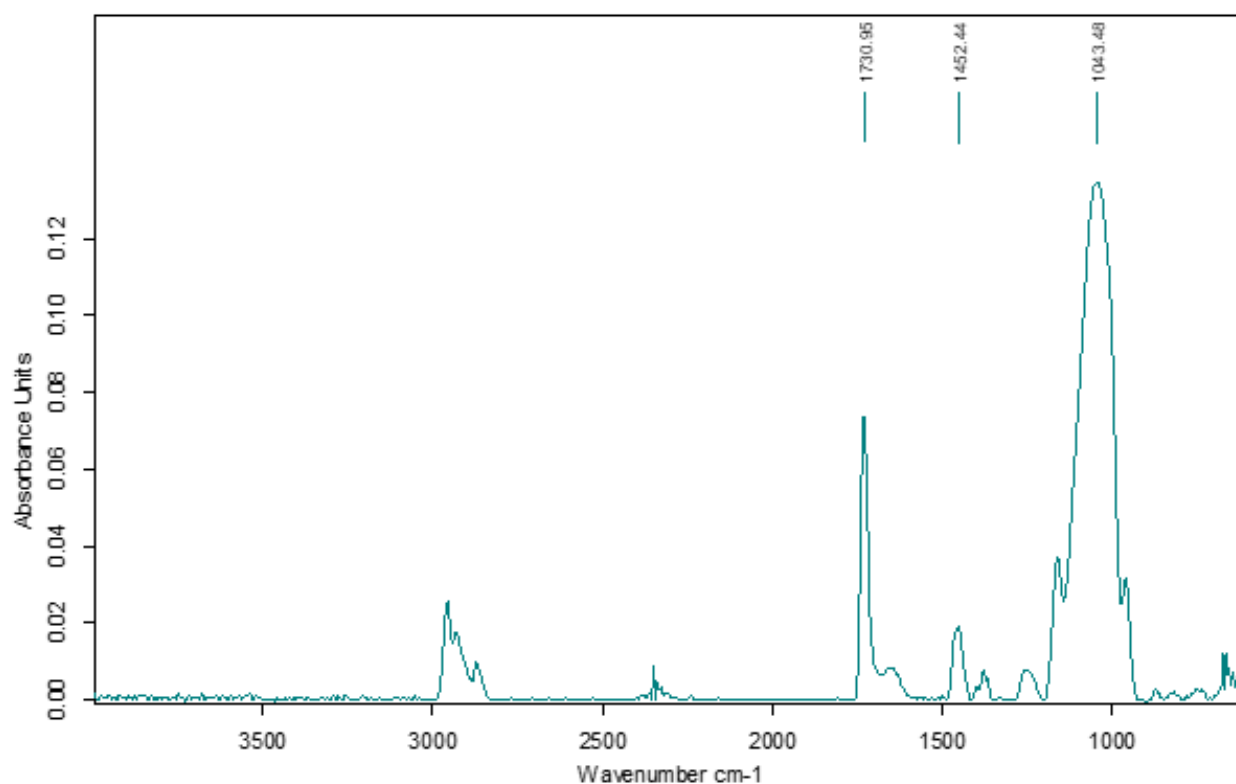
Light microscope images (1000x) of membrane foulant sample



### Fourier Transform Infrared Spectroscopy Analysis

Fourier Transform Infrared Spectroscopy (FT-IR) is an analytical technique used to identify functional groups (specific groups of atoms or bonds within molecules). Infrared radiation passes through a sample, with some of the radiation absorbed and some transmitted. A measurement and interpretation of this data produces a spectrum which can then be compared and matched to the known spectra for functional groups based on the wavenumber at which bands appear and their respective shapes (e.g. sharp, broad, strong, weak).

FT-IR spectrum of the foulant sample detected one strong sharp peak at about  $1000\text{ cm}^{-1}$  which is associated with the presence of calcium phosphate. The smaller peak present around  $1700\text{ cm}^{-1}$  is indicative of colloidal sulfur.



FT-IR spectral image of the foulant sample

**Energy Dispersive Spectroscopy (EDS) Analysis**

Energy Dispersive Spectroscopy is used to determine the relative concentration of elements present in a foulant sample. EDS analysis is performed on a dry sample.

EDS analysis determined the dominant inorganic element in the membrane foulant material was calcium. Lesser amounts of phosphorous and magnesium with trace amounts (<0.50%) of silicon and sulfur were also detected. The carbon weight percentage is contributed by the carbon tape used to mount the sample during analysis but may also be contributed by the presence of foreign organics.

