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City Council

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Angelique C. Lee
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Ward 3

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Ward 6

Virgi Lindsay
Ward 7

Water Treatment Study Report for:

WATER TREATMENT PLANT OPTIMAL CORROSION CONTROL STUDY AMENDMENT PROJECT

February 2021

CORNERSTONE ENGINEERING, LLC

CE Project #19-29

CORNERSTONE ENGINEERING, LLC
"Bringing Together Ideas that Work"

City of Jackson
Attn: Charles Williams, P.E., PhD
200 South President Street
P.O. Box 17
Jackson, MS 39205

February 21, 2021

RE: Water Treatment Plant Optimal Corrosion Control Study Amendment Report

Dr. Williams:

Enclosed is the requested filter condition assessment report regarding the above referenced water treatment plant in Jackson, MS. The study primarily focused on the use of lime for pH adjustment and corrosion control at JH Fewell Water Treatment Plant in Jackson, MS.

The amended corrosion control report contained herein provides pertinent details regarding our study approach, extensive data collection reviews, weekly laboratory water parameter testing, lead and copper coupon tests, technical findings, and recommendations. In general, our scientific findings provide proof that the JH Fewell Water Treatment Plant is currently optimized for corrosion control without the need for conversion to soda ash.

If you have any questions, please let me know.

Sincerely,

Mauricka McKenzie, Sr., P.E., BCEE
Project Manager and Study Coordinator

Keith Allen, P.E., BCEE
Principal Investigator-Water Treatment Engineer

Cc: file

710 E. Northside Drive, Suite A
Clinton, MS 39056
601-473-2403

WATER TREATMENT PLANT OPTIMAL CORROSION CONTROL REPORT
AMENDMENT
JH FEWELL WATER TREATMENT PLANT
JACKSON, MISSISSIPPI
DATE: FEBRUARY 21, 2021

WATER TREATMENT ENGINEER

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EXECUTIVE SUMMARY

The purpose of the amended corrosion control study at J H Fewell Water Treatment Plant (JHF) was to determine if current finished water produced by JHF is corrosive to lead and copper, determine if increasing the alkalinity of the finished water will reduce the corrosiveness (optimize), determine if increasing the alkalinity of the finished water will cause unacceptable scaling on UV bulbs and customer plumbing, determine if increasing the alkalinity of the finished water will cause unacceptable lime turbidity resulting in customer complaints, and determine if increasing the alkalinity of the finished water will increase the calcium carbonate content enough to reduce the possibility of leached lead in the water being absorbed by the human body.

The results of the pipe rack study and the tap samples collected from distribution sites indicate that JHF finished water is up to 10 times less corrosive to lead than O B Curtis Water Treatment Plant (OBC) finished water even after optimization. Tap samples collected where chemical and pumping data show obvious service areas along with plant service changes indicated much lower lead results and many more samples where no lead was detected in the sample at all. While this could result from different plumbing fixtures and sample collectors, sites where service area changed from OBC to JHF showed the same result when sampled. The pipe rack data indicated that while new fixtures leach some lead upon installation with JHF water, they develop a passivating film over time which effectively prevents lead leaching resulting in no lead detection at all in most samples collected after week 20. While JHF finished water is not corrosive to lead, it does cause Water Quality Parameters (WQP) excursions at the ends of the JHF service area. Increasing the alkalinity to correct this is possible but scaling and lime turbidity are potential issues. Changing to liquid lime (Calcium Hydroxide) in week 20 stabilized the make-up water and continued the trend of declining lead in collected samples to no detect. Liquid lime also reduced the occurrence of lime turbidity significantly over the 7-week period in comparison to dry lime in the first 20 weeks. The average increase in turbidity from dry lime addition was 3 to 5 NTU while the average increase with liquid lime was 0.3 – 0.6 NTU.

The study indicated that an increase in alkalinity to 32.5 mg/l would provide optimized corrosion control treatment while minimizing WQP excursions at the ends of JHF service area. This can be accomplished by replacing the dry lime feed with a liquid lime feed, and by adding an option for carbon dioxide to provide enhanced coagulation in winter months with low alkalinity which may still lead to WQP excursions without the enhanced option. Also, the level of calcium carbonate hardness which can be provided for prevention of lead absorption into the bloodstream in this scenario is also likely to assist with excretion of lead already absorbed from the body even if the lead is from other sources than drinking water.

It is also noted that the addition of soda ash adds sodium to the finished water at OBC which may be detrimental to customers with hypertension. Since Jackson has a majority African American customer base who tend to be more susceptible to hypertension, limiting sodium addition to a minimum must be a priority.

Part 1 – General

Section 1.1 – Background

In 2015, the City of Jackson was out of compliance concerning tap samples for lead under the Lead and Copper Rule administered by the Environmental Protection Agency. As a result, the City commissioned an Optimum Corrosion Control Study to determine the best course of action to correct the corrosive properties that caused the lack of compliance. The original study results indicated that the failure to properly add alkalinity in the finished water at the O B Curtis Water Treatment Plant was responsible for the corrosive nature of the finished water and that a change to soda ash feed would increase Dissolved Inorganic Carbon (DIC) resulting in a less aggressive finished water. Also, the original study recommended a change to soda ash in the finished water at J H Fewell Water Treatment Plant (JHF) even though tap samples did not indicate that JHF water had caused any of the lead action level (AL) exceedances. Since subsequent tap samples during design and construction of the required upgrades at OBC did not indicate corrosion issues from JHF finished water, City officials requested permission to pursue an amended study focusing on the JHF finished water which is described below. This report provides the results of that amended study.

1.2 - Purpose of Amended Study

The purpose of the Amended Optional Corrosion Control Treatment Study is to determine if the current treatment process at the City of Jackson's JH Fewell Water Treatment Plant is sufficient to prevent lead leaching from distribution plumbing and fixtures. A second objective is to determine if raising the alkalinity to a level of protection for other distribution plumbing such as cast iron and ductile iron can be accomplished without excess scaling of UV light bulbs and lime turbidity in the finished water. A third objective is to determine if the calcium concentration in the finished water can be raised to a level to protect against the absorption of lead into the bloodstream. A fourth objective is to determine if the current treatment process can reliably meet water quality parameter requirements set in the original Optimum Corrosion Control Treatment Report, Revised November 10, 2017.

Section 1.3 – Participants and Authority

The City of Jackson entered into a professional services contract with Cornerstone Engineering, LLC on March 19, 2020 for the Amended Water Treatment Plant Optimal Corrosion Control Treatment Study. The contract specified a timeframe of 180 days for completing the water treatment study. Cornerstone Engineering, LLC had three engineers who directly participated throughout the study. The study team members consisted of Keith Allen, P.E., BCEE, who served as the principal investigator for the water treatment study; Mauricka McKenzie, Sr. P.E., BCEE, who served as the project manager and engineering coordinator for the water treatment study; and Charles Williford, P.E., who served as the quality control and quality assurance water treatment consulting engineer.

