# NORTH CENTRAL MISSOURI REGIONAL WATER COMMISSION

# DISINFECTION BYPRODUCT & TASTE AND ODOR REPORT

*DATE: NOV. 6TH, 2008*
*PN: 14813.000*

*BARTLETT & WEST, INC.*
*250 NE TUDOR RD.*
*LEE'S SUMMIT, MO 64086*

STATE OF MISSOURI
JOHN E. BRUMMER
NUMBER
E-30280
REGISTERED PROFESSIONAL ENGINEER

11/4/08

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# EXECUTIVE SUMMARY

Disinfection byproducts (DBPs) were detected in the distribution system in the NWMRWC service area in excess of MoDNR standards.

In addition, the current practice for residual disinfection is free chlorine. Some of the secondary systems are served by other suppliers who utilize free chlorine as the residual disinfectant.

For disinfection byproduct reduction it is recommended that the commission install an ammonia feed system and convert the free chlorine system to a combined chlorine system, but keeping in mind that some member systems will still have free chlorine in their system. It will be important to keep about a 2.5 mg/l total combined residual and a chlorine-to-ammonia ratio of 3:1 leaving the plant so that the ratio in the system does not exceed 5:1. A ratio greater than 5:1 can result in degradation of chloramines and overall residual.

Once implemented, the combined residual will result in a more stable and long lasting residual. The cost to convert to chloramines is $61,000.

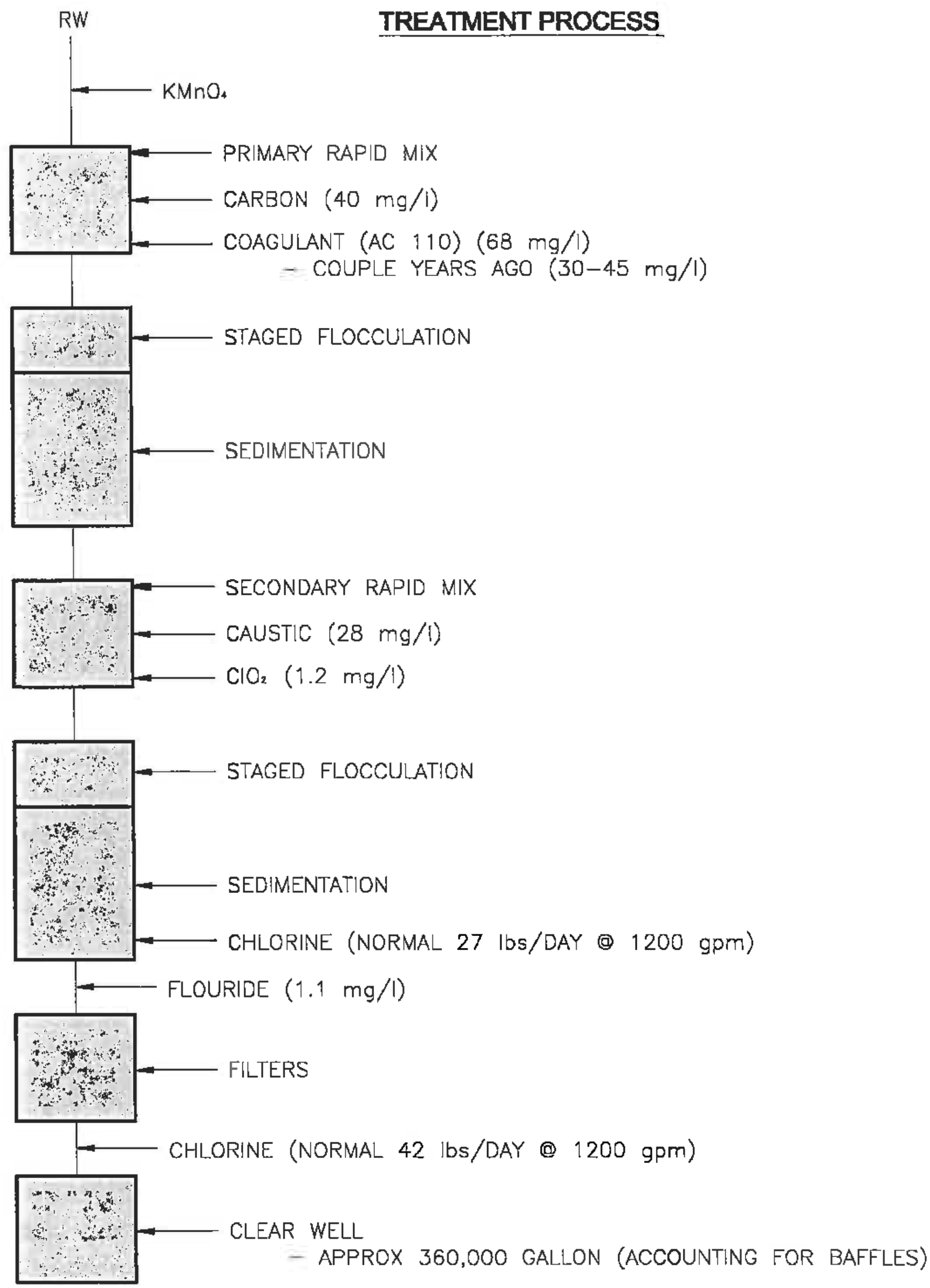
During the summer of 2007 over a two month period, the water plant (and many in northern Missouri communities) experienced some taste and odor complaints. Some municipalities described the odor as “musty” or “earthy” and some customers described an “oily aftertaste”.

Options were evaluated for removal of taste and odors in the future include increased contact time for potassium permanganate, granular activated carbon (GAC) to cap the existing filters, GAC contactor vessels, ozone, peroxide, Magnetic ion exchange, lake circulation units, and ultraviolet light.

## SECTION 2 EXISTING SYSTEM

The existing surface water treatment plant is rated for 2,000 gallons per minute (gpm) and has an average production rate of 1,200 gpm. A flow schematic of the plant is shown below. Details of each treatment component appears on the Public Water System Record following this schematic.

**TREATMENT PROCESS**



# E2.02 PUBLIC WATER SYSTEM RECORD

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SYSTEM** | Milan Municipal Water Plant | | | **PWS ID #** | 2010523 | **INITIAL** | ECB |
| **COUNTY** | Sullivan | **OWNER** | Municipal | **PLANT CAPACTIY** | 2000 gpm or 2,800,000 gpd | | |
| **POPULATION** | 1767 | **SERVICES** | 867 | **DATE** | April 1, 1998 | | |
| **DESIGN ENGINEER** | Rhodes-Sayre & Associates | | | | | | |

## INTERCONNECTIONS:

| Systems | Purpose | Connections | Approved |
|---|---|---|---|
| Premium Standard Foods, Inc. | Emergency Source for City or PSF | One | Yes |
| Sullivan County PWSD #1 | Sole source of water for the district | Two | Yes |

## SOURCE: Impounded Supply

| Name | Drainage Area | Capacity | Surface Area | Max. Depth | Recreation Control |
|---|---|---|---|---|---|
| Old Lake No. 1 | 400 acre | 42 mg | 18 acre | 33 ft | limited fishing |
| Old Lake No. 2 | 680 acre | 217 mg | 51.2 acre | 30 ft | limited fishing |
| Elmwood Lake | 4,103 acre | 3,131 acre-ft | 187 acre | 44 ft | limited fishing |

## SOURCE: Stream Supply

| Name | Drainage area | Average flow | Minimum flow | Stream Quality |
|---|---|---|---|---|
| Main Locust Creek | | | | |

## STORAGE: Purified Water

**Total Capacity** 1,430,000 gallons

| Type/Location | Capacity | Construction | Elevations | Dimensions |
|---|---|---|---|---|
| Plant Clearwell | 380,000 gal | Concrete structure under water plant | Top=847.5 ft<br>Floor=837.0 ft | 44 ft 4 in X 109 ft 6 in X 10.5 ft |
| **West Elevated Tank** - at the north end of Cherry Street | 300,000 gal | welded steel double ellipsoid | OF=1066.0 ft<br>LWL=1035.8 ft<br>Base=967.0 ft | ___ ft diameter by 99 ft tall |
| **East Elevated Pedestal** - intersection of Water & First | 750,000 gal | welded steel fluted hydropillar | OF=1067.0 ft<br>LWL=1027.0 ft<br>Base=957.0 ft | 64 ft diameter by 110 ft hwl |

## METERS:

| | |
|---|---|
| **Raw Water** | Two 14-inch flanged tube propeller meters w/ remote readouts |
| **High Service Pumps** | One 14-inch flanged tube propeller meter w/ a remote readout |
| **Filter Wash Water** | |
| **Filter Wash Water** | One 14-inch flanged tube propeller meter w/ a remote readout |
| **Other** | Plant meter is a 3-inch compound meter w/ local totaling, a ¾-inch meter is provided for each lime and carbon feeder |

## FILTERS:

| | | | |
|---|---|---|---|
| **Type** | Rapid, Gravity, Dual Media, Modified Declining Rate | **Number** | 5 |
| **Size** | 12 ft X 14 ft = 168 ft² each; 840 ft² total; side wall height=14.19 ft | | |
| **Capacity** | 3 gpm/ft² = 504 gpm each or 2520 gpm total; 2000 gpm/840 ft² = 2.38 gpm/ft² | | |
| **Type Valves** | Manual Butterfly | | |
| **Media Depths** | 12 inches of filter sand ES = 0.45 to 0.55 mm & UÇ1.6; 12 inches of anthracite ES = 0.6 to 0.8 mm & UC. 1.7 | | |
| **Type Under drain** | PVC 18-inch header &26 4-inch laterals w/ stainless steel filters, header & laterals poured in concrete | | |
| **Gravel Depths** | 4-inches of 1¼ to ¾; 4 inches of ¾ to ½; 4 inches of ½ to ½; 4 inches of ¼ to #10; 3 inches of 0.8 to 2.0 mm UC<1.70 | | |
| **Method of Backwash** | Pump from plant clearwell | **Rate** | 3360 gpm for 20 gpm/ft² |
| **Loss of Head Gauges** | Wall markings | | |
| **Rate Controllers** | Filter influent weirs and raw water pumps | | |
| **Rate Indicators** | Raw water meter | | |
| **Surface Wash Facilities** | hose & nozzle | | |

## SEDIMENTATION BASINS:

| Type | Construction | Capacity | Detention | Flow | Dimensions |
|---|---|---|---|---|---|
| Primary settling basin | Open, concrete | 500,000 gal | 250 min | 2000 gpm | 127 ft X 42 ft X 13 ft |
| Secondary settling basin | Open, concrete | 500,000 gal | 250 min | 2000 gpm | 127 ft X 42 ft X 12.83 ft |

## INTAKE:

| Type | How Protected | Water Level Selection |
|---|---|---|
| Locust Creek – Infiltration gallery | Buried below streambed packed in gravel | Two levels |
| Old Lake No. 1 - Concrete pad | Not protected | one level |
| Old Lake No. 2 - Concrete tower | 4 to 5 screened intakes w/ valves | |
| Elmwood Lake - Floating intake | concrete dead man & cables to dam | varies w/ lake level set 5 ft |

## MIXING CHAMBERS:

| Type | Capacity | Detention | Flow | $G^{-1}$/sec & mixer info. |
|---|---|---|---|---|
| Primary rapid mix | 957.44 gal | 29 sec | 2000 gpm | 4 ft X 4 ft X 8 ft - G=> 500 $^{-1}$/sec |
| Primary flocculation | 98,000 gal | 49 min | 2000 gpm | 24 ft X 42 ft X 13 - Four arms w/ minimum of 2 paddles, speed at □ paddle arm length 0.5 to 1.5 ft/sec |
| Secondary rapid mix | 957 gal | 29 sec | 2000 gpm | 4 ft X 4 ft X 8 ft - G=> 500 $^{-1}$/sec |
| Secondary flocculation | 96,000 gal | 48 min | 2000 gpm | 24 ft X 42 ft X 12.83 ft - Four arms w/ minimum of 2 paddles, speed at ½ paddle arm length 0.5 to 1.5 ft/sec |

