Ketchikan and Fawn Lakes Water Treatment Plant Pilot Study

Prepared for

Ketchikan
Public
Utilities
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Alaska

CH2M HILL

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regulated inorganic compounds. A March 14, 1988, first-draw sample collected at the Bailey Powerhouse was tested for lead and copper and met current standards.

STUDY PERIOD WATER QUALITY ANALYSES

The three test phases were selected to identify seasonal fluctuations in the various water quality parameters. It was also anticipated that the water quality during one of the test periods would represent the "poorest" quality water. The reason for establishing design criteria under these conditions was to verify that the treatment goals could be met at all times.

Water quality was relatively consistent throughout the testing period and agreed with the historical data with few exceptions. Table 3-1 summarizes the various parameters.

TEMPERATURE

As expected, the raw water temperature fluctuated significantly with the seasons. Water temperature ranged from 1° to 16°C (33.8° to 60.8°F). Average water temperatures for Phases I, II, and III were 3.9°, 6.1°, and 15.3°C (39°, 43.1°, and 59.5°F), respectively. A cold spell in late January and early February 1989, ambient temperatures between 10° and 12°F, provided the cold water coagulation conditions desired during Phase I.

TURBIDITY

The data summarized in Table 3-1 represent the results of grab sample turbidity measurements. More extensive raw water turbidity data were collected during the pilot runs and appear in filter run graphs. This continuous recorded data, 1- to 5-minute intervals, provided a better picture of periodic turbidity fluctuations that result from unidentified causes such as distribution system maintenance, hydraulic surges, and runoff events.

Average turbidities were 0.43, 0.18, and 0.31 NTU for Phases I, II, and III, respectively. Two relatively high turbidity events were observed during Phase I testing. The first occurred January 25, 1989, during the pilot plant start-up and was perhaps attributable to initial flushing of hoses and piping. Turbidities ranged between 0.7 and 1.3 NTU and decreased to 0.2 NTU by the following day. The second high turbidity event occurred February 27, 1989, and was attributable to periodic maintenance within the chlorination building. The operation of valves created a disturbance that resulted in turbidities in excess of 130 NTU at the pilot trailer. The observed sediments suggested that similar disturbances caused by hydraulic surges may be responsible for periodic customer complaints. The turbidity recorded during this event was not included in the Phase I turbidity summary because the identified cause was related to the distribution system. The lowest turbidity water, observed in April 1989 (Phase II), was probably attributable to the spring snow melt. The geology of the watershed apparently precluded the suspension of significant amounts of sediments that could contribute to turbidity measurement. This watershed characteristic would explain the general consistency of the water quality.

Table 3-1
WATER QUALITY SUMMARY

Parameter	Phase I	Phase II	Phase III
Temperature (C)			
Average	3.9	6.1	15.3
High	7.5	8.5	16.0
Low	1.0	4.5	14.0
Turbidity (NTU)			
Average	0.43	0.18	0.31
High	1.30	0.40	0.42
Low	0.12	0.12	0.20
pH			
Average	6.16	6.35	6.36
High	6.72	6.50	6.73
Low	5.70	6.25	6.22
Color (CU)	<10	<10	<10
Alkalinity (mg/L at $CaC0_3$)			
Average	2.3	2.2	2.4
High	3.5	2.4	2.5
Low	1.5	2.0	2.2
Hardness (mg/L at $CaC0_3$)			
Average	3.2	3.2	3.1
High	3.3	3.5	3.1
Low	3.1	3.0	3.0
Total Organic Carbon (mg/L)	2.1	1.5	0.23
Maximum Total THM (micrograms/L)			
Average	125	130	145
High	156	---	---
Low	94	---	---
Total Dissolved Solids (mg/L)	47	---	---
Conductivity (micromhos/cm)			
Average	17.0	16.0	---
High	20.2	---	---
Low	14.0	---	---
Chlorine Demand (mg/L in 24 hours)			
Raw Water	1.3	1.84	0.95
Treated Water	---	1.00	---
Langelier Index	-4.61 to -5.36	-5.83	-4.75
Metals (mg/L)			
Lead	<0.005	---	---
Copper	0.014	---	---
Aluminum	<0.3	---	---

HYDROGEN ION CONCENTRATION

The hydrogen ion concentration fluctuated one pH unit during the study. Average pH measurements were 6.16, 6.35, and 6.36 for Phases I, II, and III, respectively. The average pH was somewhat lower for Phase I than for Phases II and III. The lower average pH correlated with the period of increased precipitation during February and March.