The project participants for the City of Jackson included the Dr. Charles Williams, Jr., P.E., who is the City Engineer/Public Works Director; Mary Carter, who the Deputy Public Works Director and a Certified Water Operator; Terrence Byrd, who is the plant manager and the lead Certified Water Operator for the JH Fewell Water Treatment Plant and Mousetta Spann, who is the plant manager for the OB Curtis Water Treatment Plant.

Part 2 – Introduction

Section 2.1 – General Information

The City of Jackson has two drinking water distribution systems separated by valves; one using wells as a source and free chlorine disinfection and the other using surface water and chloramine disinfection. The surface water system is served by two different treatment plants with different water treatment objectives and results. The OB Curtis Water Treatment Plant is located northeast of the City near the Barnett Reservoir in Ridgeland, MS, and consists of two different treatment processes: one conventional and the other membranes with a capacity of 25 MGD each (total 50 MGD). The JH Fewell Water Treatment Plant is located east of downtown Jackson near the Pearl River, and consists of conventional treatment processes with a capacity of 20 MGD (maximum). The treatment processes employed at these two plants are as follows.

The conventional treatment process at OB Curtis consists of pre-oxidation, rapid mix, coagulation, flocculation, sedimentation, filtration, UV light disinfection, free chlorine for virus control followed by ammonia for creation of chloramines used for distribution residual, pH adjustment, and fluoridation. The chemicals fed are potassium permanganate (intake and/or pre-oxidation basin), aluminum chlorohydrate (ACH) (rapid mix), soda ash (rapid mix or clear well), chlorine, ammonia, and hydrofluorosilicic acid.

The membrane treatment process at OB Curtis consists of pre-oxidation, rapid mix, coagulation, membrane filtration (6 trains), free chlorine for virus control followed by ammonia for creation of chloramines used for distribution residual, pH adjustment, and fluoridation. The chemical addition is the same as the conventional process.

The JH Fewell Water Treatment Plant process consists of rapid mix, coagulation, flocculation, sedimentation, filtration, free chlorine for virus control followed by ammonia for creation of chloramines used for distribution residual, pH adjustment, fluoridation, and UV light disinfection. The chemicals fed are potassium permanganate (not routinely used), aluminum sulfate (alum) (rapid mix), dry hydrated Lime (rapid mix and clear well), chlorine, ammonia, and hydrofluorosilicic acid.

Section 2.2 – Current Situation

The JH Fewell and OB Curtis plants are not separated in the distribution system by valves but are separated hydraulically into clear zones that can be determined using chemical analyses such as the Water Quality Parameter samples. Therefore, the lead and copper samples can be separated by plant service during the time of collection. This is reflected by general mapping in the appendix and is also identified in the spreadsheets with sample site number and address. By this method we can determine which plants have caused distribution system lead leaching and occurrence in the clear plant service areas and the normal mixing zones between plants.

As is stated in the Optimum Corrosion Control Treatment Report, Revised November 10, 2017, the coupon method of corrosion study gives an idea of general corrosiveness of the water but does not predict the specific effect on lead containing plumbing or fittings. In addition to the coupon study method and apparatus, this study employed pipe loops with copper pipe, solder joints, and plumbing fixtures bought new and taken from home renovations in the Jackson water distribution system (originally placed 1990's) and new outdoor faucets which are non-potable and do not meet the current definition of lead free.

The OB Curtis plant employs aluminum chlorohydrate (ACH) as the primary coagulant while the JH Fewell plant employs aluminum sulfate (alum) as the primary coagulant. The original Optimum Corrosion Control Treatment Report found that low alkalinity and pH of finished water at OB Curtis was due to the inability to successfully convey the powdered and slaked lime solution to the clear well for post treatment, so it was recommended soda ash be used as an alternative which unlike lime raises Dissolved Inorganic Carbon (DIC). As part of this amended study, we researched the likely causes of the high lead samples and concluded that the addition of ACH may be the ultimate cause since the inconsistent lime mixing in the clear well at JH Fewell caused no such issues in the 402 samples that have been collected from sites clearly served by the older plant. At OB Curtis, declining and inconsistent alkalinity and pH levels will leave chloride as the controlling film component which will accelerate lead leaching especially from brass fittings which are the likely majority contributors of lead content in City of Jackson tap water. The original study recommended DIC treatment will overcome the electrical attraction of chlorides thereby replacing the destructive chloride films with carbonate films (better than chloride but oxides and hydroxides are the goal) which has appeared to decrease the lead leaching caused by OBC finished water prior to the correct application of soda ash feed. However, during the time when Soda Ash was being implemented at OB Curtis, liquid lime feed was installed on the clear well at OB Curtis and lead sampling produced the lowest number of action level (AL) violations since the original Lead and Copper Rule compliance in 2015. As described in the discussion below, an in-depth analysis of the results showed the average lead leaching with liquid lime was 46% of optimized DIC treatment with soda ash on the same sample pool served by OBC.

AT JHF, the original study recommended DIC (Dissolved Inorganic Carbon) treatment will overcome the electrical attraction of sulfates thereby replacing the passivating sulfate films with carbonate films (much more corrosive to lead than sulfate films) which should increase the lead leaching caused by JHF finished water. While continuation of DIC treatment to achieve oxide and hydroxide coatings will ultimately achieve protection comparable to the existing sulfate coatings, it is unlikely to happen with total chlorine residuals and pH less than 10 when employing soda ash feed. The results of the amended study demonstration unit described herein indicates that the changing of films (sulfate to carbonate) will begin at an alkalinity just less than 40 mg/l. However, since this was accomplished with lime feed rather than soda ash, the number may be lower with soda ash due to less interference from general calcium carbonate coatings indicated by the higher scaling potential. Also, these results indicate that the point of stability for scale formation between sulfates and carbonates may occur at an alkalinity between 26 and 40 mg/l. Tank 2 with an average make-up alkalinity of 32.3 mg/l, showed better results both overall and in each study category than either Tank 1 (current finished water) with an average make-up alkalinity of 26.3 mg/l or Tank 3 with make-up alkalinity of 38.1 mg/l. This suggests that the point of maximum effectiveness of both film regimes lies between 25 and 40 mg/l alkalinity at JHF.

Section 2.3 JHF CC Study Pipe Rack Unit

The purpose of the Pipe Rack units used in this study was to determine the level of lime feed for alkalinity addition that improves general corrosivity without increasing lead dissolution and customer complaints. Also, the purpose was to give a general indication if copper pipe, brass fitting, and solder joints within the customer's plumbing are affected by the increased alkalinity.

