By Daryn Martin, KRWA Technical Assistant/Training Coordinator

An Inexpensive, Common-Sense (Simple) Chlorination Change Reduces DBPs at Elmdale

Elmdale, Kansas is a beautiful little hamlet on the banks of the Cottonwood River in the Flint Hills of Chase County. Once a bustling rail town, today Elmdale is known as the home to YMCA Camp Wood, a youth camp that has been serving children and teens from all across the Midwest for more than a hundred years.

A 42-foot-deep well serves Elmdale's 40 residents. The water is disinfected and then softened by an ion-exchange softening system before storage in a 1000-gallon pneumatic storage tank. Production averages around 5000 gallons daily. It's your typical, everyday small town with no budget for major improvements. But that's just what the city was facing due to drinking water violations.

Disinfection byproducts (DBPs) are a common headache for water system operators. Formed when free chlorine reacts with organics in water, DBPs are generally a concern for surface water operators and their wholesale customers. Because of the absence of organics in the water, groundwater systems rarely have issues with DBPs. Elmdale was one of only three groundwater systems to incur a Maximum Contaminant Level (MCL) violation in 2020, according to KDHE's latest Annual Compliance Report (www.kdhe.ks.gov/526/Annual-Compliance-Reports).

Elmdale had not experienced issues with DBPs until September 2017 when a routine sample showed a Total Trihalomethane (TTHM) level of 270 parts per billion (ppb) and a Haloacetic Acids (HAA) level of 200 ppb. EPA limits TTHM to 80 ppb and HAA to 60 ppb. These levels were off the chart. The city began sampling quarterly after that and received nineteen MCL violations since. KDHE ultimately began enforcement proceedings against the city, threatening fines if the compliance problems continued. If that were not bad enough, in November 2019, the Kansas News Service quoted a report by The Environmental Working Group that blasted Kansas Public Water Suppliers. The reporter specifically pointed out that Elmdale had the "fifth-highest levels" of TTHM in the entire country. I took offense to the article and wrote a response published in the March 2020 issue of *The Kansas Lifeline*. You can find it at www.krwa.net/portals/krwa/lifeline/2003/ContaminatedArticle.pdf. All past issues (since 1997) of *The Kansas Lifeline* are available on our website. They are a great reference tool for researching problems.

Mark Davis, Operator at Elmdale, measures chlorine residual in the city's water plant. Since switching chlorination points, chlorine demand has reduced by about 35 percent, saving the city money in chemical costs.

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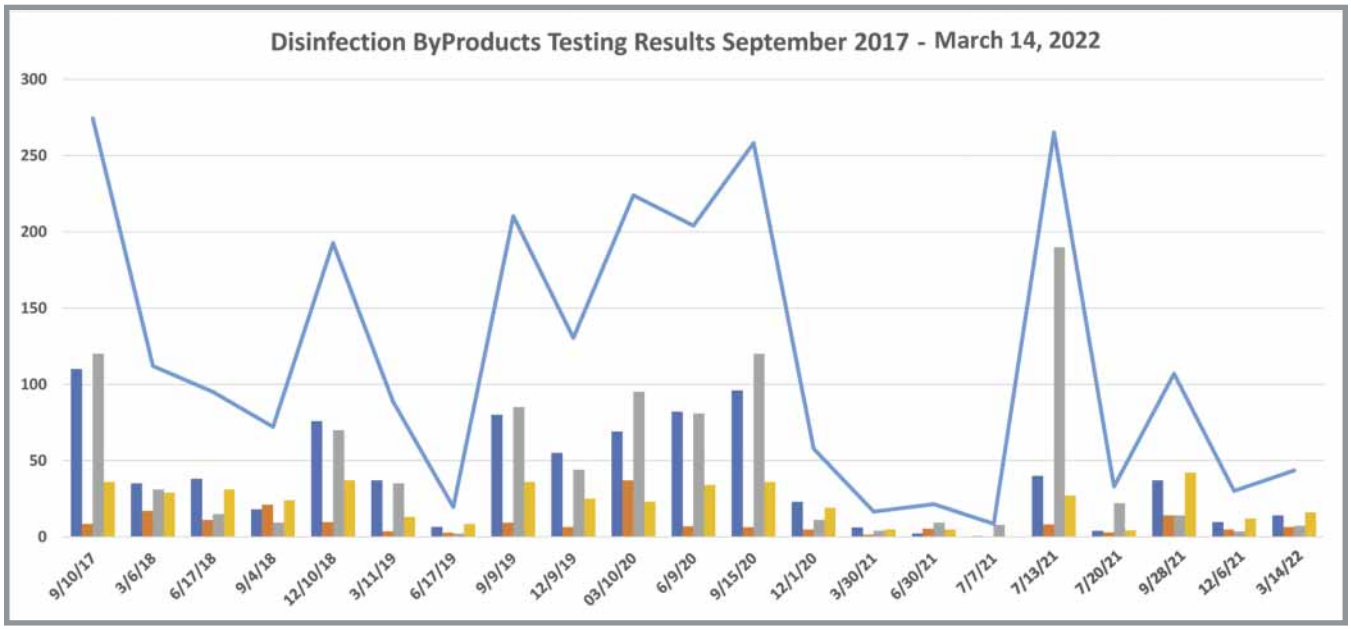

The figure shows Elmdale's total trihalomethane (TTHM) results since September 2017. The line graph represents TTHM. The bars represent the four species of trihalomethanes that EPA regulates. Adding the individual species together results in the total trihalomethane level.

