Investigation of Water Quality Issues

submitted to the City of Red Bud

March, 2014

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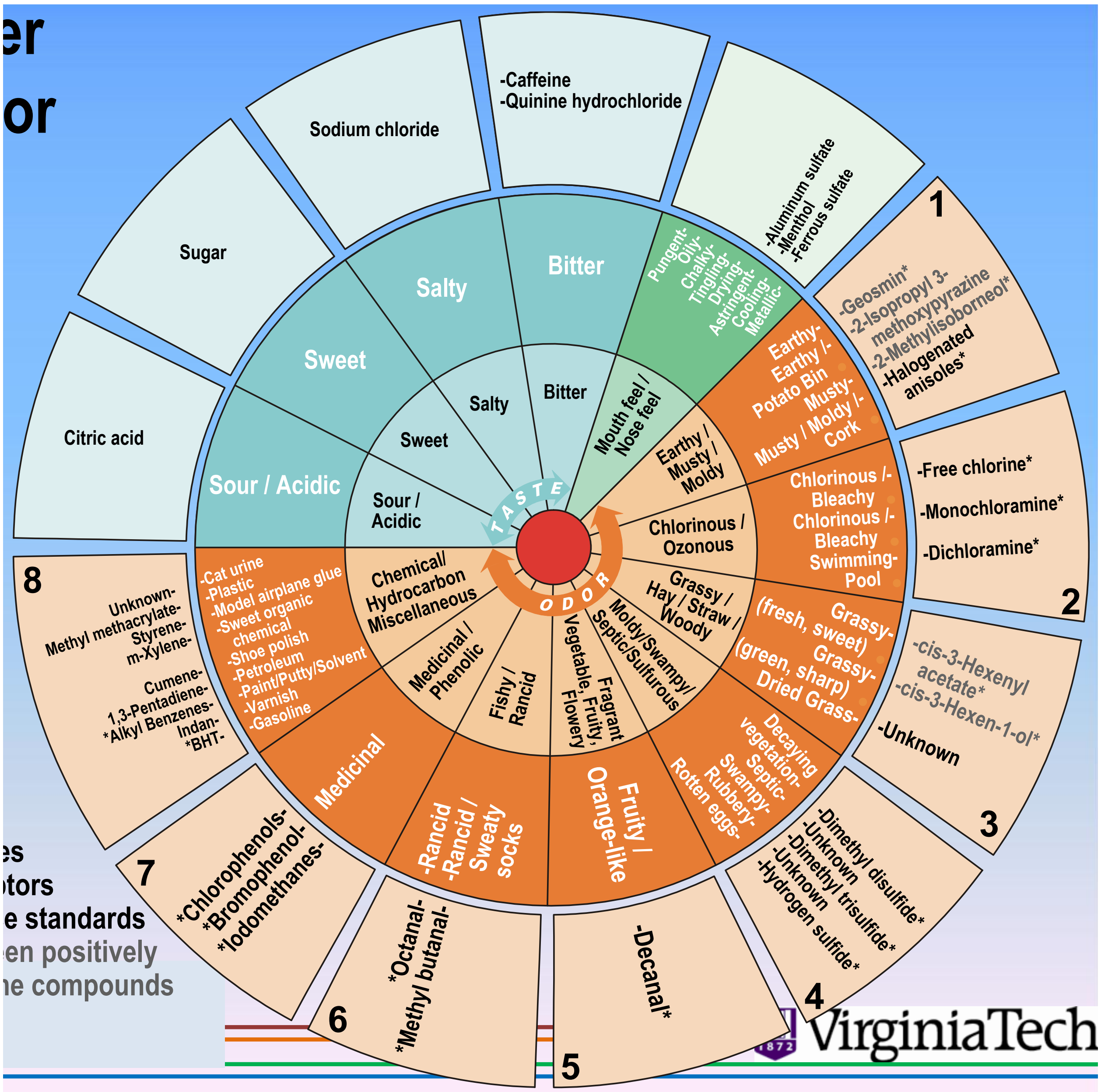
Background

The City of Red Bud wishes to improve the taste of its drinking water. The purpose of this investigation was to diagnose potential chemical and microbiological causes of taste and odor issues and to recommend remedial actions.

Onsite investigations and discussions took place on February 24 and 25, 2014.