COLOR

The raw water color was consistently less than 10 CU as measured with a HACH colorimetric test kit. A visual comparison between the raw and finished water indicated further reduction in the color causing constituents. This reduction in color caused by coagulation/filtration suggested that turbidity accounts for some "apparent" color. The low color measured is less than the color measurements reported by KPU and was probably caused by differences in test methods.

ALKALINITY

Alkalinity was relatively consistent, ranging between 1.5 and 3.5 mg/L as $CaCO_3$. Average alkalinities were 2.3, 2.2, and 2.4 mg/L as $CaCO_3$ for Phases I, II, and III, respectively. These average values were significantly greater than the 0.4 ppm measured by ADEC and reported in the Ketchikan water supply report previously referenced.

HARDNESS

The raw water hardness was very consistent, ranging between 3.0 and 3.5 mg/L as $CaCO_3$. The average hardness was 3.2, 3.2, and 3.1 for Phases I, II, and III, respectively.

TOC

Measured TOCs ranged between 0.23 and 2.1 mg/L. The lowest measurement unexpectedly occurred during Phase III, August 1989, and the sample with the highest measured concentration was collected during Phase I, February 1989. Greater organic concentrations typically would be expected during the warm summer months when microbiological activity is highest.

TOTAL TRIHALOMETHANE FORMATION POTENTIAL (TTHMFP)

The TTHMFP is a measurement of the maximum THM concentration that can result from excessive chlorination. The test is usually used to categorize raw waters and can be useful in identifying seasonal fluctuations in the THM formation potential. However, because of the high applied chlorine dose, TTHMFP analyses do not provide a realistic estimate of THM concentrations that will occur in the distribution system. Figure 3-1 presents the TTHMFP results for the various laboratory samples. TTHMFP ranged between 94 and 156 micrograms/L. Average TTHMFP were 125, 130, and 145 for Phases I, II, and III, respectively. With increasing temperature, progressively higher formation potentials would be anticipated; however, the differences observed were not considered overly significant.

