TETRA TECH

MEMORANDUM

To:	Steve Skalski, P.E. Senior Civil Engineer City of Kalamazoo
From:	James Christopher, P.E. Vic Cooperwasser, P.E. Andrea Netcher, PhD, E.I.
Date:	March 3, 2017
Subject:	**City of Kalamazoo** **Desktop Corrosion Control Chemical Analysis**
Tt #:	200-19743-16001

BACKGROUND AND PURPOSE

The City of Kalamazoo (City) has been feeding sodium hexametaphosphate which has acted as a sequestering agent for iron, manganese, and calcium as well as a corrosion control measure. The City has installed iron removal facilities at some of their supply facilities and the requirement for sequestration of iron and calcium has become a secondary concern compared to the need to continue to maintain adequate corrosion control within the system at those facilities. The City is considering changing to a liquid corrosion control chemical for ease of application and in an effort to provide a higher level of corrosion control against lead and other metallic components in the distribution system. Therefore, the City would like to have a recommendation of the product(s) that would be appropriate for their system.

SCOPE

The City contracted with Tetra Tech to perform a desktop analysis and review of the current corrosion control practices to provide a recommendation for a liquid phosphate corrosion inhibitor. Tetra Tech's scope of services included the following tasks:

1. Review of recent lead and copper tap sampling results to determine the level of corrosion control provided by the current practices relative to lead and copper corrosion to establish a baseline of performance.
2. Review of water quality from each of the sources individually and of blends, as appropriate to simulate mixing of waters from different sources to determine the calcium carbonate saturation index and precipitation potential of the source waters and blends. Calculation of the Larson-Skold indices for each of the sources and blends as a comparison of their relative corrosion potential toward iron and steel.

3. Use the water quality information provided and the flow charts contained in "Lead Control Strategies" AWWARF, 1990 and Revised Guidance Manual for Selecting Lead and Copper Control Strategies USEPA, March, 2016 to compare current practices to recommended treatment options for lead and copper corrosion control. Using the water quality of the individual sources and blends to determine the existing level of corrosion control provided by phosphate addition and the dose that would be required using orthophosphate to achieve a theoretical lead solubility of 0.015 mg/L.
4. Use the above information and information from corrosion control treatment manufacturers to develop recommendations for the type and dose of product to replace the existing sodium hexametaphosphate chemical.

EXISTING SYSTEM AND FACILITIES

The City of Kalamazoo supplies drinking water to City residents and the majority of Kalamazoo County through an interconnected distribution system. The City's system is complex consisting of nine (9) different pressure districts supplied by sixteen (16) water pumping stations. Additionally, the system contains sixteen (16) booster and bleeder stations that are capable of transferring water between the pressure districts. A summary of the City's water system is provided in **Table 1**. The City's service area map containing the pressure district zones and corresponding stations is included in **Attachment A**.

With the exception of the Ultra High, West Side High, and West Side Low districts, water is supplied to each water pumping station from either a single or a combination of groundwater wells. At each station, the treatment scheme consists of chlorination for disinfection, fluoridation, and sodium hexametaphosphate addition for sequestering iron and providing corrosion control. Stations No. 1 and No. 11 provide additional treatment to remove iron. The same range of chemical feed doses are applied at the pumping stations; however, Station #24 applies a slightly higher dose of sodium hexametaphosphate. The chemical dose ranges for each water pumping station is provided in **Table 2**.

Table 1. City of Kalamazoo Water System

Pressure District	Station No.	Well No.	Station Design Capacity (MGD)	Station Managed Capacity (MGD)	Storage Facilities and Distribution
Low	Station #1	1-1 1-2 1-3 1-4 1-5 1-6	9.72	8.64	• 7 MG Ground Storage Tank • Cast Iron and Ductile Iron Water Mains
	Station #2	2-1	2.88	1.73	
	Station #3	3-1 3-2A 3-3 3-4 3-5 7-3 7-4 7-5	4.03	2.74	
Intermediate	Station #5	5-1A 5-2A	1.73	1.73	• 0.5 MG Elevated Storage Tank

Pressure District	Station No.	Well No.	Station Design Capacity (MGD)	Station Managed Capacity (MGD)	Storage Facilities and Distribution
		5-3A 5-4A			• Cast Iron and Ductile Iron Water Mains
	Station #14	14-1 14-2 14-3 14-4 14-5	2.30	2.30	
High	Station #4[(1)]	4-1 4-2 4-3 4-4 4-5 4-6 4-7 4-8 4-9 4-10	6.34	3.00	• 0.35 MG and 0.75 MG Elevated Storage Tanks • Cast Iron and Ductile Iron Water Mains
	Station #8	8-1 8-2 8-3 8-4 8-5	3.46	2.50	
	Station #9	9-1 9-2 9-3A 9-4A 9-5 9-6 9-7 9-8 9-9 9-10 9-11 9-12	4.03	2.50	
	Station #12	12-1B 12-2A 12-3B 12-4A	1.73	1.73	
	Station #17	17-1	1.01	1.01	
	Station #18	18-1 18-2	1.80	1.80	
	Station #39	39-1 39-2	3.74	2.74	

Pressure District	Station No.	Well No.	Station Design Capacity (MGD)	Station Managed Capacity (MGD)	Storage Facilities and Distribution
East Side High	Station #25	25-1 25-2 25-3 25-4 25-5 25-6 25-7 25-8 25-9	6.48	2.00	• 1.5 MG Elevated Storage Tank • Cast Iron and Ductile Iron Water Mains
Northwest High	Station #11[(2)]	11-1 11-2 11-3 11-4 11-5 11-6 11-7	2.59	2.59	• 1.5 MG Elevated Storage Tank • Cast Iron and Ductile Iron Water Mains
Super High	Station #22	22-1 22-2 22-4 22-5 22-6	3.17	3.17	• 1.5 MG Elevated Storage Tank • Ductile Iron Water Mains
	Station #24	24-1 24-2 24-5 24-6 24-7 24-8 24-9 24-10 24-11 24-12 24-14A 24-15 24-16 24-17A 24-18A	10.94	5.00	
Ultra High	Booster/bleeder stations supply water from Super High and Northwest High				• 1.0 MG Elevated Storage Tank • Ductile Iron Mains
West Side High	Booster/bleeder stations supply water from Super High				• Ductile Iron Mains
West Side Low	Booster/bleeder stations supply water from Super High				• Ductile Iron Mains

(1) Station is capable of discharging to Low.
(2) Station is capable of discharging to High.

Table 2. Treatment Chemical Dosages

Treatment Chemical	Typical Dose Range
Chlorine	0.8 to 1.3 mg/L
Fluoride	0.7 mg/L
Sodium hexametaphosphate	1.0 to 1.5 mg/L
Sodium hexametaphosphate at Station #24	2.0 to 2.5 mg/L

WATER QUALITY REVIEW

Water Quality Data

The City provided raw well water quality data from each of the water pumping stations to assist in characterizing the chemistry and corrosion potential of the groundwater sources. A summary of the average water quality data for the water supply wells is provided in **Table 3**. Blending of the waters, determining the water quality after chemical dosing, and calculating of the Langelier Saturation Index (LSI) were performed using a spreadsheet model based on the equations contained in Standard Methods 2330B. The Tetra Tech (RTW) Model for Water Process & Corrosion Chemistry was used to calculate the calcium carbonate precipitation potential.

As presented in **Table 3**, the City's groundwater sources are rich in alkalinity and hardness. Based on the data reviewed, average alkalinity ranges between about 200 and 340 mg/L as $CaCO_3$; and total hardness concentrations are greater than about 300 mg/L as $CaCO_3$. The corresponding dissolved inorganic carbon (DIC) ranges from approximately 60 to 110 mg/L C. The station water quality data shows that the pH levels vary through the system. On average, the majority of the stations have a pH range from about 6.5 to 7.2 pH units, while 5 of the 16 stations have higher pH values between 7.2 and 8.1 pH units.

The majority of the water supply wells are characterized by elevated iron and manganese levels. The secondary maximum contaminant levels (MCLs) for iron and manganese are 0.3 mg/L and 0.05 mg/L, respectively. With the exception of Stations No. 14, 22, and 25, the iron levels at the stations were greater than the secondary MCL of 0.3 mg/L. Similarly, the source water manganese concentrations were higher than the secondary MCL with the exception of Station No. 24. Iron removal treatment is provided at Stations No. 1 and 11. Polyphosphate can be applied to sequester iron and manganese and prevent possible color, particulate, taste, and staining issues in the drinking water distribution system.

On average, the lead and copper levels in the groundwater supply were less than about 0.006 mg/L and 0.045 mg/L, respectively. Based on these source water concentrations, the source water does not significantly contribute to lead and copper levels measured during regulatory tap sampling.

The City conducted a round of water quality sampling from each of the water pumping stations on June 30, 2016. The water quality parameters analyzed included chloride, fluoride, hardness, iron, nitrate, nitrite, sodium, and sulfate. Additional water quality parameters, including antimony, arsenic, barium, beryllium, cadmium, chromium, mercury, nickel, selenium, and thallium, were tested for Station 9. In addition to this sampling data, the City provided their water quality monitoring reports for the months of May and June 2016, which include the pH, ortho-phosphate, and sodium hexametaphosphate levels from the online water pumping stations. The water quality results from the June 30th sampling and monitoring reports is provided in **Attachment A**. These additional water quality data sets were used to supplement the raw well water quality summarized in **Table 3**.