## CHEMICAL TREATMENT:

| Chemical Used | How Applied | Where Applied | Feeder Range | Operating Range |
|---|---|---|---|---|
| Bulk liquid alum | a 5000 gal bulk tank, a diaphragm transfer pump, feed pump is a W&T Encore700, w/ 50 gal day tank on scales | Primary rapid mix | 25 gph max | 100:1 |
| Bulk liquid alum | a 5000 gal bulk tank, a diaphragm transfer pump, feed pump is a W&T Encore700, w/ 50 gal day tank on scales | Secondary rapid mix | 50 gph max | 100:1 |
| Hydrated lime (bagged) | W&T 32.055 w/ 1½ inch screw, high speed gear box, bag loader, 35 gal tank w/ mixer | Primary rapid mix | 45 pph max | 20:1 |
| Hydrated lime (bagged) | W&T 32.055 w/ 1½ inch screw, high speed gear box, bag loader, 35 gal tank w/ mixer | Secondary rapid mix | 45 pph max | 20:1 |
| Powdered activated carbon (bagged) | W&T 32.055 w/ 1½ inch screw, high speed gear box, bag loader, 35 gal tank w/ mixer | Primary rapid mix | 40 pph max | 20:1 |
| Potassium permanganate | W&T Encore700 diaphragm pump, w/ mixer & 50 gal tank on scales | Raw water line | | 100:1 |
| Caustic Soda | W&T Encore700 diaphragm pump, w/ 300 gal carboy on scales | Secondary rapid mix | | 100:1 |
| Polymer | W&T Maxi Yield & diaphragm pump w/ carboy on scales | Primary or Secondary rapid mix | 1 mg/l max | 200:1 |
| Liquid Ammonia | W&T Encore700 diaphragm pump, w/ 55 gal carboy on scales | Finished water | | 100:1 |
| Chlorine gas (ton) | W&T V75 all vacuum chlorinator | Spare feeder | 5 to 100 ppd | 20:1 |
| Chlorine gas (ton) | W&T V75 all vacuum chlorinator | Primary rapid mix | 12.5 to 250 ppd | 20:1 |
| Chlorine gas (ton) | W&T V75 all vacuum chlorinator | Secondary rapid mix | 10 to 200 ppd | 20:1 |
| Chlorine gas (ton) | W&T V75 all vacuum chlorinator | Filter effluent | 2.5 to 50 ppd | 20:1 |

## PUMPS: (not including wells)

| Purpose | Type | # | Manufacture | Location | Capacity |
|---|---|---|---|---|---|
| Creek Pump | Vertical turbine variable speed | 1 | | Locust Creek | 1,500 gpm at 280 ft<br>2,500 gpm at 500 ft |
| Creek Pump | Vertical turbine variable speed | 1 | | Locust Creek | 800 gpm at 260 ft<br>260 gpm at 230 ft |
| Low Service | Vertical Centrifugal - split case, double suction, single stage, 25 hp, 1775 rpm | 2 | Aurora or Ingersol Rand | water plant | 2000 gpm at 30 ft |
| Sump pump | Submergible centrifugal - ½ hp | 1 | Hydromatic SPD 50H/100 | Plant foundation sump | 23 gpm at 40 ft |
| Alum transfer pumps | Dual headed diaphragm | 2 | W&T A748 | Water plant | 500 gpd at 150 psi per head |
| Filter wash water pump | Vertical turbine - soft start, 50 hp | | Aurora or Ingersol Rand | water plant | 3360 gpm at 42 ft |
| High Service | Vertical turbine - soft start, 120 hp | 2 | Aurora or Ingersol Rand | water plant | 1000 gpm at 340 ft |

## LABORATORY TESTS: Bacteriological

| | |
|---|---|
| **Where is test made** | Send samples to Department of Health Laboratory in Jefferson City, Missouri |

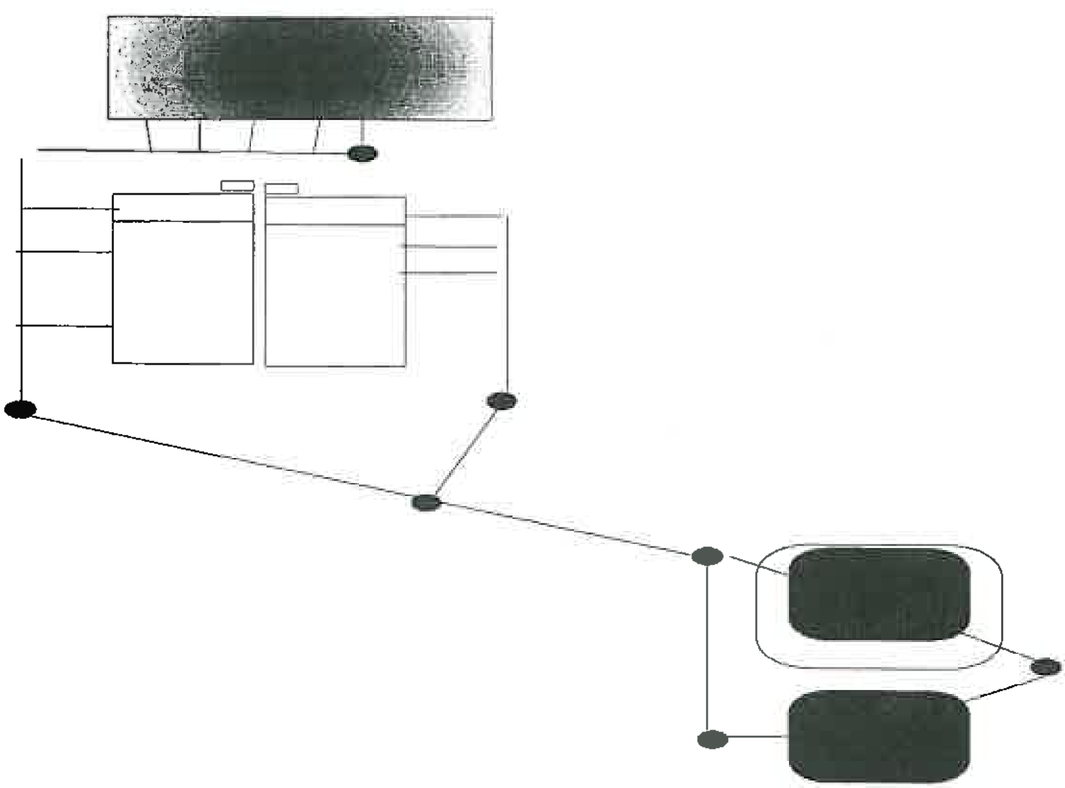
## LABORATORY TESTS: Chemical

| | | | |
|---|---|---|---|
| **Alkalinity** | Automatic burette | **Hardness** | Automatic burette |
| **pH** | Electrode and meter | **Fluoride** | |
| **Iron** | | **Manganese** | |
| **Aluminum** | | **Phosphate** | |
| **Chlorine** | | | |
| **Turbidity** | Continuous monitors on each filter effluent | | |
| **Other** | | | |

## PLANT WASTE WATER DISPOSAL:

| | | | |
|---|---|---|---|
| **Type of residuals** | Filter wash water and coagulant clarification sludge from surface water treatment plant | | |
| **Method of disposal** | Two earthen lagoons each holding 28,287 ft□ with a 3-foot freeboard. The bottom of each lagoon is 39 feet square and provides a water depth of 7 feet. 3 to 1 slopes are specified on the berms | | |
| **Point of Discharge** | SE¼, SW¼, Sec. 35, T63N, R20W of Sullivan County, Mo. to East Locust Creek | **NPDES permit** | |
| **Domestic waste** | Yes | **Method of disposal** | A 5ft diameter by 10 ft deep sealed precast concrete manhole holding 1500 gallons. The manhole acts as a holding tank. Sewage will be pumped and hauled to city treatment plant |

## DIAGRAM:



## SECTION 3 - DISINFECTANT BY PRODUCT REDUCTION

The best way to reduce disinfection by products are to remove or oxidize the natural organic matter or precursors prior to chlorine addition.

Chlorine has been safely used for more than 100 years for disinfection of drinking water to protect public health from diseases which are caused by bacteria, viruses and other disease causing organisms. Chloramines, the monochloramine form in particular, have also been used as a disinfectant since the 1930's (USEPA). Chloramines are produced by combining chlorine and ammonia. While obviously toxic at high levels, neither pose health concerns to humans at the levels used for drinking water disinfection.

Chloramines are weaker disinfectants than chlorine, but are more stable, thus extending disinfectant benefits throughout the distribution system. They are not used as the primary disinfectant. Chloramines are used for maintaining a disinfectant residual in the distribution system so that disinfected drinking water is kept safe.

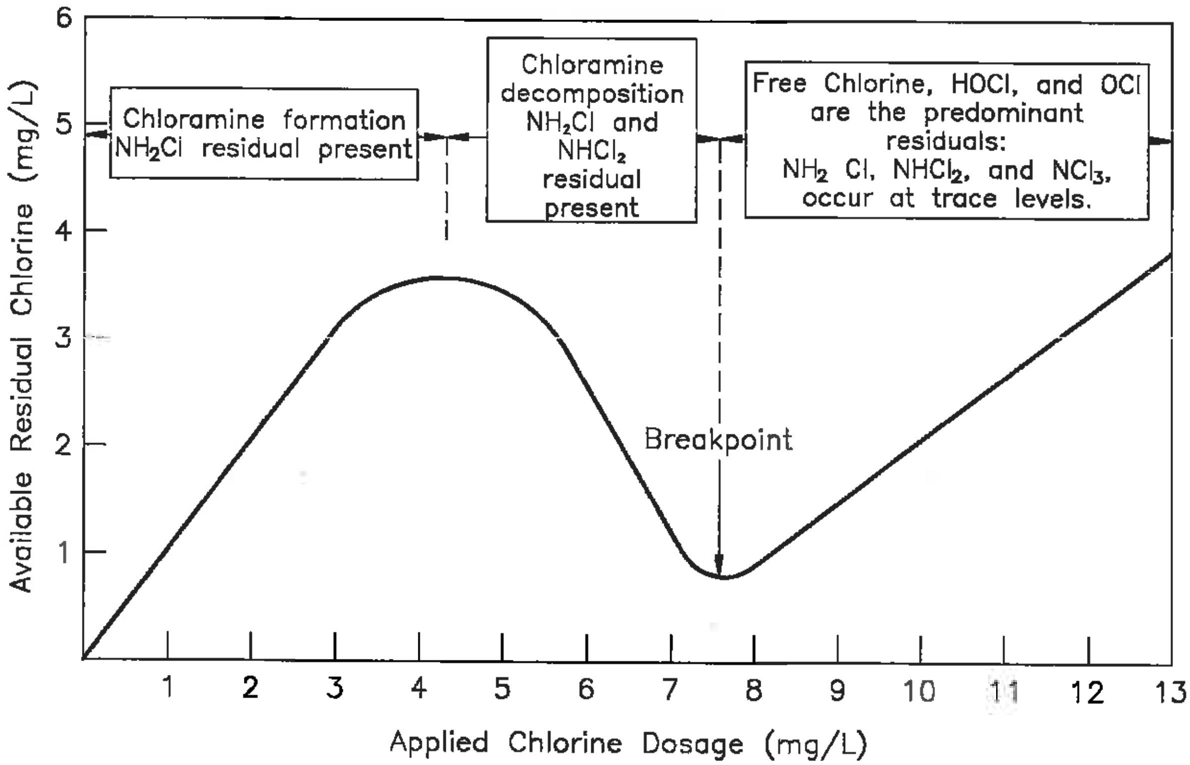
Chloramination involves the addition of anhydrous or aqueous ammonia (NH3) before or after the addition of chlorine (HOCl) to produce monochloramine (NH2Cl).

This reaction is as follows:
NH3 + HOCl = NH2Cl + H20

A method called breakpoint chlorination is used to determine to proper ratio of chlorine to ammonia. A breakpoint curve appears below. On the left side of the curve to the first peak is where water systems need maintain their chloramination formation, from zero to 5 mg/l of chlorine for each milligram of ammonia.

As an example 5 mg/l of chlorine reacting with 1 mg/l of ammonia gives you a 5:1 ratio. At any point above that ratio, you actually begin to degrade chloramine and begin to lose overall chlorine residual. You can keep adding chlorine until you reach the breakpoint where additional chlorine added results in free chlorine residual.

In NCMRWC's case, the ideal ratio of chlorine to ammonia is about 3:1. This way when the NCMRWC's chloraminated water meets the secondary systems that have 1 to 1.5 mg/l residual of free chlorine from other suppliers, the ratio will still be in the 5:1 or lower range.