Virginia Tech has modified a flavor wheel for use in discussing tastes and odors in drinking water.

Taste Testing

Water was tasted at multiple locations around town, including the water treatment plant, City Hall, private residences, restaurants, and the Country Inn. There were no obvious taste, odor, or color issues found. To our palates, the water tasted neutral, flat, and pretty much like water.

However, in talking to local residents about the water, the ‘word on the street’ was that Red Bud had poor quality water. Words such as chlorinous, bitter, dirty, metallic, rotten eggs, and nasty were used. But many of the water quality concerns tended to be ephemeral or historic, and there seemed to be some consensus that things aren’t currently as bad as they used to be.

Some people reported a certain seasonality to taste and odor in that the issue was more pronounced in the summer. Others reported not having noticed any seasonal variations.

There appeared to be a certain locality to water quality issues, in that parts of town with older iron pipes could be more likely to have discolored or metallic-tasting water.

The water’s hardness contributes to the general perception of low-quality water. A substantial number of residents filter and/or soften the water at their homes and businesses. Used filters observed in one residence were quite clean.

Another contributor to the general perception of low-quality water is the occasional plant upsets that allow iron and manganese to enter the system. A small amount of manganese can produce a large amount of color, which goes a long way towards coloring people’s opinions about the quality of their water. Despite the fact that these types of plant upsets are extremely uncommon these days, their legend lives on.

Although we did not detect chlorinous tastes or odors, chlorine levels are such that they could certainly be detected by sensitive individuals. This issue could certainly be addressed.

But perception is reality, and opinions and ideas about drinking water quality should be taken seriously, investigated, and fully addressed.

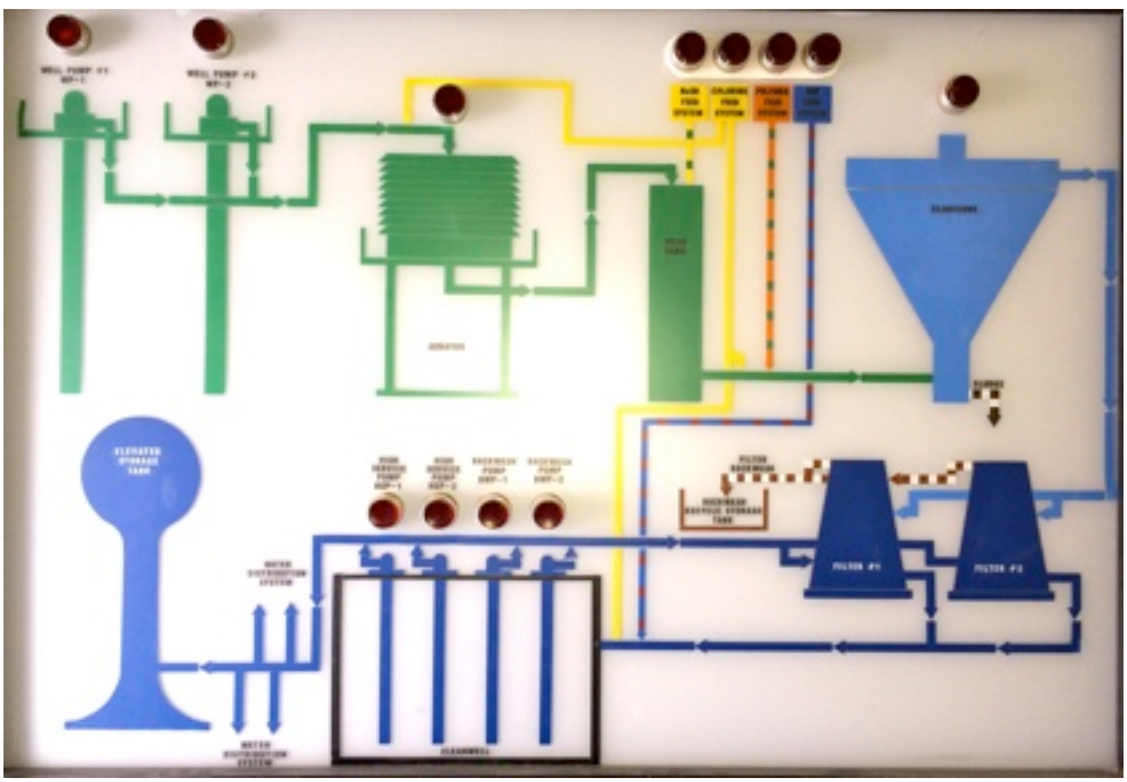
It would help to clearly define water quality issues by developing a standardized water quality concern logging and response system. Information gathered will help to define, locate, and respond to taste, odor, and color issues. Some sort of survey and public discussion on taste, odor, color, and water quality issues would also be helpful.