Table 3. Water Quality Results

Parameter	Unit	Station 1	Station 2	Station 3	Station 4	Station 5	Station 8	Station 9	Station 11	Station 12	Station 14	Station 17	Station 18	Station 22	Station 24	Station 25	Station 39
Alkalinity	mg $CaCO_3$/L	NA	311	NA	NA	338	264	225	258	262	285	251	257	233	197	261	254
Alkalinity After Chem	mg $CaCO_3$/L	NA	308	NA	NA	335	261	223	255	259	282	248	254	230	194	258	251
Ammonia Nitrogen	mg/L	NA	0.083	NA	NA	0.168	0.191	0.087	0.243	0.114	0.062	0.151	0.123	0.026	0.177	0.110	0.274
Arsenic*	µg/L	6	3	2	7	2	10	6	2	8	2	4	3	2	2	1	4
Bicarbonate, calc'd	mg/L	NA	375	NA	NA	408	318	271	311	313	344	302	310	280	237	314	306
Calcium*	µg/L	NA	110,150	98,143	82,557	106,000	87,580	67,425	85,800	72,600	99,840	86,150	80,400	68,400	55,193	80,867	88,800
Carbonate, calc'd	mg/L	NA	0.4	NA	NA	0.2	0.2	0.1	0.1	1.4	0.1	0.3	0.1	0.3	0.1	0.3	0.2
CO_2, calc'd	mg/L	NA	37	NA	NA	77	38	92	152	6	152	56	62	26	100	49	49
Chloride*	mg/L	NA	110.1	10.0	NA	66.5	65.1	52.9	64.0	27.6	79.9	19.4	33.7	17.3	16.0	15.9	24.5
Conductivity*	umhos/cm	NA	888	878	727	916	752	626	741	625	836	543	595	524	441	597	623
Copper*	µg/L	NA	45	20	21	20	20	20	20	23	20	22	20	20	20	20	28
DIC, calc'd	mg C/L	NA	84	NA	NA	101	73	78	103	63	109	75	78	62	74	75	74
Dissolved Oxygen*	mg/L	NA	2.3	1.5	1.9	4.0	3.5	1.6	1.6	2.3	5.1	1.6	3.2	3.5	1.5	4.7	1.8
Fluoride*	mg/L	0.98	0.59	NA	NA	0.13	0.13	0.09	0.13	0.17	0.06	0.17	0.09	0.11	0.09	0.08	0.15
Iron*	µg/L	NA	877	930	1,797	664	1,360	2,081	843	665	275	1,444	1,080	212	990	83	221
Lead*	µg/L	NA	2.6	3.0	3.0	3.0	5.0	3.0	3.0	3.0	3.0	2.3	3.0	3.0	5.9	3.0	3.0
Magnesium*	µg/L	NA	35,500	32,014	28,586	31,650	30,460	24,583	32,957	28,800	29,320	22,650	23,700	26,060	19,567	25,378	19,011
Manganese*	µg/L	NA	152	106	231	328	236	193	132	64	139	359	150	168	42	75	118
Nitrate Nitrogen	mg/L	0.44	0.34	NA	NA	1.00	0.10	0.10	0.10	0.10	1.18	0.09	0.10	1.06	0.10	1.34	1.40
Nitrite Nitrogen	mg/L	NA	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0
Ortho Phosphorous	mg/L	NA	0.09	NA	NA	0.10	0.10	0.10	0.10	0.10	0.10	0.14	0.10	0.10	0.10	0.10	0.07
pH	pH units	NA	7.30	6.87	6.90	6.98	7.16	6.72	6.54	8.11	6.59	7.24	6.95	7.38	6.67	7.13	7.12
pH after Chem Add	pH units	NA	7.25	NA	NA	6.96	7.13	6.70	6.53	7.93	6.58	7.18	6.93	7.32	6.65	7.10	7.10
Silicate*	µg/L	NA	8,426	5,271	7,214	15,300	16,200	12	13,114	16	13,340	6,205	15,550	13,160	13,593	13,811	7,894
Sodium*	µg/L	49,000	65,250	36,343	27,614	33,625	25,500	28,433	23,943	10,525	38,280	7,460	12,550	5,940	8,400	8,511	14,955
Sulfate*	mg/L	44.5	54.3	NA	NA	53.0	44.0	20.9	35.3	35.0	33.0	26.4	21.0	32.2	15.5	35.8	32.3
Temperature	C°	NA	14.0	NA	NA	13.7	12.5	12.8	11.6	12.9	13.1	12.2	11.3	10.3	11.8	13.2	12.0
Temperature	F°	NA	57.1	NA	NA	57.2	54.6	55.1	52.8	55.2	55.6	54.0	52.3	50.6	53.3	55.7	53.6
Total Dissolved Solids	mg/L	NA	561	555	460	618	501	378	446	359	539	344	360	290	284	433	392
Total Hardness	grains/gal	NA	22	NA	NA	27	24	19	23	22	24	20	21	19	16	20	17
Total Hardness	mg/L $CaCO_3$	NA	371	NA	NA	462	417	NA	398	368	NA	347	359	328	NA	NA	294
Zinc*	µg/L	NA		24	43	20	29	NA	20	20	NA	13	20	20	NA	NA	15

*Parameters analyzed by Kar Laboratories of Kalamazoo. NA = Not Available (not analyzed for this parameter). DIC = Dissolved Inorganic Carbon. Calc'd = Calculated Value. Chem = Chemical Addition

In this complex inner-connected distribution system, there can be numerous iterations of source water blending scenarios. Therefore, we performed a blending analysis of adjacent station pairs. To simulate this probable mixing of the water supplies in the distribution system, the water quality from adjacent stations were blended in 25% increments. A general description of the blend ratios are summarized as follows:

- 100% Station A and 0% Station B
- 75% Station A and 25% Station B
- 50% Station A and 50% Station B
- 25% Station A and 75% Station B
- 0% Station A and 100% Station B

The composite water quality of each of these blends were calculated for 23 adjacent station pairs and is presented in **Tables A-1** through **A-23** of **Attachment A**. Interestingly for some of the combination of adjacent pairs, blended pH levels were found to be slightly higher than individual station pH levels. This pH change is likely due to a shift in carbonate species towards bicarbonate as waters are blended.

Lead and Copper Sampling

In 1991, the Environmental Protection Agency (EPA) promulgated the Lead and Copper Rule (LCR) to minimize lead (Pb) and copper (Cu) levels in drinking water. Most utilities have low levels of lead and copper in the water entering the distribution system; however, it was determined that waters that were corrosive toward lead and copper could contribute significant concentrations of these constituents at the consumer's tap where lead, copper, and brass components were present in the service lines and plumbing system. The 1991 LCR, and subsequent revisions, establishes an action level (AL) of 0.015 mg/L for lead and 1.3 mg/L for copper based on the 90^{th} percentile level of water samples collected at the tap within the business or residential structure. It's important to note that action level exceedance is not considered a violation; however, a 90^{th} percentile exceedance of the action level triggers additional requirements, including water quality monitoring, corrosion control treatment, source water monitoring or treatment, public education, and lead service line replacement. The results of the City's lead and copper sampling have not exceeded the action levels and the City is under reduced monitoring on a triennial basis.

The City provided their lead and copper monitoring results from 2002, 2005, 2008, 2011, and 2014. The lead and copper testing results were reviewed and compared by sampling location. The comparisons between the 2002 through 2014 lead and copper testing results are presented in **Figures 1 and 2**, respectively. Lead and copper concentrations that were less than the laboratory detection limit (<3 µg/L for lead and <20 µg/L for copper) were assigned a value equal to the detection limit so that they would be shown on the graph and locations with no concentration value indicate that a sample was not collected from that location during that sampling period. A summary of the 90^{th} percentile lead and copper concentrations, upon which the regulations are based, is provided in **Table 4**.

The lead and copper 90^{th} percentile concentrations were below the action levels of 15 ppb and 1,300 ppb, respectively, at which the Lead and Copper Rule would require further action by the utility. As shown in **Figure 1**, the majority of the lead tap sampling results were below the lead laboratory detection limit of 3 ppb. Lead concentrations greater than the 15 ppb action level were observed during the 2002, 2005, 2008, and 2014 sampling years. Nevertheless, the 90^{th} percentile concentration in each year remained below the 15 ppb action level.

As illustrated in **Figure 2**, the copper tap sampling results were below the copper action level of 1,300 ppb with the exception of two locational results in 2014. Even with the higher copper concentrations at these locations, the 90^{th} percentile concentration remained below the copper action level in 2014. As compared to the lead compliance data, the copper tap sampling concentrations appear to have fluctuated more between sampling locations, particularly during the most recent 2014 sampling round. The 2014 sampling round had a higher 90^{th} percentile copper concentration as compared to previous sampling years.