**Breakpoint Chlorination Curve (Wolfe, et. al)**

It is recommended that the Commission carry 2.5 mg/l of total chlorine (chloramine) residual leaving the water treatment plant. This will require that the chlorinator feeding chlorine to the filter effluent (clearwell influent) be modified to allow sufficient chlorine addition to accomplish this goal.

The U.S. EPA recognizes three analytical methods as acceptable for measuring residual chloramines. These methods are:

- Amperometric Titration (Standard Method 4500-C1 D and ASTM Method D 1253-86)
- DPD Ferrous Titrimetric (Standard Method 4500-C1 F)
- DPD Colorimetric (Standard Method 4500-C1 G)

The Hach Company also offers an online monochloramine analyzer that can be connected to a controller that relays information to an ammonia feeder so ammonia dosage is optimized to maintain the correct chlorine-to-ammonia ratio.

3.3 Advantages to chloramines

- Since chloramine is not as reactive as chlorine, it forms fewer disinfection byproducts. Some disinfection byproducts, such as the trihalomethanes (THMs) and halo acetic acids (HAAs), may have adverse health effects and are closely regulated (see separate Q&As on disinfection and disinfection byproducts).

- Because a chloramine residual is more stable and longer lasting than free chlorine, it provides better protection against bacterial regrowth in systems with large storage tanks and dead-end water mains.
- Chloramine, like chlorine, is effective in controlling biofilm, which is a coating in the pipe caused by bacteria. Controlling biofilm also tends to reduce coliform bacteria concentrations and biofilm-induced corrosion of pipes.
- Because chloramine does not tend to react with organic compounds, many systems will experience fewer taste and odor complaints when using chloramine.
- Chloramine technology is relatively easy to install and operate. It is also among the less expensive disinfectant alternatives to chlorine.

### 3.4 Disadvantages of chloramines

Drawbacks to the use of chloramine can include potential water quality problems (e.g., nitrification and corrosion) if the treatment process is not carefully controlled and the system's operational practices are not appropriately adjusted for the new disinfectant. Chloramine can change the chemical properties of the water, which can impact corrosion of lead and copper. Nitrification in the distribution system can also occur when using chloramine. Nitrification can have a detrimental effect on water quality (such as loss of disinfectant residual). Nitrification results from the bacterial oxidation of ammonia (conversion of ammonia into nitrite and then nitrate) but can be controlled by optimizing the chloramination process or by applying occasional free chlorination practices. It is very important to maintain and monitor distribution system water quality so that these issues do not become problems. Notification must also be given to kidney dialysis patients.

Monochloramine has been designated as not classifiable as to human carcinogenicity. MCL (Drinking Water): There is no MCL for chloramine but there is a MRDL (maximum residual disinfectant level) of 4.0 mg/L for chloramines as $Cl_2$.

### 3.5 Sources of Ammonia

There are basically two options for the ammonia source, anhydrous and aqueous ammonia. Anhydrous typically comes in 150 pound cylinders and require gas feed equipment. Aqueous ammonia can be purchase in bulk solution or batched on-site with dry chemicals such as ammonium sulfate.

Due to the relative hazard of anhydrous, isolation, spill monitoring and emergency response plan requirements make this source unattractive for the NWMRWC. It is recommended that ammonium sulfate be selected as the source of ammonia. Dry aluminum sulfate can be purchased and mixed into a solution to form a 20 to 30 percent ammonia solution.

## 3.6 Residual Chloramine Conversion

An ammonium sulfate batch tank and feeder should be placed in the existing lime feed room. A metering pump will be required to deliver the correct dose of ammonia solution to the point of application in the pump room. To inject the ammonia into the discharge piping of the high service pumps, a static injection mixer is required upstream of the existing meter to ensure complete mixing. The proper ratio of ammonia to chlorine will be monitored by continuous readings taken after ammonia addition and after the meter by installing a Hach APA 6,000 ammonia/monochloramine analyzer. The recommended setup is illustrated in Figure 3-1. It is recommended that the total chlorine residual be about 2.5 mg/l. That will require that the chlorine residual be boosted to 2.5 mg/l either through the clearwell influent or at the discharge piping prior to addition of ammonia. The ammonia feeder will be controlled by sending a 4 – 20 milliamp signal from the APA 6000 to a control panel that regulates the dosage. It is assumed that the flow rate out of the plant will be consistent. If the flow rate out of the plant varies, a flow pacing scheme will need to implemented tying the flow meter to the dosage of ammonia and chlorine. The cost to convert to chloramines is tabulated below.


**Passive Hach APA 6000 Ammonia/Monochloramine Analyzer**

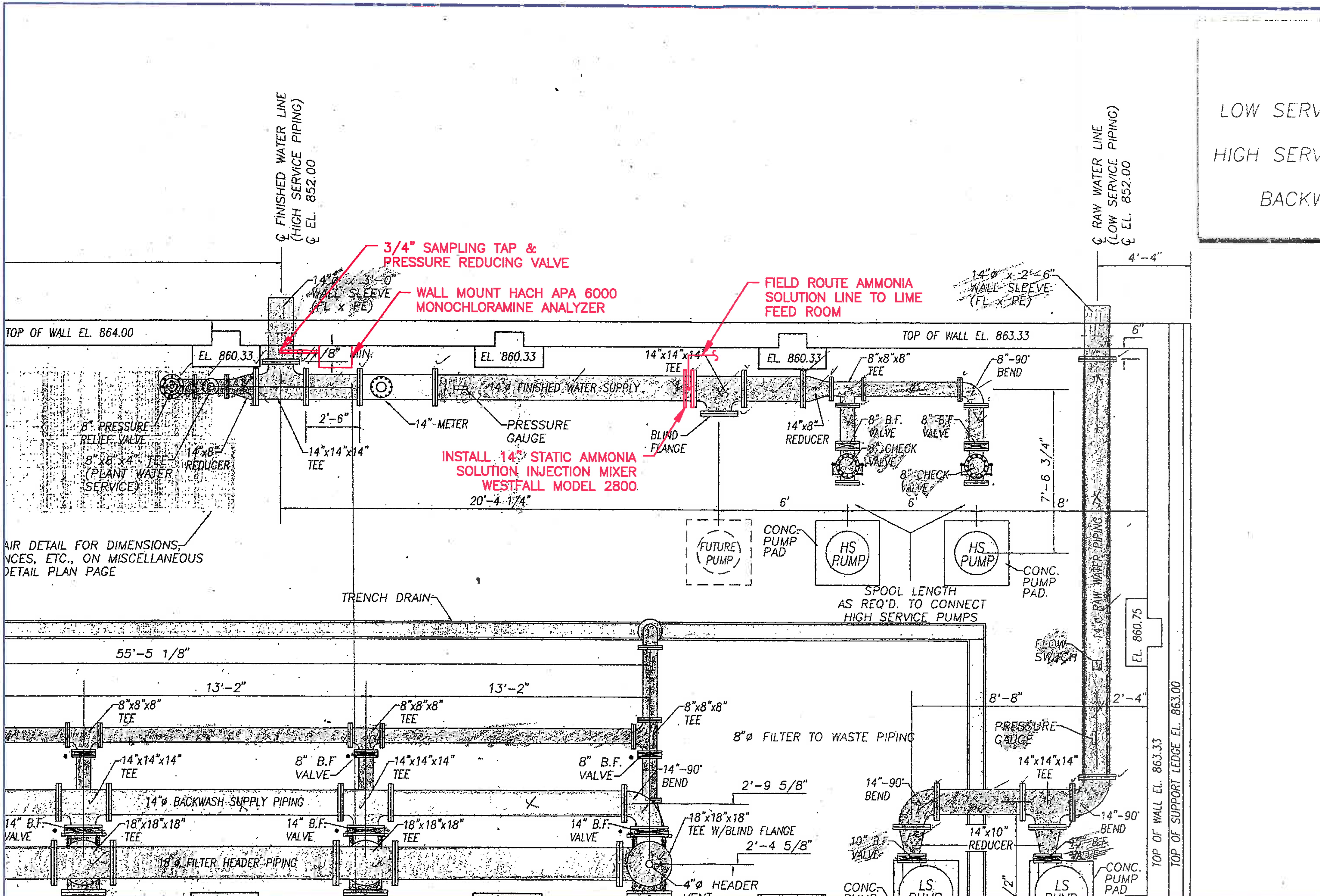



**FIGURE 3-1**
**AMMONIA FEED MODIFICATIONS**

**North Central Missouri Regional Water Commission**
**Ammonia Feed System**
**Engineer's Opinion of Probable Cost**
**November-08**

## Unit Price Summary

| Item Number | Description of Item | Estimated Quantity | Units | Unit Price | Total Cost |
|---|---|---|---|---|---|
| **1.0** | **Mobilization** | 1 | LS | $ 4,500.00 | $ 4,500.00 |
| | | | | ***Subtotal*** | ***$ 4,500.00*** |
| **2.0** | **Equipment Cost** | | | | |
| 2.1 | Piping | 100 | LF | $ 40.00 | $ 4,000.00 |
| 2.2 | 14" Static Mixer Model 2800 & Injection | 1 | EA | $ 6,460.00 | $ 6,460.00 |
| 2.3 | Chemical Feed System with 55 gal Tank | 1 | EA | $ 2,905.00 | $ 2,905.00 |
| 2.4 | Control Panel | 1 | EA | $ 2,000.00 | $ 2,000.00 |
| 2.5 | Chlorization Modifications | 1 | EA | $ 2,000.00 | $ 2,000.00 |
| 2.6 | Instrumentation | 1 | EA | $ 5,000.00 | $ 5,000.00 |
| 2.7 | Monochloramine Analyzer & Reagents | 1 | EA | $ 12,300.00 | $ 12,300.00 |
| 2.8 | Maintenance Program (yearly) | 1 | EA | $ 4,500.00 | $ 4,500.00 |
| 2.9 | Platform Scale | 1 | EA | $ 1,000.00 | $ 1,000.00 |
| | | | | ***Subtotal*** | ***$ 40,165.00*** |
| **3.0** | **Installation (25%)** | 1 | EA | $ 10,041.25 | $ 10,041.25 |
| | | | | ***Subtotal*** | ***$ 10,041.25*** |
| **4.0** | **Contingency (10%)** | 1 | EA | $ 5,470.63 | $ 5,470.63 |
| | | | | ***Subtotal*** | ***$ 5,470.63*** |
| **TOTAL PROJECT COST** | | | | | **$ 61,000.00** |

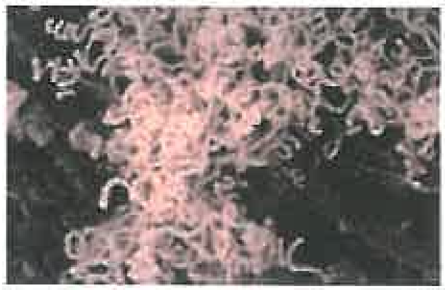
# SECTION 4 TASTE AND ODOR REDUCTION

During the summer of 2007 over a two month period, the water plant (and many in northern Missouri) experienced some taste and odor complaints. Some municipalities described the odor as "musty" or "earthy" and some customers described an "oily aftertaste".

It is suspected that the source of the taste and odors is attributed to MIB and geosmin.

Actinomycetes are a broad group of bacteria that form thread- like filaments in the soil. They are responsible for the distinctive scent of freshly exposed, moist soil.

Actinomycete Structure
National Science and Technology Center



Actinomycetes — small, filamentous bacteria — also can produce geosmin and MIB but are difficult to identify in water supplies because they are non-pigmented, extremely small and do not produce blooms. Major agents of decay, they inhabit lake sediments and dying aquatic weeds as well as dead plants in the surrounding watershed. T&O problems often follow rainfall that produces watershed runoff. Rain during a drought may raise the reservoir water level but also wash MIB and geosmin produced by actinomycetes in soil and decaying vegetation into the reservoir.

In order to address taste and odor issues, the follow options were evaluated

## 4.1 Contact Tank

A contact tank with a minimum of 30 minutes of detention time ahead of the clarifiers would allow for some contact time with a variety of chemicals including potassium permanganate, ozone, peroxide, or powdered activated carbon for preoxidation or adsorption of organic material. The tank should be baffled to eliminate short circuiting.

## 4.2 Potassium Permanganate ($KMnO4$)

Potassium permanganate is currently used at the plant. Increased contact time can be achieved by adding this chemical at the intake and using detention time in the pipeline or in a dedicated contact tank at the plant.

