WATER QUALITY IMPACTS ON TEXTILE

DYE HOUSE OPERATIONS

By

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CHAPTER I

INTRODUCTION

Water quality, as it relates to textile dye and finishing operations, has traditionally been accepted as it is, and/or not fully understood. Seasonal influences such as runoff, humic materials, and algae contribute a considerable variation to the quality of the surface or reservoir water being used in textile processing. Processing problems that can be directly attributed to the seasonal water quality variations are generally:

- Staining of whites and light shades
- Off-shade dyeing due to solids deposition in the cloth
- Dye complexation or chelation

Sometimes an "induced" water quality problem can arise from the installation and/or repair of existing water lines or the installation of new auxiliary processing equipment. Waste heat recovery systems generally fall into this "induced" category. With the introduction of hot water into old cold water lines, a considerable thermal disturbance is generally experienced. Old corrosion by-products are removed and subsequently react with dyes (chelation) or directly stain white cloth in the bleach kiers. Some heat recovery systems inadvertently produce acidic hot water which will intensify the problems.

Although the cause may be identifiable, the effect is generally a loss in quality goods and an increase in rework. The complexities of dye house operations are increasing dramatically with machine computerization, environmental constraints and, subsequently, new and alternative sensitive dye stuffs.

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Quite often, dye house operators, through experience and/or technical assistance from chemical suppliers, will add an "auxiliary" to overcome the unseen problems. As a result, expensive "formulations" are habitually added to take care of the unknown and eminent problems.

Over the years, the number of auxiliaries have dramatically increased along with their cost. It is not uncommon to find eight to nine auxiliaries purchased from six to seven different supply companies in a single dye bath with little or no understanding of the function of half of them. Auxiliary addition is a common practice that continues in fear of the effects, if withdrawn.

Water quality at two different textile dye houses was evaluated to define and identify processing problems. Both facilities are geographically within twenty-three (23) miles of one another but each has a significantly different source and quality of water. Manufacturing problems at one facility were suspected to be from the water sources alone, while the other facility experienced dyeing and finishing problems after the installation of a non-conventional waste heat recovery system for hot water generation.

CHAPTER II

LITERATURE REVIEW

Problem Identification

The common denominator in every textile dyeing facility is water, and unfortunately very little, if any, work has been conducted, either internally or externally, to identify the source and/or the degree of metal ion contamination at various textile facilities. Baseline data is virtually nonexistent and until recently was not even contemplated as a viable investigative tool. Many textile facilities, in particular those that utilize surface water supplies, often experience transient operational problems that are directly attributable to seasonal water quality variations. Historically, the problems were accepted as transient or, in most cases, blamed on individual workers. Coincidentally, as the workers were ultimately let go for performance reasons, the seasonal time frame was such that the problems also went away. By deduction, it was apparent to management that the operator was at fault and the proper decision had been made.

Today's textile industry supports a more highly educated staff that are generally more open to the analytical approach and investigative reasoning needed to approach and define a problem or a group of problems. Since the number of processing steps that are performed on any one piece of fabric can be large (i.e., 4-8 steps), the matrix of cause and effect can be complicated; especially when it is only at the final inspection station that a problem is identified. Although some problems are obvious, many others are not.

Metal Ion Impacts

Soluble metal ion species that are of concern in the complexing and competitive reactions with various dyestuffs and bleaching operations are primarily iron, manganese, and copper. Copper and/or iron often has a dulling effect on various dye colors although the effect varies from dye to dye (1). For example, anthraquinone dyes are particularly metal sensitive. Copper residuals will produce a dull pink shade instead of the normal bright pinkish red when Disperse Red 60 (an anthraquinone dye) is used. Iron will also produce a dulling effect with Disperse Red 60. Table I presents a list of anthraquinone dyes that exhibit varying degrees of interaction when complexed by metal ions (2). Generally, the complexing reaction is one of chelation as described by Figure 1 (2). Manganese produces a brown to black staining of white or dyed cloth. The characteristic color for any one individual dye is a function of the electron distribution in the dye molecule. When this distribution is changed (i.e., chelated), the dye color is subsequently changed (2).

Particulate (insoluble) metal species are a concern to the different types of dyes because of the varying pH values they are applied at. For example, reactive dyes are applied to cotton and other cellulosic fibers under mild alkaline conditions. Particulate metals would not possess the ability to readily chelate with the dyestuff as the soluble species would. Acid dyes are a water soluble anionic class generally applied to nitrogenous fibers such as wool and silk. The metal problem here is compounded by the acid medium required for dye application and the resultant partial or total resolubilization of the particulate metal species.

Soluble and particulate metals in the application of bleaching and scouring is very detrimental. This process basically involves the alkaline boil of

cotton/ poly-cotton with hydrogen peroxide. The alkaline environment precipitates the soluble fraction as a ferric hydroxide, while the particulate iron simultaneously reacts with the hydrogen peroxide to rapidly diminish the peroxide concentration and burn holes in the fabric. The precipitated ferric hydroxide yellows the fabric and renders it unsuitable for further processing. Generally, the spoiled goods are reworked with oxalic acid to remove the iron (ferric hydroxide) stain and rebleached.

TABLE I

ANTHRAQUINONE DYES THAT CHELATE WITH METALS

C.I. Name

Disperse Red   4

Disperse Red   55

Disperse Red   60

Disperse Red   91

Disperse Red   96

Disperse Red   116

Disperse Red   263

Disperse Blue 27

Disperse Blue 56

Disperse Blue 73

Disperse Blue 118

Generally, yellows are insensitive to metals

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ANTHRAQUINONE DYE STRUCTURE
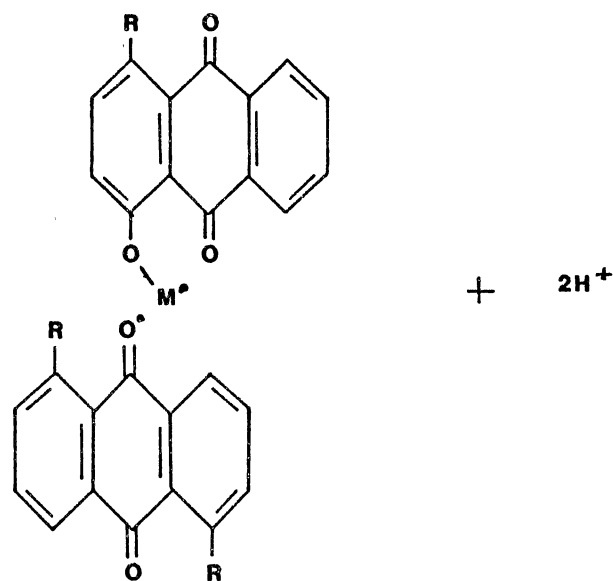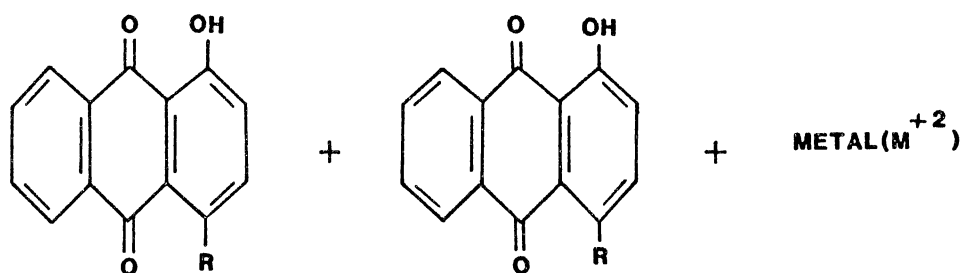
CHELATED RING STRUCTURE

Figure 1. Anthraquinone Dye Chelant Ring
Structure

The source of the soluble and particulate metal concentrations is generally the plant influent water source and, with older dye houses, a considerable quantity can be contributed from corrosion by-products within the iron piping systems. Periodically, water finishing unit processes within a particular facility (i.e., sand filters, zeolite softeners) will contribute slug type quantities because of their ability to concentrate the contaminants. Carryover from the boiler with live steam injection can be a significant but potentially transient condition. Other sources of metal contamination (2) could be the textile fabric (greige) goods and auxiliary chemicals which are added to the processing bath.

Studies conducted by Kowalski (3, 4, 5), Somers and Clark et al. (6) evaluated numerous dye bath and bleaching conditions and the effects of various chelants and sequesterants to control hardness, iron, copper, and manganese. Copper and iron values as low as 0.1 ppm (7) have been found to cause staining in alkaline beam dyeing and jet operations. Bleaching applications were significantly affected by iron values as low as 0.5-1.0 ppm (8).

Metal Ion Control

Metal ion sequestration and/or chelation in the dye bath and bleaching operations is controlled by inactivation of the metal ion by chemical reaction with an organic or inorganic complexing agent to form a ring structure. The most commonly used aminocarboxylate chelant is ethylenediaminetetraacetic acid (EDTA) or nitrilotriacetic acid (NTA). EDTA typically complexes (9) metals similar to the ring structure shown in Figure 2 (9). Other hydroxycarboxylic acid chelants such as citric acid and gluconic acid are commonly used.