Elements	Foulant Sample Weight Percent (wt%)
Carbon	44.75
Oxygen	36.88
Calcium	11.18
Phosphorous	6.04
Magnesium	0.81
Silicon	0.20
Sulfur	0.14

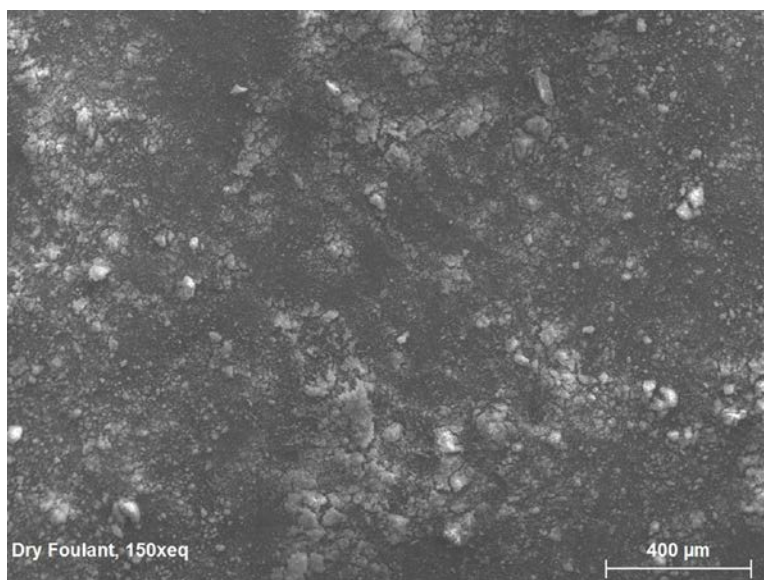




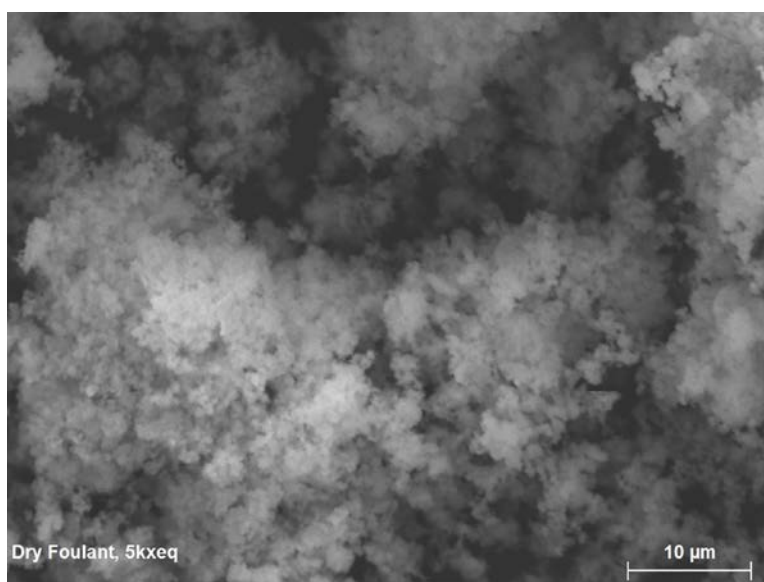
### Scanning Electron Microscope (SEM) Imaging

SEM imaging is performed on the foulant sample to observe the topography of the foulant material. Foulant morphology can be an indicator of the type of foulant.

SEM imaging (150x) portrayed the foulant sample as granular material. Close-up SEM imaging (5000x) revealed the granular foulant varied in size from 1-50  $\mu\text{m}$ .