## 4.3 Source Options

### 4.3.1 Water recirculation (Solar Bee)

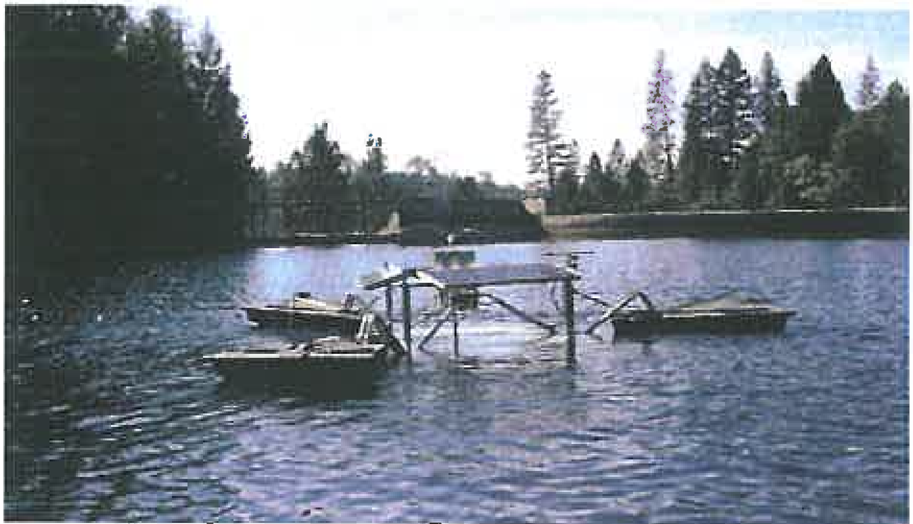


Figure 4 - 1 Passive Solar Power Circulation Unit

Cost -$50,000 per unit (3 units required to treat a 3 week volume around the intake) Over the 25+-year expected life of the SolarBee, costs are about $50-$70/acre/year.

### 4.3.2 Copper Sulfate broadcasting

Copper sulfate is used as an algaecide for small to medium sized reservoirs and in relatively shallow water. It is used periodically at the existing plant and is fed in the retention basin at the head of the plant. Broadcasting in the lake around the intake may have limited effect due to the depth to the intake screens and large overall surface area of the lake.

## 4.4 Chemical Options

### 4.4.1 Ozone (Bromates, biological byproduct removal)

Ozone is a powerful oxidant commonly used to treat surface water containing organic matter. Ozone can accomplish several things simultaneously such as metal oxidation, taste and odor control, organics oxidation, and C*T credit. Ozonation of raw water should be considered if the source water has relatively high concentrations of total organic carbon (>5 mg/L) and the concentration of chlorinated disinfection by-products is approaching the regulatory limits for these compounds. Ozonation does not result in the addition of solids that must be disposed, and will oxidize metal ions, taste and odor compounds, natural organic matter (NOM), and synthetic organic carbons (SOCs). Research has shown that pre-oxidizing raw water with ozone before coagulation/flocculation enhances floc formation and shortens settling time. The chemical nature of the organic matter becomes more polar by the ozonation process, whereby the organics can be coagulated and settled more easily. On top of these potential gains, ozone also disinfects and can gain the plant additional C*T credit without the addition of chlorine. However, as with most disinfectants, ozone can produce DBPs, most notably bromates, aldehydes, and ketones. Of these, only the concentration of bromate is strictly regulated. Ozone does not, however, provide a long-lasting residual concentration that can be carried into the distribution system. A secondary disinfectant (free or combined chlorine) must be utilized to maintain a residual in the distribution system. It should be noted, that if the source water *Cryptosporidium* testing (LT2ESWTR) classifies the source water in Bins 2, 3, or 4, extra consideration should be given to ozone

Ozone is produced by passing an electrical charge through oxygen, creating a molecule with three atoms of oxygen, $O_3$. This ozone molecule, when applied for drinking water treatment, is effective in the reduction or elimination of color, taste and odor problems associated with many water supplies. Ozone can also effectively destroy bacteria and inactivate viruses more rapidly than other disinfectant chemicals, and leaves oxygen as its sole by-product. Because it is environmentally friendly, ozone disinfection is suitable for municipal water treatment.

Figure 4 -2 - Ozone Generator

4.4.2 Ozone/Hydrogen Peroxide

Several methods have been used to increase ozone decomposition and produce high concentrations of hydroxyl radicals. One of the most common of these processes involves adding hydrogen peroxide to ozonated water, a process commonly referred to as peroxone.

Ozone can oxidize compounds in a range of 20–90% (dependent on the type of compound) [6]. Ozone is more effective for the oxidation of unsaturated compounds. As was the case for the oxidation of pesticides, ozone combined with hydrogen peroxide (AOP process) is more effective than ozone alone. Geosmin and 2-methylisoborneol (MIB) are examples of resistant odorous compounds, which are often present in the water. These are produced by algae and have a low odor and taste threshold. Nevertheless, ozone is still very affectively removes these compounds, see table below.

**Geosmin and MIB Removal**

| Treatment | Feed Rate, mg/L | Removal, % | |
|---|---|---|---|
| | | Geosmin | MIB |
| Powdered activated carbon | 10 | 40 | 62 |
| | 25 | 52 | 65 |
| Potassium permanganate | 0.8 | 42 | 28 |
| Chlorine | 2 | 45 | 33 |
| Hydrogen peroxide | 1 | 50 | 72 |
| Ozone | 2.5 | 94 | 77 |
| Ozone and hydrogen peroxide | 2.5 | 97 | 95 |

From Kawamura, 2000.

- Recommend biological filters by using GAC or existing filter to go biological by not adding chlorine.

Costs

Capital cost ozone system installed $500,000
Oxygen source – liquid oxygen
Estimated Ozone Dosage 2 mg/L
Estimated peroxide dosage 1 mg/L
Daily production 1.7mgd x 2mg/l x 8.34 = 83.4 lb/day
Cost to generate Ozone 5.5 kwH/lb
Estimated daily cost of producing Ozone $12/day

## 4.5 Powder Activated Carbon (PAC)

Powder activated carbon is currently being used and added at the primary rapid mix.

### Comparison between Ozone and Peroxone Oxidation

| Process | Ozone | Peroxone |
|---|---|---|
| Ozone decomposition rate | "Normal" decomposition producing hydroxyl radical as an intermediate product | Accelerated ozone decomposition increases the hydroxyl radical concentration above that of ozone alone. |
| Ozone residual | 5-10 minutes | Very short lived due to rapid reaction. |
| Oxidation path | Usually direct aqueous molecular ozone oxidation | Primarily hydroxyl radical oxidation. |
| Ability to oxidize iron and manganese | Excellent | Less effective. |
| Ability to oxidize taste and odor compounds | Variable | Good, hydroxyl radical more reactive than ozone. |
| Ability to oxidize chlorinated organics | Poor | Good, hydroxyl radical more reactive than ozone. |
| Disinfection ability | Excellent | Good, but systems can only receive CT credit if they have a measurable ozone residual. |
| Ability to detect residual for disinfection monitoring | Good | Poor. Cannot calculate CT value for disinfection credit. |

## 4.6 GAC Caps

Caps on existing filters - GAC program from Calgon $2,400/month

## 4.7 GAC Contactor Vessels

This is a method of running water through a packed column or granular activated carbon by using booster pumps and forcing water through a vertical tank. An empty bed contact time of approximately 10 minutes is required. Replacement of the carbon is required every 2 to 8 years depending on frequency of use. Estimate cost for this option is $425,000.

Figure 4-3 GAC Contactor Vessels (Courtesy Tonka Equipment Company )

## 4.8 Chlorine Dioxide

Chlorine dioxide is a disinfectant that is gaining popularity in the water treatment industry primarily due to the fact that it does not form THMs and HAAs in significant amounts. It is a very strong oxidant whose properties are not adversely affected by a higher pH, as is the case with free chlorine. Chlorine dioxide is currently in use at the plant and has been effective in improving taste and odor.

## 4.9 UV and Hydrogen Peroxide

Research has established the fundamental reaction kinetics between hydroxyl radicals and geosmin, 2-MIB, and potentially other taste and odor-causing compounds common in drinking water. UV/H2O2 systems are being implemented in larger water treatment plants to provide taste and odor control.

## 4.10 Mechanical Equipment

4.10.1 Ion Exchange - Miex Equipment

This is a relatively.new technology that has been proven to remove dissolved organic carbon (DOC) using a proprietary ion exchange resin. This option would require construction of concrete tanks and would be installed ahead of the existing process trains to remove DOC before it can impact other treatment processes.

DOC inhibits the effectiveness of traditional treatment processes by:

- Reacting with coagulants causing slower, less effective flocculation and increasing coagulant demand
- Interfering with the performance of activated carbon by competing with targeted compounds for active sites
- Reducing the capacity of membrane filtration by fouling
- Reacting with disinfectants, thus increasing chemical demand and DBP levels

DOC is a fraction of TOC that is difficult to remove by traditional treatment processes. Additionally, traditional solutions for the removal of DOC involve the application of complex water treatment processes, requiring large capital outlays and significant increases in operating costs.

Additional benefits of DOC removal with MIEX® Resin include:

- Significantly less waste residuals
- Color removal
- Reduced chlorine demand for disinfection
- Significant reductions in disinfection by-product formation

MIEX Resin is mixed with raw water containing the negatively charged target anions, which exchange for chloride ions on the resin's active sites in a process referred to as "adsorption."

When the resin is loaded, it is separated from the water and mixed with brine (NaCl) to exhange with chloride target anions off the resin. This is known as "regeneration."

See the diagram below for an example of the anion exchange used to remove negatively charged humic and fulvic acids from water to reduce DOC.

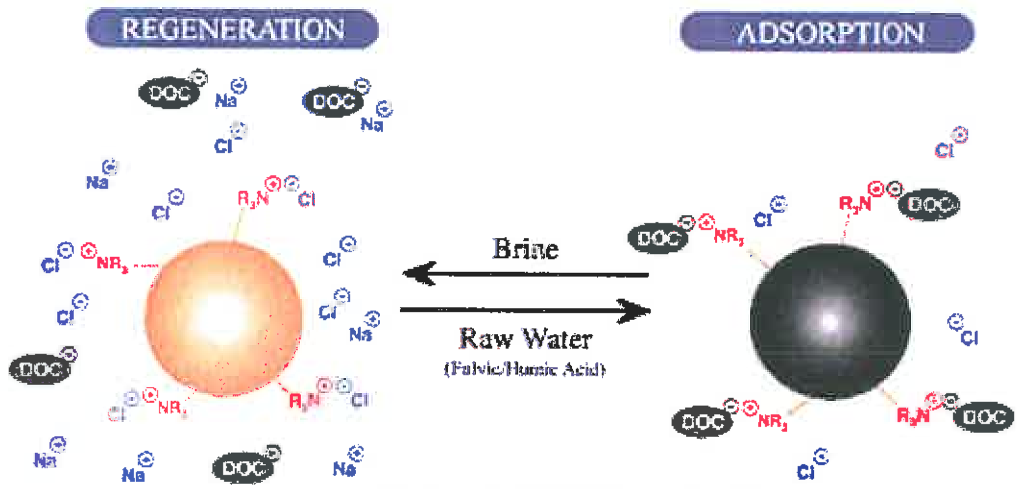


Figure 4-4 - MIEX Generation Diagram

The MIEX® Resin is designed specifically to be used in a continuous ion exchange process that utilizes the high surface area of the resin beads to provide ion exchange in mixed or fluidized bed reactors at very low resin concentrations and short detention times. The magnetic properties of the resin beads result in the beads forming agglomerates that will settle rapidly or fluidize at high hydraulic loading rates, thus allowing small unit process footprints.

In the high rate configuration, raw water fed to the base of the reactor vessel is mixed with the MIEX Resin and the ion exchange process occurs in a fluidized bed. In the fluidized bed the magnetic particles are attracted to each other to form large agglomerates that form a stable resin suspension at hydraulic loading rates of up to 12 gpm/ft$^2$. An agitator operating at slow speeds keeps the resin/water suspension uniformly mixed. A small stream of resin is withdrawn from the reactor vessel, regenerated with a 12% NaCl solution and returned to maintain the ion exchange capacity of the process.

A series of plates (or tube settlers) at the top of the reactor vessel separate the resin from the water and treated effluent overflows into collection launders to downstream treatment processes.