Organophosphonates are sequestering agents used primarily in metal cleaning activities but when properly applied will sequester metal ions in a

HO$_2$CCH$_2$ CH$_2$CO$_2$H

NCH$_2$CH$_2$N

HO$_2$CCH$_2$ CH$_2$CO$_2$H
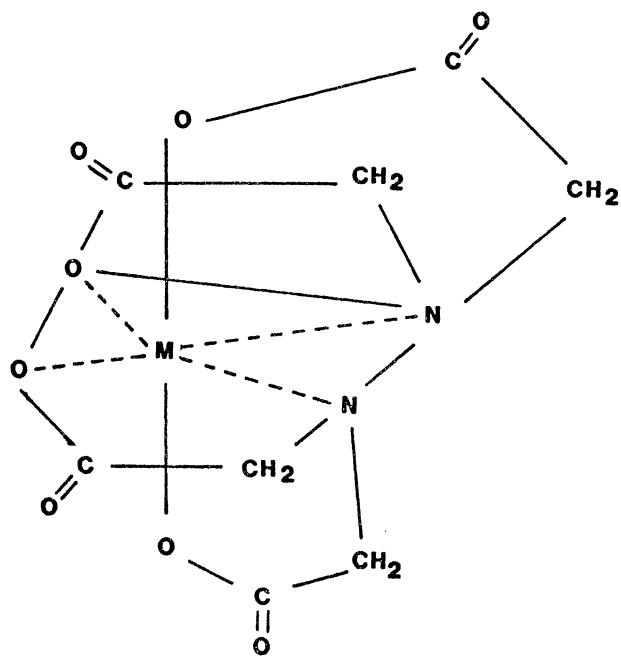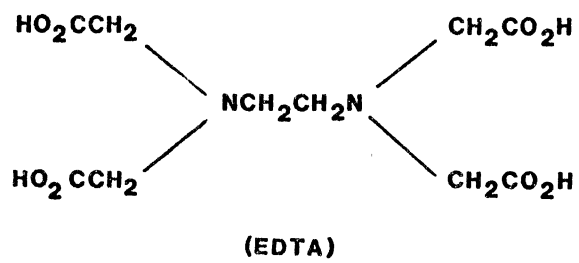
(EDTA)

Figure 2. Metal Chelation by EDTA

process water supply leaving them in a soluble and non-reactive state. An additional physical contribution made by the organophosphonates is that it has the unique ability to protect metal surfaces (i.e.) pipe internals from additional oxidation and corrosion by-product migration) even in the presence of precipitating agents. Chelants and organophosphonates commonly used are listed in Table II.

TABLE II

CHELANTS AND SEQUESTRANTS

Chelants

Hydroxycarboxylic Acid

        Gluconic Acid

        Citric Acid

        Glucoheptonic Acid

Amino Carboxylates

        Nitrilotriacetic Acid (NTA)

        Ethylenedieminetetraacetic Acid (EDTA)

        Diethylenetriaminepentacetic Acid (DTPA)

Organophosphonate Sequestrants

Amino tri (methylene phosphonic acid) - ATMP

1-Hydroxyethylidene - 1, 1-diphosphonic acid - HEDP

Ethylenediamine tetra (methylene phosphonic acid - EDTMP

Hexamethylenediaminetetra (methylenephosphonic acid) - DTPMP

CHAPTER III

MATERIALS AND METHODS

Textile Water Use

Depending upon the size of a particular dye house, the type of equipment being used and the complexity of the dye procedures, a comprehensive water use rate of 8-15 gallons of water per pound of fabric will generally be required. Jet machine non-contact cooling water, unless recovered and reused, can account for a considerable volume of water. When reused, although originally a non-contact cooling water, the potential for corrosion by-product pick-up and oxygen pitting corrosion activity is increased as it travels through the intended cooling process and returns for future use. Typical process areas that require water are shown in Figure 3.

When dealing with the actual dye tub operation, the amount of water required is generally dealt with on a weight ratio of liquid to fabric. Common dyeing liquor ratios are in the neighborhood of 1:100 fabric to water with rinse volumes generally 200-500% greater than the water volume required for dyeing. Liquor ratios of 15 to 20:1 are used when dyeing cottons and cotton blends in open (atmospheric) dye becks.

Piping materials are generally carbon steel but there are several facilities with virtually all copper and stainless steel lines. The corrosion resistant (with the exception of copper) lines that are present in some newer dye houses have been installed to prevent formation of corrosion by-products.

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                    ┌─── FRAMES
                    │
                    ├─── FINISHING
                    │
                    ├─── ATMOSPHERIC DYE TUBS
                    │
                    ├─── JET DYE TUBS (PRESSURE)
                    │
WATER ──────────────┼─── BEAM DYE TUBS
                    │
                    ├─── CHEMICAL MIX
                    │
                    ├─── HEAT EXCHANGES ──────────────┐
                    │                                 │
                    └─── BOILER                       │
                                                POTENTIAL
                                                  REUSE
         │
         └────────────────────────────── SANITARY
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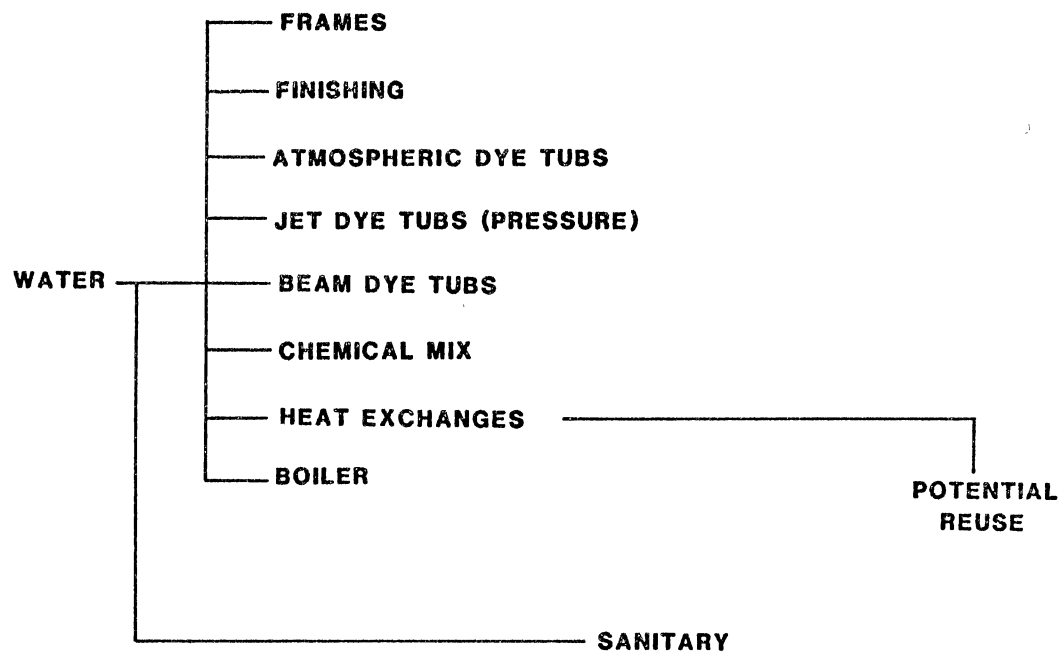
Figure 3.   Textile Water Use Area

Unfortunately, the source(s) of the metallic contaminants were not fully evaluated prior to the expense of installation. The problem can be reduced but, in a case where the contaminant is in the water supply, the problem cannot be eliminated unless the water supply is treated for metal ion removal or sequestration.

Sampling Procedures

Grab samples were collected at various sites in triplicate. One sample was retained and analyzed for conventional parameters such as alkalinity, chlorides, and hardness. One sample was acidified for total metals analysis by addition of 10 drops of concentrated nitric acid. The third sample was filtered through a 0.45 micron Millipore filter and immediately acidified for analysis of soluble metals.

Analytical Procedures

Metals

Metals were determined colorimetrically utilizing a HACH DR II spectrophotometer and procedures outlined in HACH's analytical procedures entitled Water Analysis Handbook (10).

pH

The pH determinations were done by using an Orion Research Model 601A digital ion analyzer pH meter with an Orion combination pH 91-05 electrode.

Conventional Parameters

Conventional parameters analyzed were grouped to include:

>Methyl Orange Alkalinity
>
>Chloride
>
>Total Hardness
>
>Calcium Hardness
>
>Magnesium Hardness
>
>Silica
>
>Sulfate
>
>Orthophosphate

Analysis of the conventional parameters were determined following the procedures outlined in Standard Methods for the Examination of Water and Wastewater (11).

Specific Conductance

Conductivity was determined using a Cambridge Scientific combination conductivity/pH/temperature meter. Standardization was performed using a 1000 micromho conductivity standard.

CHAPTER IV

ANALYTICAL RESULTS AND DISCUSSIONS

Dye House A

Dye House A is a commissioned facility that dyes and finishes textile products for clothing manufacturers that are commonly referred to as cut and sew operations. A broad spectrum of dye colors and dye types are utilized that necessitates a large amount of water.