Existing Water Treatment Facilities

Raw water from two wells near the Kaskaskia River is pumped seven miles through a 12” PVC transmission main to the water treatment plant. The plant was designed for the removal of iron and manganese at a maximum flow rate of 1.0 MGD, but plant operators report that a more realistic maximum flow these days is approximately 0.75 MGD. Daily water demand is on the order of 0.275 MG, and summer peak demand days are about 0.5 MG.

The treatment train consists of an aerator, detention basin, head tank, Claricone, multi-media filters, and an underground, 200,000 gallon clearwell. Two elevated storage tanks in the distribution system hold 200,000 and 500,000 gallons—about three days of typical usage.

Although the source water is very hard, the plant was not designed to soften the water at all. The hardness of the water is a likely contributor to the perception of poor water quality. Additionally, a significant portion of the population appears to own and operate home water softeners. It may be desirable to have a public discussion of the pros, cons, costs, and benefits of centralized softening at the water treatment plant.



Aeration

Aeration is particularly important for the removal of volatile organics, methane, hydrogen sulfide, and the increase of pH via the stripping of carbon dioxide. Some of these compounds can affect taste and odor.

The existing aerator is a Hydro Group IDA 78-10, which is an induced-draft wood slat aerator. Although it is not simple to open and fully examine the interior, there is a small service hatch near the bottom that was removed.

Staff reported that there may be an issue with the fan which causes it to blow air in the wrong direction (downwards into the unit). This should be remedied. The need for a fine screen held on to the fan with a bungee cord should be reevaluated, as this restricts air flow.

The side air intake vent screens are encrusted with debris that severely inhibits air flow. These screens should be cleaned or replaced with coarser screens that allow better air flow and don't get clogged as easily.

Based on a peek inside the small access panel, the interior of the aerator appears to be in decent shape. The wood slats are intact, and there is not a large amount of solids buildup. At some point, the large side of the aerator should be removed for a more thorough inspection and cleaning.

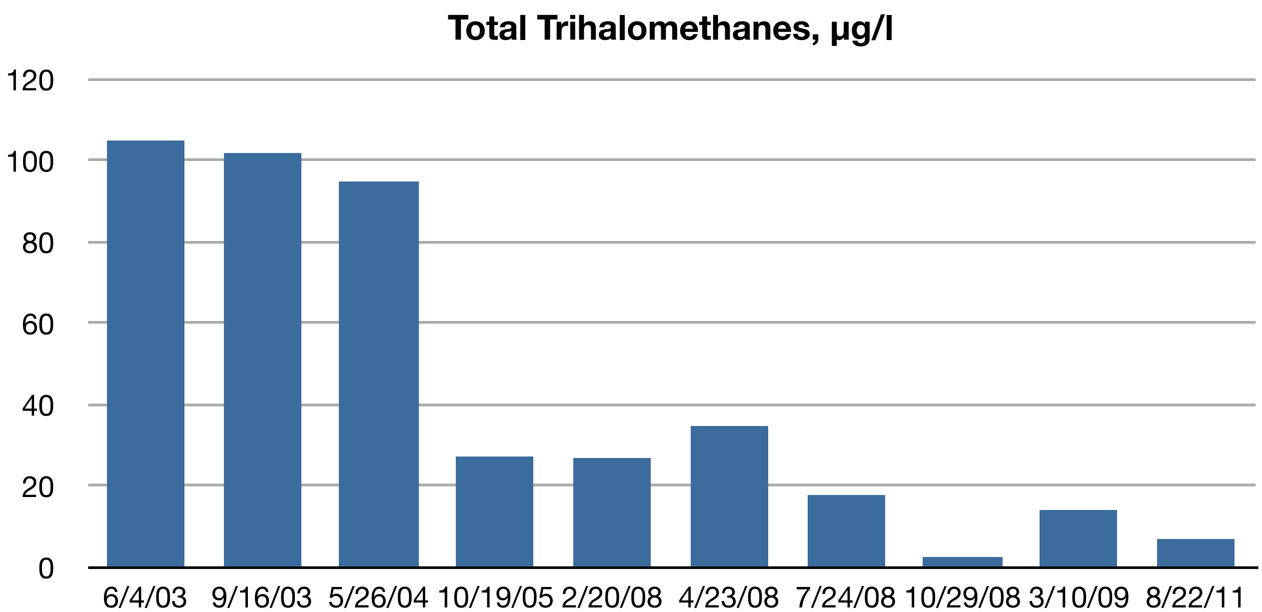
In order to evaluate the performance of the aerator, it would be helpful to have a sample tap at its effluent. This would allow staff to monitor aerator performance on an ongoing basis (via pH, dissolved oxygen, and organics).