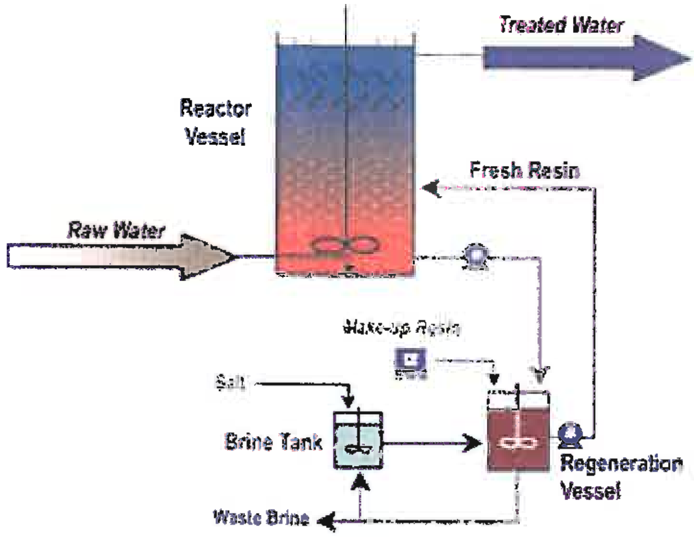



Figure 4-5 High Rate MIEX Process Flow Diagram

Figure 4-6 MIEX Treatment System: High Rate Configuration

Laboratory Testing

Orica Watercare can perform comprehensive laboratory simulations to measure the effectiveness of MIEX® resin treatment on water and wastewater sources. Full reports of the feasibility results along with a budgetary proposal can be provided upon request. Contact your local office for more details on the test procedures or to arrange laboratory treatability testing of your water or wastewater stream.

Pilot Studies

Pilot trial studies can also be performed to verify performance of the MIEX System and/or to gain necessary approvals before implementation.

Orica Watercare has a fleet of pilot plants that are fully automated and can simulate a full range of MIEX® treatment scenarios. Control of the process is accomplished through touch screen Human Machine Interfaces (HMI) with a field engineer from Orica operating the system and logging data during the trial.

Approximately six weeks prior to the beginning of a pilot trial, Orica Watercare will typically conduct a correlation test on the source water. This correlation will allow the pilot plant to be optimized to meet the quality objectives during the first few days of the trial.

During a pilot trial, samples are analyzed on-site everyday to verify the water quality goals are being met and the plant is running efficiently. Samples are also taken and sent to an independent lab for verification of contaminant levels. The results of the pilot trial are documented in a comprehensive pilot report and issued to the customer once all the data has been received.

The capital cost for this option is estiamated at $750,000.

# APPENDIX

# TASTE & ODOR MONITORING

**Quote Ref #:** 



**Contact:**
**Company:**
**Address:**
**Phone:**
**Fax:**

**Sample Matrix** DW
**Testing Frequency:** As Needed
**Lab Turnaround Time:** As Needed
**Estimated Start Date:**
**Payment Terms:** Upon Receipt

We are pleased to submit the following quotation. Prices are firm thru 12/31/08, provided PO is received within 45 days and prior to receipt of samples. Work may not begin, or is COD, until receipt of a completed vendor application & credit approval. Client is responsible for sample collection and delivery to the lab in acceptable condition within 24 hours. Payment for services is due upon receipt of invoice and not contingent upon third party payments. All other MWH Labs' standard terms & conditions apply unless otherwise specified herein. Submittal of samples to MWH constitutes acceptance of these terms, unless otherwise agreed to in writing.

| ITEM | QTY | TEST PARAMETER | TEST METHOD | UNIT PRICE | EXT'D PRICE |
|---|---|---|---|---|---|
| 1 | | Analytical Tests | | | |
| | 1 | MIB and Geosmin by SPME - 3 and 5 ng/L MRLs | SM 6040D | $200 | $200 |
| | 1 | MIB and Geosmin by SPME - 1 ng/L MRLs | SM 6040D | $250 | $250 |
| | 1 | Algae Identification | SM 10900 | $100 | $100 |
| | 1 | Algae Enumeration | SM 10200 | $75 | $75 |
| 2 | | Miscellaneous Items | | | |
| | 1 | Sample Kit - Cooler, Pre-preserved Sample Containers, Ice Packs, Custody form. | | $0 | $0 |
| | 1 | Sample Kit Delivery - Delivery within 5 working days. | | $0 | $0 |
| | 1 | Verbal or E-Mail Results within 72 hours of sample receipt | | | 1.5 x listed unit price |
| | 1 | Verbal or E-Mail Results within 24-48 hours of sample receipt | | | 2.0 x listed unit price |
| | 1 | Hardcopy Report Deliverable - Results + Batch QC | | $0 | $0 |
| | 1 | Electronic Report Deliverable - Sortable results posted to secure website location. | | $0 | $0 |

*NOTES:*

1. *Please contact an MWH Project Manager to advise of all incoming orders at least 48 hours in advance of sample submission. All Fri-Sat-Sun sample submissions must be approved in advance.*
2. *Client is responsible for sample return shipment arrangements and costs.*

**Submitted:** ______________________ **Accepted:** ______________________

**Rick Zimmer, Sales Manager**
**MWH Laboratories**
a division of MWH Americas, Inc.

RECEIPT OF SAMPLES BY MWH LABS CONSTITUTES ACCEPTANCE OF THE ABOVE TERMS & CONDITIONS, NOT WITHSTANDING ANY PROVISIONS TO THE CONTRARY IN CLIENT'S PURCHASE ORDER, UNLESS AN ALTERNATIVE AGREEMENT HAS BEEN SIGNED BY US.

WESTFALL

WESTFALL MANUFACTURING CO.
16 Peckham Dr
Bristol, RI 02809
Voice: 888-928-3747 or 401-253-3799
Fax: 401-253-6530
info@westfallmfg.net www.westfallmfg.com

# QUOTATION

11/5/08

| | |
|---|---|
| **TO:** Bartlett & West | **FROM:** SCOTT OLSON |
| **ATTN:** Molly Pesce | **FAX:** 401-253-6530 |
| **FAX/EMAIL:** molly.pesce@bartwest.com | **REF:** Static Mixers |

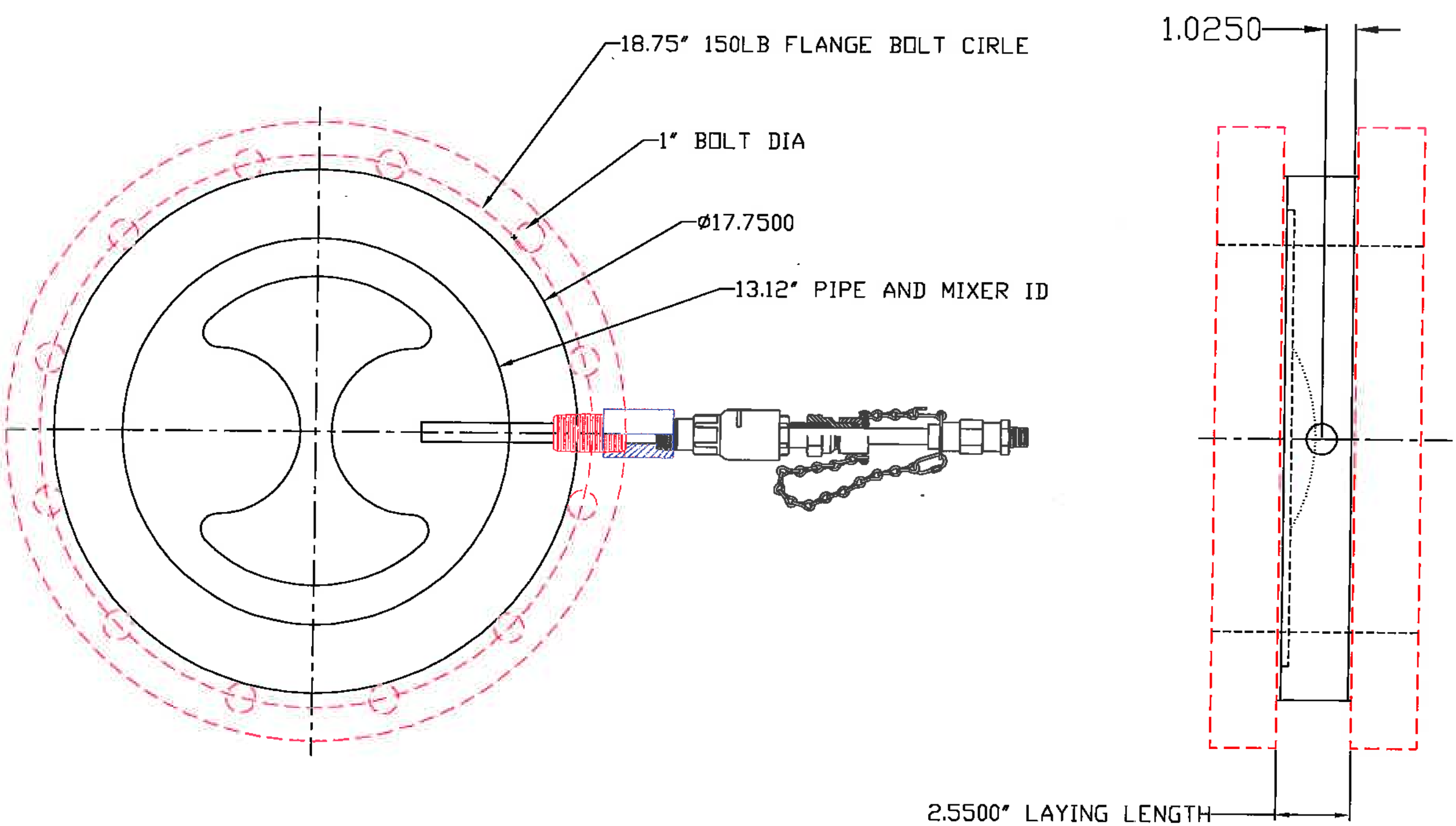
**WE ARE PLEASED TO OFFER OUR QUOTATION FOR THE FOLLOWING**

| ITEM | QTY | DESCRIPTION | UNIT PRICE | EXTENDED |
|---|---|---|---|---|
| A | 1 | 4" STATIC MIXER MODEL 2800<br>316SS MOUNTING RING<br>(1) .8 BETA 316SS MIXER PLATE<br>(1) EB-145 – ¾" BRASS CORP STOP WITH PVC SOLUTION TUBE<br>(2) 1/8" EPDM GASKETS<br>LAYING LENGTH 2.55" WITH GASKETS<br>**INJECTION CHEMICALS: AMMONIA**<br><br>NOTE:<br>1) MIXER IS DESIGNED TO INSTALL BETWEEN 150# FLANGES. | $6,460.00 | $6,460.00 |

| | |
|---|---|
| **TERMS**: NET 30 DAYS<br><br>**SHIPMENT**: 4-6 WEEKS ARO<br>FREIGHT PREPAID AND ADD<br><br>**EST. WEIGHT**: 80 LBS<br><br>**FOB**: BRISTOL, RI<br><br>**O&M MANUALS:** FIRST TWO: NO CHARGE<br>ADDITIONAL O&M MANUALS: $20 EACH | WESTFALL MANUFACTURING CO.<br><br>BY: ________<br>Please sign and return original copy.<br>Retain duplicate copy for your records.<br><br>ACCEPTED BY: ________<br><br>TITLE: DATE:<br><br>***QUOTE IS VALID FOR 30 DAYS*** |

NOTES:
316 STAINLESS STEEL MOUNTING RING.
(1) .8 BETA 316 STAINLESS STEEL MIXING PLATE.
(1) ¾" 316 STAINLESS STEEL CLOSE NIPPLE AND COUPLING
(1) ¾" EB-145 BRASS CORP STOP WITH PVC SOLUTION TUBE
(2) ⅛" EPDM GASKETS

| REVISIONS | | | |
|---|---|---|---|
| LTR | DATE | BY | DESCRIPTION |
| | | | |




14" STATIC MIXER O & I

| | | |
|---|---|---|
| DIMENSIONS IN INCHES (MM) UNLESS OTHERWISE NOTED | WESTFALL MANFACTURING CO. BRISTOL R I 02809 U S A | |
| | 14" MODEL 2800 STATIC MIXER | |
| | DRW. SAO | DRW. No. 3636 |