Each pipe rack demonstration unit used in this study consisted of a plastic make-up tank filled to 100 liters when starting make-up water detention for maximum hold time (7 days or 3.5 days), plastic plumbing to three coupon test racks, three old brass fitting taken from the Jackson water distribution system (1990 vintage), and a new brass yard faucet marked "not for potable use" attached with at least 10 feet of three-quarter inch copper pipe with solder joints and brass fittings. The old brass and new brass fittings were connected to system pressure (approximately 90 psi) by a bypass valve that was opened behind the tank water and closed when filling piping. To ensure that no system water was against the faucets and fittings on Tank 2 and Tank 3, the first sample from each old brass faucet was taken to Waypoint Analytical, a private laboratory in the Jackson area, and evaluated for lead, copper, alkalinity, calcium, magnesium, and total hardness. Also, a second 250 ml sample was collected consecutively from each old brass faucet and evaluated on site for pH, alkalinity, and total chlorine. A 250 ml sample was also collected from each tank and was taken to Waypoint Analytical and evaluated for alkalinity, calcium, magnesium and total hardness to ensure that the water quality in the sample was consistent with that of the tank. Each unit was flushed 3 times between sampling with flushing under system pressure for the non-coupon pipe racks. A 250 ml sample was collected at each pipe rack which differs from the original study since EPA describes investigative sampling as using a 250 ml sample volume instead of the customary 1 liter sample volume for lead and copper investigative samples. The smaller sample volume prevents the dilution of sample with water that was not in contact with the actual plumbing fixture producing the lead. The actual sample volume in contact with the coupons was 180.2 ml contained in 2 inches of 1-inch PVC above the valve and 3 inches of 2-inch PVC containing the 3-inch coupon. Every four weeks, the system pressure pipe racks were extensively flushed for 15 – 20 minutes under full system pressure to prevent excess film formation on the pipe racks. The pipe rack units are described below, and pictures of the pipe rack units are contained in Appendix E.

Unit 1 – Finished water with no additional treatment or amendment.

Unit 2 – Finished water with 10 mg/l of alkalinity added (0.8 g of lime/100 liters) for first 20 weeks.

Finished water with 7 mg/l of alkalinity added (50 ML of 1% CaOH/100 liters) for last 7 weeks.

Unit 3 – Finished water with 20 mg/l of alkalinity added (1.6 g of lime/100 liters) for first 20 weeks.

Finished water with 14 mg/l of alkalinity added (100 ML of 1% CaOH/100 liters) for last 7 weeks.

Data was collected and is presented in spreadsheet form in Appendix B (figures 12 – 32) with the following results identified as necessary: pH, alkalinity, calcium hardness, conductivity, temperature, sulfate, chloride, total chlorine, free chlorine, lead, and copper.

All parameters were evaluated on site with Hach HQ411d, Hach pocket pal pro, Hach digital titrator, Fisher Brand traceable conductivity meter, Hach Dr1900, and Core Balance scale, with the exception of total hardness which was taken from JHF daily sampling and calculated stoichiometrically. Also, samples for alkalinity, calcium hardness, total hardness, calcium, magnesium, lead, and copper were collected on sample day and taken to Waypoint Analytical. All on-site samples were evaluated with coordination of JHF lab results where appropriate. The lead and copper coupons were purchased from the same source and are identical to those used in the original corrosion control study. They are pre-weighed and certified for reweighing after the study. Testing was performed after 7 days of detention except once a month where 3.5 days was used. Each unit was flushed approximately 6 - 8 hours prior to sampling. Each rack was sampled once a week except the new brass fitting racks which were sampled every 2 weeks for the first 24 weeks and weekly for the last 3 weeks. The lead and copper sample size in this study was 250 ml rather than the lead and copper tap samples volume of 1 liter for reasons explained below.

Part 3 - Results of Bench and Desktop Studies

Section 3.1 Purpose of Bench Top Study

The purpose of the bench top study was to determine if raising the alkalinity in JHF finished water with lime will increase lime turbidity and scaling to unacceptable levels in the distribution system. The purpose also included evaluation of the original corrosion control study with specific attention to results from JHF and sample results from semi-annual lead and copper sampling. The objectives of this study were as follows:

1. To determine the amount of alkalinity addition with lime from current practice that is likely to be acceptable to customers in the distribution system at JHF.

2. To use the Langelier Saturation Index (LSI) to predict scaling issues that may result from the alkalinity addition to achieve DIC optimization.

3. To determine the amount of calcium carbonate remaining in the finished water available to prohibit lead absorption from biological assimilation into the bloodstream.

The results of the pipe rack study and specific sampling for turbidity increase do tend to show that increasing the dry lime feed by 8 mg/l to raise the alkalinity by an average of 8-10 mg/l in Tank 2 indicate an increase of about 3 to 5 NTU in finished water due to the dry lime (lime turbidity). While this increase will not cause a violation of the Safe Drinking Water Act since it can be easily shown to be caused by the lime and not coming from the combined filter effluent, it may cause objectional aesthetic properties which will lead to customer complaints. So, during the last seven weeks of the study, the stock lime make-up solution was changed to Calcium Hydroxide (liquid lime) at 5 mg/l of 1% solution resulting in an approximate addition of 6-8 mg/l alkalinity. The increase in turbidity during this time due to liquid lime was 0.3 to 0.5 NTU which is 10 times less than the increase due to dry lime addition in the first twenty weeks.

The increase in average LSI during the study from finished water is presented below:

	Tank 1 finished water	Tank 2 (7 – 10 mg/l alk. incr.)	Tank 3 (14 – 20 mg/l alk. incr.)
LSI	0.76	1.1	1.4

As shown above, the average increase in LSI of make-up water is indicative of higher calcium carbonate scaling in both Tank 2 and Tank 3. So, the selected alkalinity increase should be less than 7 mg/l to keep the LSI below 1 for the scaling control.

Results from the pipe racks (Appendix B, Figure 27) show that the average calcium carbonate content (calcium bicarbonate hardness) in Tank 2 is 32.3 mg/l. Calcium in sufficient quantities (1.1-6.6 mg/l Ca/ppb lead) will reduce lead absorption into the bloodstream by as much as 75% to 99%, respectively as shown in a study by Blake and Mann in 1983. The 1983 study shows the effectiveness of calcium (bicarbonate form and phosphate form) in preventing the absorption of lead into the bloodstream (source: Blake, K. C. H., Barbezat, G. O. & Mann, M. <u>Effect of dietary constituents on the gastrointestinal</u>

absorption of 203pb in man, Environmental research 30(1), 182–187 (1983). Later studies (Source: Anca Rădulescu1 & Steven Lundgren, Scientific Reports, October 2, 2019) have shown that the positive effects of calcium in drinking water does not depend on lead level. Any amount of calcium has at least some effect of preventing lead absorption into the bloodstream.

Evidence suggests that calcium competes with lead for sites (for example similar to ion exchange) in the blood, liver, brain and bone. Even after the lead has been absorbed, it has been shown that sufficient calcium intake can reverse lead affinity and cause excretion of the lead from the body. A study published by Anca Rădulescu1 & Steven Lundgren on October 2, 2019 states "it was shown that the competitive presence of calcium can affect: (1) lead's intestinal absorption, (2) its kinetics between soft tissues; (3) its storage in bones and its mobilization from osseous to non-osseous tissue; (4) its retention versus excretion rates; (5) the toxic response of the body to lead. Early research in rodents has revealed that a lower Ca diet increased their susceptibility to the toxic effects of lead (including order of magnitude higher lead blood levels, anemia, renal problems)".