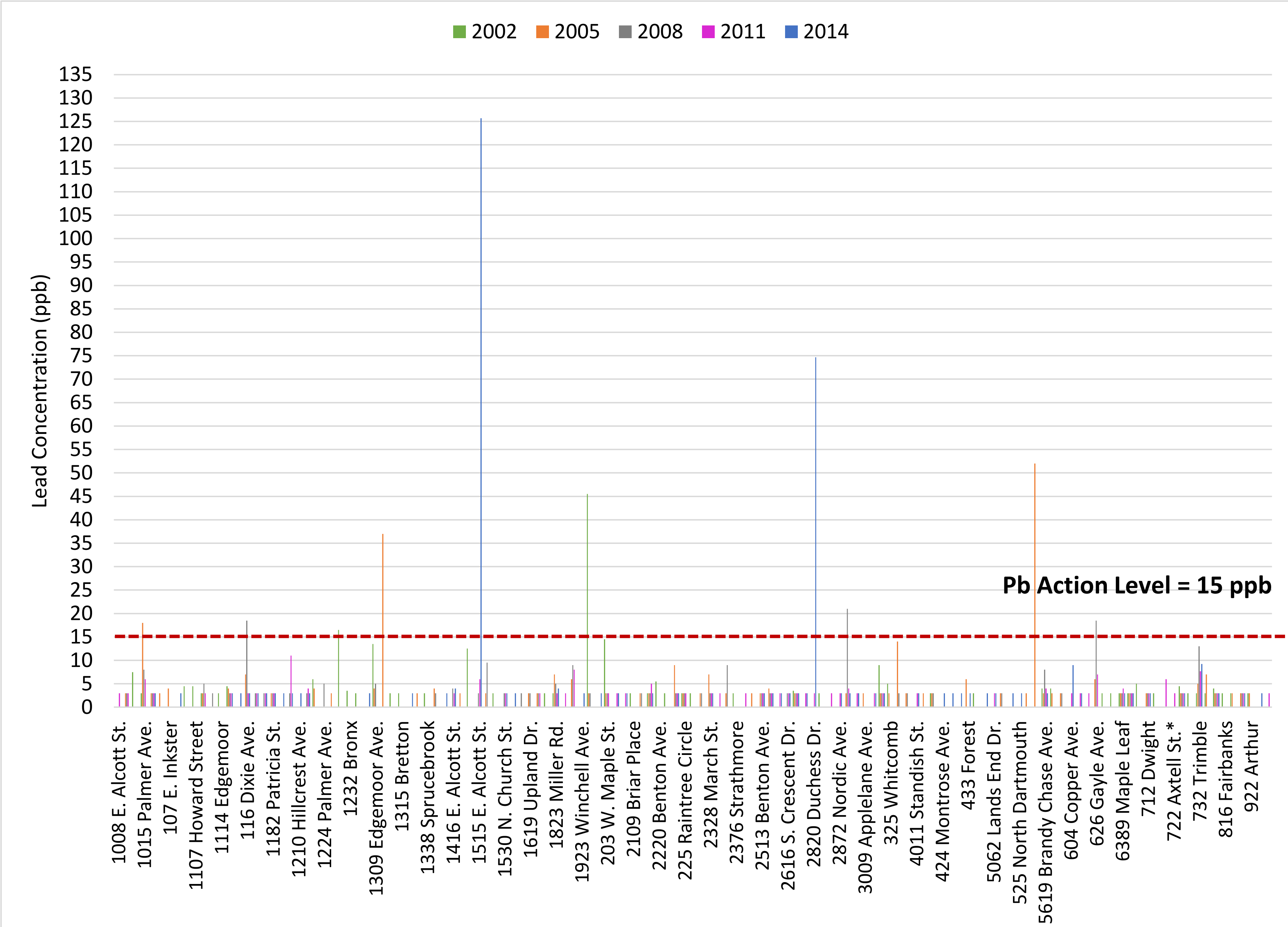


Figure 1. Kalamazoo Water Distribution System Lead Levels

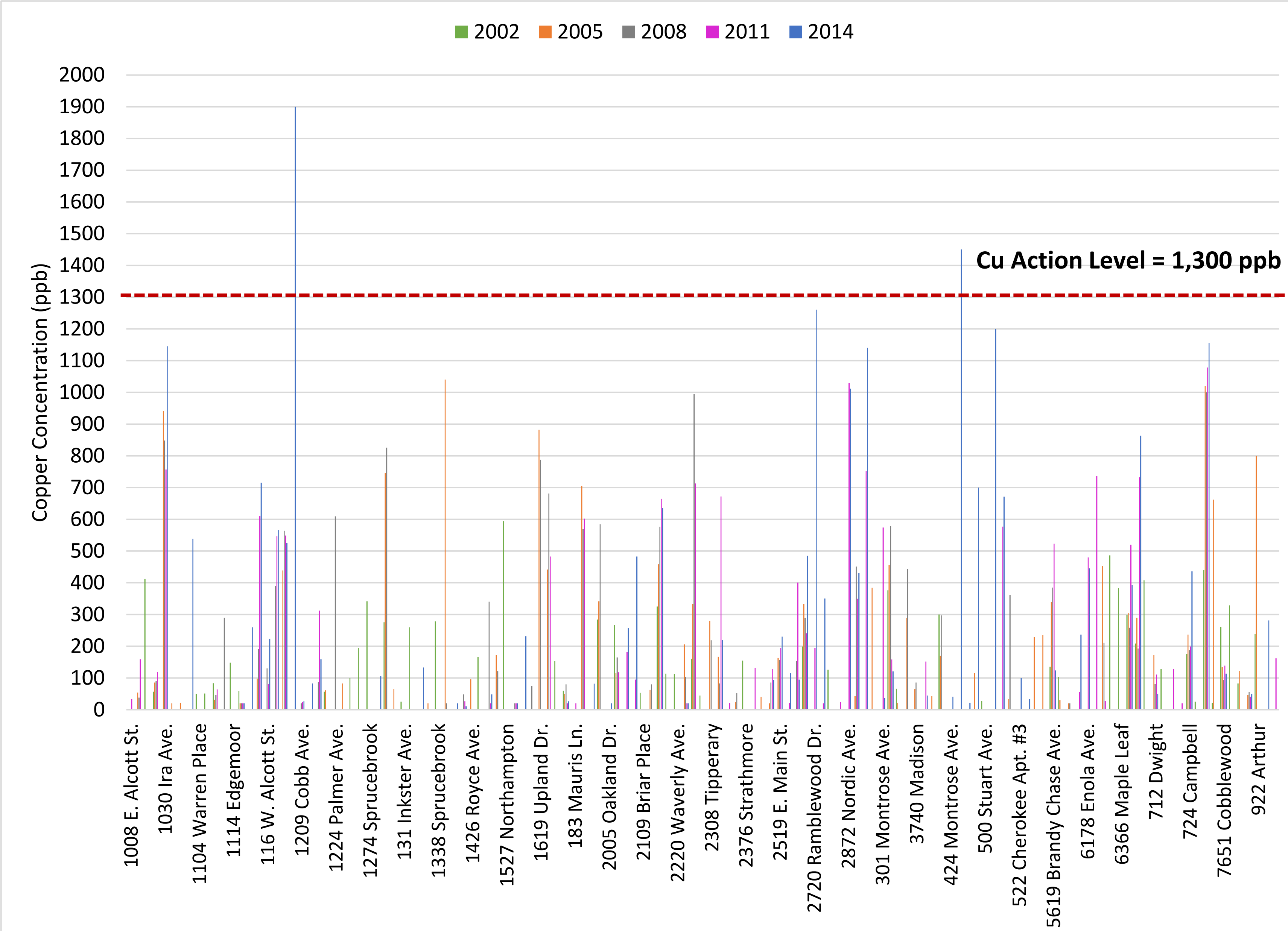


Figure 2. Kalamazoo Water Distribution System Copper Levels

Table 4. Lead and Copper 90th Percentile Concentrations

Year	Lead 90th Percentile Conc. (ppb)	Copper 90th Percentile Conc. (ppb)
2002	12.5	408
2005	9	745
2008	9.5	681
2011	6	732
2014	9	1,145

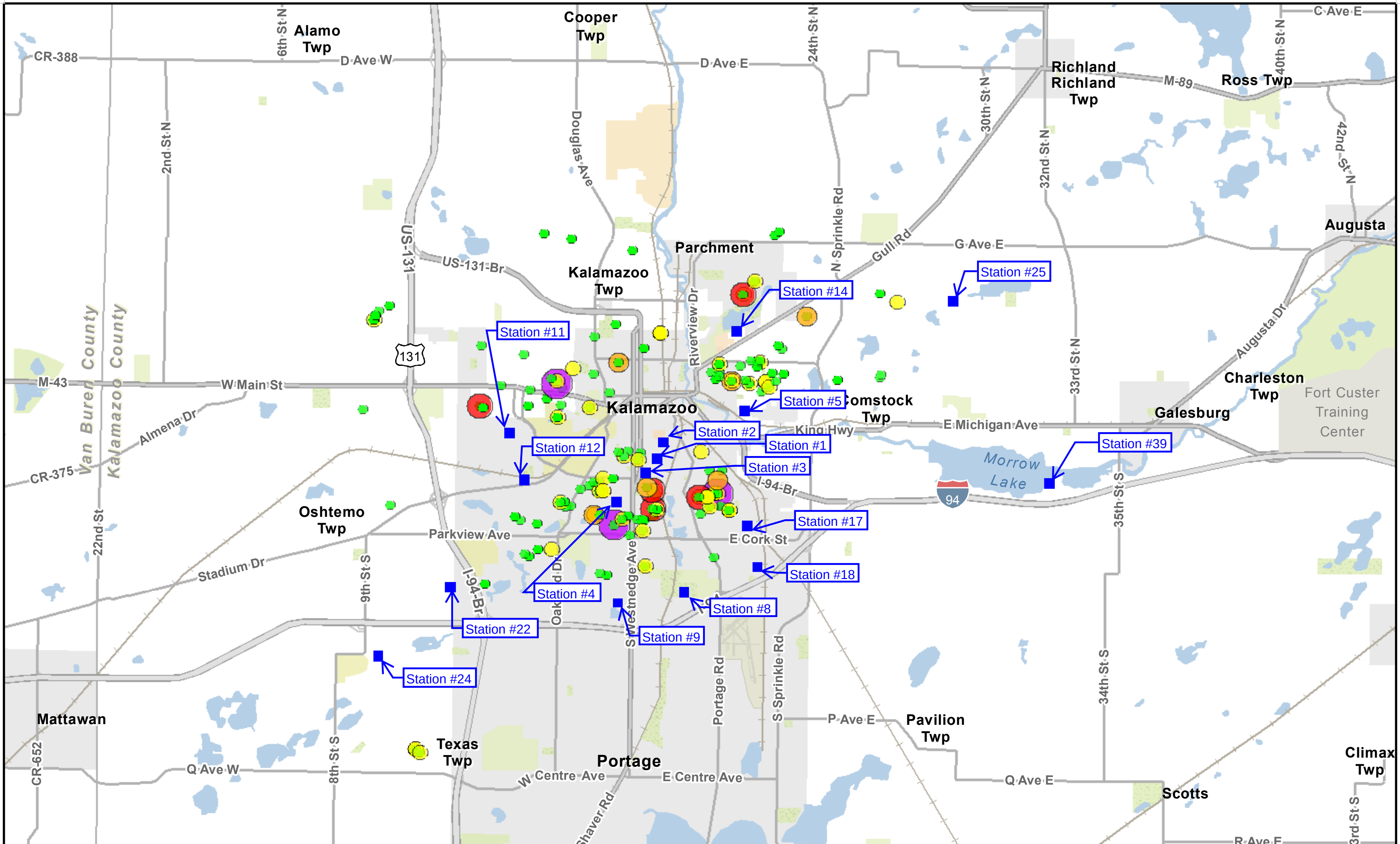
To examine the spatial variation in the lead and copper tap sample results, the data was plotted on an aerial map for each year. A composite of the lead and copper data for the combined years is shown in **Figures 3** and **4**, respectively. The plotted lead and copper data for individual years is included in **Attachment B**. As shown in **Figures 3** and **4**, higher lead and copper levels occurred at individual tap sampling locations near Stations No. 1, 2, 3, 4, 5, 11 and 14. Generally, the higher concentrations were found in the west part of the low pressure zone, the intermediate pressure zone, the high pressure zone in the vicinity of Station 4, and the northwest high pressure zone.

Of the sampling locations with elevated lead levels, the lead concentration fell above the action level near Stations No. 1, 2, 3, 4, 11 and 14. Similarly, the measured copper concentration was greater than the action level near Stations No. 1, 2, 3 and 11. The majority of these stations had average pH levels less than 7. The higher concentrations found in these areas may be due to the water quality in these locations, but tap sampling is not performed under controlled conditions and therefore, other factors such as age of the structures, service and plumbing materials of construction, water use and age and sampling procedure may be a primary or contributing cause.

Orthophosphate Sampling Data

The City provided orthophosphate data collected throughout the distribution system from June to November 2016. While the current corrosion inhibitor applied is in the form of polyphosphate chains, these polyphosphate chains break-down to orthophosphate over time in the distribution system (AWWA, 2011; EPA, 2016). Therefore, the orthophosphate data was reviewed and analyzed to identify the typical orthophosphate levels observed in the distribution system. Understanding these typical levels helps to establish a baseline condition for applying changes in corrosion control practices.

The average orthophosphate concentration for each sampling location is presented in **Figure 5**. In the figure, the average orthophosphate levels are shown by the column bars and the corresponding minimum to maximum ranges are depicted by the line brackets. Additionally, the data was organized and plotted spatially by sampling location, as shown in **Figure 6,** to examine apparent variations in orthophosphate levels throughout the system. The complete set of the orthophosphate sampling results is provided in **Attachment A**.