When faced with elevated DBPs, water treatment operators will likely focus on limiting the formation rather than removing the formed byproducts. This can be achieved by physically removing organics from the water with coagulation, flocculation and sedimentation processes upstream of the chlorine application point. Less organics in the water when chlorine is added equals less byproduct formation. It also reduces chlorine demand in the water, which helps limit DBP formation.

Another practice that treatment plant operators use to comply with DBP regulations is chloramine disinfection. When ammonia is added to water with free chlorine in it, chloramines are formed. Because chloramine is a much weaker disinfectant, its use dramatically limits DBP formation. To my knowledge, every surface water treatment plant in Kansas except one uses chloramines to comply with DBP regulations. Some groundwater systems with DBP formation problems have begun to use chloramine disinfection to limit formation due to reactions with bromine in the raw water. Elmdale considered this an unfavorable option due to engineering, permitting, ongoing operations, and maintenance costs.

Elmdale received a cooler of bottles to collect samples at the treatment plant and from various points in the distribution system, representing increasing water age. Analyses showed that TTHM levels nearly exceeded the MCL before leaving the treatment plant. Levels increased in each sample the further away from the plant they were collected.

An investigation was begun into the source water. Investigative well samples were collected and shipped to an investigative lab for analysis. Two samples were taken for the well profile, one from the static water column and one during the pumping cycle to sample the aquifer. This type of profile is used to identify potential fouling or corrosion issues. The report indicated some biological growth in the well, but the levels of organics were well below what is commonly associated with DBPs. The focus was then shifted to the distribution system, and the timing was perfect.

Elmdale received an invitation from KDHE staff to participate in an Area Wide Optimization Program (AWOP) DBP study. AWOP is usually reserved for surface water treatment systems, but the ongoing DBP issue in Elmdale warranted their participation. The study funded sampling from multiple surface water plants, their distribution systems and their wholesale customers' distribution systems. The goal was to see how byproducts form

through distribution systems as the water ages. Elmdale received a cooler of bottles to collect samples at the treatment plant and from various points in the distribution system, representing increasing water age. Analyses showed that TTHM levels nearly exceeded the MCL before leaving the treatment plant. Levels increased in each sample the further away from the plant they were collected.

The AWOP study mentors suggested the DBP formation may be due to something in the treatment plant itself. The treatment plant in Elmdale is pretty simple. Inject sodium hypochlorite into the raw water and send it through an ion exchange softener, basically a large, household water softener. Historic DBP levels were compared to total hardness levels from the same period. When the softener was installed, hardness levels declined (obviously), but DBP levels skyrocketed. That could not be a coincidence, so it was recommended that the city bypass the water softener, sample again and compare the results. The softener was taken offline, much to the dismay of customers used to softened water, and the system was flushed. Another cooler of bottles was filled and shipped to the lab. The results were shocking. DBP levels were dramatically lower when the water was not softened!

Elmdale Operator Mark Davis adds salt to the softening system's brine tank. The city started chlorinating downstream of the softener to reduce disinfection byproduct formation.

After reviewing the design of the Elmdale Water Treatment Plant, it was determined that the city should plumb in an additional point of chlorination downstream of the softener. The hypothesis being that the chlorine was reacting with something in the softener. The main suspect was bromide in the system's regeneration salt, which could result in high DBPs. Chlorinated water can also damage the softener's media. The city met with KDHE's engineering group and proposed a plan to add a second chlorination point. The approved design allowed for chlorination downstream of the softener but prior to the pneumatic storage tank to ensure all water was properly disinfected. The change-over process was to be done in stages, with DBP samples collected weekly to monitor changes. Samples were collected from the compliance sampling location and submitted to the KDHE lab for analysis. Results took longer than a week to receive, so proceeding steps were taken without knowing each sample's results.

The initial sample was collected with the softener bypassed. Excellent results. Step One was to plumb a new chlorine injection point and start

chlorinating downstream of the softener. Another sample was taken with even lower DBP results. TTHM and HAA levels are in the single digits! The plan was beginning to look promising.

Step Two of the process was to return the softener to service, but without regenerating the media. The DBP results were extremely high! If it were a compliance sample, Elmdale would have had a violation. And not just one violation, but FOUR due to compliance being determined on an annual average. It was determined that stagnant water in the softening unit (which had been offline for months during this process) had some growth that reacted with the chlorine, resulting in high byproducts. Step Three was to initiate the salt regeneration process and sample again. The exceptionally low results were back! The hypothesis appeared to be correct.

Elmdale has been chlorinating downstream of the water softener for months now. After the third quarter compliance sample in 2021, the city of Elmdale's TTHM Locational Running Annual Average was below the MCL. It was the first time in fifteen quarters that the city was in compliance!

Operator Mark Davis says the water quality is greatly improved and chlorine use in the small system has been reduced by about 35 percent.

Because of some intuitive thinking and lots of help from KDHE, EPA and their contractors, the city of Elmdale was able to achieve compliance without blowing the entire budget. The Elmdale Project was completed without hiring consulting engineers, listening to salesmen or putting a single shovel in the dirt. The city took time to thoroughly investigate the problem rather than simply throw money at a contaminant. The ratepayers will likely save thousands of dollars in the years to come.

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Daryn Martin began work with KRWA in August 2019. He previously was a Water Program Inspector and Environmental Program Administrator at KDHE's Wichita office. Prior to joining KDHE, he worked as an operator in the El Dorado Water Treatment Plant. He holds a Class IV water operator certification.