Therefore, a 32.5 mg/l level of calcium bicarbonate hardness should be beneficial at all levels of lead for health protection against lead exposure.

Section 3.2 – Purpose of Desk Top Study

The purpose of the desk top study involved evaluation of the previous corrosion control study with specific attention to results from JHF and sample results from semi-annual lead and copper sampling along with WQP's from treatment plants and in the distribution system. The objectives of this study were as follows:

1. To incorporate pertinent information from the previous corrosion control study. The previous study at JHF included 3 coupon racks using current finished water (unit 1), orthophosphate (unit 2), and addition of Soda Ash following filtration (Unit 3). Results of the coupon studies from the previous study for unit 1 and unit 3 will be incorporated into the amended study.

2. An evaluation of lead and copper sample results since 2015 to assess the magnitude of lead issues in the distribution system and to determine if finished water from JHF contributed to AL (action level) exceedances during this time.

3. An evaluation of WQP sample results since 2015 to determine the areas of service for the JHF and OBC.

4. An evaluation of the increase in alkalinity required to obtain reasonable WQP parameters for pH, Alkalinity, and Hardness for both plants, if OBC continues to leach more lead from plumbing even after corrective corrosion control treatment is installed.

A comparison of the coupon study on JHF from the previous study indicates comparable results. The previous study included the normal 1 liter sample volume used in lead and copper distribution sampling while this study used the more conservative 250 ml sample required for investigation. The smaller sample would indicate (in this case) that the additional water volume used in the original study would include mostly water that was not in contact with the coupons since the coupons were contained within 3 inches of 2-inch plastic pipe above 2 inches of 1 inch pipe above the sample valve, which would mean that approximately 180 ml of sample was in contact and downstream of the coupons. Therefore, the same quantity of lead by weight would be contained in the 250 ml sample from this amended study as would be contained in the liter sample from the original study, with 4 times the sample volume. The average lead from the previous study for coupons on finished water was 15.8 ppb while the average lead from the coupons on finished water from this amended study adjusted for sample volume was 7.5 ppb. For Tank 2, the adjusted lead result was 4.8 ppb and for Tank 3 it was 5.6 ppb. Since these studies were not run side by side and at the same time, only a comparison of general corrosiveness can be made but it is still very favorable to Tank 2 as the solution for optimum corrosion control even when compared with the selected option of soda ash addition which yielded 10.6 ppb lead. Therefore, in average lead leaching from the coupons, all three options in the amended study showed favorable results compared with the selected best option from the original study.

The results from the coupon racks on this amended study show a reasonable decline throughout the study with all coupon racks going below the ACL for lead and Tank 2 and Tank 3 declining to no detect for the last 3 weeks. Tank 2 and Tank 3 water showed to be the least corrosive to the coupons and showed a passivating film forming within 4 to 6 weeks of the start of the study. While Tank 3 was the least corrosive to the coupons with the highest alkalinity, other considerations will likely indicate Tank 2 as the treatment choice since the distribution issues from Tank 3 may outweigh the benefits.

The coupons were extracted and sent for certified weight analysis. The following comparison shows that the higher alkalinity water was less corrosive to copper as expected with Tank 2 and Tank 3 showing exactly the same corrosion level which indicates no appreciable benefit to the higher alkalinity. The lead coupon in Tank 2 was not correctly weighed at one or the other time but Tank 1 which is the current finished water was slightly less corrosive than Tank 3 with the higher alkalinity.

Tank	Metal	Coupon tag ID	factory Wgt (g)	study Wgt (g)(waypoint)	Difference (g)	MYP
1	Copper	UM378	12.9981	12.9955	0.0026	0.0095
2	Copper	UM377	12.9956	12.9943	0.0013	0.0047
3	Copper	UM376	12.9877	12.9864	0.0013	0.0047
1	Lead	WI179	17.4785	17.4841	0.0044	0.0127
2	Lead	WI178	17.6015	17.6050	-0.0035	
3	LEAD	WI180	17.4862	17.4807	0.0055	0.0159

The distribution lead and copper test results found by the City in the 2020 sampling as shown in Appendix A clearly indicate that current treatment at JHF is much more protective of lead containing plumbing materials than is any water produced during the 2020 sampling period at OBC. In every case where a side by side comparison could be made, JHF finished water was more than 10 times better at controlling average lead sample content than was OBC finished water.

The WQP results shown in Appendix C indicate that current JHF finished water cannot meet the selected WQP parameters set from the previous study. In fact, it is clear in all cases where clear plant service can be determined, almost all the "excursions" found are clearly from JHF. This means that some adjustment will be required to current treatment in order to meet these WQP parameters. The parameters could be adjusted for JHF treatment but no adjustment can fully account for low alkalinity, high turbidity water during cold winter weather in the JHF service area. Tank 2 adjustment can conceivably meet current WQP parameters and would have no problem if parameter targets were reduced slightly. This would probably require a change from dry lime to liquid lime as the increase in lime turbidity is significant using current dry lime product. Also, switching to liquid lime will reduce mixing and inconsistent lime slurry concentration issues resulting in a more consistent finished water from JHF with respect to water stability.

Part 4 - Results of Corrosion Control Study

Section 4.1 Pipe Racks

The generalized results of this study are shown below for each tank. Note that the lead and copper was sampled 27 times for Coupon and old brass pipe racks, and 15 times for new brass pipe racks. It is also noted that the sample size was 250 ml rather than 1 liter in the study which is more compatible with actual sample size in contact with lead containing plumbing.

The results from Tank 1 JH Fewell water treatment plant finished water which received no further treatment or amendment are shown below.

- Average sample lab alkalinity – 26.3 mg/l
- Sample lab alkalinity <= 25 mg/l – 14/27
- Sample lab alkalinity <= 20 mg/l – 3/27
- Average make up alkalinity - 26.6 mg/l
- Make up alkalinity <= 26 mg/l – 14/27
- Average Sample pH – 8.9
- Sample pH <= 8.5 – 5
- Sample pH >= 9.7 – 0
- Average make up pH – 9.4
- Make up pH <= 8.5 – 0
- Make up pH >= 9.7 – 0
- Number of coupon lead samples < AL – 11, Note: all occurred after sample week 17
- Sample week coupon lead < AL – 17
- Number of coupon lead samples < detection - 0
- Number of old brass lead samples < ACL – 25, Note: 23 occurred after sample week 4
- Sample week old brass Lead < AL – 4
- Number of old brass lead samples < detection – 11
- Number of new brass lead samples < ACL – 7, Note: 2 occurred after sample week 25
- Sample week new brass lead < AL – 25
- Number of new brass lead samples < detection – 5, note: 4 of 5 occurred after sample week 19
- Average sample day LSI – 0.38
- Average sample day DIC – 5.8
- Average make up day LSI – 0.8
- Average make up day DIC – 5.3

Existing finished water meets all corrosion control criteria for lead and copper. However, there were 19 WQP excursions on sample day which will not meet the minimum of 9 even with mitigation steps. Also, JHF lab alkalinities were recorded on 23 make up days with 15 <= 25 mg/l which indicates 15 excursions on alkalinity from JHF during corrosion control study. If alkalinity target were lowered to 20, 3 excursions would still be recorded on Tank 1 and 5 would be recorded based on JHF lab results on makeup days. This means 8 excursions just on alkalinity which would not meet the minimum of 9 given pH constraints for CO_2 removal (pH 8.34)

The results from Tank 2 JH Fewell water treatment plant finished water with 8 mg/l of dry lime (plant) added for first 20 sample days and 5 mg/l of 1% CaOH for last 7 sample days are shown below.