LEGEND

Lead Concentration (ppb) - 2002, 2005, 2008, 2011, and 2014

- \> 0 - 3.9
- 4 - 9.9
- 10 - 14.9
- 15 - 49.9
- Greater than 50

N

0 2.25 Miles

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WATER QUALITY TESTING

LEAD CONCENTRATION

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FIGURE 3

Source: City of Kalamazoo

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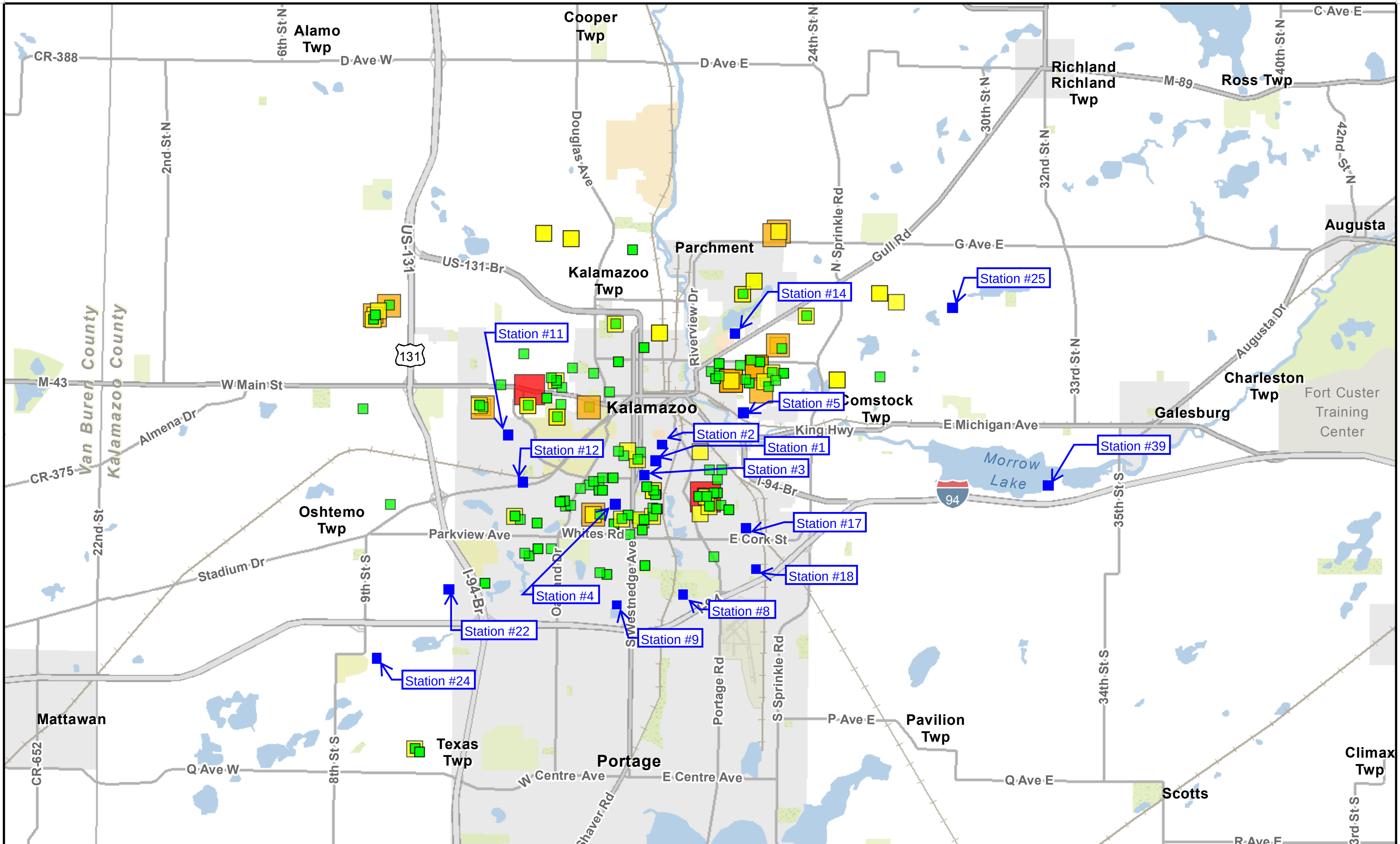

LEGEND

Copper Concentration (ppb) - 2002, 2005, 2008, 2011, and 2014

- > 0 - 399
- 400 - 799
- 800 - 1299
- Greater than 1300

N

0 — 2.25 Miles

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WATER QUALITY TESTING

COPPER CONCENTRATION

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FIGURE 4

Source: City of Kalamazoo

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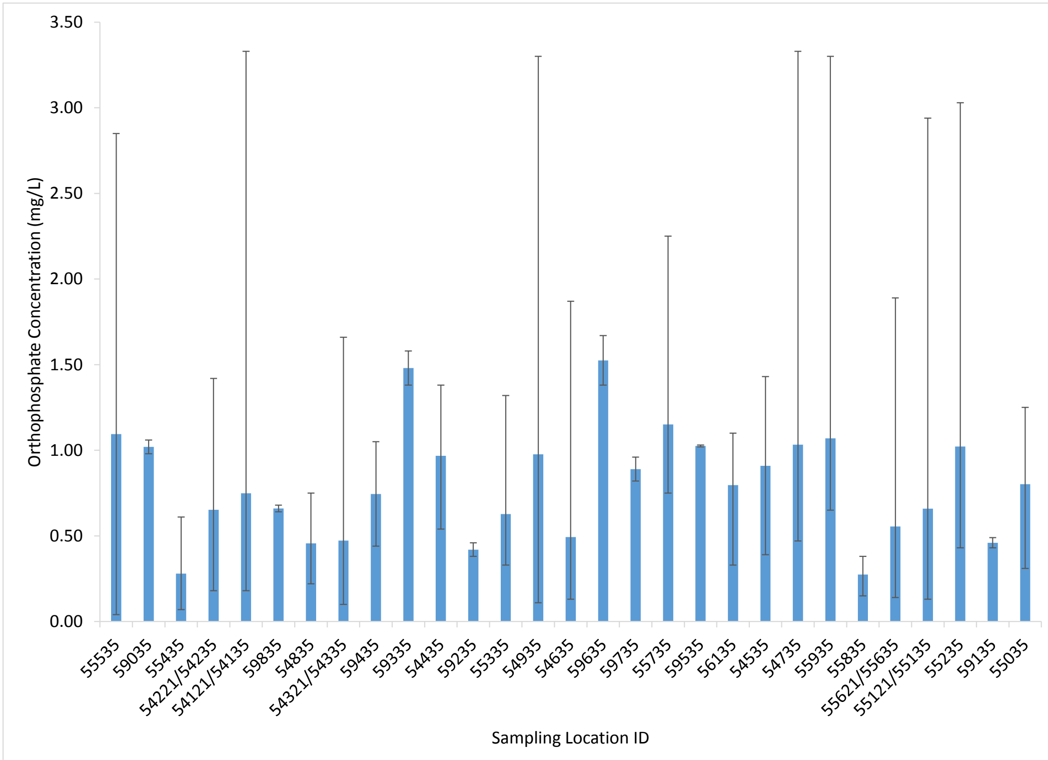
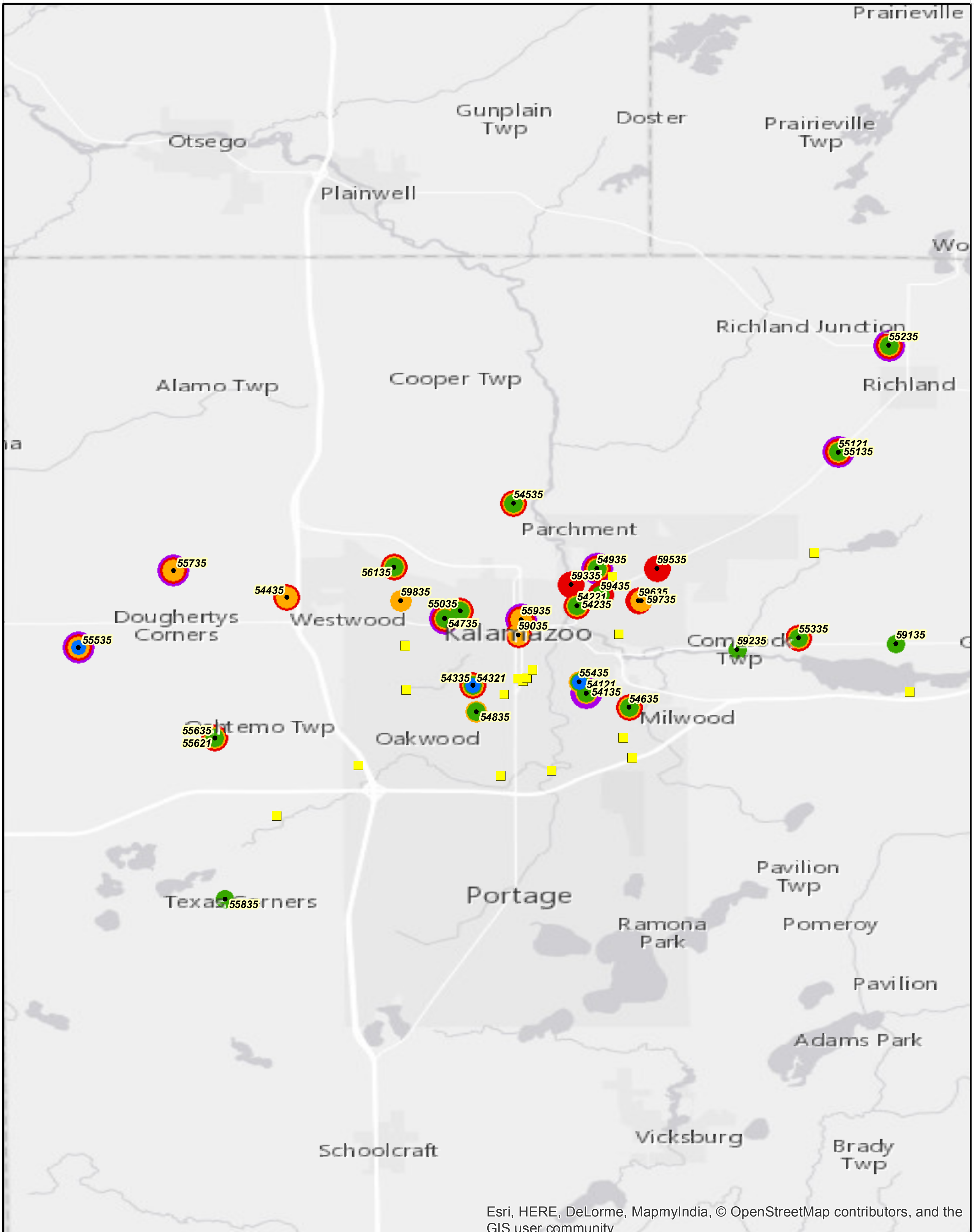


Figure 5. Average Orthophosphate Levels

The average orthophosphate levels at the sampling locations ranged from about 0.3 mg/L to 1.5 mg/L. Across the distribution system, the orthophosphate levels fluctuated from 0.04 mg/L to about 3.3 mg/L and averaged near 0.75 mg/L overall. The aerial representation shown in **Figure 6** does not appear to reveal any definitive patterns in varying orthophosphate results. Nevertheless, it confirms the break-down of polyphosphate to orthophosphate from the sodium hexametaphosphate. Although the occurrence and extent of this breakdown is difficult to predict, fluctuations in orthophosphate levels are typically influenced by varying water age and water quality conditions. Therefore, the higher orthophosphate levels most likely corresponded to sampling conditions with longer detention times and possibly warmer water temperatures (EPA, 2016; Ketrane et al., 2009).

Due to the complex nature of this system, the overall average orthophosphate level (0.75 mg/L) may not be representative of each pressure district. Therefore, a simplified, but more tailored approach was applied to estimate the typical or "benchmark" orthophosphate levels for each pressure district. The sample location results were first sorted by pressure district, then analyzed according to statistical averages, ranges, frequency distributions, and probability plots. A summary of the orthophosphate averages and corresponding maximum and minimum ranges is presented in **Table 5**. No sampling points were located within the West Side Low; therefore, the West Side High results were used to estimate the benchmark level for the West Side Low pressure district. **Figures 7** through **14** illustrate the frequency distributions and probability plots for each pressure district data set.



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COMBINED ORTHOPHOSPHATE LEVELS

FIGURE 6

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For each pressure district, the typical orthophosphate level was based upon the average and highest frequency range from the histogram distribution. As an example, if the average fell within the highest frequency range, then the benchmark level was estimated as the corresponding highest frequency range. If the average fell out of the range, then the estimated benchmark range was adjusted to include the observed average. The estimated benchmark orthophosphate levels for each pressure district are included in **Table 5**.