# Advantages of The Static Injection Mixer

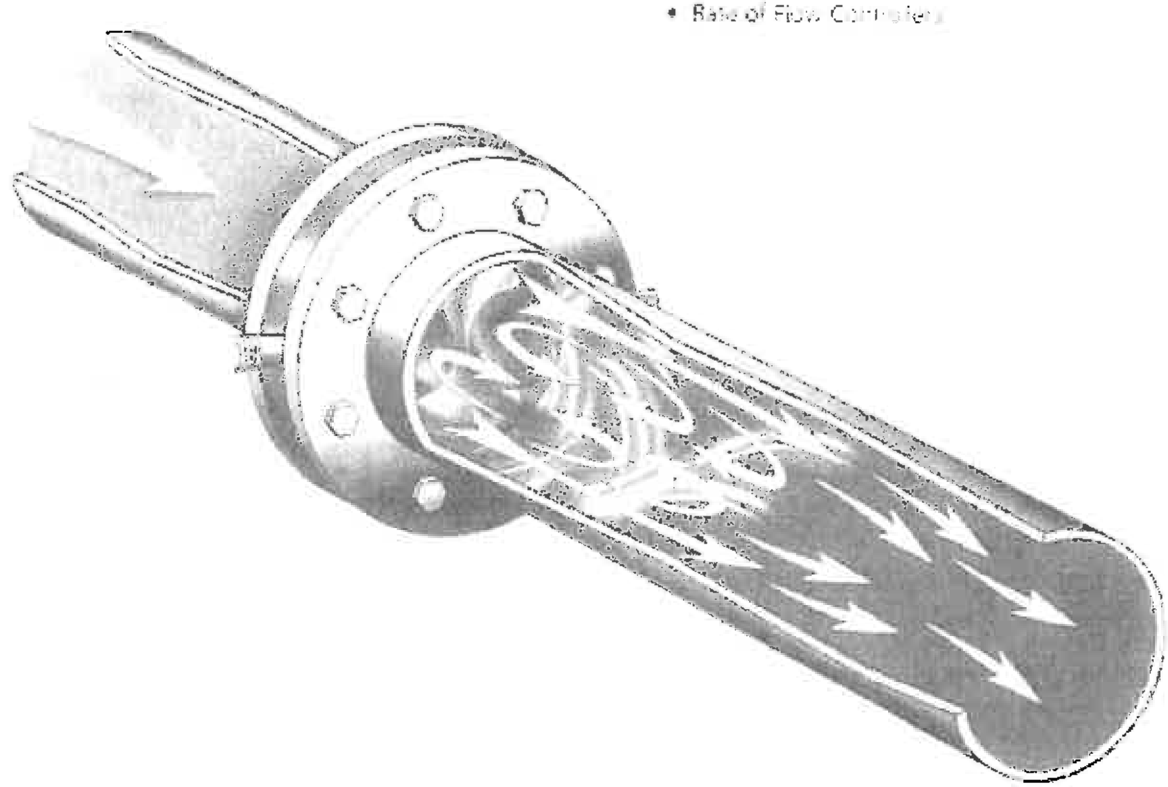
- Low Cost
- Short Laying Length
- Integral Injection Fittings
- Predictable Mixing
- Easy Installation and Hook-up
- Long Service Life
- No Maintenance Requirements
- No Moving Parts
- Available in Any Material: PVC, FRP, 316 ST.STL., Titanium, etc.

## Information Required for Express Service Quotation:

- Main Pipe Size and I.D.
- Main Line Fluid and Flow Rate
- Main Line Temperature, Pressure and Viscosity
- Quantity of Injected Fluids
- Flow Rate, Temperature, Viscosity of Each Injected Fluid
- Material of Mixer Body Ring
- Material of Mixer Plate
- Injection Fitting Material
- Gasket Material
- Other Special Requirements

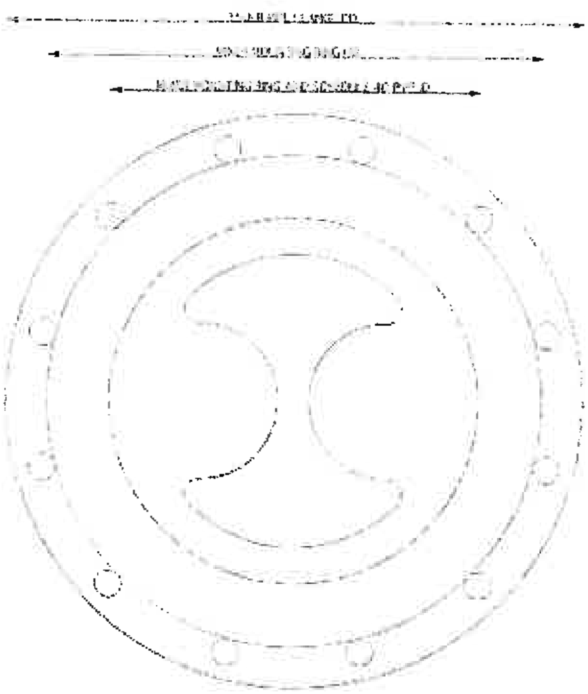
## Other Westfall Products

- Vacuum Diatomaceous Earth Filter Systems
- Diatomaceous Earth Recovery Flumes
- D.E. and Dry Chemical Feeders
- 3 Way Control Valves
- Rotary Drum Filters
- Venturi Flow Meters
- Rate of Flow Controllers

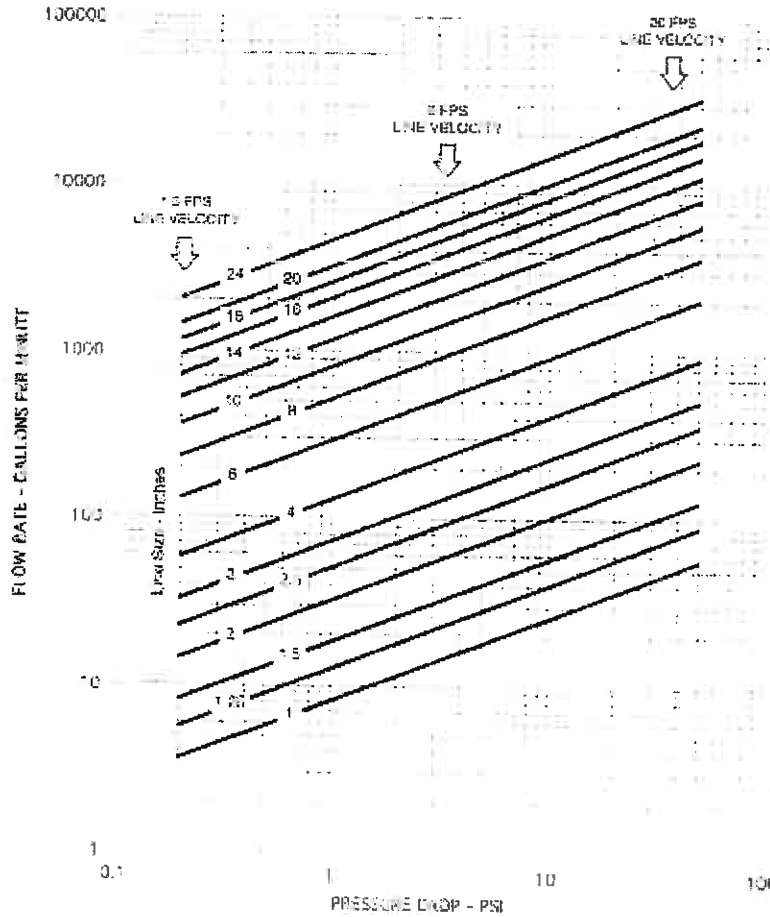


WESTFALL

WESTFALL MANUFACTURING COMPANY
16 Peckham Drive
Bristol, RI 02809-2733
Email: info@westfallmfg.net
Web-site: www.westfallmfg.com
Tel: 401-253-3799
(888) 928-3747
Fax: 401-253-6530



## Westfall Injection Mixer - Headloss




## 150 Lb. Mixer Dimensions in Inches

| NOMINAL PIPE SIZE | MIXER MOUNTING RING AND SCHEDULE 40 PIPE ID | MIXER MOUNTING RING OD | 150 LB PIPE FLANGE OD | MIXER PLATE THICKNESS | LAYING LENGTH WITH 1/8" GASKETS AND 1/4" NOZZLES | LAYING LENGTH WITH 1/8" GASKETS AND 1/2" NOZZLES |
|---|---|---|---|---|---|---|
| 0.50 | 0.62 | 1.88 | 3.50 | 0.095 | 1.25 | 2.00 |
| 0.75 | 0.82 | 2.25 | 3.88 | 0.095 | 1.25 | 2.00 |
| 1.00 | 1.05 | 2.63 | 4.25 | 0.095 | 1.25 | 2.00 |
| 1.25 | 1.38 | 3.00 | 4.63 | 0.095 | 1.25 | 2.00 |
| 1.50 | 1.61 | 3.38 | 5.00 | 0.095 | 1.25 | 2.00 |
| 2.00 | 2.07 | 4.13 | 6.00 | 0.125 | 1.25 | 2.00 |
| 2.50 | 2.47 | 4.88 | 7.00 | 0.125 | 1.25 | 2.00 |
| 3.00 | 3.07 | 5.38 | 7.50 | 0.125 | 1.25 | 2.00 |
| 4.00 | 4.03 | 6.88 | 9.00 | 0.125 | 1.25 | 2.00 |
| 5.00 | 5.05 | 7.75 | 10.00 | 0.125 | 1.25 | 2.00 |
| 6.00 | 6.07 | 8.75 | 11.00 | 0.125 | 1.25 | 2.00 |
| 8.00 | 7.98 | 11.00 | 13.50 | 0.188 | 1.31 | 2.06 |
| 10.00 | 10.02 | 13.38 | 16.00 | 0.188 | 1.31 | 2.06 |
| 12.00 | 11.94 | 16.13 | 19.00 | 0.250 | 1.38 | 2.13 |
| 14.00 | 13.12 | 17.75 | 21.00 | 0.250 | 1.38 | 2.13 |
| 16.00 | 15.00 | 20.25 | 23.50 | 0.313 | 1.50 | 2.19 |
| 18.00 | 16.88 | 21.63 | 25.00 | 0.313 | 1.75 | 2.19 |
| 20.00 | 18.81 | 23.88 | 27.50 | 0.375 | 1.88 | 2.25 |
| 24.00 | 22.63 | 28.25 | 32.00 | 0.375 | 2.25 | 2.25 |

# **MADDEN** Manufacturing, Inc.

P.O. Box 387 Elkhart, IN 46515
Ph: 574-295-4292 FAX: 574-295-7562
Email: stuart@maddenmfg.com website: www.maddenmfg.com


## QUOTATION

Date: November 6, 2008

To: Molly Pesce
Bartlett & West
Lees Summit, MO

From: Stuart C. Barb

Quotation No. BART8-1106

Thank you for your inquiry.

Item No: 1
Qty: 1
Part No: TE504
Description: Chemical feed system, with 55 gallon tank, metering pump, mixer, table and suction side piping, per proposal specification no. 8-1106, items a-e
Net Price each: $2,905.00

Item No: 2
Qty: 1
Description: Control panel, 1 ph power,per proposal specification no. 8-1106, item f
Net Price each: $1,800.00

Adder for 3 phase power: $200.00

Shipping weight: 200 lbs

Terms: Net 30 days for firms with approved credit
Freight policy: F.O.B. our Elkhart, IN plant, with no freight allowance
Shipments lead time: 4-6 weeks ARO
Prices are in US dollars, firm for 90 days.

Comments: Items not included in the proposal specification are not included in the price.
Please let us know if you need any additional information.

PROPOSAL SPECIFICATION No. 8-1106

TE504 CHEMICAL FEED SYSTEM

The Contractor shall furnish and install a Madden chemical feed system, part no. TE504 for ammonium sulfate solution consisting of the following equipment:

A. Pump, Madden part no. JN101A simplex diaphragm metering pump, rated for 0.1 to 1.0 gallons per hour at a maximum pressure of 250 psi. The pump output will be adjustable while the pump is running. The motor will be 1/3 HP, 1/60/115-230., 1725 rpm, TEFC. The pump will be finished with acrylic enamel. Pump wetted end construction: PVC head and valve bodies, Neoprene diaphragm, Teflon valve seats, ceramic valve balls, double ball valves for both inlet and outlet valves. The outlet piping connection will be 1/4" NPT.