Water Quality Data

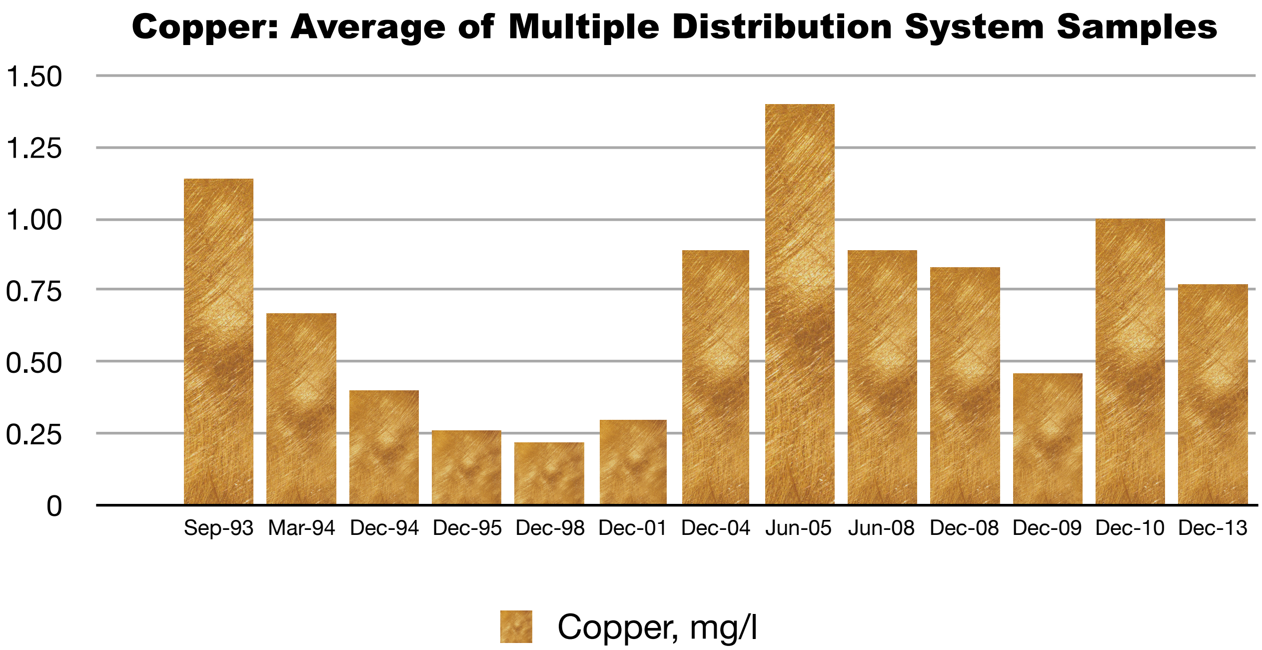
Prior to onsite investigations, data available through IEPA's Drinking Water Watch was reviewed.