These benchmark levels provide a baseline for future changes in corrosion control strategies. When considering the conversion to a new corrosion inhibitor chemical, the initial dose of the new chemical would be based on matching current orthophosphate levels in the system to prevent rapid changes in distribution system water quality. The new corrosion control chemical dose would then be adjusted as needed based on water quality monitoring results or manufacturer recommendations.

Table 5. Orthophosphate Concentration by Pressure District

Parameter	Minimum	Maximum	Average	Highest Frequency Range	Estimated Benchmark Orthophosphate Level
Low	0.07	3.33	0.73	0.51 – 0.75	0.5 – 0.75
Intermediate	0.11	3.3	0.83	0.75 – 1.0	0.75 – 1.0
High	0.1	1.87	0.47	0.26 – 0.5	0.25 – 0.5
East Side High	0.13	3.03	0.83	0.51 – 0.75	0.5 – 1.0
Northwest High	0.31	3.33	0.87	0.76 – 1.0	0.75 – 1.0
Super High	0.14	1.89	0.42	0.26 – 0.5	0.25 – 0.5
Ultra High	0.54	2.25	1.06	0.76 – 1.0	0.75 – 1.25
West Side High	0.04	2.85	1.09	0.76 – 1.0	0.75 – 1.25
West Side Low[1]	--	--	--	--	0.75 – 1.25

1. Estimated benchmark level based on West Side High pressure district results.

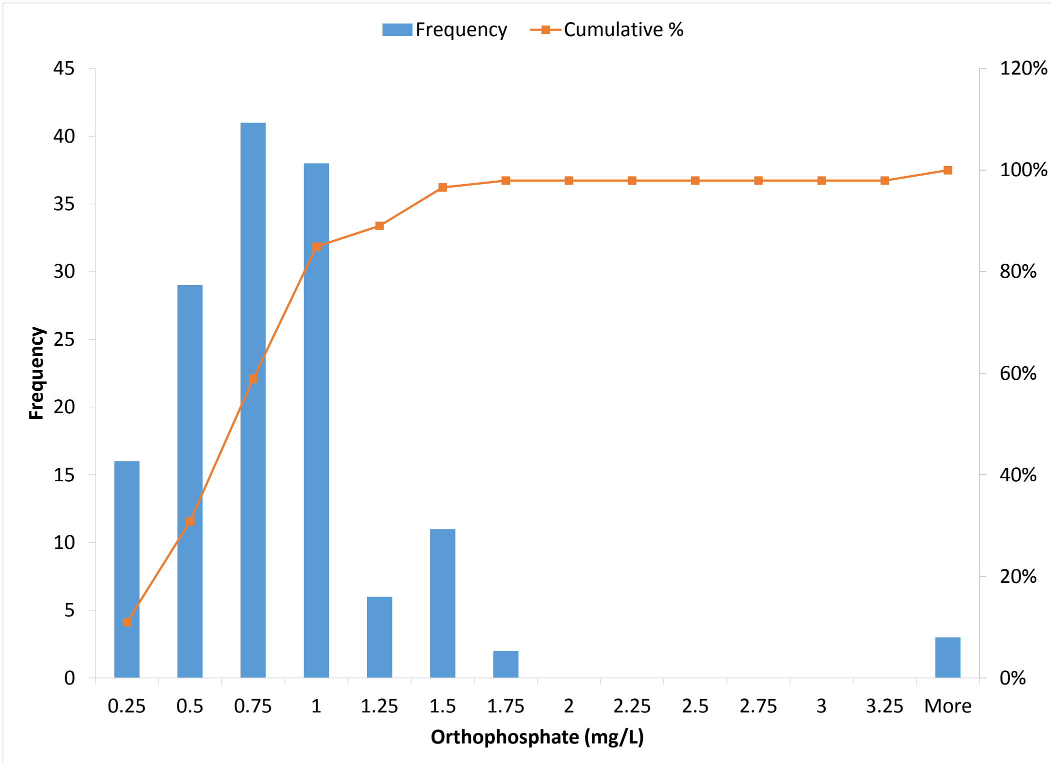


Figure 7. Low Pressure District Orthophosphate Frequency Distribution and Probability Plot

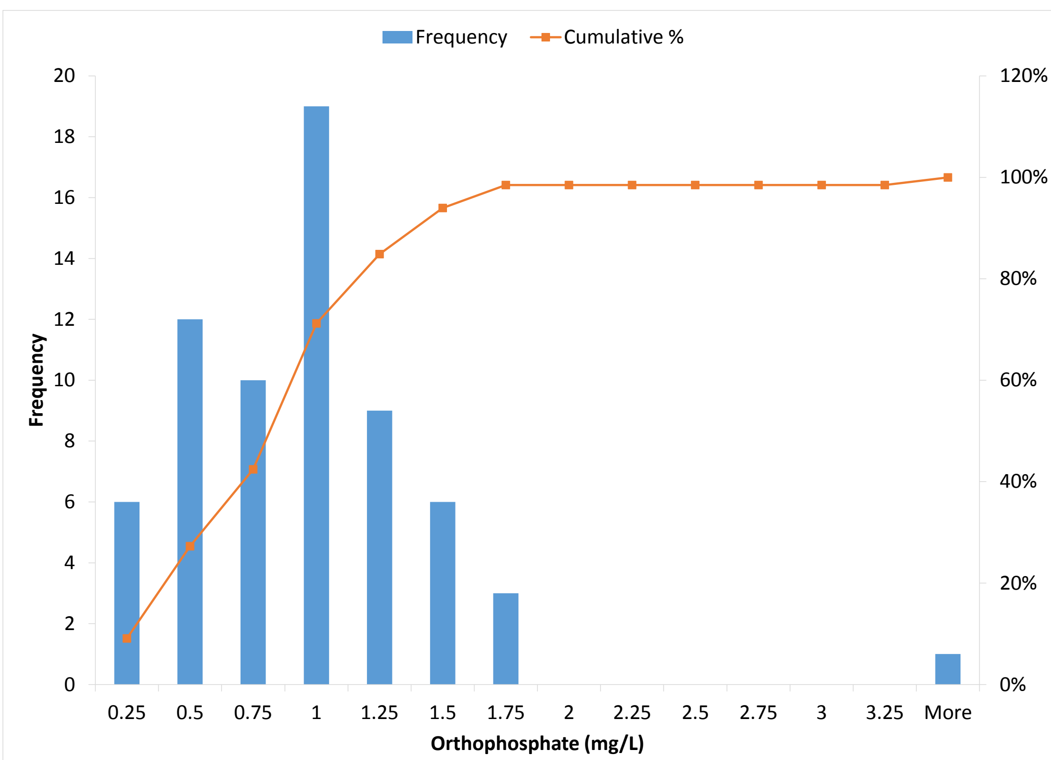


Figure 8. Intermediate Pressure District Orthophosphate Frequency Distribution and Probability Plot

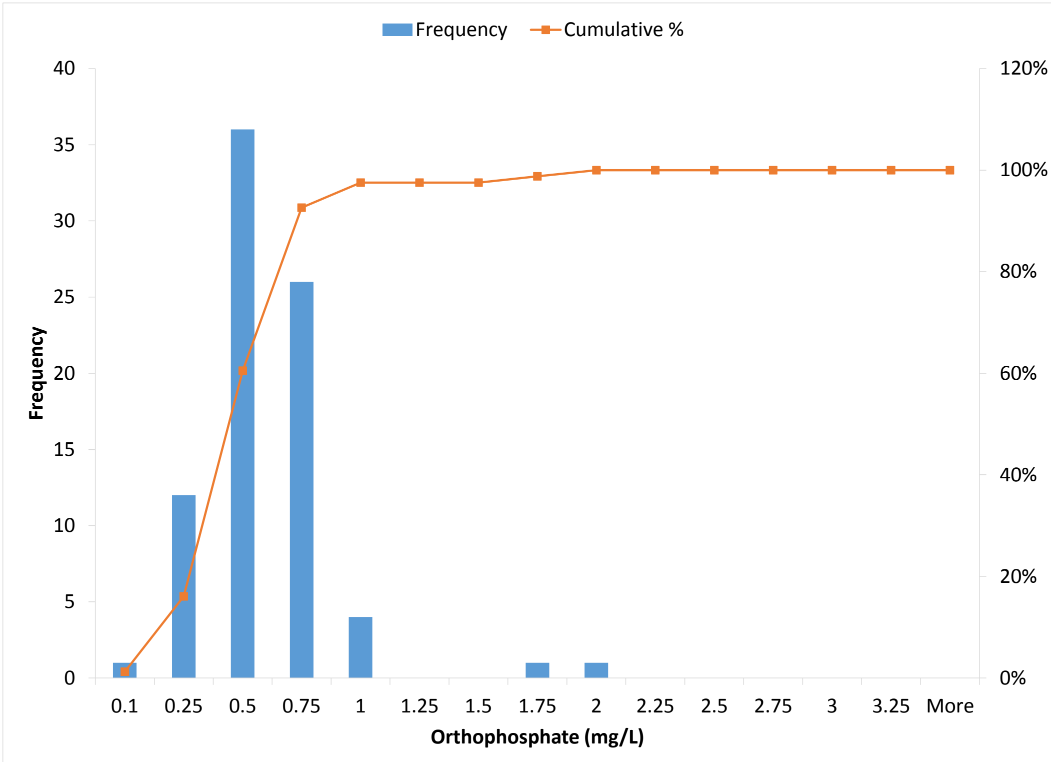


Figure 9. High Pressure District Orthophosphate Frequency Distribution and Probability Plot

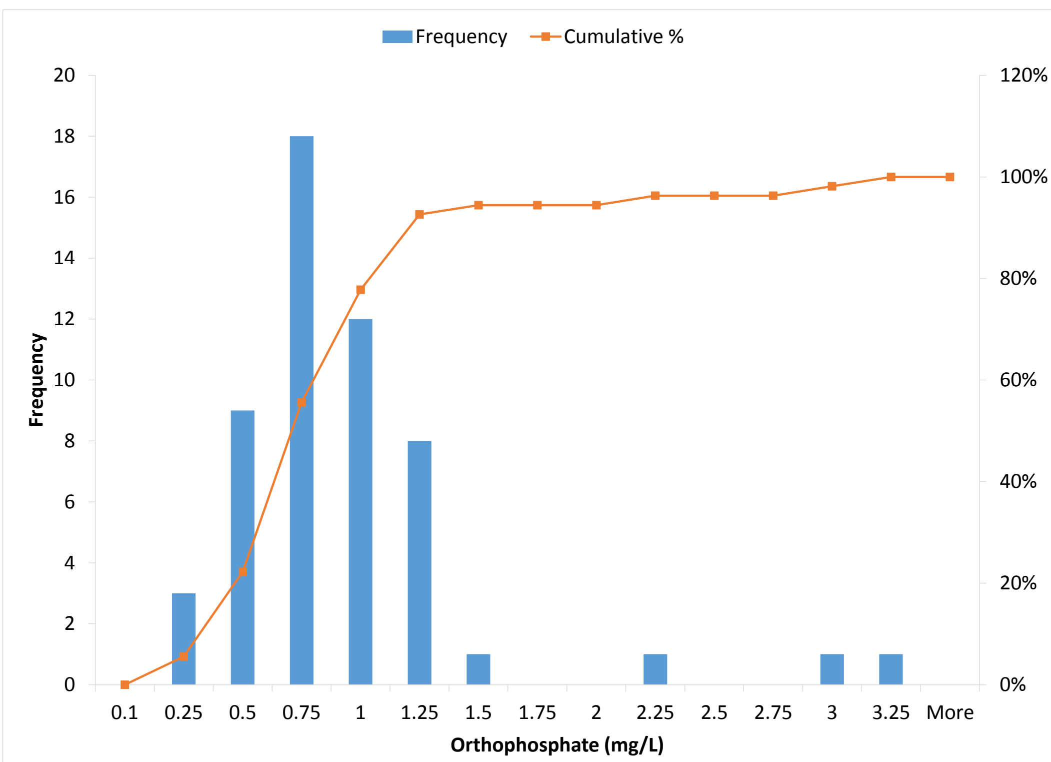


Figure 10. East Side High Pressure District Orthophosphate Frequency Distribution and Probability Plot