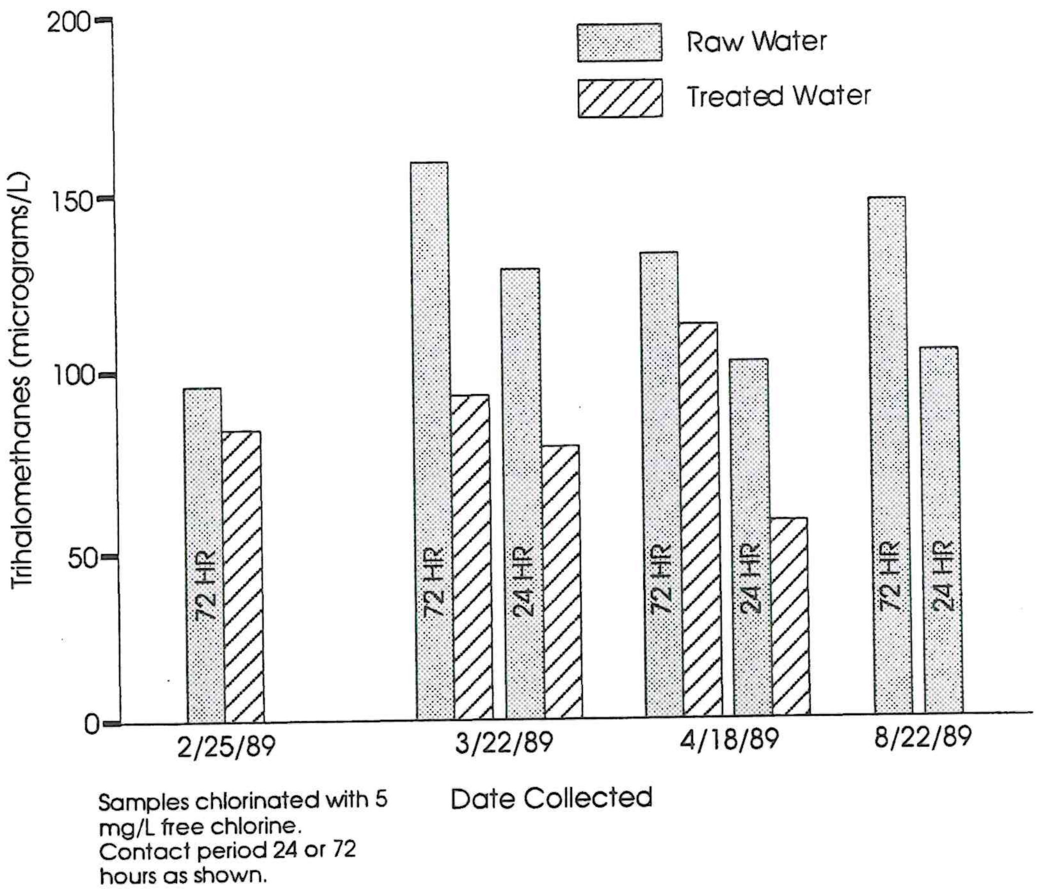

Figure 3-1
Maximum Total THM Results

Distribution System THMs

Distribution system THMs are measurements conducted on samples taken from the distribution system. The samples are immediately "fixed" to prevent further chlorine reactions and are then analyzed. Two samples were collected. Concentrations of 18 and 21 micrograms/L were obtained for the Coast Guard galley and the Ketchikan Ready Mix office, respectively. These sample points represent the south and north ends of the distribution system. These concentrations meet current and anticipated future regulations and correlated with the simulated distribution system THM testing.

Simulated Distribution System THMs

Simulated distribution system THMs were the most useful test for estimating THM concentrations in the distribution system because this test can be conducted onsite under controlled conditions. The test consisted of chlorinating a sample (raw or treated) with a known chlorine concentration for a set contact period. On completion of the test, the sample was "fixed" to stop the chlorine reactions and sent to the laboratory for analysis. Simulated distribution system THM tests allowed estimation of maximum concentrations likely to occur in the distribution system and provided rate of formation data.

Figure 3-2 summarizes the simulated distribution system results. The table, separated into two charts, provides data for applied chlorine doses of 1 and 2 mg/L free available chlorine and a 24-hour chlorine contact period. Treatment generally removed a portion of the THM precursors thereby reducing the THM formation potential.

With coagulation/filtration treatment (no preozonation), reductions in formation potential ranged between 22 and 51 percent. As anticipated, a higher chlorine dose resulted in somewhat higher THM concentrations for the same contact period. Coagulation/filtration treatment resulted in a comparable formation potential reduction at the higher applied chlorine dose (2 mg/L).

Ozonation alone or ozonation in conjunction with coagulation/filtration treatment also reduced the THM formation potential. The effect of ozonation alone was very dependent on ozone dose. Reductions ranged widely from 9 and 72 percent with the highest reductions resulting from a 2.0 mg/L applied ozone dose.

Ozonation in conjunction with coagulation/filtration treatment also reduced the THM formation potential with a 1.4 mg/L ozone dose. A 0.6 mg/L dose resulted in a higher formation potential than observed for coagulation/filtration alone. This result could be anticipated, because the literature does contain references indicating that for certain waters and low ozone dosage, organics are partially oxidized and provide additional sites for chlorine interaction.