Plant A draws a total of 1.8-2.0 mgd process water from three separate sources; city water supply, an on-site deep well, and the nearby Swatara Creek. The city water supply is a blended source that is flow-proportioned from Black Creek and Adams Run Reservoirs by the city in an attempt to achieve acceptable iron and manganese values for potable consumption and use. Blending by the city is often required due to the acid mine drainage in the vicinity of the Black Creek Reservoir and the subsequent contamination that results. Figure 4 shows the area where the two city water sources are drawn from. The manganese content of the city water was often zero but never found to exceed 0.3 mg/L. The iron concentration of the city water was relatively low and generally found to range from 0.2-0.4 mg/L. The iron concentration that was detected was determined to be primarily in the soluble state. Dye House A water requirements from the city water supply are restricted to 600,000-650,000 gallons per day resulting in a mandatory water usage of approximately 1.4 mgd from the other two plentiful, but inferior, supply sources.
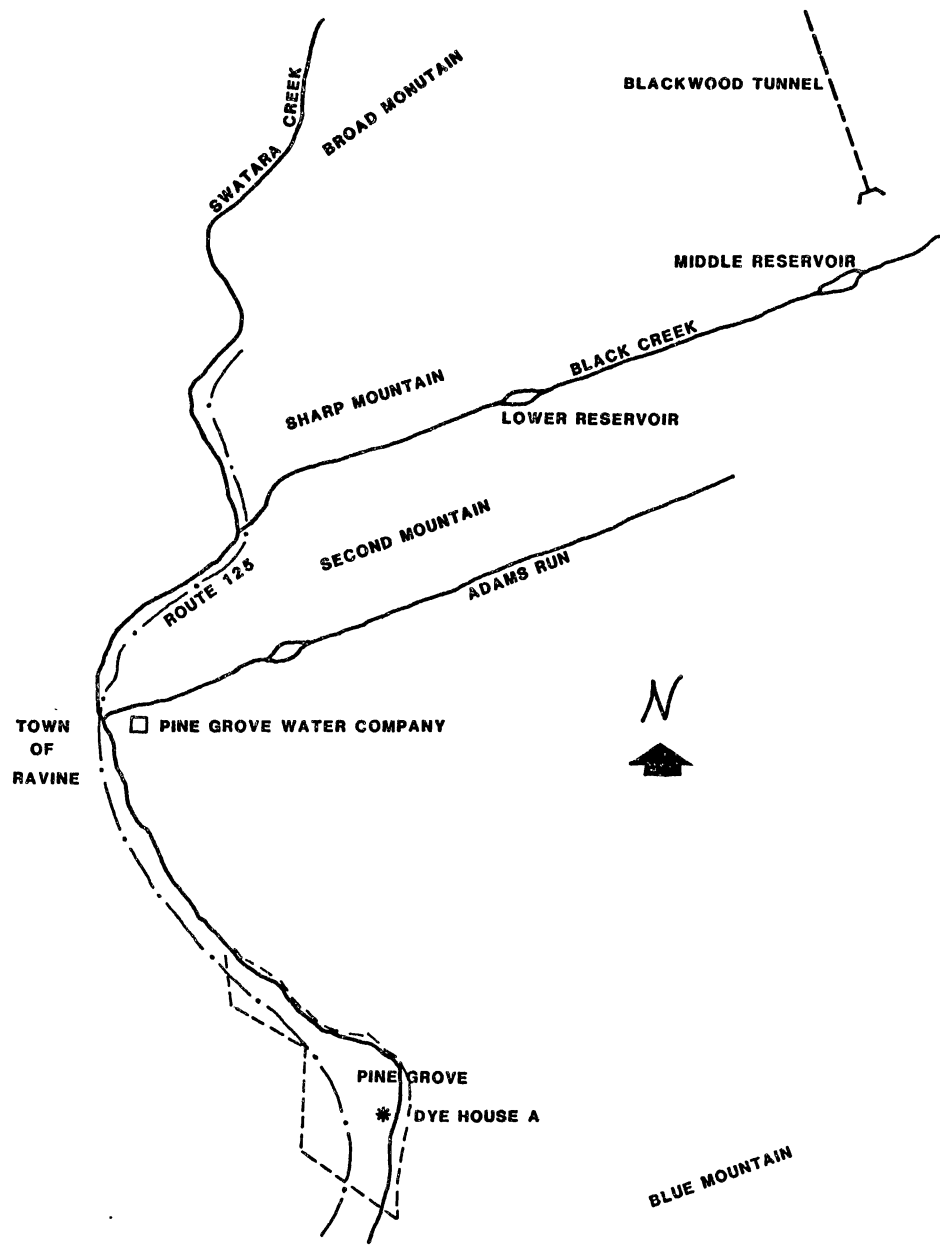
Figure 4. Area of Study - Dyehouse A

The well water analysis shows a poor water supply. Filtration through a 0.45 micron filter showed extremely high levels of filterable solids with an iron content ranging from 0.7-1.2 mg/L. The manganese concentrations ranged from 0.7-1.3 mg/L. Both the iron and manganese contents were found to be primarily in the soluble form. Plant usage requirements of the well water averaged 300,000-350,000 gpd.

The creek water iron and manganese concentrations were highly transient, exhibiting values of 0.13-1.1 mg/L iron and 0.4-2.5 mg/L of manganese. The iron content was found to be primarily particulate (insoluble) in form and could be removed by 8-10 micron filtration.

Table III presents a summary range of the iron and manganese concentrations found in the three water supplies used by Dye House A. Tables IV, V, and VI present the summary data for the conventional water quality criteria of the city, well, and creek water supplies, respectively. Appendix A presents the individual data collected from selected sources and samples.

TABLE III

METALS SUMMARY FROM DYE HOUSE A PROCESS WATER SUPPLIES

Source	Iron (ppm) Total	Soluble	Manganese (ppm) Total	Soluble
City Water	0.2-0.4	0.2-0.4	0.0-0.3	0.0-0.3
Plant Blended	0.3-0.9	0.15-0.7	0.1-0.5	0.1-0.5
Well Water	0.7-2.5	0.5-2.0	0.7-1.3	0.7-1.3
Creek Water	0.13-1.1	0.05-0.15	0.4-2.5	0.4-2.5

TABLE IV

DYEHOUSE A WATER QUALITY DATA SUMMARY
CITY WATER SUPPLY

Determination	Minimum Value	Maximum Value	Average Value	Number of Samples Analyzed
pH	5.34	7.5	5.9	18
Specific Conductance, micromhos 25C	23	44	32	18
Methyl Orange Alkalinity as $CaCO_3$, ppm	14	26	20	18
Chloride as Cl, ppm	6	10	9	18
Total Hardness as $CaCO_3$, ppm	8	40	25	18
Calcium as $CaCO_3$, ppm	6	14	9	18
Magnesium as $CaCO_3$, ppm	28	2	16	18
Silica as SiO_2, ppm	3.0	4.2	3.7	18
Sulfate as SO_4, ppm	3	7	5.8	18
Ortho Phosphate as PO_4, ppm	0	1.9	1.2	18
Total Copper as Cu, ppm	0	0.11	0.06	8
Total Iron as Fe, ppm	0.19	0.35	0.30	18
Soluble Iron as Fe, ppm	0.09	0.25	0.17	18
Total Manganese as Mn, ppm	0	0.3	0.1	18
Soluble Manganese as Mn, ppm	0	0.3	0.1	18

TABLE V

DYEHOUSE A WATER QUALITY DATA SUMMARY
WELL WATER SUPPLY

Determination	Minimum Value	Maximum Value	Average Value	Number of Samples Analyzed
pH	6.36	7.3	6.8	18
Specific Conductance, micromhos 25C	360	480	460	18
Methyl Orange Alkalinity as $CaCO_3$, ppm	150	165	162	18
Chloride as Cl, ppm	20	28	24	18
Total Hardness as $CaCO_3$, ppm	148	150	149	18
Calcium as $CaCO_3$, ppm	105	120	110	18
Magnesium as $CaCO_3$, ppm	28	45	39	18
Silica as SiO_2, ppm	12	15	11.7	18
Sulfate as SO_4, ppm	45	64	52	18
Ortho Phosphate as PO_4, ppm	1.75	2.6	2.2	18
Total Copper as Cu, ppm	0	0.9	0.2	8
Total Iron as Fe, ppm	0.72	2.5	1.75	18
Soluble Iron as Fe, ppm	0.60	2.2	1.55	18
Total Manganese as Mn, ppm	0.5	1.2	1.1	18
Soluble Manganese as Mn, ppm	0.5	1.2	1.1	18

TABLE VI

DYEHOUSE A WATER QUALITY DATA SUMMARY
CREEK WATER SUPPLY

Determination	Minimum Value	Maximum Value	Average Value	Number of Samples Analyzed
pH	6.01	7.12	7.05	18
Specific Conductance, micromhos 25C	185	190	188	18
Methyl Orange Alkalinity as $CaCO_3$, ppm	16	24	20	18
Chloride as Cl, ppm	14	18	16	18
Total Hardness as $CaCO_3$. ppm	82	92	86	18
Calcium as $CaCO_3$	32	36	34	18
Magnesium as $CaCO_3$	50	56	52	18
Silica as SiO_2, ppm	4.0	5.5	5.0	18
Sulfate as SO_4, ppm	4.0	5.5	4.6	18
Ortho Phosphate as PO_4, ppm	0.9	2.3	1.75	18
Total Copper as Cu, ppm	0	0	0	8
Total Iron as Fe, ppm	0.4	2.72	1.8	18
Soluble Iron as Fe, ppm	0.05	0.9	0.66	18
Total Manganese as Mn, ppm	0.7	1.2	1.0	18
Soluble Manganese as Mn, ppm	0.3	0.9	0.5	18

Table III also presents a fourth water source which is a supply blended internally by the plant on a flow proportioned basis. During periods of drought and/or forced conservation by the city, a proportioning ratio of 2:1 well to city is often used. With normal periods of precipitation and an abundant supply, a greater use of the city water is allowed, resulting in well water to city water ratios of 1:1 to 1:2. Analysis of the iron and manganese data shown in Table III clearly shows the need to conduct a blending of the well water. The city water is obviously the best water supply available but can be an unreliable source due to previous water use restrictions. City water iron and manganese values are relatively low although the Swatara Creek is a common source for both the city and Dye House A. The city water is chlorinated and with a suitable contact time in the distribution system the iron and manganese are oxidized and subsequently reduced in concentration. Periods of high demand have caused problems in the past due to the increased water velocity and the subsequent scouring effect. Iron and manganese sludges are periodically swept into the plant requiring extensive line flushes and rework of stained goods. Water lines with relatively low flows and/or only periodic usage experience post precipitation of the iron and manganese in the water lines. A sludge was often seen deposited on white goods and has been analytically confirmed to be predominately iron and manganese.