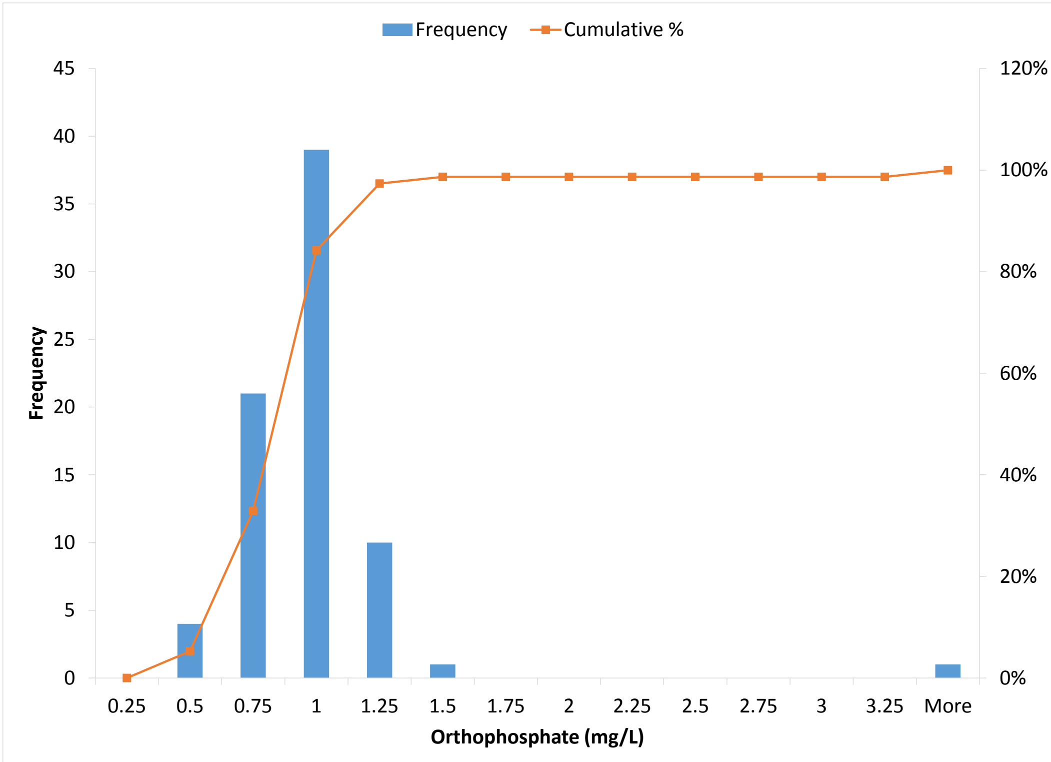


Figure 11. Northwest High Pressure District Orthophosphate Frequency Distribution and Probability Plot

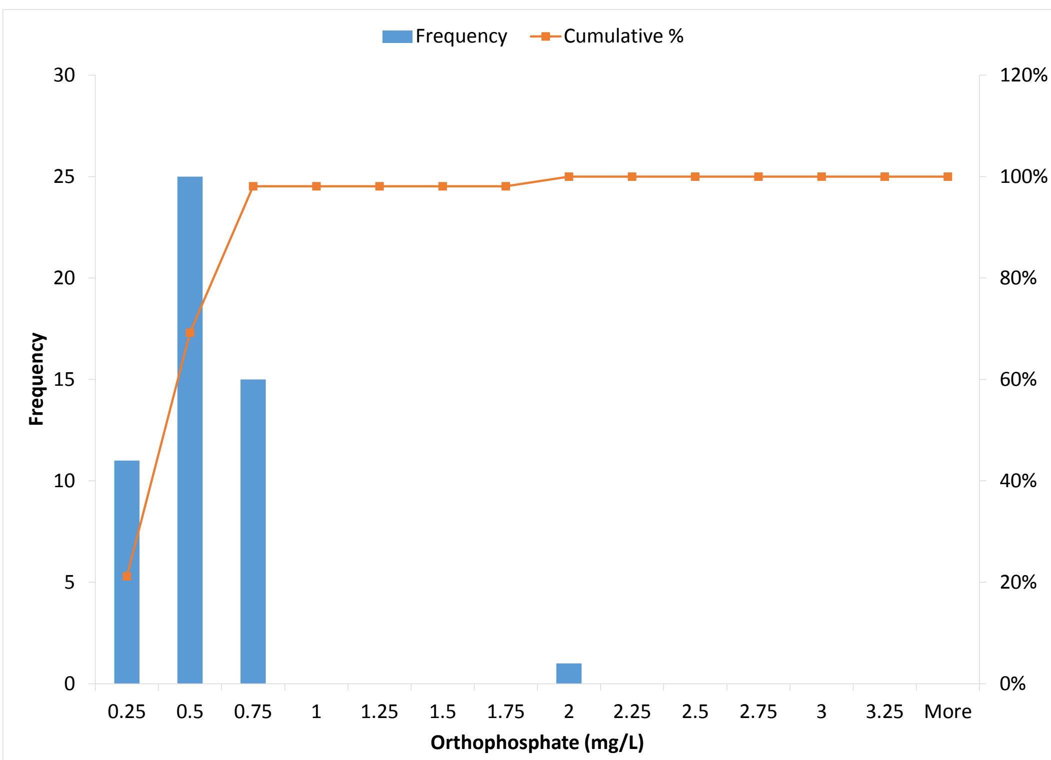


Figure 12. Super High Pressure District Orthophosphate Frequency Distribution and Probability Plot

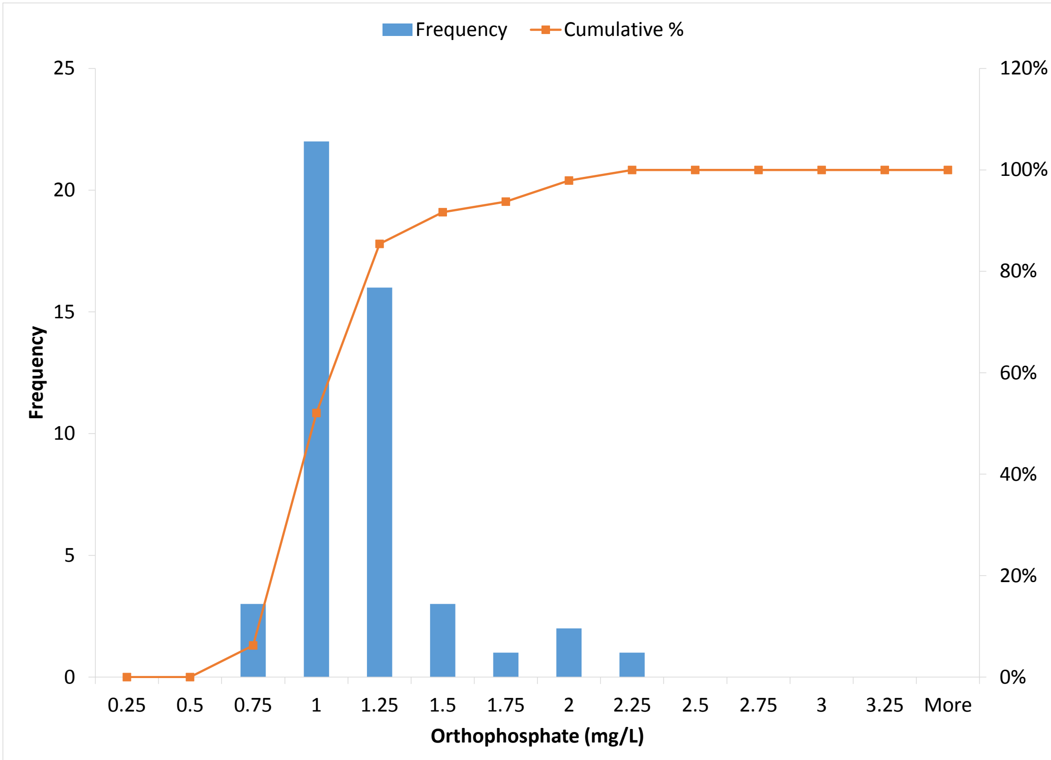


Figure 13. Ultra High Pressure District Orthophosphate Frequency Distribution and Probability Plot

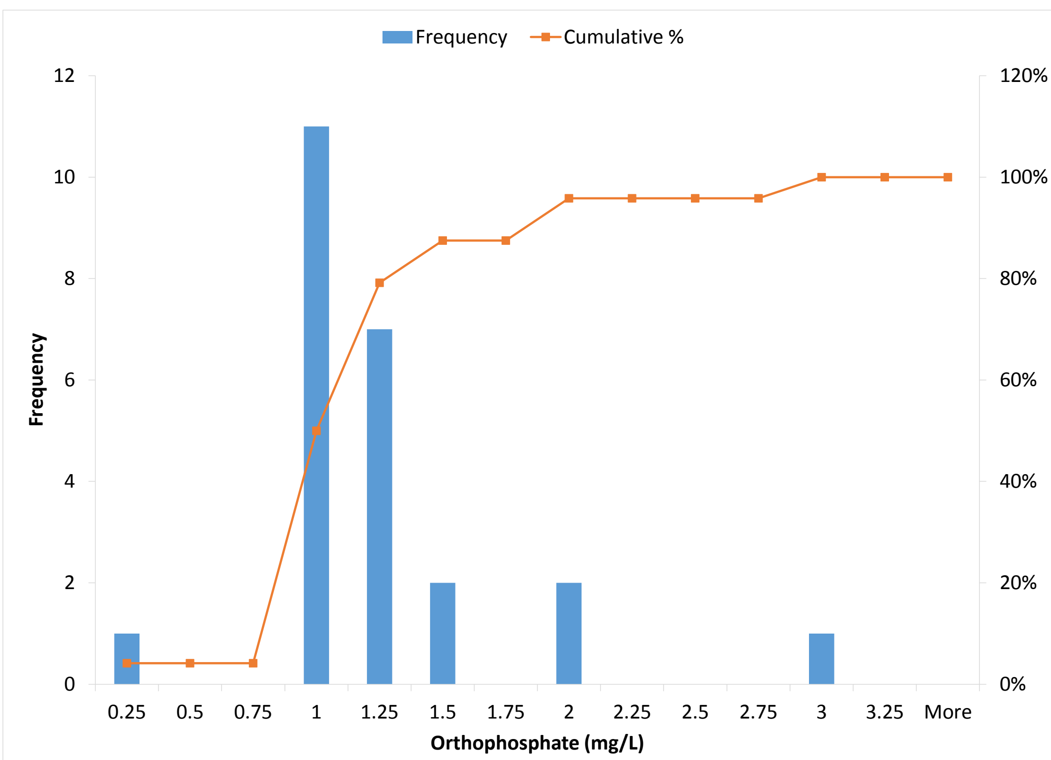


Figure 14. West Side High Pressure District Orthophosphate Frequency Distribution and Probability Plot

CORROSION POTENTIAL ANALYSIS

Corrosion Indices

The values of corrosion indices for the City's current drinking water supplies were determined using the Langelier Saturation Index (LSI), the calcium carbonate precipitation potential (CCPP), and the Larson-Skold Index. The indices were calculated for the individual water plants and the identified water quality blends. A summary of the LSI, CCPP, and Larson-Skold results for the individual stations is presented in **Table 6**. The LSI, CCPP, and Larson-Skold results for the blended station pairs are included in **Tables A-1** through **A-23** of **Attachment A**. The following sections provide a brief overview of theory and discussion of results.