B. Tank, Madden part no. TF302, 55 gallon polyethylene, 22" diameter X 36" height. Includes hinged cover, and one 1/4" PVC bulkhead fitting installed.

C. Mixer, Madden part no. AA103A, 1725 rpm direct drive, constructed with 1/2" stainless steel shaft and 4" stainless steel propeller. The motor will be 1/3 HP, 1 phase 60 Hz, 115 v., TEFC.

D. Table for pump and tank, part no. TF202, 26" wide X 36" long X 16" high. Constructed with 11 gauge formed steel top, 2" angle iron legs. With fabricated vertical steel channel with pad for mounting mixer motor. Finished with acrylic enamel.

E. Pump suction tubing, 3/8" Nylon reinforced PVC tube with fittings. Includes one PVC valve, and one plugged Tee for tank drain, and one Y strainer.

F. (Optional) Electrical control pane, NEMA 12 enclosure, rotating panel disconnect switch; START-STOP push button switches for each motor; green ON pilot light for each motor, overload type motor starters; engraved plastic ID plates; to be installed on structural support attached to the table; includes wiring from the panel box to each motor in flexible plastic conduit; 1/60/115 power

Specifications for: Bartlett & West, Lees Summit, MO

By: S. Barb
November 6, 2008

| CL2 | CH2 | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|
| | | FILTER NO. 1 | ON | 6:30 | 3:30 | | 149 |
| | | | OFF | 11:00 | 7:30 | | 9 |
| | | | HOURS | 4½ | 4 | 9 | 158 |
| | | FILTER NO. 2 | ON | 6:30 | 3:30 | | 99 |
| | | | OFF | 11:00 | 7:30 | | 9 |
| | | | HOURS | 4½ | 4 | 9 | 108 |
| 66 | 1.36 | FILTER NO. 3 | ON | 6:30 | 3:30 | | 37 |
| | | | OFF | 11:00 | 7:30 | | 9 |
| 61 | 1.29 | | HOURS | 4½ | 4 | 9 | 46 |
| | | FILTER NO. 4 | ON | 6:30 | 3:30 | | 28 |
| 61 | 1.31 | | OFF | 11:00 | 7:30 | | 9 |
| | | | HOURS | 4½ | 4 | 9 | 37 |
| | | FILTER NO. 5 | ON | 6:30 | 3:30 | | 9 |
| | | | OFF | 11:00 | 7:30 | | 9 |
| | | | HOURS | 4½ | 4 | 9 | 18 |
| | | HIGH SERVICE PUMP NO. 1 1,000 GPM | ON | 6:30 | 3:30 | | |
| 53 | 1.31 | | OFF | 11:00 | 7:30 | | |
| | | | HOURS | 4½ | 4 | 9 | |
| 79 | 1.55 | HIGH SERVICE PUMP NO. 2 1,000 GPM | ON | | | | |
| | | | OFF | | | | |
| | | | HOURS | | | | |
| | | LOW SERVICE PUMP NO. 1 | ON | 6:30 | 3:30 | | |
| | | | OFF | 11:00 | 7:30 | | |
| | | | HOURS | 4½ | 4 | 9 | |
| ICE | | LOW SERVICE PUMP NO. 2 | ON | | | | |
| | | | OFF | | | | |
| | | | HOURS | | | | |

| RAW WATER METER | |
|---|---|
| Today | 138 520 000 |
| Past | 137 905 000 |
| Out Put | 615 000 |
| This Month | |
| TOTAL | |

| | |
|---|---|
| OPERATOR | |
| DAY | |
| NIGHT | |
| WEEKEND | COON |

| | Time | pH | Temp | Alk. | Hardness | Turb | Fluoride | Fin. | CC |
|---|---|---|---|---|---|---|---|---|---|
| RAW | 8:00 | 7.83 | | 96 | 84 | 4.60 | | | |
| TOP FILTER | 7:30 | 8.65 | | 98 | | .23 | | | |
| | 9:00 | 8.72 | | 100 | | .34 | | | |
| | 11:00 | 8.72 | | 100 | | .37 | | | |
| | 5:00 | 8.67 | | 98 | | .28 | | | |
| | 7:00 | 8.64 | | 97 | | .31 | | | |
| FINISHED | 7:30 | 8.23 | 11.0 | 94 | 70 | .057 | 1.17 | | |
| | 9:00 | 8.30 | | 95 | | .055 | | | |
| | 11:00 | 8.30 | | 95 | | .061 | | | |
| | 5:00 | 8.25 | | 94 | | .055 | | | |
| | 7:00 | 8.22 | | 93 | | .059 | | | |

## METER READINGS

| | Master 1# | Backwash | Plant |
|---|---|---|---|
| TODAY | 213447 000 | 2812000 | 7959550 |
| PAST | 212846000 | 2789000 | 7957990 |
| OUTPUT | 601 000 | 23000 | 1560 |
| THIS MONTH | | | |
| TOTAL | | | |

| Filter No. 1 | Filter No. 2 | Filter No. 3 | Filter No. 4 | Filter No. 5 | High Service Pump No. 1 | High Service Pump No. 2 | Low Service Pump No. 1 | Low Service Pump No. 2 | Sludge Collector No. 1 |
|---|---|---|---|---|---|---|---|---|---|
| 9 | 9 | 9 | 9 | 9 | 9 | 0 | 9 | 0 | 0 |

| HR | P P M | Grams Per Min. by Wt. | ML/Min. | New CL2 TANKS | CHLORINE | Cyl. Wt. | Lbs. Used | Polymer |
|---|---|---|---|---|---|---|---|---|
| | | | 173 | | PRIMARY | 1130-1110 | 20 | |
| 52LBS | | | | | SECONDARY | 895 | | |
| | | | | | POST No. 2 | | | |

| | LIME | ALUM | CA |
|---|---|---|---|
| TODAY | | | |
| THIS MONTH | | | |
| TOTAL | | | |

**North Central Missouri Regional Water Commission** 14813.002

Total Organic Carbon Analysis
Alkalinity Analysis

| Report Date | Date Collected | Sample Location | Alkalinity (mg/L) | TOC (mg/L) | TOC (mg/L) |
|---|---|---|---|---|---|
| 1/10/2007 | 1/5/2007 | Raw Water, Plant | 102 | 7.19 | |
| 1/10/2007 | 1/5/2007 | Filter Effluent, Plant Tap | | | 3.88 |
| 2/23/2007 | 2/12/2007 | Raw Water, Plant | 115 | 8.03 | |
| 2/23/2007 | 2/12/2007 | Filter Effluent, Plant Tap | | | 4.02 |
| 3/26/2007 | 3/6/2007 | Raw Water, Plant | 102 | 8.64 | |
| 3/26/2007 | 3/6/2007 | Filter Effluent, Plant Tap | | | 3.08 |
| 4/17/2007 | 4/10/2007 | Raw Water, Plant | 90 | 8.78 | |
| 4/17/2007 | 4/10/2007 | Filter Effluent, Plant Tap | | | 3.99 |
| 5/31/2007 | 5/17/2007 | Raw Water, Plant | 76 | 9.19 | |
| 5/31/2007 | 5/17/2007 | Filter Effluent, Plant Tap | | | 4.04 |
| 6/21/2007 | 6/5/2007 | Raw Water, Plant | 72 | 8.78 | |
| 6/21/2007 | 6/5/2007 | Filter Effluent, Plant Tap | | | 3.52 |
| 8/2/2007 | 7/11/2007 | Raw Water, Plant | 82 | 8.53 | |
| 8/2/2007 | 7/11/2007 | Filter Effluent, Plant Tap | | | 4.40 |
| 8/28/2007 | 8/20/2007 | Raw Water, Plant | 90 | 8.06 | |
| 8/28/2007 | 8/20/2007 | Filter Effluent, Plant Tap | | | 3.81 |
| 10/17/2007 | 9/6/2007 | Raw Water, Plant | 90 | 7.66 | |
| 10/17/2007 | 9/6/2007 | Filter Effluent, Plant Tap | | | 3.26 |
| 10/19/2007 | 10/11/2007 | Raw Water, Plant | 92 | 7.33 | |
| 10/19/2007 | 10/10/2007 | Filter Effluent, Plant Tap | | | 4.10 |
| 12/12/2007 | 11/15/2007 | Raw Water, Plant | 96 | 6.83 | |
| 12/12/2007 | 11/15/2007 | Filter Effluent, Plant Tap | | | 3.87 |
| 1/3/2008 | 12/4/2007 | Raw Water, Plant | 98 | 6.80 | |
| 1/3/2008 | 12/4/2007 | Filter Effluent, Plant Tap | | | 3.86 |

**North Central Missouri Regional Water Commission**

14813.002

Quarterly Total Haloacetic Acids (HAA5)
Quarterly Total Trihalomethanes (THHM)

| Report Date | Date Collected | Sample Location | Total HAA5 | MCL | Total THM | MCL |
|---|---|---|---|---|---|---|
| March-07 | | Plant | 33.1 | 60 | 24.2 | 80 |
| March-07 | | PWSD #1 BPS | 34.3 | 60 | 24.8 | 80 |
| March-07 | | Green City BPS | 34.2 | 60 | 26.3 | 80 |
| March-07 | | Green City MMS | 40.7 | 60 | 23.7 | 80 |
| June-07 | | Plant | 76.4 | 60 | 58.6 | 80 |
| June-07 | | PWSD #1 BPS | 66.8 | 60 | 66.1 | 80 |
| June-07 | | Green City BPS | 63.3 | 60 | 60.8 | 80 |
| June-07 | | Green City MMS | 63.9 | 60 | 65.9 | 80 |
| October-07 | 9/6/2007 | Plant | 26.3 | 60 | 45.2 | 80 |
| October-07 | 9/6/2007 | PWSD #1 BPS | 18.1 | 60 | 48 | 80 |
| October-07 | 9/6/2007 | Green City BPS | 26.8 | 60 | 47.2 | 80 |
| October-07 | 9/6/2007 | Green City MMS | 35.2 | 60 | 52.4 | 80 |
| January-08 | 12/4/2007 | Plant | 31.3 | 60 | 33 | 80 |
| January-08 | 12/4/2007 | PWSD #1 BPS | 65.4 | 60 | 25 | 80 |
| January-08 | 12/4/2007 | Green City BPS | 31.5 | 60 | 29.8 | 80 |
| January-08 | 12/4/2007 | Green City MMS | 32.1 | 60 | 40.4 | 80 |

| | | | | | | |
|---|---|---|---|---|---|---|
| March-07 | | Plant | 33.1 | 60 | 24.2 | 80 |
| June-07 | | Plant | 76.4 | 60 | 58.6 | 80 |
| October-07 | 9/6/2007 | Plant | 26.3 | 60 | 45.2 | 80 |
| January-08 | 12/4/2007 | Plant | 31.3 | 60 | 33 | 80 |
| March-07 | | PWSD #1 BPS | 34.3 | 60 | 24.8 | 80 |
| June-07 | | PWSD #1 BPS | 66.8 | 60 | 66.1 | 80 |
| October-07 | 9/6/2007 | PWSD #1 BPS | 18.1 | 60 | 48 | 80 |
| January-08 | 12/4/2007 | PWSD #1 BPS | 65.4 | 60 | 25 | 80 |
| March-07 | | Green City BPS | 34.2 | 60 | 26.3 | 80 |
| June-07 | | Green City BPS | 63.3 | 60 | 60.8 | 80 |
| October-07 | 9/6/2007 | Green City BPS | 26.8 | 60 | 47.2 | 80 |
| January-08 | 12/4/2007 | Green City BPS | 31.5 | 60 | 29.8 | 80 |
| March-07 | | Green City MMS | 40.7 | 60 | 23.7 | 80 |
| June-07 | | Green City MMS | 63.9 | 60 | 65.9 | 80 |
| October-07 | 9/6/2007 | Green City MMS | 35.2 | 60 | 52.4 | 80 |
| January-08 | 12/4/2007 | Green City MMS | 32.1 | 60 | 40.4 | 80 |