Data shown in Table III were collected and analyzed during a period of time that Dye House A exhibited a finished fabric rejection rate in excess of 23%. Rejects are expected and considered to be normal when held at a 2%-5% fabric weight value for any particular textile manufacturing day. A five percent value is generally the upper limit and is not acceptable if a rejection rate at this level is maintained for a period of five or more days. Sludge and slough-off from piping internals were obvious problems but dyeing problems

continued with, what appeared to be, good water. Operating personnel were being implicated and several chemical manufacturing firms stood to lose a considerable amount of business, since the dye assist and auxiliaries were being questioned as to their involvement. Preliminary suspicions were brought to light when a plant water supply sample was filtered through a 0.45 micron millipore filter and a considerable amount of suspended, but not visually apparent, material was retained. Metals analysis confirmed that a majority of the dyeing problems were a result of high concentrations of iron and manganese.

Dye House B

Dye House B is a smaller commissioned dye house similar to Dye House A, previously described, in that its operation consists of bleaching, dyeing, and finishing. The dissimilar facts are that Dye House B is older by approximately forty years, consumes only 700,000 gallons of water per day, has a schedule 80 carbon steel piping distribution system with an incoming line pressure of 150 psig and has installed a heat recovery system and revenue sharing concept marketed by Time Energy Systems of Houston, Texas.

The heat recovery process consists of a 4-pass shell and tube heat exchanger, followed by a counter flow direct contact stainless steel KEMCO stack gas economizer, for recovery of waste heat from the boiler exhaust gases. The boiler was a 700 horsepower Cleaver Brooks fire tube unit burning natural gas. Operationally, the combustion gases enter the bottom of the KEMCO unit while water that had been preheated in the shell and tube bundle entered the top of the economizer. Stainless steel packing provided the necessary gas to water surface area for maximum heat transfer. From the storage section of the economizer, the hot water was pumped to a 30,000 gallon

insulated storage tank for future distribution and use by the dye house. Figure 5 schematically traces the heat recovery system.

With the exception of the stainless steel economizer and fill, all of the piping throughout the dye house was carbon steel. New sections of carbon steel lines were installed to distribute cold water to the dye house but the design of the heat reclamation system called for the hot water to be introduced into and conveyed by the old cold water lines. Pneumatic mixing valves supplied the necessary cold, hot, or tempered water at each dye machine.

Start-up of the system commenced with a standard water flush of the new equipment for approximately one hour, at which time the hot water from the economizer was then sent to storage for dye house use. Almost immediately, the dye house experienced rust-laden water to the degree that the water was virtually orange. In addition to the chelation of dye stuffs in the dye house, the kier bleaching operation was seriously affected due to the iron deposition that took place on the bleached or white cloth being processed. Several thousand pounds of fabric were burned by particulate iron that loosened from the old cold water pipes and reacted with the bleaching hydrogen peroxide solution. The alkaline condition that the bleach process takes place in also precipitated soluble iron as ferric hydroxide. When the kier solution was circulated, the top layers of the cloth filtered the hydroxide sludge out, subsequently staining the cloth. Basket filters with one (1) micron bag filters were installed to help eliminate the problem. Although somewhat successful for particulate iron, the filters did nothing to reduce the soluble iron staining problem of the white cloth.

Examination of the iron and pH data shown in Table VII and Figure 6 shows a significant increase in both the total and soluble iron concentrations in the hot water supply. Corresponding pH values in the hot water dropped a full
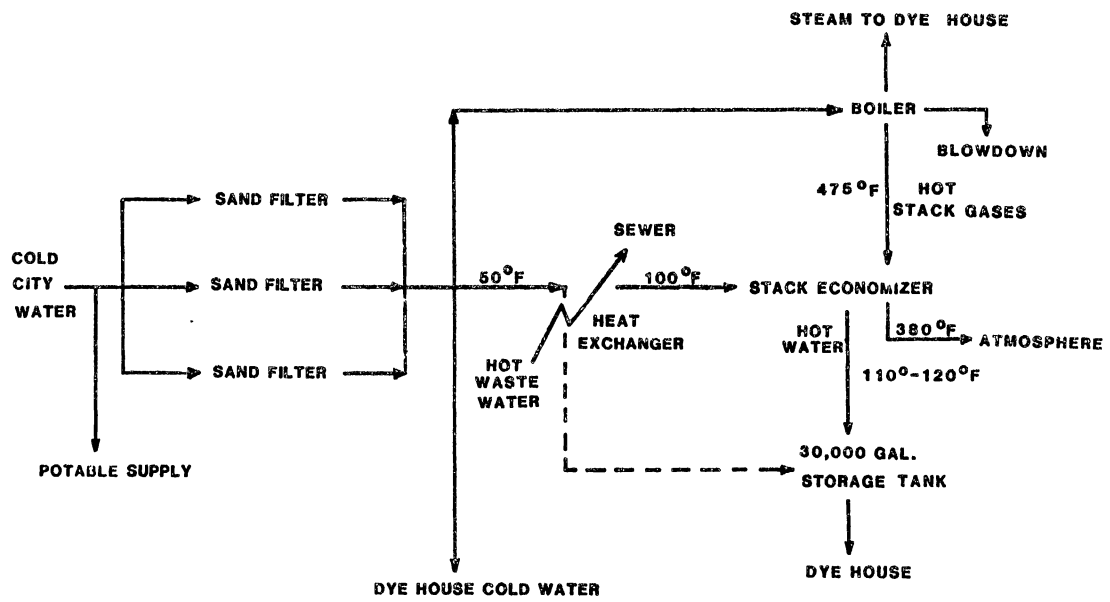
Figure 5. Dye House B Hot Water Reclamation Flow Schematic

TABLE VII

DYE HOUSE B KIER IRON AND pH CONCENTRATION SUMMARY

		PPM IRON	pH
March 23, 1985			
City Water	(T)	0.20	6.39
	(S)	0.13	
Filtered City Water	(T)	0.25	6.44
	(S)	0.8	
Kier Filter	(T)	0.11	6.45
	(S)	0.10	
Kier H.W. Supply	(T)	1.20	5.54
	(S)	1.15	
#3 Kier C.W. (F)	(T)	0.21	6.49
	(S)	0.12	
#3 Kier H.W. (F)	(T)	1.18	5.62
	(S)	1.05	
#3 Kier H.W. (UF)	(T)	1.30	5.67
	(S)	0.80	
#7 Kier C.W. (UF)	(T)	0.22	6.41
	(S)	0.18	
#7 Kier H.W. (UF)	(T)	1.15	5.58
	(S)	0.38	
#8 Kier C.W. (F)	(T)	0.21	6.44
	(S)	0.10	
#8 Kier H.W. (F)	(T)	1.15	5.61
	(S)	1.05	
#8 Kier H.W. (UF)	(T)	1.20	5.56
	(S)	0.75	
Kier "Still"[1] H.W.	(T)	0.80	5.84
	(S)	0.18	