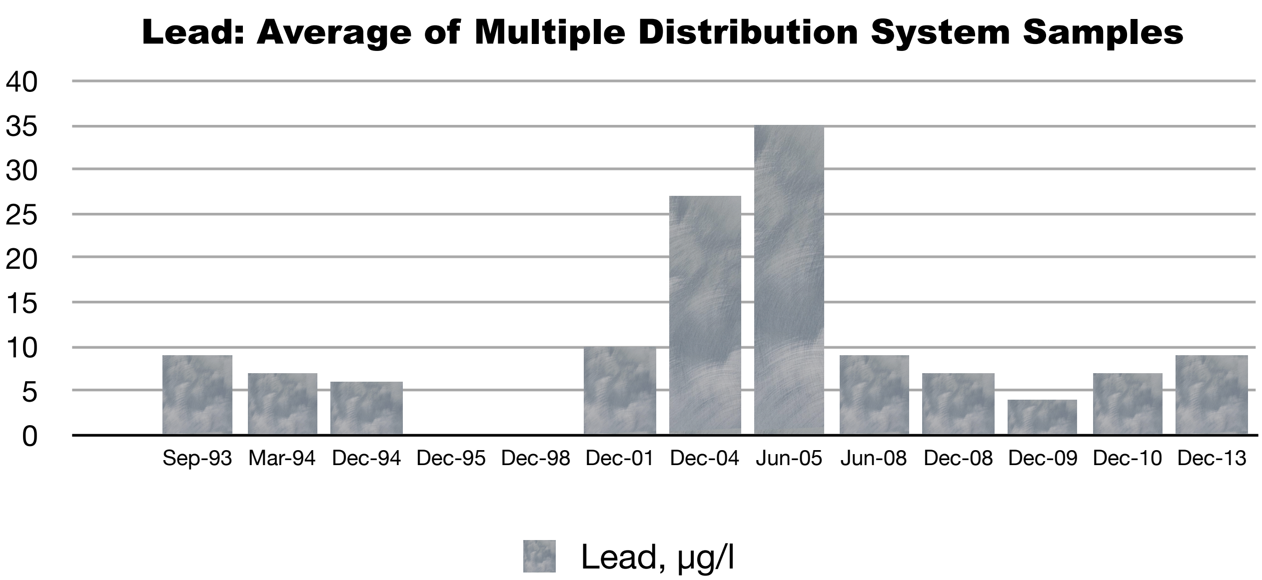
The city of Red Bud has not had a single positive coliform sample in years, which suggests that the water is extremely clean from a microbiological standpoint. (This was later confirmed with onsite observations and measurements.)

Over ten years ago, TTHM levels were above 100 μg/l. This indicates that there was a certain amount of organic matter in the source water. Since that time, operational modifications have brought the TTHM levels down, but there would still be a similar amount of organic matter remaining in the water.



Lead and copper monitoring results are shown in the following graphs. Copper may impart a metallic taste to water in levels as low as 1 mg/l, particularly for some sensitive individuals. The source of copper in the water is predominantly from copper water pipes in the home. Customers sensitive to metallic tastes could be encouraged to let the water run before drinking or replace copper pipes with PEX on the runs to drinking water taps.





Potential Chemical Causes of Taste and Odor Issues

A list of potential chemical causes of water quality issues was compiled, along with ranges of their concentrations in the treated water and estimates of their individual taste and odor thresholds (when available). This ruled out several parameters.

Remaining possible contributors included free chlorine, monochloramine, manganese, copper, methane, hydrogen sulfide, and organic compounds.