Table 6. Corrosion Indices

Station No.	Langelier Saturation Index			Calcium Carbonate Precipitation Potential (mg/L)			Larson-Skold Index		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Station 1	--	--	--	--	--	--	--	--	--
Station 2	0.31	0.59	-0.03	24	46	-5.6	0.697	1.01	0.210
Station 3	--	--	--	--	--	--	--	--	--
Station 4	--	--	--	--	--	--	--	--	--
Station 5	0.00	0.20	-0.19	-7.7	18	-37	0.45	0.47	0.42
Station 8	-0.01	0.09	-0.07	-4.3	5.3	-10	0.53	0.67	0.36
Station 9	-0.61	-0.47	-0.86	-79	-60	-152	0.43	0.52	0.38
Station 11	-0.65	-0.52	-0.74	-112	-77	-126	0.50	0.62	0.35
Station 12	0.88	1.1	0.68	32	39	26	0.29	0.35	0.23
Station 14	-0.49	-0.38	-0.64	-91	-64	-140	0.52	0.56	0.46
Station 17	--	--	--	-20	33	-141	0.22	0.46	0.13
Station 18	-0.26	-0.14	-0.39	-33	-20	-46	0.27	0.35	0.19
Station 22	0.05	0.23	-0.13	-2.8	7.6	-16	0.25	0.28	0.24
Station 24	-0.80	-0.58	-1.10	-98	-55	-160	0.19	0.50	0.05
Station 25	-0.05	0.48	-0.62	-17	24	-93	0.23	0.31	0.17
Station 39	--	--	--	-15	12	-93	0.25	0.41	0.00

Calcium Carbonate Stability

The LSI is a measure of the water's state of saturation with respect to calcium carbonate and is calculated using Equation 1 for pH values between 7.0 and 9.5 (Langelier, 1936).

$$\boldsymbol{LSI = pH - pH_s} \qquad \textbf{EQUATION 1}$$

The pH_s is the saturation pH at which the alkalinity and calcium hardness are in equilibrium with solid calcium carbonate and is calculated using Equation 2.

$$\boldsymbol{pH_s = pK'_2 - pK'_{so} - log[Ca^{2+}] - log[Alk]} \qquad \textbf{EQUATION 2}$$

Where:

pK'_2= Second dissociation constant for carbonic acid at water temperature

pK'_{so}= Solubility product constant for $CaCO_3$ at water temperature

$log[Ca^{2+}]$= Log value of the calcium concentration

$log[Alk]$= Log value of the total alkalinity concentration

The state of calcium carbonate saturation depends on the value of the LSI, which is interpreted as follows:

- LSI < 0, the solution is undersaturated with $CaCO_3$ (will dissolve $CaCO_3$)
- LSI = 0, the solution is at equilibrium with $CaCO_3$
- LSI > 0, the solution is supersaturated with $CaCO_3$ (will precipitate $CaCO_3$)

Slight precipitation of calcium carbonate can serve as a protective scale in water distribution pipes and has been associated with reduced corrosion complaints. Although maintaining a slightly positive Langelier Index is not considered a formal corrosion control method for metals, a slightly positive LSI can help protect against leaching of concrete mortar in lined steel and ductile iron pipes. Consequently, it is common practice for water utilities to add lime or caustic soda to treated water to maintain a slightly positive LSI. A higher positive Langelier Index indicates a potential for scaling, which would require feeding a sequestrant, such as polyphosphate, reducing the pH, or softening to prevent scaling. Water from Station No. 12 has the highest scaling potential, while waters from Stations No. 9, 11, and 24 have the highest potential for leaching concrete and mortar from the system.

As opposed to the LSI, which indicates the driving force for precipitation, the CCPP is an indicator of the amount of calcium carbonate that is theoretically expected to precipitate as the solution progresses towards equilibrium. Typically, a CCPP between 4 and 10 would be considered beneficial relative to calcium carbonate. Similar to the LSI results, water from Station No. 12 could precipitate the greatest quantity of calcium carbonate. On the other hand, waters from Stations No. 11, 14, and 24 could dissolve the greatest the greatest quantity of calcium carbonate. A comparison of the calculated LSI and CCPP values for the individual stations are presented in **Figures 15** and 1**6**, respectively.

Based on the blending analysis, the mixing of waters from Stations No. 2 and 7, 9 and 12, and 12 and 22 could result in a shift from positive to negative LSI values or vice versa. Similarly for these station pairs, the CCPP values could shift from a higher potential for calcium carbonate precipitation to leaching of calcium carbonate or vice versa.

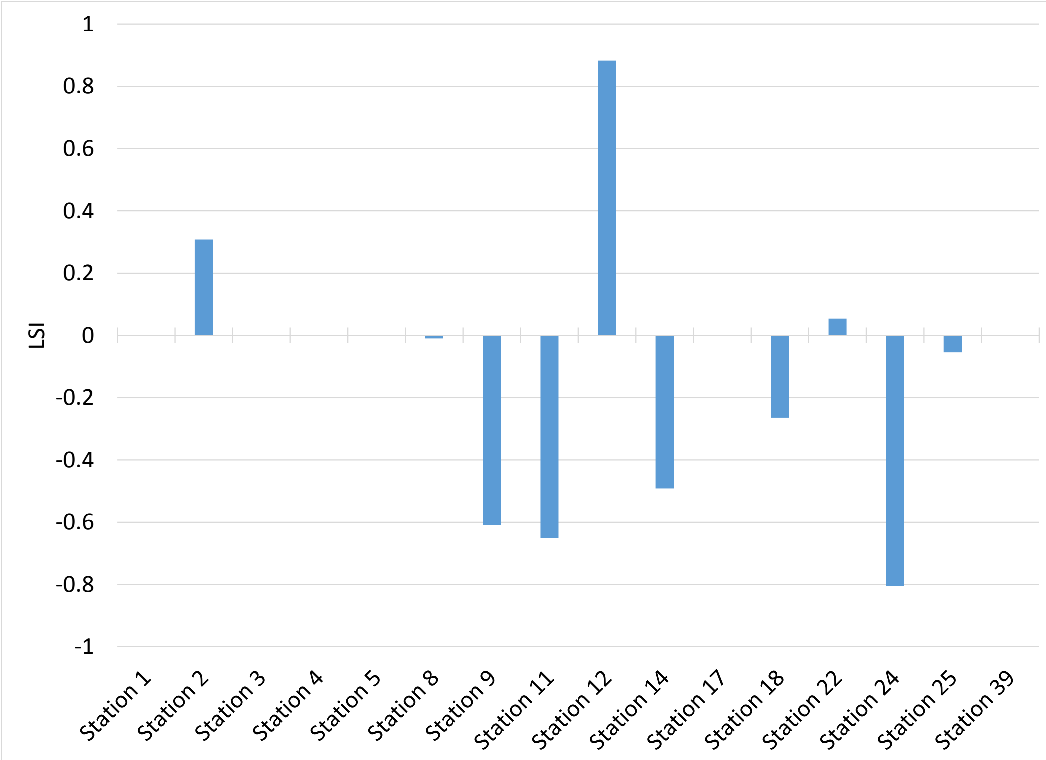


Figure 15. Comparison of LSI Values

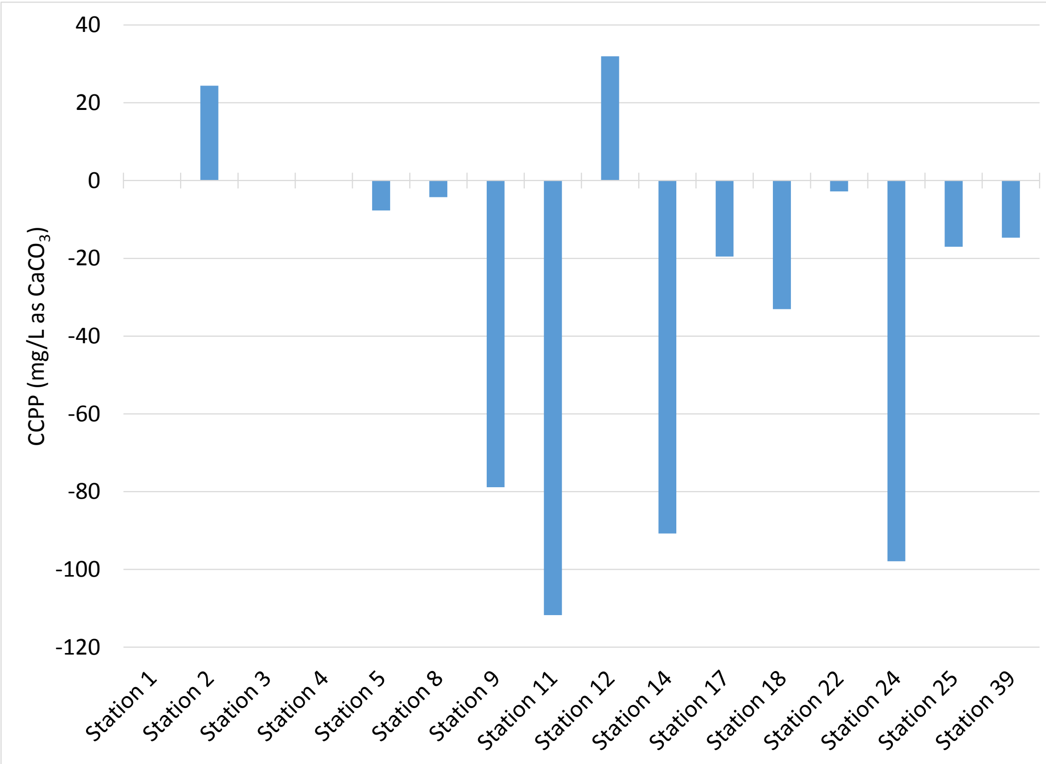


Figure 16. Comparison of CCPP Values

Larson-Skold Index

Chloride and sulfate may cause increased corrosion of iron and steel pipe by forming soluble metal compounds when combined with metal ions released by corrosion cells instead of more insoluble metal scales that provide a level of protection to the pipe surface against further corrosion. Larson and Skold (1957) studied the impact upon the ratio of chloride and sulfate ions to bicarbonate ions in solution relative to the rate of cast iron and steel corrosion. The Larson-Skold Index is calculated as the ratio of the sum of the equivalent concentrations of chloride and sulfate divided by the equivalent concentration of the bicarbonate alkalinity. Typically, Larson-Skold Index values between 0.2 and 0.3 are considered noncorrosive toward iron and steel pipe; however, values up to 1.0 have been considered acceptable. Values greater than 1.2 may indicate a tendency toward a higher rate of iron and steel corrosion and additional methods of corrosion control may be required.