LEGEND: (S) = Soluble; (T) = Total; (F) = 1.0 micron filter at Kier; (UF) = unfiltered at Kier; [1] "Still" = Hot water that was allowed to cool on standing in pipe.
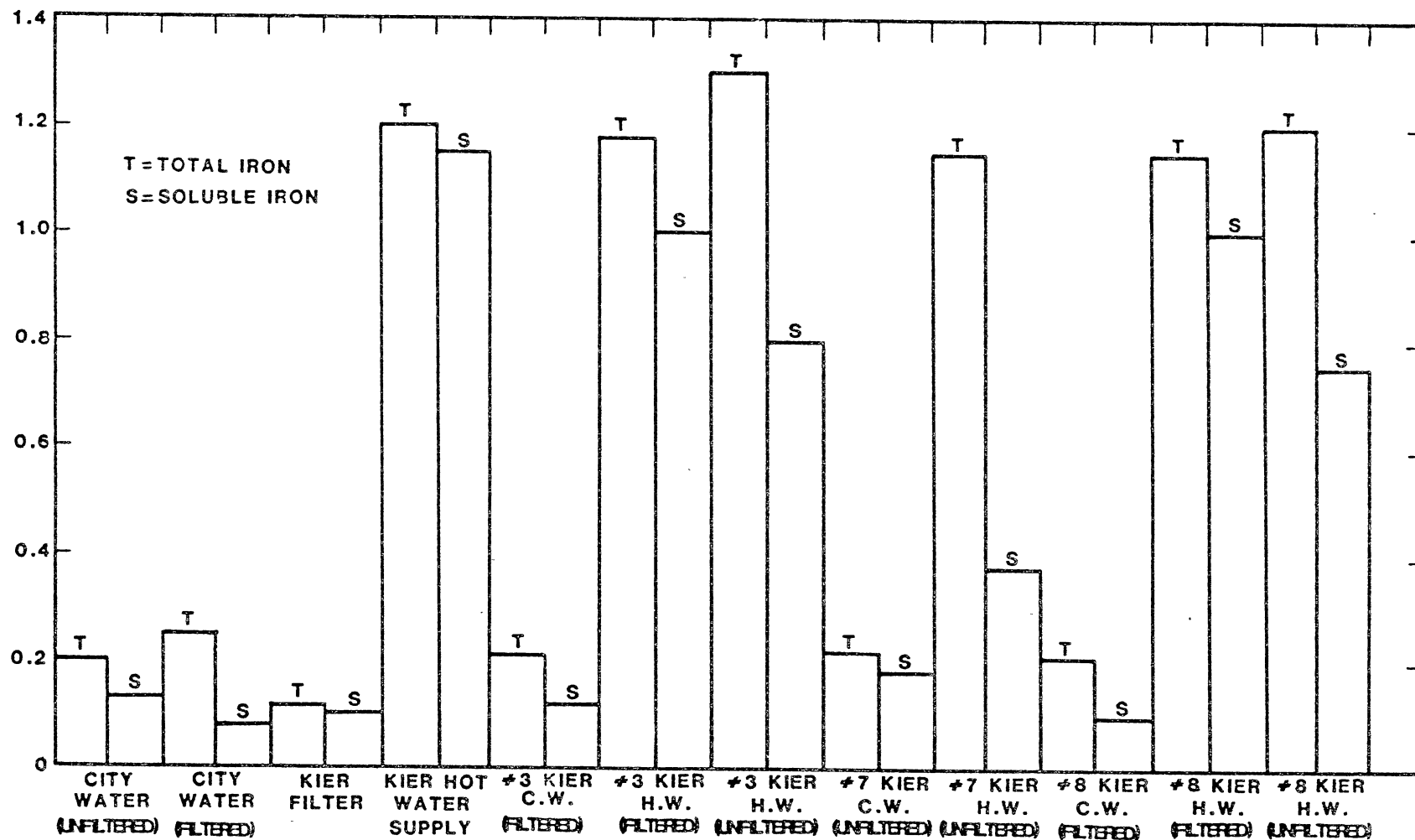
Figure 6.   Dye House B. Iron Levels – Bleach Kier Water System

pH unit or more after passing through the stack gas economizer resulting in a hot, acidic water supply. Table VIII shows a summary of the pH values at ten separate dye house water supply stations over a six-day period that the stack gas economizer was being operated. Table IX presents the total and soluble iron data collected at the ten water stations over the same six-day period, whereas Table X presents the conventional water quality summary of the city water supply. Total iron values were observed to range from 0.2 ppm in the cold water supply to 1.3 ppm in the kier hot water supply. Corresponding low pH values coincided with elevated iron values throughout the facility. Comprehensive water quality data on selected sources and samples can be found in Appendix B.

An explanation for the drop in pH and increase in iron concentration lies in the operational principle of the gas economizer. In any other application, the gas economizer would be called a gas scrubber. With the direct contact relationship of the boiler flue gas and the intended hot water, it became apparent that the low alkaline water scrubbed the carbon dioxide out of the flue gas forming carbonic acids. Sulfur was a suspect in forming sulfuric acid, but the sulfur content of the natural gas was considered to be too low to be a major contributor.

In order to test the hypothesis that the economizer was the source of the low pH water, the economizer was by-passed and non-contact hot water was sampled. Iron and pH values of the non-contact water were unchanged before and after heat reclamation.

TABLE VIII

DYE HOUSE B PH VALUES SUMMARY

Sample Location	1/28/85	2/9/85	2/10/85	2/11/85	2/26/85	3/19/85
City Water	6.21	5.95	6.22	6.50	6.01	6.31
Filtered City Water	6.00	6.00	6.22	6.45	6.00	6.26
Stack Gas Econ.	4.22	3.98	3.64	4.07	4.21	5.14
Hot Water Storage Tk.	4.03	5.44	4.50	4.42/4.43	4.25	5.35
Beck Hot Water	4.00	4.67	4.40	3.80/4.60	4.29	5.44
Bleach Mix C.W.	6.25	6.10	6.13	6.40	6.10	6.25
Wet Floor Mix H.W.	3.99	4.50	4.89	4.14	4.85	5.39
Jet H.W. Supply	4.00	4.20	4.26	4.25	4.31	5.41
Bucket Station C.W.	6.15	6.10	6.38	6.31	6.05	6.77
Heat Exchanger Inlet	6.10	6.00	6.20	6.40	5.37	6.69

LEGEND: C.W. = Cold Water; H.W. = Hot Water; (F) = Filtered at Kier;
(UF) = Unfiltered at Kier;
"Still" = Hot water that was allowed to cool on standing in pipe

TABLE IX

## DYE HOUSE B IRON CONCENTRATIONS SUMMARY B (PPM)

Sample Location		1/28/85	2/9/85	2/10/85	2/11/85	2/26/85	3/19/85
Cold City Water	(T)	0.19	0.16	0.10	0.15	0.18	0.16
	(S)	0.06	0.18	0.05	0.03	0.05	0.04
Cold Filtered	(T)	0.22	0.19	0.08	0.11	0.11	0.11
City Water	(S)	0.03	0.02	0.01	0.02	0.08	0.05
Stack Gas Econ.	(T)	1.4	0.29/1.0	1.0	0.33	0.75	0.18
H.W.	(S)	1.1	0.19/0.80	0.80	0.21	0.59	0.09
H.W. Storage Tk	(T)	0.70	0.48/0.22	0.95	0.39	0.42	0.38
	(S)	0.42	0.36/0.18	0.60	0.21	0.31	0.22
Jet Mix Tank H.W.	(T)	0.24	0.65	0.78	0.55	0.69	0.49
	(S)	0.19	0.48	0.55	0.30	0.49	0.28
Floor Mix H.W.	(T)	0.48	0.90	0.80	0.36	0.66	0.82
	(S)	0.36	0.80	0.40	0.11	0.24	0.20
Beck H.W.	(T)	0.18	0.50/0.52	1.2	0.42	0.95	0.41
	(S)	0.09	0.45/0.30	0.90	0.24	0.52	0.30
Kier C.W.	(T)	0.13	0.16	0.14	0.15	0.32	0.20
	(S)	0.05	0.06	0.04	0.04	0.11	0.11
Bleach Mix C.W.	(T)	0.48	0.14	0.49	0.18	0.09	0.16
	(S)	0.10	0.04	0.10	0.09	0.03	0.06
C.W. Bucket	(T)	0.19	0.16	0.21	0.11	0.11	0.18
Station	(S)	0.06	0.08	0.08	0.06	0.06	0.09
Heat Exchanger Inlet	(T)	0.20	0.22	0.20	0.18	0.14	0.12
Cold Water	(S)	0.10	0.18	0.10	0.05	0.06	0.07

LEGEND: (T) = Total; (S) = Soluble; H.W. = Hot Water; C.W. = Cold Water

TABLE X

DYEHOUSE B WATER QUALITY DATA SUMMARY
CITY WATER SUPPLY

Determination	Minimum Value	Maximum Value	Average Value	Number of Samples Analyzed
pH	6.3	6.9	6.6	25
Specific Conductance, micromhos 25C	23	35	28	25
Methyl Orange Alkalinity as $CaCO_3$, ppm	18	26	23	25
Chloride as Cl, ppm	6	8	7	25
Total Hardness as $CaCO_3$, ppm	8	12	9	25
Calcium as $CaCO_3$, ppm	6	8	7	25
Magnesium as $CaCO_3$, ppm	2	4	2	25
Silica as SiO_2, ppm	1.4	1.8	1.5	25
Sulfate as SO_4, ppm	6	8	6.4	25
Ortho Phosphate as PO_4, ppm	0.2	0.5	0.3	25
Total Copper as Cu, ppm	0	0	0	10
Total Iron as Fe, ppm	0.05	0.14	0.09	25
Soluble Iron as Fe, ppm	0.03	0.11	0.07	25
Total Manganese as Mn, ppm	0	0	0	10
Soluble Manganese as Mn, ppm	0	0	0	10

CHAPTER V

SUMMARY AND CONCLUSIONS

Dye House A

Commencing February 12, 1985, Dye House A began to experience a considerable number of product rejects. Up until this date, the production rework record was stable and had hit a monthly low of two percent.

With the exception of particulate contamination (sludge) observed on the fabric, an initial in-house investigation was unsuccessful in identifying the source of the problem(s). Subsequent metals analysis revealed a transient and unusually high level of iron and manganese in the Swatara Creek and well water. Speculation of why the increase was so abrupt was attributed to the low quantity of precipitation and a subsequent fall in the surface and groundwater water tables. This, theoretically, induced a concentrating factor of the contaminants normally found in the water supplies. Although the concentration activity was progressive, the overall impact on the production activities was rather abrupt.