- Average sample lab alkalinity – 30.5 mg/l
- Sample lab alkalinity <= 25 mg/l – 2/27
- Sample lab alkalinity <= 20 mg/l – 0/27
- Average make up alkalinity – 32.3 mg/l
- Make up alkalinity <= 26 mg/l – 0/27
- Average Sample pH – 9.0
- Sample pH <= 8.5 – 3
- Sample pH >= 9.7 – 0
- Average make up pH – 9.5
- Make up pH <= 8.5 – 0
- Make up pH >= 9.7 – 4
- Make up pH >= 10 - 2
- Number of coupon lead samples < ACL – 11, Note: 7 occurred after sample week 20
- Sample week coupon lead < ACL – 20
- Number of coupon lead samples < detection - 3
- Number of old brass lead samples < ACL – 27, Note: no samples above ACL
- Sample week old brass lead < ACL – all
- Number of old brass lead samples < detection – 25
- Number of new brass lead samples < ACL – 8, Note: 6 occurred after sample week 17
- Sample week new brass lead < ACL – 17
- Number of new brass lead samples < detection – 5, note: all 5 occurred after sample week 17
- Average sample day LSI – .67
- Average sample day DIC – 6.8
- Average make up day LSI – 1.11
- Average make up day DIC – 6.3

Tank 2 water meets all corrosion control criteria for lead and copper. There were 5 WQP excursions on sample day which will likely meet the minimum of 9 with mitigation steps taken in the monthly distribution WQP samples. If alkalinity target were lowered to 20, no excursions would be recorded on Tank 2 finished water alkalinity. However, the average makeup LSI is 1.1 which indicates more scaling on the UV bulbs requiring more cleaning and maintenance and pH is greater than the upper limit of 9.7 4 times and greater than 10 2 times.

Turbidity increased by 2 to 4 NTU in tests after 2 hours to 4 hours of settling time indicating this level of dry lime addition which may be objectionable to customers. When Liquid lime (Calcium Hydroxide) was used in the last 7 weeks of the study, the turbidity increase was between .1 and .4 NTU after 2 hours of settling which would not be objectionable to customers.

The results from Tank 3 JH Fewell water treatment plant finished water with 16 mg/l of dry lime (plant) added for first 20 sample days and 10 mg/l of 1% Calcium Hydroxide for last 7 sample days are shown below.

- Average sample lab alkalinity –32.6 mg/l
- Sample lab alkalinity <= 25 mg/l – 2/27
- Sample lab alkalinity <= 20 mg/l – 1/27
- Average make up alkalinity – 38.1 mg/l
- Make up alkalinity <= 26 mg/l – 0/27
- Average Sample pH – 9.1
- Sample pH <= 8.5 – 5
- Sample pH >= 9.7 – 2
- Sample pH >= 10 – 0
- Average make up pH – 9.6
- Make up pH <= 8.5 – 0
- Make up pH >= 9.7 – 10
- Make up pH >= 10 – 7
- Number of coupon lead samples < ACL – 12, Note: 11 occurred after sample week 16
- Sample week coupon lead < ACL – 16
- Number of coupon lead samples < detection - 5
- Number of old brass lead samples < ACL – 26, Note: 14 occurred after sample week 13
- Sample week old brass lead < ACL – 13
- Number of old brass lead samples < detection – 21
- Number of new brass lead samples < ACL – 8, Note: 4 occurred after sample week 21
- Sample week new brass lead < ACL – 21
- Number of new brass lead samples < detection – 7, note: 4 occurred after sample week 21
- Average sample day LSI – .79
- Average sample day DIC – 7.0
- Average make up day LSI – 1.42
- Average make up day DIC – 6.8

Tank 3 water meets all corrosion control criteria for lead and copper. There were 7 WQP excursions on sample day which may meet the minimum of 9 with mitigation steps taken in the monthly distribution WQP samples. If alkalinity target were lowered to 20, 1 excursions would be recorded on Tank 3 finished water alkalinity. However, the average make up LSI is above 1.4 which indicates significantly more scaling on the UV bulbs requiring more cleaning and maintenance and pH is greater than the upper limit of 9.7 10 times and greater than 10 7 times.

Turbidity typically increased by 3 to 5 NTU in tests after 2 hours to 4 hours of settling time indicating dry lime addition at this level which may be objectionable to customers. When Liquid lime (Calcium

Hydroxide) was used in the last 7 weeks of the study, the turbidity increase was between .3 and .6 NTU after 2 hours of settling which would not likely be objectionable to customers.

Section 4.2 General Pipe Rack Trends

Figures 12-33 in Appendix B show general trends on all of the pipe racks that suggest that corrosion of lead and copper does follow similar trends. There appears to be a definite connection between lower alkalinity and pH on corrosion rates of both lead and copper as expected. However, as the time of contact with the water from the start of the study increased (both new brass and coupon components were installed new at the time the study started), the dependence of results on pH and alkalinity was significantly reduced. This indicates the formation of scale over time (typically 6 weeks to 6 months) along with reduction of exposed area in the form of metal oxides, carbonates, sulfates, and chlorides depending on the water quality. While consistent treatment is required to maintain these scales, the films reduce the immediate reaction of corrosion rates to instantaneous changes in water quality. Generally, the new brass and coupon rack units trended downward from installation to week 20 with some excursions on the new brass due to aggressive flushing approximately every four weeks. In weeks 21-27, the lead results dropped generally below action level (AL) and down to no detect for the remainder of the study. The graphs in Appendix B (figures 12-20) show the lead and copper trends on each tank and pipe rack with respect to time, pH, and alkalinity. The graphs show 8 of the 9 pipe rack's lead results descending below detection limit for the last few weeks of the study. Only the coupon rack for Tank 1 continued to show detectable lead at the end of the study. These results are shown in table form in Figures 21-33, and support the conclusion of corrosion scales that prohibit the lead leaching from lead containing plumbing and fixtures. This data suggests a lead sulfate scale which would not react to aggressive flushing has formed consistently on the new metal on both the coupons and the new brass after 20 weeks of water contact. This seems to be supported by the tap sample results shown in Appendix A with JHF finished water consistently giving much lower lead results than OBC with the only consistent treatment difference being use of coagulant.