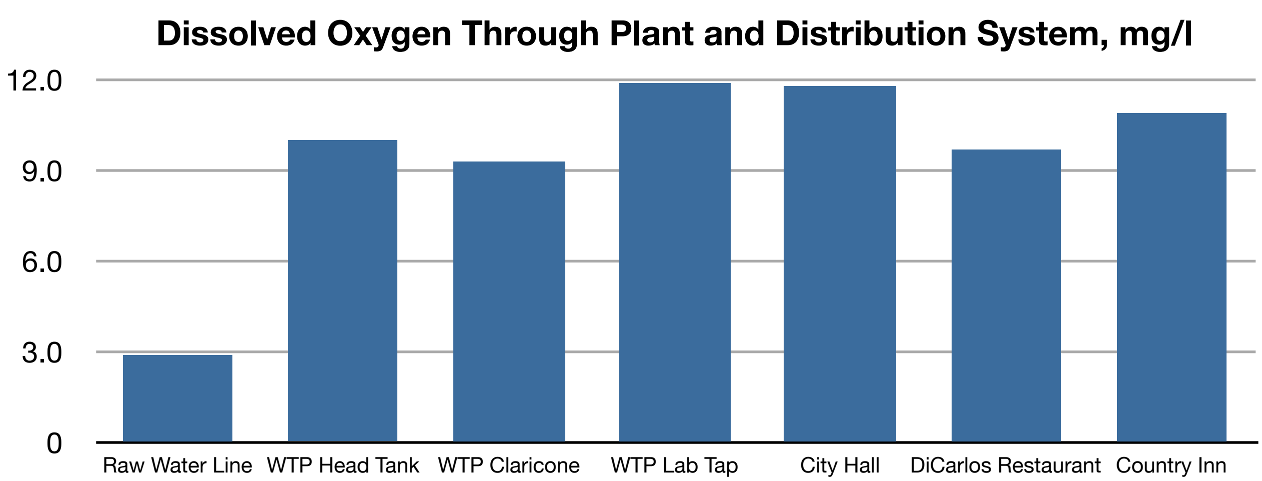
PARAMETER	**FINISHED WATER CONCENTRATION** mg/l	**TASTE/ODOR THRESHOLD** mg/l	**NOTES**
Free Chlorine	2 - 3	0.3	
Monochloramine	1 - 2	0.5	
Dichloramine	minimal at pH > 7	0.15	
Trichloramine	non-existant at pH > 4	0.02	
Manganese	ND - 0.03	0.05 (Secondary MCL)	bitter metallic taste
Iron	ND - 0.038	0.3 (Secondary MCL)	metallic taste
Zinc	ND - 0.007	5 (Secondary MCL)	metallic taste
Copper	0.2 - 1.4	1 (Secondary MCL)	metallic taste
Methane	no data		
Hydrogen Sulfide	no data		
organics	no data		

Potential Biological Causes of Taste and Odor Issues

Since microbiological growth can result in taste and odor issues, we looked for any obvious evidence of biological activity in the plant and distribution system. It should be noted that no bacteriological analyses were performed—only basic observations were made.

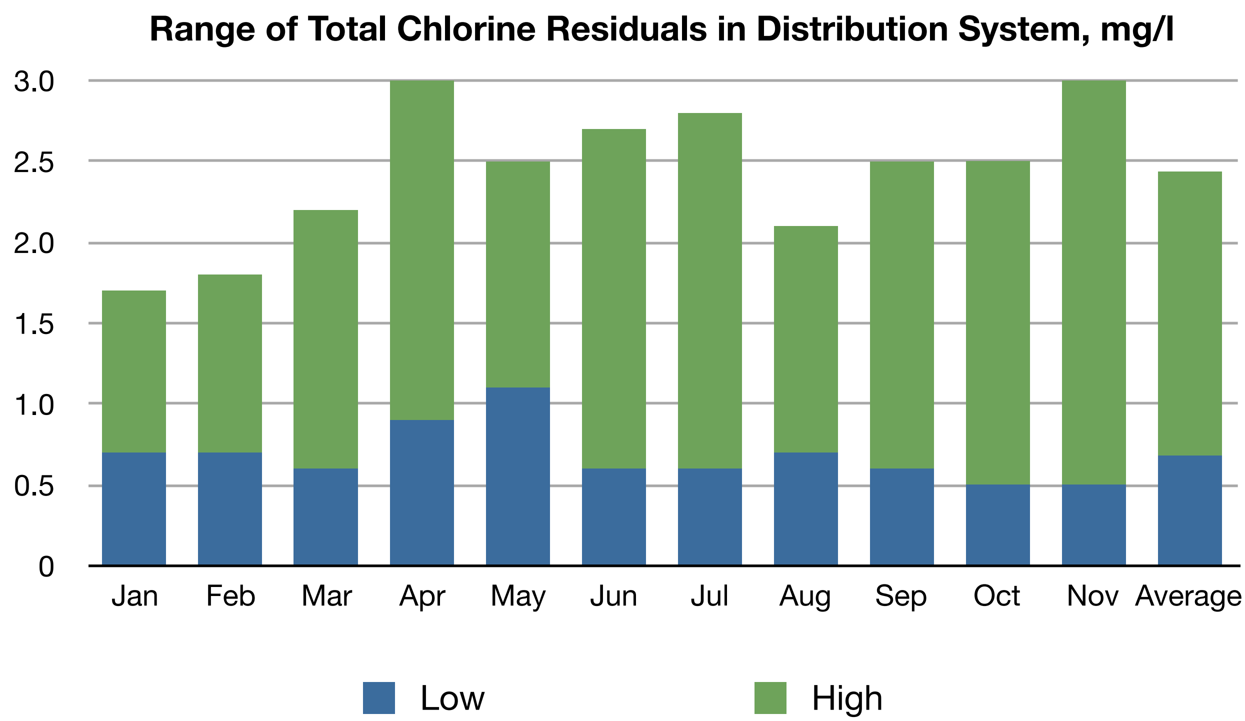
A grab sample from the plant's filter media appeared extremely clean and showed no signs of significant biological growth. Additionally, both the sand and anthracite were free of encrustation from calcium carbonate or any sort of buildup.