Recommendations for an interim and long-term solution would include the following:

1. Addition of a chelant to the dye bath for sequestration of the iron and manganese before the dye chemicals are added.

2. Injection of a sequestrant to the water supply at each of the plant sources.

3. Installation of an iron and manganese removal system.

4. Investigate areas of water conservation and reuse.

Dye House B

High iron concentrations in the dye house hot water supply were identified as a direct result of the start-up of the stack gas economizer. Gas scrubbing of the carbon dioxide and carbonic acid formation was apparently responsible for the low pH values. Since pH and iron values of the non-contact hot water remained at levels equal to the incoming city water, the induced problem was obviously the economizer.

Recommendations that should be considered for a remedial and long-term solution would include the following:

1. Abandon the stack gas economizer.

2. Install a pH control system to adjust the final pH of the economizer produced hot water supply.

3. Inject a sequestrant to the water supply to inhibit the removal of iron corrosion by-products and chelate the iron present.

4. Use excess in-bath sequestrants and dispersants.

5. Redesign the water distribution system so that the new piping network distributes hot water instead of the hot water being in the old cold water lines.

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APPENDIXES

APPENDIX A

DYEHOUSE A WATER QUALITY DATA

DYEHOUSE A WATER QUALITY DATA
CITY WATER SUPPLY

Determination	1985 Sample Data			
	5-28	5-29	6-10	6-11
pH	6.11	7.3	7.5	5.34
Specific Conductance, micromhos 25C	28	42	44	28
Methyl Orange Alkalinity as $CaCO_3$, ppm	22	20	18	14
Chloride as Cl, ppm	6	6	8	8
Total Hardness as $CaCO_3$, ppm	40	8	14	22
Calcium as $CaCO_3$, ppm	12	6	6	8
Magnesium as $CaCO_3$, ppm	28	2	8	14
Silica as SiO_2, ppm	3.5	3.5	3.0	3.4
Sulfate as SO_4, ppm	7	7	6	6
Ortho Phosphate as PO_4, ppm	1.7	1.8	1.9	1.6
Total Copper as Cu, ppm	0	0	0.1	0
Total Iron as Fe, ppm	0.33	0.26	0.35	0.30
Soluble Iron as Fe, ppm	0.21	0.15	0.25	0.23
Total Manganese as Mn, ppm	0	0.1	0	0
Soluble Manganese as Mn, ppm	0	0.1	0	0

DYEHOUSE A WATER QUALITY DATA
CITY WATER SUPPLY

Determination	1985 Sample Data			
	6-22	6-25	6-26	6-28
pH	5.43	5.68	6.23	6.10
Specific Conductance, micromhos 25C	23	29	30	26
Methyl Orange Alkalinity as $CaCO_3$, ppm	26	20	24	26
Chloride as Cl, ppm	10	8	12	10
Total Hardness as $CaCO_3$, ppm	38	26	32	30
Calcium as $CaCO_3$, ppm	10	14	15	15
Magnesium as $CaCO_3$, ppm	28	12	17	15
Silica as SiO_2, ppm	3.4	4.2	3.6	2.9
Sulfate as SO_4, ppm	3	3	2.5	3
Ortho Phosphate as PO_4, ppm	0	0.6	0.5	0.6
Total Copper as Cu, ppm	0.11	0	0	0
Total Iron as Fe, ppm	0.19	0.3	0.26	0.17
Soluble Iron as Fe, ppm	0.09	0.2	0.16	0.08
Total Manganese as Mn, ppm	0.3	0	0.08	0.
Soluble Manganese as Mn, ppm	0.3	0	0.08	0

DYEHOUSE A WATER QUALITY DATA
CREEK WATER SUPPLY

Determination	1985 Sample Data			
	5-28	5-29	6-10	6-11
pH	6.01	5.23	7.01	7.10
Specific Conductance, micromhos 25C	190	185	191	195
Methyl Orange Alkalinity as $CaCO_3$, ppm	18	16	20	20
Chloride as Cl, ppm	18	14	14	16
Total Hardness as $CaCO_3$, ppm	92	86	84	82
Calcium as $CaCO_3$, ppm	36	36	34	34
Magnesium as $CaCO_3$, ppm	56	50	50	48
Silica as SiO_2, ppm	5.2	5.5	5.0	4.5
Sulfate as SO_4, ppm	75	78	80	75
Ortho Phosphate as PO_4, ppm	1.2	0.9	1.0	1.4
Total Copper as Cu, ppm	0	0	0	0
Total Iron as Fe, ppm	2.4	2.72	1.0	1.0
Soluble Iron as Fe, ppm	0.6	0.82	0.4	0.1
Total Manganese as Mn, ppm	1.2	1.2	0.8	0.8
Soluble Manganese as Mn, ppm	0.8	0.9	0.4	0.6

DYEHOUSE A WATER QUALITY DATA
CREEK WATER SUPPLY

Determination	1985 Sample Data			
	6-22	6-25	6-26	6-28
pH	7.10	4.98	7.51	7.71
Specific Conductance, micromhos 25C	180	197	207	209
Methyl Orange Alkalinity as $CaCO_3$, ppm	36	22	30	30
Chloride as Cl, ppm	12	12	12	14
Total Hardness as $CaCO_3$, ppm	80	76	80	74
Calcium as $CaCO_3$, ppm	52	46	48	46
Magnesium as $CaCO_3$, ppm	28	30	32	28
Silica as SiO_2, ppm	4.4	5.2	4.0	4.0
Sulfate as SO_4, ppm	61	68	70	71
Ortho Phosphate as PO_4, ppm	0.7	1.4	1.2	1.0
Total Copper as Cu, ppm	0.09	0.1	0	0
Total Iron as Fe, ppm	0.13	2.0	1.0	1.15
Soluble Iron as Fe, ppm	0.05	1.0	0.09	0.09
Total Manganese as Mn, ppm	0.4	0.9	0.6	1.0
Soluble Manganese as Mn, ppm	0.4	0.8	0.4	1.0

DYEHOUSE A WATER QUALITY DATA
CREEK WATER SUPPLY

Determination	1985 Sample Data			
	7-10	7-11	7-15	7-16
pH	7.51	7.71	7.6	7.34
Specific Conductance, micromhos 25C	207	207	204	28
Methyl Orange Alkalinity as $CaCO_3$, ppm	30	30	32	24
Chloride as Cl, ppm	12	14	12	12
Total Hardness as $CaCO_3$, ppm	80	74	102	92
Calcium as $CaCO_3$, ppm	48	46	50	44
Magnesium as $CaCO_3$, ppm	32	28	52	48
Silica as SiO_2, ppm	4	4	4	4
Sulfate as SO_4, ppm	78	71	68	70
Ortho Phosphate as PO_4, ppm	1.2	1.0	1.8	1.2
Total Copper as Cu, ppm	0	0	0	0
Total Iron as Fe, ppm	1.0	1.15	0.78	0.53
Soluble Iron as Fe, ppm	0.09	0.15	0.09	0.07
Total Manganese as Mn, ppm	0.6	1.0	0.6	0.6
Soluble Manganese as Mn, ppm	0.4	1.0	0.6	0.6

DYEHOUSE A WATER QUALITY DATA
WELL WATER SUPPLY

Determination	1985 Sample Data			
	5-28	5-29	6-10	6-11
pH	6.36	7.1	7.3	6.5
Specific Conductance, micromhos 25C	360	443	480	450
Methyl Orange Alkalinity as $CaCO_3$, ppm	150	165	162	155
Chloride as Cl, ppm	24	20	20	24
Total Hardness as $CaCO_3$, ppm	150	149	150	148
Calcium as $CaCO_3$, ppm	110	110	105	110
Magnesium as $CaCO_3$, ppm	40	39	45	38
Silica as SiO_2, ppm	11	15	12	11.6
Sulfate as SO_4, ppm	64	50	45	55
Ortho Phosphate as PO_4, ppm	2.5	1.9	2.0	1.75
Total Copper as Cu, ppm	0.09	0	0	0.05
Total Iron as Fe, ppm	0.72	2.5	1.5	1.9
Soluble Iron as Fe, ppm	0.60	2.2	0.9	1.0
Total Manganese as Mn, ppm	0.7	1.2	0.5	1.1
Soluble Manganese as Mn, ppm	0.7	1.2	0.5	1.1

DYEHOUSE A WATER QUALITY DATA
WELL WATER SUPPLY

Determination	1985 Sample Data			
	6-22	6-25	6-26	6-28
pH	6.8	6.9	6.75	6.85
Specific Conductance, micromhos 25C	464	395	443	451
Methyl Orange Alkalinity as $CaCO_3$, ppm	145	155	149	156
Chloride as Cl, ppm	22	28	26	22
Total Hardness as $CaCO_3$, ppm	149	148	149	150
Calcium as $CaCO_3$, ppm	109	120	120	121
Magnesium as $CaCO_3$, ppm	40	28	29	29
Silica as SiO_2, ppm	14	15	15	15
Sulfate as SO_4, ppm	60	61	60	61
Ortho Phosphate as PO_4, ppm	2.6	2.0	2.4	2.2
Total Copper as Cu, ppm	0.05	0	0	0
Total Iron as Fe, ppm	0.9	1.2	1.2	1.0
Soluble Iron as Fe, ppm	0.8	0.5	0.8	0.9
Total Manganese as Mn, ppm	0.9	1.2	1.1	1.0
Soluble Manganese as Mn, ppm	0.8	1.1	1.1	1.0