Another possible factor explaining these results is the change to liquid lime (Calcium Hydroxide) after week 20. Liquid lime was used in week 19 for make up water but the concentration to get the proper alkalinity addition was not corrected until week 20. The liquid lime generally stabilized the make up water chemistry likely due to the dry lime product variability and the consistency of the liquid lime.

Section 4.3 Monthly WQP Samples

The City originally selected the top 25 sampling sites from the 2015 Lead and Copper sampling for WQP analysis in the distribution system of which 7 sites were served by the well system. This left 18 WQP sites actually on the surface water system served by OBC and JHF. Since these sites were not selected based on distribution system coverage, it is difficult to make generalizations about plant service even though comparing hardness and alkalinity gives a general indication of service. In January of 2018, the City selected 40 sites for WQP which are more representative of distribution system coverage. Using hardness and alkalinity along with percentage production from each plant, the distribution system service areas can be determined. In November 2019, the optimum corrosion control method using soda ash addition was successfully implemented at OBC. Therefore, the optimum corrosion control treatment installed at OBC can be compared with the existing treatment at JHF.

Since January of 2018, the City has collected monthly samples for water quality parameters (WQP) at these 40 sites around the distribution system. Of these 40 sites, 17 are served at least partially by JHF especially in 2020 since membrane train and filter issues at OBC caused a greater reliance on water from JHF. This caused service from Fewell to move farther North than normal into the transition areas where the water would mix. While this improves Lead results in these areas it deteriorates the WQP results due to age of water and loss of chlorine residual. The following distribution alkalinity and pH results are based on sites clearly being served by JHF at the time of sample collection.

- Sample alkalinity <= 25 mg/l
  - June 2020 – 9
  - July 2020 – 8
  - August 2020 – 2
  - September 2020 – 8
  - October 2020 – 9
  - November 2020 – 7
  - December 2020 – 14
- Sample alkalinity <= 20 mg/l
  - June 2020 – 5
  - July 2020 – 2
  - August 2020 – 1
  - September 2020 – 2
  - October 2020 – 4
  - November 2020 – 3
  - December 2020 – 8
- Sample pH <= 8.5
  - June 2020 – 0
  - July 2020 – 4
  - August 2020 – 2
  - September 2020 – 3
  - October 2020 – 4
  - November 2020 – 3
  - December 2020 – 9
- Sample pH >= 9.7
  - June 2020 – 0
  - July 2020 – 0
  - August 2020 – 0
  - September 2020 – 0
  - October 2020 – 0
  - November 2020 – 0
  - December 2020 – 0

Based on these results, there are 17 sample sites of the 40 total that are partially or totally served by J H Fewell water treatment plant. While the current water treatment process at JHF is not corrosive to lead or copper containing pipes and fixtures, it cannot meet current or any reasonable water quality parameters during cold weather months such as December 2020. Of 17 sampling sites clearly served by

JHF in December 2020, 14 were below current WQP minimums set by the MSDH on Alkalinity and 9 were below the current WQP minimums set by the MSDH on pH. This is due to low raw water alkalinity during cold weather months and process constraints that make raising these levels to current minimums difficult. Even if the Alkalinity minimum was lowered to 20 mg/l, December 2020 would still have produced 8 alkalinity excursions and 9 pH excursions.

Section 4.4 Distribution Lead and Copper Sample Results

After violating the lead and copper rule in 2015, the City of Jackson was required to select Water Quality Parameter (WQP) sites to check the chemical quality of water in the distribution system to help determine the corrosiveness with respect to lead and copper. From 2016 to 2017, the City of Jackson used the 25 sites from the 2015 sampling period that yielded the highest lead results. In January of 2018, the City began using 40 sites selected from the Bacteriological sampling site plan which gave a more representative distribution of sites with plant service area and geographic area in mind. At that time, the coverage areas between O B Curtis (OBC) and J H Fewell (JHF) were subjective since no updated hydraulic analysis exists to determine general service areas from the plants. Also, since the treatment processes were similar with respect to WQP parameters, it was difficult to properly designate those service areas although the higher hardness typically produced by JHF gave a good reference for most of the sample sites. When Soda Ash treatment was installed at OBC in late 2017 (installation was ultimately unsuccessful) and Lime was discontinued, the soft water produced at OBC gave clear indication of the service areas in most of the 2018 WQP sampling results. However, as problems developed in the Soda Ash feed changeover during 2018, the City eventually switched back to lime in late 2018. Through 2019 until the corrected optimum corrosion control treatment was installed in late November, the service area was less defined but plant production could be used to predict service area along with hardness results. Appendix C gives the WQP sample results from February 2018 to December 2020. The WQP sample results in 2018 and late 2019 and 2020 compared with plant pumping data presented in Appendix D show that JHF serves much farther North and East of Highway 55 when pumping at 20 MGD as opposed to 10 MGD. The WQP sample results give a good indication of plant service area from 2018 – 2020 for the sample sites. Using Chemical data from WQP sample results during months coinciding with lead and copper tap samples and daily JHF plant production records shown in Appendix C, service area maps were developed showing the service coverage at the time of sampling in 2018 (JHF average production around 10 MGD daily production) and 2020 (JHF average production around 20 MGD daily production). These service areas are consistent with pumping data from previous years also but during 2015 OBC was serving the South well system which would have changed the flow dynamics at that time. The following discussion breaks the Lead and Copper results since 2015 into sections based on the circumstances and plant service areas that applied at the time of sample collection including WQP concentrations and plant production.

Total results from 2015 to present:

Overall:

Service Plant	# of Sites	ACL Exceed	average result (ppb)	# of no detects
Curtis	516	65	10	72
Fewell	402	5	1.2	244
Both	119	13	4.6	32

This data indicates that 48 samples are included in Both and Curtis service and 22 are included in Both and Fewell service because of WQP determination since 2018. Although those labeled Both can be served by either plant depending on immediate plant production, 6 of 13 AL exceedances on Both are clearly served by Curtis and 0 of 13 are clearly served by Fewell.

These results show that sites served by the Fewell plant are typically low in the AL exceedances where definitive chemical data is available to assess plant service of the sites. Of 402 total samples served by Fewell at the time of sampling, 244 had no lead detected at all. Of the 5 AL exceedances' 3 occurred at the same residence in the same year (2018) and did not violate before or since. On Curtis, 25 of the AL exceedances occurred at 8 sites with one site exceeding 8 times it was sampled. On sites labeled Both, 7 exceedances occurred at 2 sites.

This indicates that current treatment at Fewell is likely to result in 10 times lower average lead over these sampling periods, that it is 4.3 times as likely to provide no detect results, and that it is 10 times as likely to provide results below the AL as compared with water treated by Curtis.