TDS/CONDUCTIVITY

A single TDS test was conducted on the raw water. This was correlated to conductivity, which was measured periodically throughout the study. No significant fluctuations in conductivity were observed.

CHLORINE DEMAND

Figure 3-3 depicts the results of the chlorine demand testing conducted during each testing phase. Chlorine demand fluctuated significantly during the study. This fluctuation suggested that seasonal adjustment of the applied chlorine dose should be considered. The demand was 1.3, 1.84, and 0.95 for Phases I, II, and III, respectively, as determined from a 1.5 to 2.0 mg/L applied free chlorine dose and a 24-hour contact period.

LANGELIER INDEX (L.I.)

The Langelier Index is not a measurement, but a calculation determined by pH, alkalinity, hardness, temperature, and TDS. The L.I. indicated a corrosive water and ranged between -4.61 and -5.83. The difference between the L.I. calculated during the study period and the L.I. calculated in ADEC's report previously referenced is the higher alkalinity concentration measured during the study.

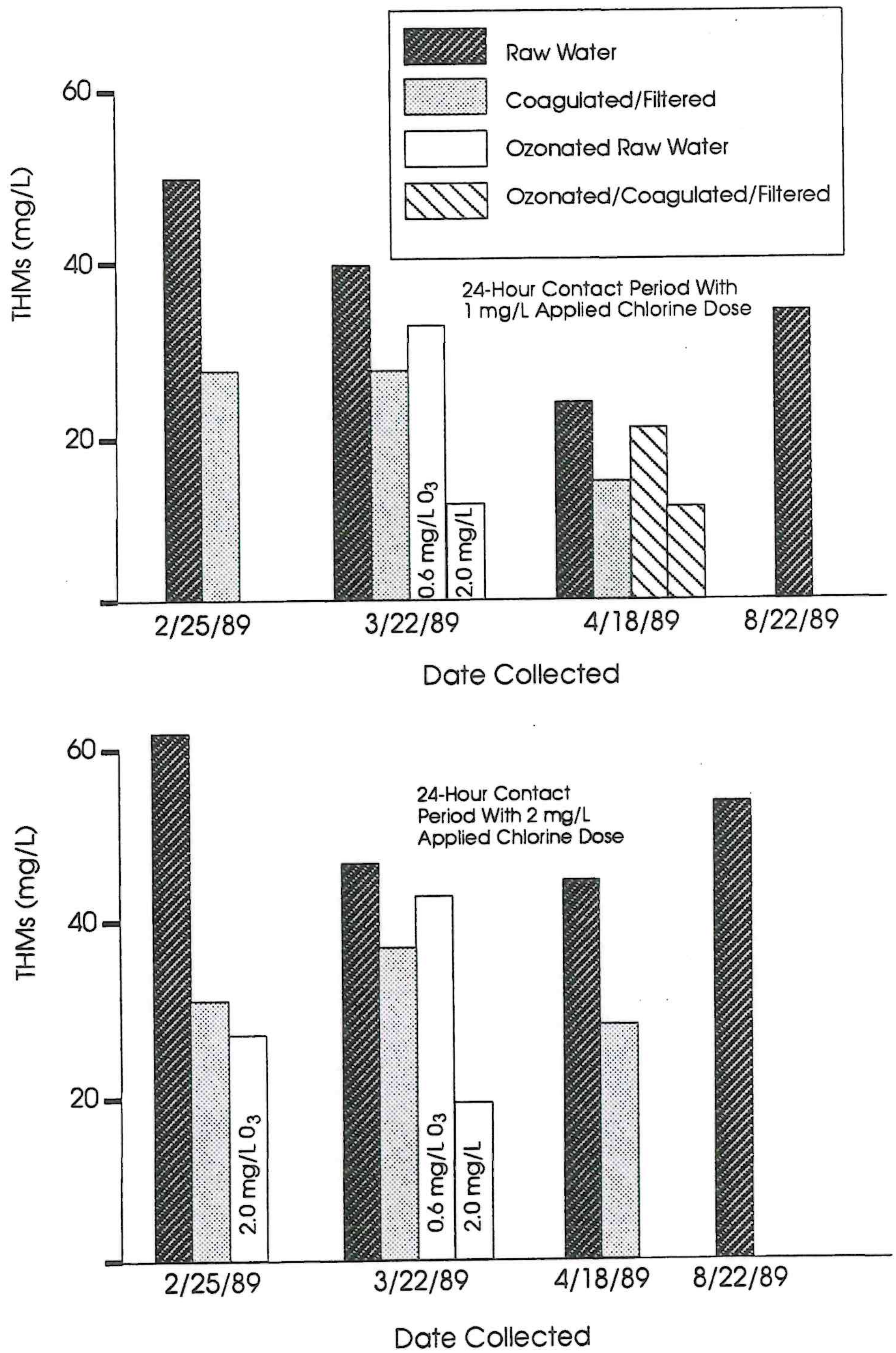

Figure 3-2
Simulated Distribution System Results

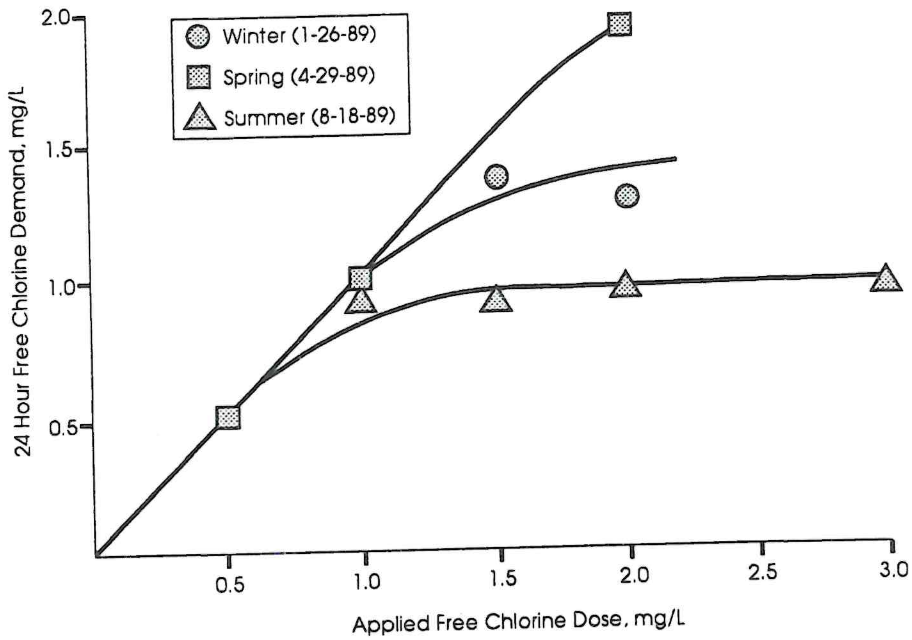

Figure 3-3
Chlorine Demand

CONCLUSIONS AND TREATMENT ASSESSMENT

The water quality analyses conducted throughout the study indicated a fairly consistent and high quality raw water source, which is advantageous from a treatment perspective. Water quality fluctuations often pose operational difficulties.

The testing confirmed that the supply is highly corrosive and suggested that, as a minimum, pH adjustment will be required for mitigation.

The high turbidity observed as a result of distribution system maintenance pointed to a possible cause of periodic customer complaints. Without filtration, sediments accumulate in the pipelines and are subject to hydraulic surges. A comprehensive flushing program is a possible interim solution.

THM formation potential can be classified as low to moderate. The existing treatment and distribution system should have no problem achieving the current 100 microgram/L MCL. However, there is a strong consensus within the waterworks industry that the MCL will be reduced. For this reason, alternatives to free chlorination were evaluated.

The Ketchikan Lake supply is a good candidate for direct filtration.

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