DYEHOUSE A WATER QUALITY DATA
BLENDED WATER SUPPLY

Determination	1985 Sample Data			
	5-28	5-29	6-10	6-11
pH	6.41	6.25	6.50	6.80
Specific Conductance, micromhos 25C	120	125	122	136
Methyl Orange Alkalinity as $CaCO_3$, ppm	52	48	50	51
Chloride as Cl, ppm	14	14	12	14
Total Hardness as $CaCO_3$, ppm	48	56	60	44
Calcium as $CaCO_3$, ppm	44	40	45	40
Magnesium as $CaCO_3$, ppm	4	16	15	4
Silica as SiO_2, ppm	5	4.8	5	4.9
Sulfate as SO_4, ppm	18	16	18	20
Ortho Phosphate as PO_4, ppm	2	2.1	1.9	1.0
Total Copper as Cu, ppm	0	0.1	0	0.4
Total Iron as Fe, ppm	0.39	0.23	0.32	0.39
Soluble Iron as Fe, ppm	0.26	0.18	0.28	0.30
Total Manganese as Mn, ppm	0.1	0.1	0.5	0.3
Soluble Manganese as Mn, ppm	0.1	0.1	0.5	0.3

DYEHOUSE A WATER QUALITY DATA
BLENDED WATER SUPPLY

Determination	1985 Sample Data			
	6-22	6-25	6-26	6-28
pH	6.21	6.40	6.36	6.42
Specific Conductance, micromhos 25C	120	122	128	126
Methyl Orange Alkalinity as $CaCO_3$, ppm	51	48	46	50
Chloride as Cl, ppm	12	16	14	15
Total Hardness as $CaCO_3$, ppm	50	48	51	50
Calcium as $CaCO_3$, ppm	41	40	41	42
Magnesium as $CaCO_3$, ppm	9	8	10	8
Silica as SiO_2, ppm	4.9	5.0	5.0	4.8
Sulfate as SO_4, ppm	16	18	16	17
Ortho Phosphate as PO_4, ppm	1.5	2.1	1.3	1.7
Total Copper as Cu, ppm	0	1.2	0	0
Total Iron as Fe, ppm	0.5	0.44	0.36	0.39
Soluble Iron as Fe, ppm	0.3	0.15	0.14	0.09
Total Manganese as Mn, ppm	0.1	0.1	0.2	0.1
Soluble Manganese as Mn, ppm	0.1	0	0	0.1

APPENDIX B

DYEHOUSE B WATER QUALITY DATA

DYEHOUSE B WATER QUALITY DATA

Date: January 1, 1985

Determination	City Water	Plant Filtered City Water	Sample Point Stack Gas Tank	Hot Water Tank	#17 Mix Tank
pH	6.21	6.00	4.22	4.03	--
Specific Conductance, micromhos 25C	26	24	28	28	--
Methyl Orange Alkalinity as $CaCO_3$, ppm	12	20	18	16	--
Chloride as Cl, ppm	4	8	8	14	--
Total Hardness as $CaCO_3$ ppm	20	36	28	26	--
Calcium as $CaCO_3$, ppm	12	10	22	12	--
Magnesium as $CaCO_3$, ppm	8	26	6	14	--
Silica as SiO_2, ppm	1.3	1.9	1.8	1.8	--
Sulfate as SO_4, ppm	2	4	3	2	--
Ortho Phosphate as PO_4 pm	0.5	0.8	0.7	0.5	--
Total Copper as Cu, ppm	0.02	0	--	0	0.5
Total Iron as Fe, ppm	0.19	0.22	1.4	0.70	0.24
Soluble Iron as Fe, ppm	0.06	0.03	1.1	0.42	0.19
Total Manganese as Mn, ppm	0	0	--	0	0
Total Aluminum as Al, ppm	0.08	0.03	--	0	0
Soluble Copper as Cu, ppm	0.02	0	0	0	--
Soluble Manganese as Mn, ppm	0	0	0.1	0	--
Soluble Aluminum as Al, ppm	0	0	0	0	--

DYEHOUSE B WATER QUALITY DATA

Date: <u>February 9, 1985</u>

Determination	City Water	Stack Econ.	Stack Econ. Filter Outlet 1140 Hours	Sample Point Stack Econ. Filter Outlet 1420 Hours	Hot Water Tank 1420 Hours	Hot Water Storage Before DH
pH	5.95	3.98	4.38	4.45	5.20	5.44
Specific Conductance, micromhos 25C	25	30	31	--	--	26
Methyl Orange Alkalinity as $CaCO_3$, ppm	24	30	26	--	--	20
Chloride as Cl, ppm	8	8	6	--	--	8
Total Hardness as $CaCO_3$, ppm	10	10	14	--	--	12
Calcium as $CaCO_3$, ppm	6	4	8	--	--	8
Magnesium as $CaCO_3$ ppm	4	6	6	--	--	4
Silica as SiO_2, ppm	1.4	1.6	1.9	--	--	1.2
Sulfate as SO_4, ppm	0	1	3	--	--	0
Ortho Phosphate as PO_4, ppm	0	1.0	1.3	1.5	0.5	0
Total Copper as Cu, ppm	0	0	0	0	0	0
Total Iron as Fe, ppm	0.16	0.29	0.48	1.0	0.48	0.22
Soluble Iron as Fe, ppm	0.08	0.29	0.22	0.80	0.36	0.18
Manganese as Mn, ppm	0	0	0	0	0	0
Aluminum as Al, ppm	0.01	0.02	--	0.04	0	0

DYEHOUSE B WATER QUALITY DATA

Date: January 28, 1985	Sample Point		
Determination	Floor Mix Tank	#6 Beck Hot Water	Kier Fill Cold Water Line
pH	3.99	4.0	5.5
Specific Conductance, micromhos 25C	28	28	24
Methyl Orange Alkalinity as $CaCO_3$, ppm	19	19	20
Chloride as Cl, ppm	5	5	4
Total Hardness as $CaCO_3$, ppm	18	18	18
Calcium as $CaCO_3$, ppm	12	12	12
Magnesium as $CaCO_3$, ppm	6	6	6
Silica as SiO_2, ppm	1.6	1.6	1.7
Sulfate as SO_4, ppm	3	3	3
Ortho Phosphate as PO_4, ppm	0.55	0.50	0.6
Total Copper as Cu, ppm	0.85	0	0.80
Total Iron as Fe, ppm	0.48	0.18	0.13
Soluble Iron as Fe, ppm	0.36	0.09	0.10
Total Manganese as Mn, ppm	0	0	0.1
Total Aluminum as Al, ppm	0	0	0

DYEHOUSE B WATER QUALITY DATA

Date: February 9, 1985/February 10-85

| Determination | #7 Beck 1330 Hours | #7 Hot Water 1515 Hours | City Water 0900 Hours | Sample Point | | |
				Cold Water Bleach Mix Rooms	Hot Water Wet Floor	Econ. Outlet 0930 Hours
pH	4.40	4.67	6.22	6.13	4.89	3.64
Specific Conductance, micromhos 25C	--	31	25	40	27	33
Methyl Orange Alkalinity as $CaCO_3$, ppm	--	22	28	24	24	18
Chloride as Cl, ppm	--	8	10	10	8	8
Total Hardness as $CaCO_3$, ppm	--	12	12	0	28	26
Calcium as $CaCO_3$, ppm	--	10	12	0	12	14
Magnesium as $CaCO_3$, ppm	--	2	0	0	16	12
Silica as SiO_2, ppm	--	1.5	1.5	1.8	1.6	1.2
Sulfate as SO_4, ppm	--	2	2	3	0	0
Ortho Phosphate as PO_4, ppm	--	1.0	0	4.7	0	0.9
Total Copper as Cu, ppm	0	0	0	0	0	0.8
Total Iron as Fe, ppm	0.50	0.52	0.10	0.49	0.8	1.0
Soluble Iron as Fe, ppm	0.45	0.30	0.05	0.10	0.4	0.80

DYEHOUSE B WATER QUALITY DATA

Date: February 9, 1985/February 10-85

Determination	Hot Jet Hot Water Line	Sample Point #7 Beck Water at Bucket Station	Stack Hot Water 0830 Hours	Econ. Outlet 0930 Hours
pH	4.26	5.38	3.80	4.07
Specific Conductance, micromhos 25C	42	41	31	35
Methyl Orange Alkalinity as $CaCO_3$, ppm	22	24	26	18
Chloride as Cl, ppm	8	10	6	6
Total Hardness as $CaCO_3$, ppm	14	34	20	20
Calcium as $CaCO_3$, pm	14	12	10	10
Magnesium as $CaCO_3$, ppm	0	22	10	10
Silica as SiO_2, ppm	2.0	1.5	1.6	1.3
Sulfate as SO_4, ppm	1	0	0	0
Ortho Phosphate as PO_4, ppm	0.8	3.8	0.9	1.2
Total Copper as Cu, ppm	0	0	0	0
Total Iron as Fe, ppm	0.78	0.21	0.42	0.33
Soluble Iron as Fe, ppm	0.55	0.08	0.24	0.21