SEM image (150x) of foulant sample



Close-up SEM image (5000x) of foulant sample

**Chromatic Elemental Imaging<sup>SM</sup> (CEI<sup>SM</sup>)**

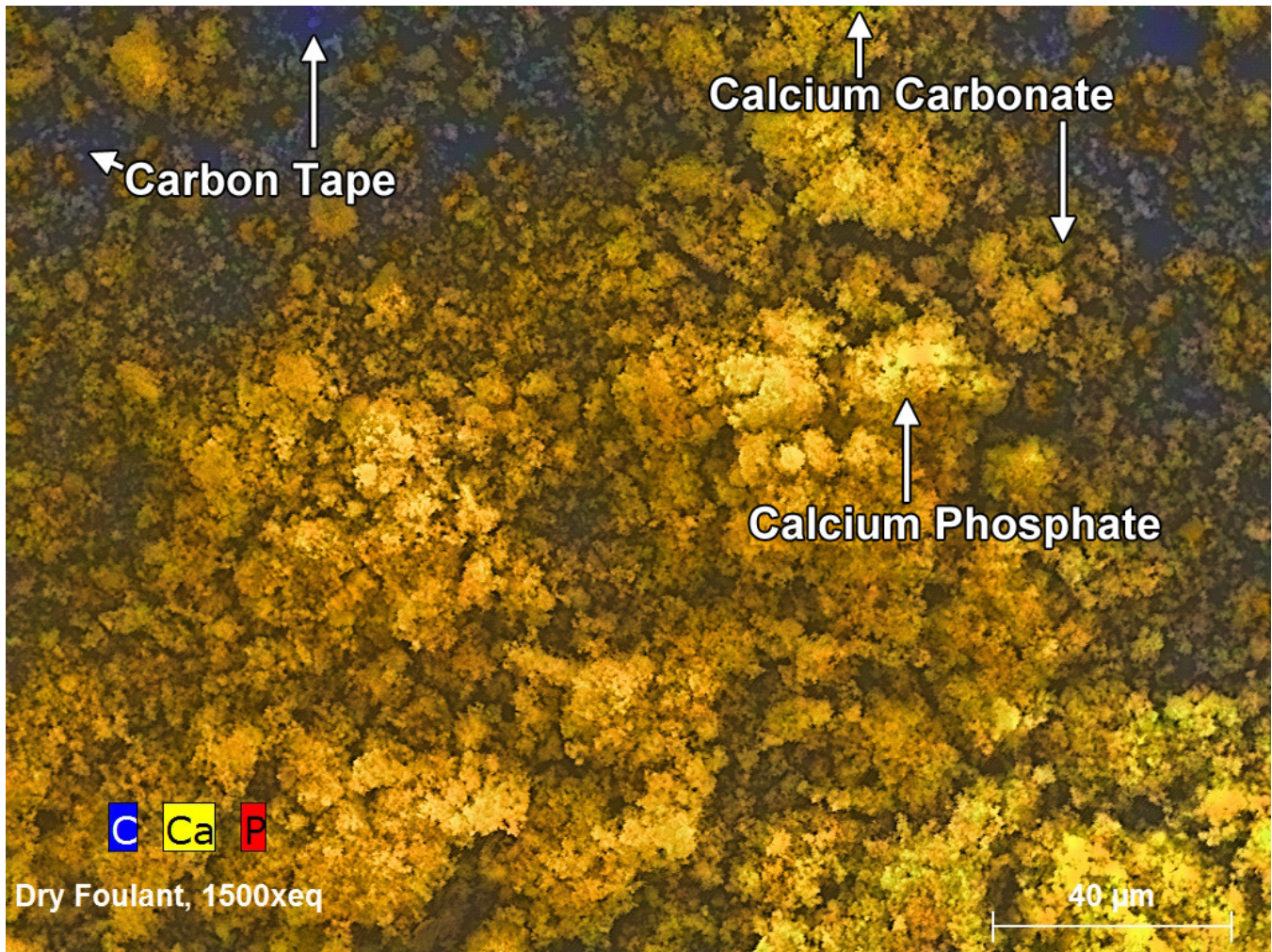
CEI is an analytical technique used to determine the spatial distribution of elements in a foulant sample. In this technique, a beam of focused electrons is accelerated across the surface of a foulant sample and interacts with the sample's inorganic elements by causing the elements to emit electrons. An element's electron emission from its atomic shell generates a characteristic X-ray spectrum that allows for its identification. CEI assigns each element a color (colors for each element are shown in a legend on the bottom left corner of the CEI image) and provides a high-resolution image where the colors correspond to the exact location of the elements in the sample. An element's color intensity in a CEI is largely influenced by its concentration in the foulant sample; i.e. elements present with higher relative concentrations are displayed with greater color intensity in the image. CEI can uniquely identify the distinct elements in a mixed foulant sample.



CEI image (1500x) of the foulant sample



CEI<sup>SM</sup> confirmed the granular foulant material as calcium phosphate (combination of yellow and red). A small amount of calcium carbonate (combination of yellow and blue) was also observed scattered throughout the granular material. The carbon tape (dark blue) was visible beneath the foulant material.



CEI image (1500x) of the foulant sample with labels



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## Certification by Laboratory

Report Number	Report Content	Report Date
WO#081618-5	Foulant Analysis	September 13, 2018

We the undersigned being the technical specialists in membrane autopsy and related testing procedures and protocol for Avista Technologies certify to the best of our knowledge and belief that the tests listed in this report have been conducted following Avista's standard testing practices and that the results are accurate and complete.

By signing this certificate neither the laboratory employees nor their employer makes any warranty, expressed or implied, concerning the cleaning study results.

Date: 09/13/2018

Signed:

A handwritten signature in black ink, appearing to read "ML", written over a horizontal line.

Megan Lee

Laboratory Services Manager

A handwritten signature in black ink, appearing to read "Jessica Foster", written over a horizontal line.

Jessica Foster

Laboratory Services Chemist