2020 samples:

Since the prescribed treatment process from the previous Optimum Corrosion Control Study was finally successfully implemented at OBC in November of 2019, the following analysis is of the 2020 Lead and Copper sample results in March and October 2020 while the OBC was producing water treated according to the original study recommendations and JHF was treating water as it has historically. The following is a comparison of plant service sample results based on WQP sample results and plant production records from the months samples were collected. The alkalinity and hardness results from the WQP samples indicate the chemical difference between the low hardness water produced by OBC and the much higher hardness water produced at JHF. All samples were shown to be served either by Curtis or Fewell.

2020 results:

Service Plant	# of Sites	ACL Exceed	average result (ppb)	# of no detects
Curtis	96	6	11.4	21
Fewell	87	2	1.2	62

These results indicate from sites served by JHF with the current treatment process in place, that JHF finished water is typically much less corrosive to lead than the optimum corrosion control employed at OBC. JHF served sites resulted in few AL exceedances and showed much lower average lead levels and a much higher percentage of samples with no lead detected. Of 87 total samples served by Fewell at the time of sampling, 62 had no lead detected at all or 71.2 %. This compares very favorably to the optimum DIC method employed at OBC where only 21 of 96 or 21.9% of samples had no lead detected. However, the average lead contained in OBC samples was almost 10 times that contained in Fewell samples, and there were 3 times as many AL exceedances from optimized Curtis treated water as from current Fewell treated water. It is also noted that 6 additional samples on sites served by OBC in 2020 would exceed the proposed trigger level in the Lead and Copper Rule revisions of 10 ppb while no additional samples on sites served by JHF would have exceeded. It is further noted that of 402 samples from sites served by JHF since 2015, only 1 additional sample would be added if the new trigger level of 10 ppb had been in force.

In any case, even though lead and copper corrosion is shown to be significantly less, the current JHF water cannot meet the selected WQP parameters according to WQP analysis above. All of the WQP excursions since optimized treatment was successfully employed at OBC have been on sites clearly served by JHF. It is clear that a set of parameters must be adopted for JHF separately from OBC since the optimized versions of the treatment processes are also significantly different.

Comparison of 2018 and 2020 results:

In 2018, the predominant treatment technique at OBC was soda ash feed for pH and alkalinity correction according to the optimum corrosion control recommendations from the original study. Although the treatment process was flawed due to soda ash storage and feed issues, the comparison of transition areas that were served by OBC in 2018 but switched to JHF in 2020 due to production issues at OBC in 2020 are pertinent to this discussion. The following is a discussion of these issues with data for those sites that are common to both 2018 and 2020 sampling periods.

Comparison of 2018 and 2020 transition site results:

Service Plant	# of Sites	ACL Exceed	average result (ppb)	# of no detects
Curtis (2018)	9	1	10	3
Fewell (2020)	9	0	0.5	6

This data indicates that the existing JHF finished water is much less aggressive to customer plumbing when compared to DIC treatment with Soda Ash at OBC. These 9 sites were served by OBC in 2018 when production at JHF was around 10 MGD (see Appendix D) but switched to JHF in 2020 when daily production from JHF increased to approximately 20 MGD (maximum). The marked difference in results for these sites with the same plumbing and collection procedure must be considered even if the DIC treatment was not considered optimum for the entire time. The improvement from OBC to JHF plant service is consistent with results shown in the overall sample results and from the comparison of samples after the corrected optimum corrosion control was installed at OBC. The average lead result is 20 times higher when OBC is serving the site with half the no detects and an AL exceedance.

Comparison of 2019 with liquid lime feed and optimized DIC treatment using Soda Ash in 2020:

In 2019, the OBC switched to liquid lime feed in the clear well for pH and alkalinity adjustment of the finished water. The following data shows the relative results for 2019 and 2020 for a comparison of adequate adjustment using liquid lime as opposed to optimum treatment at OBC with soda ash and without liquid lime in 2020.

Comparison of 2019 and 2020 Curtis site results:

Service Plant	# of Sites	ACL Exceed	average result (ppb)	# of no detects
Curtis (2019)	101	4	5	20
Curtis (2020)	96	6	11.4	21

This comparison of actual sites with the same plumbing and collection procedures indicates that treatment with liquid lime at OBC was more successful at prohibiting lead leaching in 2019 than the optimized treatment with only soda ash employed successfully in 2020. The average lead results for OBC were over 2 times as high in 2020 as in 2019. There was a 50% increase in AL exceedances and no detects were approximately the same. These results indicate that even though OBC finished water is inherently more corrosive because of the use of ACH instead of Alum than JHF, and that the use of Lime is actually more protective of lead containing plumbing and fixtures than optimized treatment with only soda ash when employing ACH.

Section 4.5 Analysis of Corrosion Properties

The increased lead leaching from finished water at Curtis over Fewell is likely caused by Chlorides added with the coagulant ACH. When alkalinity is low, the pH for water near the pipe typically decreases due to biofilms, bacterial activity, etc. Brass and bronze fittings and faucets typically have hundreds of tiny bubbles of pure lead on the surface that form during the intense heating and cooling process when being fabricated. These bubbles become anodes that can leach lead into the water. When pH is below 8.4 and alkalinity is low, the normal oxide films that should form on these nodes may not be present. As pH falls, the anode will form complexes with other things in the water such as chloride and sulfate. If chloride is present in absence of sulfate, the resulting lead chloride coating at the node will accelerate lead leaching. If sufficient Sulfate (Alum coagulant) is present, the lead sulfate coating on the node will reduce lead leaching as verified in this study. (Sources: Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems, EPA, Page 18, Journal - American Water Works Association 99(7):96-109 · July 2007, Edwards and Triantafyllidou, 2007;Hu et al., 2012, Nguyen et al., 2011b). This explains why plumbing fixtures at sites on Fewell tend to leach much less lead than those on Curtis, even after optimization of DIC with soda ash at Curtis.

The purpose of the optimized corrosion control treatment (DIC) at Curtis is to increase alkalinity (stabilizing pH) to a level where the lead chloride is replaced by lead carbonates or lead oxides. However, if the oxide is not formed, the carbonate can be scoured off of the node by sudden surges (turning on the faucet). The theory of the DIC method is to drive the lead coating to stable Oxides/Hydroxides which prohibit most lead leaching. However, if the coating remains mostly Bicarbonate/Carbonate, the coating is much less protective.

In the case of Fewell water, the addition of Alum increases sulfate to levels that under low alkalinity, unstable pH conditions near the pipe surface, and causes the formation of lead sulfate coatings which tend to prohibit lead leaching. As the alkalinity is increased, stabilizing pH, the sulfate at the site will be replaced by carbonate just as above which will increase lead leaching until the stable oxide is formed.