DYEHOUSE B WATER QUALITY DATA

Date: <u>February 11, 1985</u>

Determination	Hot Water Tank 0930 Hours	Hot Water Tank 12:45	#5 Beck Hot Water	#6 Beck Bucket Station Cold Water
pH	4.42	4.43	4.60	5.31
Specific Conductance, micromhos 25C	35	34	35	30
Methyl Orange Alkalinity as $CaCO_3$, ppm	26	24	22	22
Chloride as Cl, ppm	10	8	8	10
Total Hardness as $CaCO_3$, ppm	34	10	22	0
Calcium as $CaCO_3$, ppm	10	10	12	0
Magnesium as $CaCO_3$, ppm	24	0	10	0
Silica as SiO_2, ppm	1.7	1.3	1.2	1.6
Sulfate as SO_4, ppm	0	1	1	1
Ortho Phosphate as PO_4, ppm	1.6	1.0	1.9	1.6
Total Copper as Cu, ppm	0	0	0	0
Total Iron as Fe, ppm	0.39	0.34	0.42	0.22
Soluble Iron as Fe, ppm	0.21	0.28	0.24	0.16

Sample Point (header above columns #5 and #6)

DYEHOUSE B WATER QUALITY DATA

Date: February 26, 1985

Determination	Heat Exchanger Outlet	Hot Water Storage Outlet	Plant Filter Outlet	#1 Filter Outlet	Sample Point Jet Mix Tank Hot Water
pH	6.37	4.25	6.01	6.00	4.31
Specific Conductance, micromhos 25C	28	29	22	30	31
Methyl Orange Alkalinity as $CaCO_3$, ppm	10	20	18	18	22
Chloride as Cl, ppm	4	6	8	8	12
Total Hardness as $CaCO_3$, ppm	6	32	10	18	52
Calcium as $CaCO_3$, ppm	6	12	10	10	12
Magnesium as $CaCO_3$, ppm	0	20	0	8	40
Silica as SiO_2, ppm	1.6	1.7	1.7	1.9	2.0
Sulfate as SO_4, ppm	0	0	0	0	0
Ortho Phosphate as PO_4, ppm	1.2	1.6	0.4	0	2.4
Total Copper as Cu, ppm	0	0.01	--	--	--
Total Iron as Fe, ppm	0.14	0.42	0.18	0.11	0.69
Soluble Iron as Fe, ppm	0.06	0.31	0.05	0.08	0.49

DYEHOUSE B WATER QUALITY DATA

Date: February 26 1985

Determination	Stack Econ. Outlet	#7 Beck Hot Water	Floor Mix Area Hot Water
		Sample Point	
pH	4.21	4.29	4.85
Specific Conductance, micromhos 25C	29	25	22
Methyl Orange Alkalinity as $CaCO_3$, ppm	18	18	22
Chloride as Cl, ppm	6	8	8
Total Hardness as $CaCO_3$, ppm	34	32	10
Calcium as $CaCO_3$, ppm	16	10	8
Magnesium as $CaCO_3$, ppm	18	22	2
Silica as SiO_2, ppm	1.8	1.3	1.8
Sulfate as SO_4, ppm	0	0	0
Ortho Phosphate as PO_4, ppm	2.2	1.6	0.7
Total Iron as Fe, ppm	0.75	0.95	0.66
Soluble Iron as Fe, ppm	0.59	0.52	0.24

DYEHOUSE B WATER QUALITY DATA

Date: <u>March 19, 1985</u>

Determination	Unfil- tered City Water	Fil- tered City Water	Heat Ex- changer Inlet	Stack Econ. Outlet	Hot Water Storage Tank	Cold Water Beck Bucket Station
pH	6.31	6.26	6.69	5.14	5.35	6.77
Specific Conductance, micromhos 25C	23	24	29	32	31	29
Methyl Orange Alkalinity as $CaCO_3$,ppm	22	18	22	20	24	28
Chloride as Cl, ppm	8	6	8	6	8	6
Total Hardness as $CaCO_3$,ppm	10	12	8	10	12	10
Calcium as $CaCO_3$, ppm	8	8	6	8	10	8
Magnesium as $CaCO_3$, ppm	2	4	2	2	2	2
Silica as SiO_2, ppm	1.8	1.7	1.4	1.8	1.5	1.8
Sulfate as SO_4, ppm	5	2	0	0	0	0
Ortho Phosphate as PO_4,ppm	0.5	0.2	1.9	1.9	1.9	1.9
Total Copper as Cu, ppm	0	0	0	0	0	0
Total Iron as Fe, ppm	0.16	0.11	0.12	0.18	0.38	0.18
Soluble Iron as Fe, ppm	0.04	0.05	0.07	0.09	0.22	0.09

DYEHOUSE B WATER QUALITY DATA

Date: <u>February 9, 1985</u>

Determination	Hot Water Beck Fill	Sample Point Jet Mix Tub Hot Water	Hot Water Wet Floor
pH	5.44	5.41	5.39
Specific Conductance, micromhos 25C	31	34	24
Methyl Orange Alkalinity as $CaCO_3$, ppm	18	16	26
Chloride as Cl, ppm	8	10	8
Total Hardness as $CaCO_3$, ppm	22	16	42
Calcium as $CaCO_3$, ppm	18	14	32
Magnesium as $CaCO_3$, ppm	4	2	10
Silica as SiO_2, ppm	1.6	2.0	1.9
Sulfate as SO_4, ppm	1	2	2
Ortho Phosphate as PO_4, ppm	1.9	1.8	1.8
Total Copper as Cu, ppm	0	0	0
Total Iron as Fe, ppm	0.41	0.49	0.82
Soluble Iron as Fe, ppm	0.30	0.28	0.20

DYEHOUSE B WATER QUALITY DATA

Date: March 23, 1985

Determination	City Water	Filtered City Water	Sample Point Kier Filter	Kier Hot Water Filter RM.	#3 Cold Water Filtered	#3 Hot Water Filtered
pH	6.39	6.44	6.45	5.54	6.49	5.62
Specific Conductance, micromhos 25C	24	26	26	37	27	38
Methyl Orange Alkalinity as $CaCO_3$, ppm	16	20	16	20	22	22
Chloride as Cl, ppm	8	6	6	8	8	6
Total Hardness as $CaCO_3$, ppm	22	10	8	22	6	--
Calcium as $CaCO_3$, ppm	8	6	--	--	--	--
Magnesium as $CaCO_3$, ppm	14	4	--	--	--	--
Silica as SiO_2, ppm	1.8	1.8	1.5	1.8	1.8	1.9
Sulfate as SO_4, ppm	6	3	2	2	2	5
Ortho Phosphate as PO_4, ppm	0.2	0.5	0.4	2.5	0.5	2.6
Total Copper as Cu, ppm	0	0	0	0.22	0	0
Total Iron as Fe, ppm	0.20	0.25	0.11	1.20	0.21	1.18
Soluble Iron as Fe ppm	0.13	0.08	0.10	1.15	0.12	1.05

DYEHOUSE B WATER QUALITY DATA

Date: March 23, 1985

Determination	#3 Kier Hot Water Unfiltered	#7 Kier Cold Water Unfiltered	#7 Kier Hot Water Unfiltered	#8 Kier Cold Water Filtered	#8 Kier Hot Water Filtered
pH	5.76	6.41	5.58	6.44	5.61
Specific Conductance, micromhos 25C	35	25	34	25	38
Methyl Orange Alkalinity as $CaCO_3$, ppm	24	20	22	22	30
Chloride as Cl, ppm	8	8	6	6	8
Total Hardness as $CaCO_3$, ppm	--	8	--	10	--
Calcium as $CaCO_3$, ppm	--	6	--	4	--
Magnesium as $CaCO_3$, ppm	--	2	--	4	--
Silica as SiO_2, ppm	2.2	1.6	1.9	1.6	2.2
Sulfate as SO_4, ppm	5	3	2	0	3
Ortho Phosphate as PO_4, ppm	2.6	0.4	2.5	0.6	2.6
Total Copper as Cu, ppm	0.04	0	0.02	0	0.01
Total Iron as Fe, ppm	1.30	0.22	1.15	0.21	1.15
Soluble Iron as Fe, ppm	0.80	0.18	0.38	0.10	1.05

The header row is labeled "Sample Point" above the five columns.

DYEHOUSE B WATER QUALITY DATA

Date: March 23, 1985

Determination	Sample Point	
	#3 Kier Hot Water Unfiltered	Kier "Cold" Hot Water
pH	5.56	5.84
Specific Conductance, micromhos 25C	29	200
Phenolphthalein Alkalinity as $CaCO_3$, ppm	0	0
Methyl Orange Alkalinity as $CaCO_3$, ppm	22	20
Chloride as Cl, ppm	10	8
Total Hardness as $CaCO_3$, ppm	18	14
Calcium as $CaCO_3$, ppm	18	14
Magnesium as $CaCO_3$, ppm	0	0
Silica as SiO_2, ppm	2.2	1.7
Sulfate as SO_4, ppm	7	2
Ortho Phosphate as PO_4, ppm	2.4	0
Total Copper as Fe, ppm	0.03	0
Total Iron as Fe, ppm	1.20	0.80
Soluble Iron as Fe, ppm	0.75	0.18

VITA \

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Master of Science

Thesis: WATER QUALITY IMPACTS ON TEXTILE DYE HOUSE OPERATIONS

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