Microbiological growth tends to be associated with dissolved oxygen depletion, so DO was measured in the raw water, through the water treatment plant, and at several points in the distribution system. Even in the farthest reaches of the system, there was no significant oxygen depletion, as oxygen levels remained near saturation.



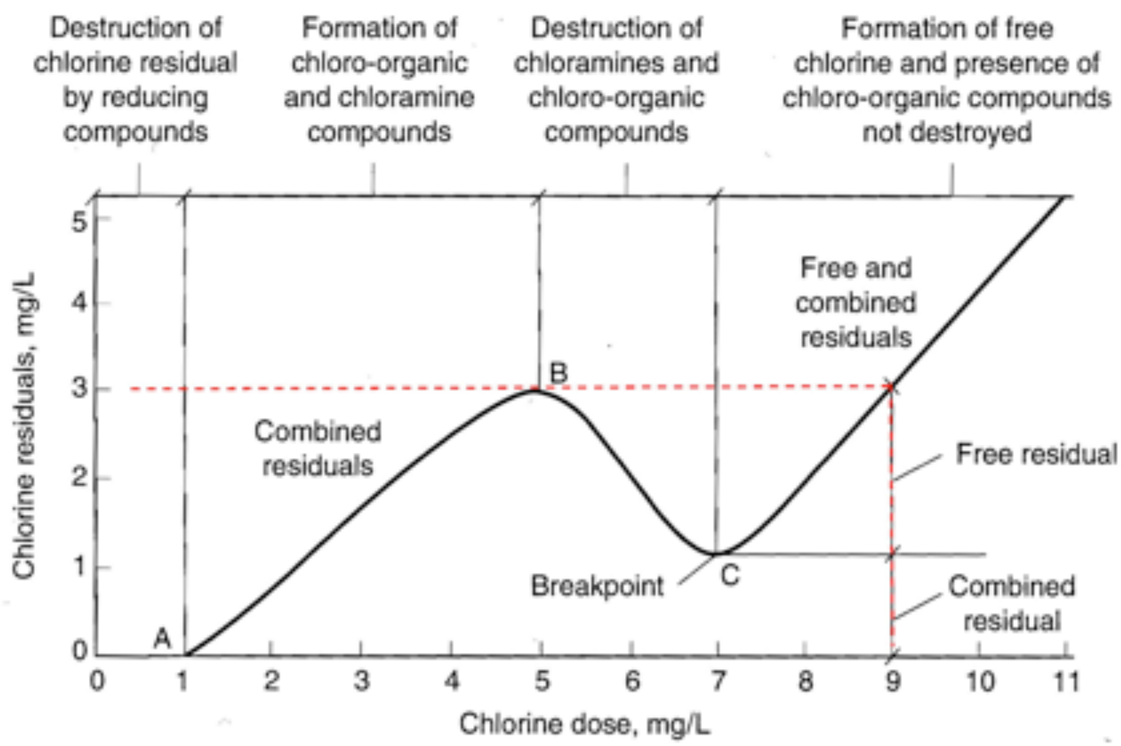
Chlorine levels, however, seemed to decrease during distribution. This graph shows the monthly ranges of total chlorine measurements at the coliform sampling sites throughout 2013. On average, the total chlorine levels ranged from 0.7 to 2.5 mg/l. The lowest chlorine residuals tended to be found at the Fire House. While the actual values of the chlorine residuals are all certainly within the acceptable range, the fact that there is an average 70% loss of chlorine is suboptimal. If the chlorine residual was more persistent and stable, lesser amounts of chlorine could be fed at the water treatment plant, which should reduce chlorinous tastes and odors.