# NORTH CENTRAL MISSOURI
# REGIONAL WATER COMMISSION
## *Monthly Water Quality Report*

**Date: December 2007**

| | CHEMICAL ANALYSIS | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RAW WATER CHEMICAL ANALYSIS | | | | TOP FILTER CHEMICAL ANALYSIS | | | FINISHED CHEMICAL ANALYSIS | | | | | |
| DATE | pH | Alkalinity (mg/l) | Hardness (mg/l) | Turbidity (ntu) | pH | Alkalinity (mg/l) | Turbidity (ntu) | pH | Temp | Alkalinity (mg/l) | Hardness (mg/l) | Turbidity (ntu) | Fluoride (mg/l) |
| 1 | 7.830 | 96 | 84 | 4.50 | 8.680 | 98.60 | 0.306 | 8.260 | 11.00 | 94.20 | 70 | 0.0574 | 1.17 |
| 2 | 7.900 | 98 | 84 | 5.00 | 8.658 | 99.60 | 0.300 | 8.316 | 12.30 | 94.60 | 70 | 0.0594 | 1.14 |
| 3 | 7.860 | 98 | 77 | 4.50 | 8.448 | 100.40 | 0.292 | 8.150 | 10.00 | 93.20 | 62 | 0.0546 | 1.40 |
| 4 | 7.700 | 96 | 76 | 4.00 | 8.620 | 99.25 | 0.366 | 8.185 | 11.00 | 95.00 | 68 | 0.0555 | 1.30 |
| 5 | 7.710 | 94 | 72 | 4.50 | 8.582 | 99.60 | 0.394 | 8.148 | 11.20 | 91.60 | 67 | 0.0552 | 1.27 |
| 6 | 7.800 | 94 | 76 | 3.90 | 8.5525 | 98.50 | 0.032 | 8.163 | 10.80 | 91.00 | 66 | 0.05625 | 1.30 |
| 7 | 8.000 | 98 | 86 | 3.65 | 8.466 | 99.80 | 0.370 | 8.176 | 10.30 | 93.80 | 68 | 0.0562 | 1.19 |
| 8 | 8.010 | 98 | 86 | 3.75 | 8.460 | 98.20 | 0.310 | 8.186 | 10.00 | 92.80 | 68 | 0.064 | 1.17 |
| 9 | 7.660 | 100 | 86 | 4.30 | 8.454 | 101.40 | 0.472 | 7.986 | 9.60 | 96.80 | 80 | 0.0628 | 0.96 |
| 10 | 7.650 | 98 | 82 | 3.80 | 8.585 | 100.50 | 0.358 | 8.143 | 10.00 | 96.50 | 71 | 0.05825 | 1.17 |
| 11 | 7.690 | 98 | 78 | 3.80 | 8.5425 | 101.25 | 0.418 | 8.148 | 10.10 | 95.00 | 66 | 0.05675 | 1.05 |
| 12 | 7.650 | 98 | 76 | 4.10 | 8.510 | 102.20 | 0.454 | 8.156 | 9.80 | 95.60 | 64 | 0.0532 | 1.00 |
| 13 | 7.670 | 98 | 70 | 3.95 | 8.7925 | 103.50 | 0.420 | 8.163 | 9.50 | 98.25 | 66 | 0.05375 | 1.15 |
| 14 | 7.720 | 100 | 70 | 4.30 | 8.285 | 99.75 | 0.453 | 8.145 | 10.20 | 95.75 | 70 | 0.05225 | 1.13 |
| 15 | 7.700 | 98 | 72 | 5.00 | 8.136 | 94.40 | 0.486 | 8.108 | 10.00 | 96.00 | 68 | 0.0594 | 0.98 |
| 16 | 7.680 | 96 | 68 | 5.30 | 8.094 | 96.20 | 0.454 | 8.114 | 9.00 | 95.80 | 70 | 0.063 | 0.00 |
| 17 | 7.550 | 94 | 64 | 4.60 | 7.588 | 91.20 | 0.526 | 7.736 | 8.95 | 96.40 | 72 | 0.0564 | 1.25 |
| 18 | 7.650 | 98 | 78 | 4.75 | 8.0075 | 99.25 | 0.388 | 7.886 | 9.90 | 96.50 | 72 | 0.05525 | 1.06 |
| 19 | 7.630 | 99 | 77 | 4.78 | 7.792 | 98.20 | 0.484 | 7.986 | 10.00 | 99.40 | 75 | 0.0552 | 0.965 |
| 20 | 7.700 | 100 | 82 | 4.85 | 7.916 | 99.80 | 0.446 | 7.982 | 10.00 | 99.40 | 75 | 0.0582 | 1.25 |
| 21 | 7.650 | 100 | 86 | 4.75 | 7.768 | 98.60 | 0.414 | 7.958 | 11.00 | 99.60 | 80 | 0.055 | 1.24 |
| 22 | 7.660 | 98 | 0 | 5.10 | 7.8425 | 98.00 | 0.363 | 7.923 | 11.00 | 100.50 | 82 | 0.05425 | 0.00 |
| 23 | 7.660 | 99 | 86 | 5.25 | 7.844 | 97.80 | 0.336 | 7.948 | 10.00 | 100.60 | 82 | 0.0558 | 1.21 |
| 24 | 7.600 | 100 | 82 | 5.20 | 7.928 | 99.40 | 0.414 | 7.930 | 10.50 | 99.20 | 78 | 0.0564 | 1.30 |
| 25 | 7.630 | 100 | 82 | 5.15 | 7.920 | 98.80 | 0.308 | 7.910 | 10.50 | 99.60 | 78 | 0.055 | 1.27 |
| 26 | 7.680 | 100 | 89 | 5.25 | 7.636 | 98.80 | 0.374 | 7.760 | 9.40 | 98.80 | 87 | 0.0632 | 1.00 |
| 27 | 7.700 | 98 | 83 | 5.25 | 7.852 | 98.00 | 0.390 | 7.844 | 9.10 | 96.20 | 68 | 0.0584 | 0.75 |
| 28 | 7.550 | 99 | 80 | 4.90 | 7.082 | 99.60 | 0.390 | 7.936 | 9.00 | 99.20 | 82 | 0.0542 | 1.35 |
| 29 | 7.570 | 99 | 80 | 4.75 | 7.912 | 98.80 | 0.372 | 7.926 | 8.50 | 99.40 | [illegible] | 0.0646 | 1.30 |
| 30 | 7.550 | 96 | 80 | 4.50 | 7.912 | 98.00 | 0.348 | 7.858 | 9.00 | 97.80 | 82 | 0.0618 | 1.27 |
| 31 | 7.490 | 97 | 80 | 4.55 | 7.746 | 99.00 | 0.368 | 7.862 | 9.80 | 100.60 | 86 | 0.065 | 1.00 |
| AVG | 7.694 | 97.90 | 79.13 | 4.580 | 8.175 | 98.92 | 0.380 | 8.033 | 10.05 | 96.69 | 73.39 | 0.0573 | 1.08 |

| | CHLORINE RESIDUAL | | | METER READINGS | | | | CHEMICAL USAGE | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | Top Filter | Total Cl2 (mg/l) | Free Cl2 (mg/l) | Raw Water Output | Master #1 Output | Backwash Output | Plant Output | Polymer (ML/Min.) | KMNO4 (lbs.) | Carbon (lbs.) | NaOH (ML/Min.) | Chlorine Used (lbs.) | Weather (°F) |
| 1 | 0.996 | 1.660 | 1.364 | 615000 | 601000 | 23000 | 15600 | 173 | 65 | 50 | 92 | 20 | 26 |
| 2 | 1.066 | 1.720 | 1.402 | 554000 | 541000 | 0 | 14900 | 172 | 67 | 50 | 93 | 20 | 38 |
| 3 | 0.916 | 1.560 | 1.296 | 666000 | 650000 | 0 | 15500 | 170 | 45 | 100 | 92 | 15 | 15 |
| 4 | 0.860 | 1.630 | 1.330 | 608000 | 650000 | 0 | 15600 | 170 | 42 | 150 | 92 | 15 | 20 |
| 5 | 0.910 | 1.740 | 1.414 | 645000 | 621000 | 21000 | 15100 | 170 | 40 | 150 | 92 | 15 | 29 |
| 6 | 0.835 | 1.720 | 1.403 | 686000 | 622000 | 20000 | 15500 | 168 | 44 | 100 | 92 | 30 | 17 |
| 7 | 0.928 | 1.724 | 1.376 | 592000 | 602000 | 0 | 16000 | 167 | 43 | 100 | 92 | 15 | 28 |
| 8 | 0.976 | 1.702 | 1.356 | 573000 | 583000 | 0 | 14300 | 167 | 70 | 100 | 92 | 20 | 20 |
| 9 | 1.068 | 1.748 | 1.406 | 566000 | 590000 | 0 | 15100 | 172 | 60 | 100 | 92 | 20 | 14 |
| 10 | 0.903 | 1.753 | 1.395 | 619000 | 634000 | 0 | 15700 | 170 | 42 | 100 | 92 | 20 | 18 |
| 11 | 0.926 | 1.770 | 1.415 | 646000 | 648000 | 0 | 15300 | 174 | 43 | 150 | 92 | 20 | 30 |
| 12 | 1.012 | 1.790 | 1.464 | 601000 | 583000 | 23000 | 15400 | 170 | 40 | 150 | 92 | 15 | 24 |
| 13 | 0.920 | 1.753 | 1.410 | 635000 | 619000 | 24000 | 15400 | 170 | 41 | 100 | 87 | 20 | 26 |
| 14 | 0.955 | 1.680 | 1.375 | 609000 | 605000 | 0 | 15900 | 170 | 41 | 150 | 87 | 15 | 18 |
| 15 | 1.030 | 1.810 | 1.460 | 617000 | 597000 | 21000 | 15300 | 0 | 0 | 150 | 0 | 15 | 17 |
| 16 | 1.064 | 1.758 | 1.378 | 681000 | 577000 | 0 | 19800 | 0 | 0 | 100 | 0 | 30 | 12 |
| 17 | 0.940 | 1.760 | 1.392 | 739000 | 701000 | 0 | 14900 | 160 | 45 | 100 | 87 | 20 | 4 |
| 18 | 0.980 | 1.810 | 1.455 | 631000 | 665000 | 0 | 15000 | 158 | 43 | 100 | 87 | 20 | 28 |
| 19 | 1.056 | 1.910 | 1.520 | 625000 | 627000 | 0 | 15100 | 160 | 46 | 100 | 50 | 15 | 18 |
| 20 | 1.020 | 1.874 | 1.526 | 678000 | 619000 | 21000 | 15000 | 159 | 45 | 100 | 50 | 25 | 30 |
| 21 | 0.958 | 1.774 | 1.440 | 637000 | 630000 | 0 | 15000 | 160 | 44 | 100 | 50 | 20 | 37 |
| 22 | 1.070 | 1.975 | 1.608 | 647000 | 623000 | 21000 | 15900 | 160 | 0 | 100 | 56 | 25 | 40 |
| 23 | 1.152 | 2.030 | 1.692 | 617000 | 622000 | 0 | 19000 | 0 | 0 | 100 | 0 | 25 | 10 |
| 24 | 0.978 | 2.056 | 1.672 | 651000 | 612000 | 0 | 16400 | 160 | 44 | 50 | 52 | 20 | 18 |
| 25 | 0.964 | 1.916 | 1.534 | 658000 | 642000 | 21000 | 15000 | 161 | 45 | 100 | 52 | 25 | 16 |
| 26 | 0.976 | 1.780 | 1.428 | 717000 | 672000 | 0 | 15100 | 158 | 45 | 50 | 52 | 15 | 21 |
| 27 | 1.112 | 2.000 | 1.582 | 612000 | 642000 | 0 | 61100 | 159 | 47 | 100 | 52 | 20 | 21 |
| 28 | 1.236 | 2.224 | 1.850 | 682000 | 620000 | 23000 | 92000 | 159 | 45 | 100 | 52 | 25 | 24 |
| 29 | 1.312 | 2.232 | 1.816 | 640000 | 600000 | 21000 | 91700 | 159 | 60 | 50 | 52 | 3 | 14 |
| 30 | 1.070 | 2.122 | 1.740 | 643000 | 616000 | 0 | 90500 | 160 | 75 | 100 | 53 | 20 | 10 |
| 31 | 1.212 | 2.030 | 1.582 | 686000 | 655000 | 0 | 93600 | 0 | 46 | 50 | 0 | 20 | 20 |
| AVG | 1.013 | 1.839 | 1.485 | 638000 | 621581 | 21727 | 26958 | 165.04 | 48.63 | 100.00 | 75.04 | 22.33 | 24.56 |