Section 4.6 Analysis of Pipe Racks and Field Data Based on Chemical Quality

The pipe rack testing indicates that current JHF treatment is protective of lead plumbing and fixtures. However, optimized corrosion control for lead appears to exist at a slightly higher alkalinity in the range of a 5 mg/l increase over that found in the 32 weeks of the amended study. The average increase in make-up day alkalinity from the finished water in Tank 1 (26.58 mg/l) to Tank 2 (32.3 mg/l) is 5.72 mg/l. The average increase in sample day alkalinity from the finished water in Tank 1 (26.26 mg/l) to Tank 2 (30.48 mg/l) is 3.9 mg/l. This indicates a generally slightly scaling water in Tank 2 that loses some alkalinity over time. This means that film formation is the likely reason for the increased protection of lead plumbing and fixtures shown by the slightly higher alkalinity water in Tank 2. Tank 3 shows an increase in alkalinity to 38.11 mg/l with an almost 6 mg/l decrease on sample day. This indicates a higher scaling factor is expected in Tank 3, but which is less protective of lead plumbing and fixtures than Tank 2. Therefore, it is indicated that Tank 2 provides the optimum corrosion protection for this study. It is also evident that increasing the alkalinity above 38 mg/l at current pH levels will begin the process of replacing sulfate films with carbonate resulting in diminishing effectiveness.

The following is a comparison of lead results from each tank on all three pipe racks showing Tank 2 as the most effective method of the three treatment options.

The average lead detected per tank and rack during this study was as follows:

Pipe Rack	Tank 1	Tank 2	Tank 3
Old Brass	0.0058	0.0004	0.0020
New Brass	0.0437	0.0444	0.0570
Coupon	0.0301	0.0191	0.0224

Again, these are results with a sample volume of 250 ml rather than 1 liter as was used in the original study, which reduces the volume of water not in contact with the lead containing plumbing fixtures by a factor of as much as 4 times. While all three treatment options studied at JHF during this study showed protective properties toward lead containing plumbing fixtures, Tank 2 showed the best potential with treatment improvements (liquid lime) to promote consistency, reduce lime turbidity, control scaling and reduce lead absorption by humans.

The field data also indicates that finished water at JHF is much more protective of lead containing plumbing and fixtures. The above data clearly shows JHF sites with much less lead leaching even though WQP excursions event violations were high. The use of alum as the primary coagulant at JHF probably accounts for this outcome. The lowest observed sulfate content of the water at JHF during the study was 24 mg/l and the highest observed chloride was 13.3 mg/l, indicating that the sulfate to chloride ratio was always significantly above the 70% required to reduce lead leaching. This was also found to be the case in the original study.

Part 5 – Findings, Conclusions and Recommendations

The following recommendations are presented as a supplement to the original study. Those recommendations from the previous study that have not been completed will be included.

Section 5.1 Findings

The finished water at JHF is not the cause of lead and copper issues in the City of Jackson distribution system. Through a 28-week pipe rack study and approximately 1000 tap samples since the original AL exceedances, the results have shown JHF finished water to be unlikely to leach lead. In the tap sample results from JHF (402 samples), 61% of JHF sample site results have no detect and 99% of sample sites results were less than the AL. Also, 98.5% of JHF sample site results would still meet the proposed trigger of 10 ppb contained in the revisions to the Lead and Copper Rule being considered now. However, the current finished water will not meet the current WQP parameters set by the previous study.

The pipe rack study indicates that the current finished water at JHF, the finished water with 7 to 10 mg/l of alkalinity added, and the finished water with 14 to 20 mg/l of alkalinity added are all capable of protecting lead containing plumbing fixtures from lead leaching. However, the addition of alkalinity at higher levels will cause unacceptable increases in lime turbidity and scaling. The DIC is within parameters (5 to 10) set by the previous study on all pipe rack tanks but WQP Parameters show a similar decline after 7 days of detention that shows up in the distribution WQP samples with current finished water during cold weather.

Section 5.2 Conclusions

Even though sample results indicate JHF finished water is not corrosive to lead containing pipe and plumbing fixtures, the alkalinity and pH need to be stabilized in the distribution system. The current WQP standards recommended in the previous study cannot be met by current JHF treatment regime, but given the lead and copper results in the pipe rack and tap samples, it appears that they may simply be set too high for pH adjustment with lime even though corrosion results are much better than with soda ash at OBC. During the pipe rack study, the addition of liquid lime appeared to stabilize the make-up water in the tanks leading to an almost uniform water with respect to pH and alkalinity. This is probably due to the more consistent quality of the liquid lime as compared to dry lime, and the percentage of inert material that may be contained in the dry lime. Also, the liquid lime gave much better results with respect to lime turbidity than dry lime at similar dosage.

Liquid lime should also provide a more consistent water in the clear well since poor mixing dynamics in the clear well at JHF cause inconsistent finished water quality. The liquid lime will help in mixing and may also allow for innovative solutions to the lime distribution problem in the clear well. Also, enhanced coagulation with CO2 would allow for increasing alkalinity in the winter without increasing pH and scaling potential. Increasing alkalinity in the JHF treatment process instead of in the clear well will decrease the reliance on the inefficient clear well mixing and provide a more consistent chemical quality in the finished water.

It is noted that the unnecessary increase in finished water sodium that would result from soda ash addition at JHF could have a detrimental effect on the service area population. The minority population of Jackson is typically more susceptible to Hypertension and sodium content should be limited wherever possible especially in a common commodity provided by the City. Since JHF water already meets any reasonable corrosiveness standard with respect to Lead and Copper from the evidence presented here, the addition of soda ash would serve no logical purpose since no complaints have been received from the slightly dissimilar chemical water qualities mixing in the distribution system.

Section 5.3 Recommendations

We recommend the installation of liquid lime and carbon dioxide feed systems at JHF to fully optimize corrosion control and stabilize distribution pH and alkalinity to meet current WQP standards. We also recommend that the WQP standards for JHF service area be lowered to alkalinity > 20 mg/l and pH > 8.0. This would ensure noncorrosive water with respect to lead plumbing while allowing latitude for process changes to stabilize these parameters. The current corrosion control regime at JHF is much more dependent on chloride/sulfate ratio than the WQP parameters, and the lower parameters favor the development of sulfate coating as per the study. The target for alkalinity for the finished water at JHF will still be 32.5 mg/l, as that is the level of Optimized corrosion control suggested by these study results.

Section 5.4 Recommended Treatment Process Improvements

The following items are proposed for automation for JHF to be completed on a schedule already submitted to EPA and MSDH. They include the necessary steps to optimize corrosion control for JHF in accordance with this Amended Optimized Corrosion Control Study.

1. Decommission existing dry lime feed system.
2. Install new liquid lime feed system with automation.
3. Install components for raw water CO2 feed with automation.
4. Install all components necessary for automation and integration with SCADA system.

Note: see appendix G for process jar test analysis indicating the success of CO2 and alkalinity addition in accomplishing pH and alkalinity stabilization for treatment and distribution systems.

Section 5.5 Distribution System improvements from Previous study

The following items are from Section 4.4 of the previous study concerning distribution system upgrades, and need to be completed along with the revised items listed above.

1. A calibrated hydraulic model of the water distribution system should be created to indicate water age and plant service areas.
2. A valve location and operation program should be integrated with results of the hydraulic study to provide assistance in planning and locating leaks and closed valves.
3. A routine flushing program should be followed in conjunction with the established service areas to reduce water age and enhance disinfection residuals.