Since this decrease in distributed chlorine levels does not appear to be associated with microbiological activity, it is likely to be associated with chlorine's reactions with natural organic matter. Testing should be undertaken to better define the interactions between chlorine, ammonia, and organics.



Chlorination Issues

The classic breakpoint curve represents a simplified version of chlorine's reactions with ammonia, organics, and reducing compounds in water. First, this curve should be developed for Red Bud's source water with lab-scale testing. Second, chlorine persistence testing should be performed with finished water in the lab and clearwell monitoring overnight. Thirdly, these two concepts should be combined in a longitudinal study that also incorporates the monitoring of organics, ammonia, and forms of chlorine.



The distribution diagram for chloramine species over range of pH indicates that combined chlorine is present as monochloramine at a pH greater than about 7.2. This would suggest that there is not a significant amount of di- or trichloramines in Red Bud's water. Lab studies with the existing amperometric titrator could help to clarify the speciation of combined chloramines.

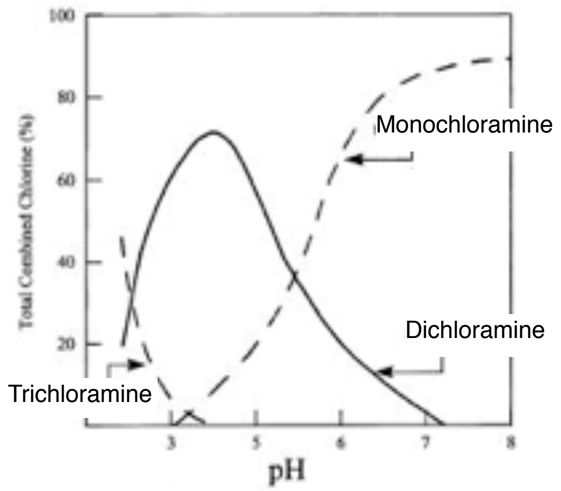


Figure 6-2. Distribution Diagram for Chloramine Species with pH

Distribution System Issues

Oftentimes, water quality diminishes with water age and distance from the treatment plant. The relatively large amount of elevated storage could contribute to water age, loss of chlorine, and overall quality deterioration.

The distribution system does not seem to have significant issues with regard to dead ends.

Intentional operation of the distribution system to maximize water quality could have benefits with regard to taste and odor, along with compliance with Disinfectans/Disinfection Byproduct Rule requirements.

Recommendations

1. Clean aerator intake screens, ensure proper operation of forced draft fan.
2. Open side of aerator for thorough inspection and cleaning.
3. Install a raw water sample tap and an aerated water sample tap.
4. Monitor aerator performance on an ongoing basis (via pH, dissolved oxygen, and organics).
5. Develop baseline data on organic matter in the raw water, through the treatment process, and in the distribution system. Send grab samples to contract labs (TOC), measure UV_{254} and color in WTP lab.
6. Consider developing in-house monitoring capabilities for organics based on existing Hach 3900 (TOC Method, UV_{254}).
7. Develop breakpoint curve through lab-scale testing.
8. Determine free and total chlorine persistence in finished water through lab-scale and plant-scale testing.
9. Combine the two concepts of breakpoint curve and chorine persistence through a longitudinal chlorination study that also incorporates organics monitoring.
10. Strive to reduce finished water chlorine levels to < 2 mg/l as combined chlorine while retaining required minimum disinfectant levels throughout the distribution system.
11. Develop a unidirectional flushing program. Evaluate flushing effectiveness vs. use of diffusers.
12. Collect water samples at upcoming Disinfection Byproducts monitoring sites (15 Cole Court, 1445 W. Market) and coliform sites. Send to contract lab for TTHM and HAA analyses.
13. Develop a computer model of the distribution system using free EPANET software.
14. Operate distribution system to minimize water age.
15. Strategically replace old cast iron pipes with PVC.
16. Consider swabbing and/or pigging raw water line and pipes in problem areas.
17. Develop a standardized water quality concern logging and response system. Use the information gathered to define, locate, and respond to taste, odor, and color issues.
18. Invite public input on taste, odor, color, and water quality issues. Consider a survey with utility bills, including gathering opinions on centralized lime softening.
19. Recommend strategic placement of PEX pipe runs in the home for those sensitive to metallic tastes and odors that may be associated with copper.