A comparison of the calculated Larson-Skold indices for the individual stations is presented in **Figure 17**. The waters from Stations No. 17 through 39 have a low potential for iron and steel corrosion based on this index, while water from Station No. 2 exhibits the highest potential for iron and steel corrosion. The Larson-Skold index is a conservative parameter; therefore, blending of the individual stations would result in a similar range in the Larson-Skold indices as the individual supplies. The Larson-Skold index results for the blended stations are included in the blended water quality tables in **Attachment A**.

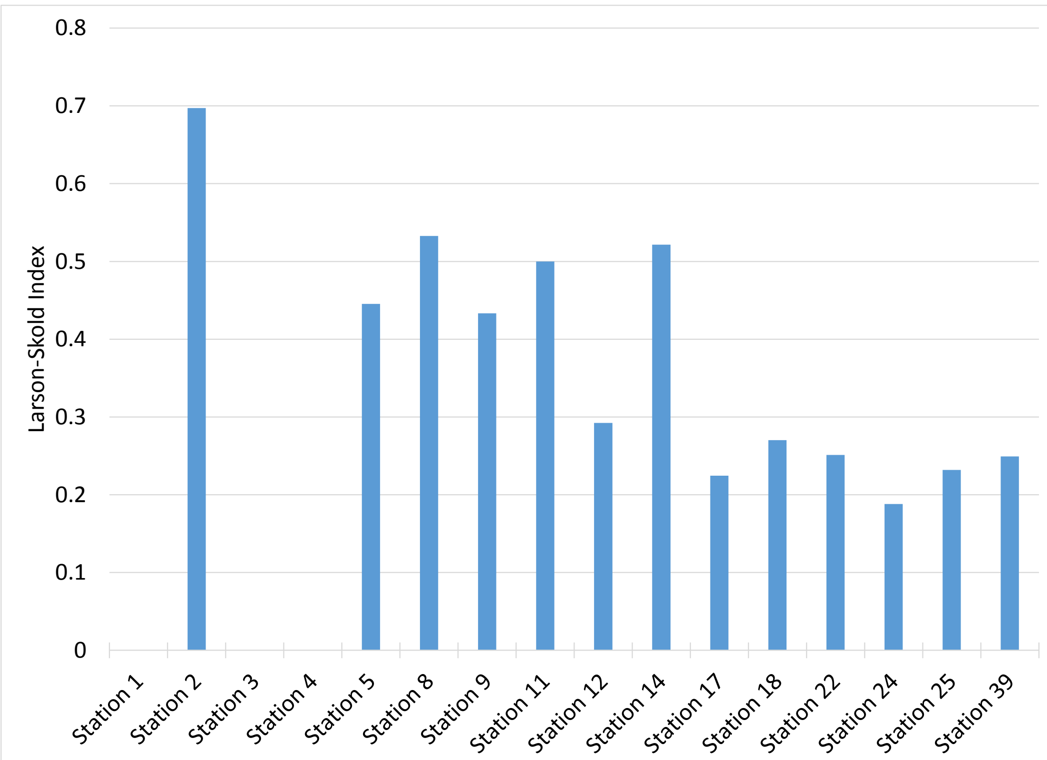


Figure 17. Comparison of Larson-Skold Indices

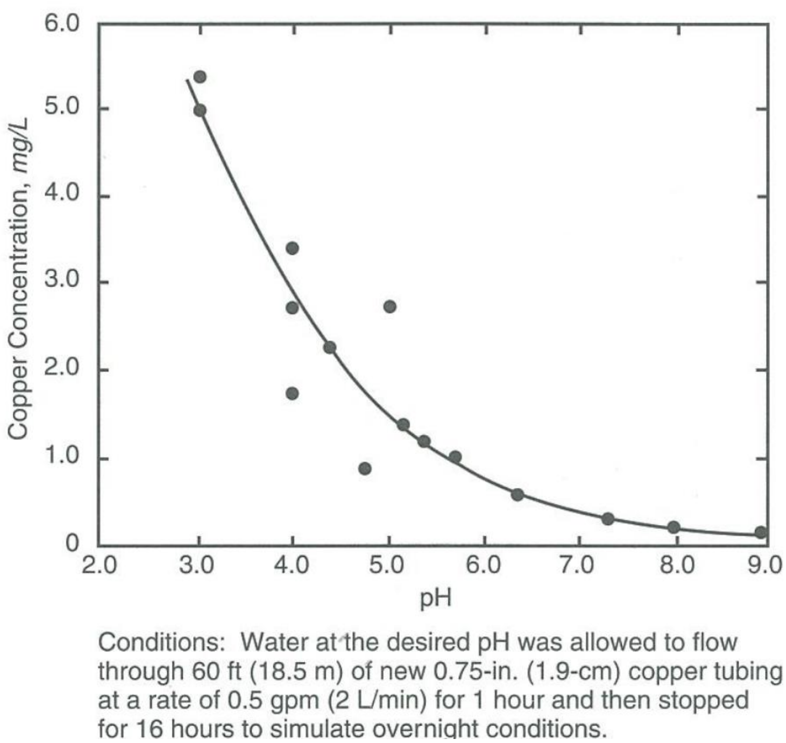
Lead and Copper Corrosion Control

Lead and copper concentrations can become elevated in the drinking water and plumbing systems when water comes in contact with materials such as certain types of pipes, lead solder and faucets containing lead, brass or bronze. The potential to reduce corrosion leading to higher lead and copper concentrations in drinking water can be improved by optimizing water quality characteristics. The water quality factors that have the greatest effect on lead and copper corrosion are pH, dissolved inorganic carbonate (DIC), orthophosphate concentration, alkalinity, and buffer intensity. Dissolved oxygen and chlorine residual are also important considerations for copper corrosion.

Copper

Corrosion of copper and release of soluble copper compounds into solution is thought to originate when the metal is oxidized, usually in the presence of dissolved oxygen and chlorine, to the +1 or +2 oxidation state. Under ideal conditions for corrosion control a uniform, tightly adherent scale of cuprite (Cu_2O) precipitates on the interior pipe surface and forms a passivation layer which prevents further corrosion and subsequent metal release. However, there are many competing reactions that can occur to form copper compounds in the form of oxides, carbonates, hydroxides, amines, chlorides, sulfates, phosphates and silicates that may govern the concentration of soluble copper under varying conditions of alkalinity, pH, DIC, ionic strength and electrical potential of the water. Therefore, very precise rules for water quality to control or limit copper corrosion and metal release into solution are difficult to develop to fit each specific water quality. However, some general tendencies have been observed. The first is that there is a general relationship between pH and the release of copper into solution. This is illustrated in **Figure 18**, which relates the release of copper from new pipe as a function of pH.

Figure 18. Effect of pH on the Release of Copper into Solution*



*Adapted from *Benjamin et al. (1996). Internal Corrosion of Water Distribution Systems. Denver, CO: Water Works Association Research Foundation*.

As the water becomes more acidic, pH < 7, the concentration of copper greatly increases and as the water becomes more alkaline, pH > 7, the release of copper into solution is at a minimum. A second general trend is that the rate of copper release tends to increase as the alkalinity of the water is increased when the pH is held constant. The alkalinity effect is less pronounced at higher pH values as compared to lower pH values for the same alkalinity concentration. The effect of various anions on the release of copper from aged pipe has been studied at pH greater than 7. The study indicated that the presence of bicarbonates and sulfates resulted in higher release of copper than chlorides. This is consistent with the finding that there is a tendency toward greater copper release as the alkalinity is increased, which in the pH range normally encountered in potable water systems also means that the concentration of bicarbonate ion is also increasing. The combination of dissolved oxygen and chlorine in the water, a high alkalinity and lower pH values in the Kalamazoo water favor the release of copper into solution.

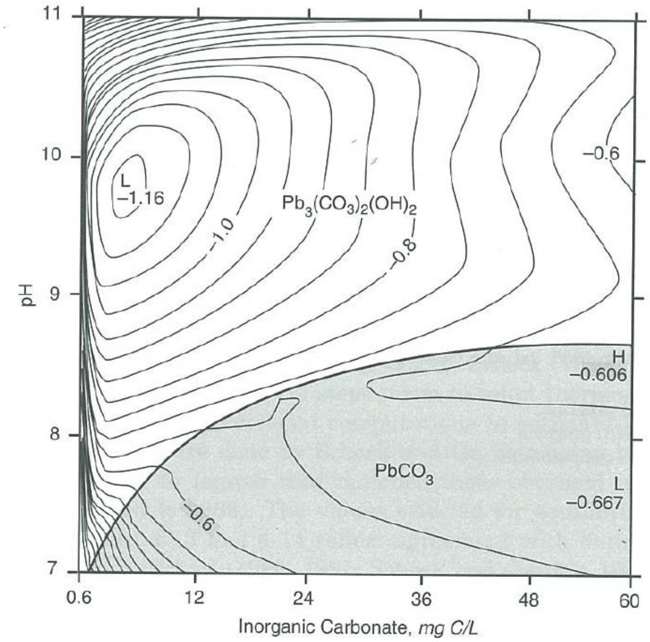
Lead

Corrosion of lead and release of soluble lead compounds into solution is thought to originate when the metal is oxidized, usually in the presence of dissolved oxygen and chlorine, to the +2 oxidation state. The degree of oxidation and release of soluble lead is dependent upon the pH, the concentration of oxidants and the complexation of the Pb^{+2} ion with various anions and ligands in the water. Under favorable conditions lead can form hydroxycarbonate, carbonate and oxides that can form an insoluble layer on the inside of the pipe surface that serves as a passivation barrier to further corrosion. Two of these compounds being hydrocerussite ($Pb_3(CO_3)_2(OH)_2$) and cerussite ($PbCO_3$). **Figure 19** shows the pH and dissolved inorganic carbonate concentrations under which these compounds would form and the equilibrium concentration of lead that would be associated with each. The formation of hydrocerussite is favored at lower concentrations of DIC and higher DIC concentrations at higher pH, >8.4. **Figure 19** also shows that the minimum lead solubility occurs at a pH of 9.8 and DIC of 4 mg/L and that as the concentration of DIC increases the equilibrium solubility of lead increases. Note that the higher DIC in the Kalamazoo raw water falls outside of the figure boundary to the right.

When orthophosphate is added to the water sparingly soluble lead hydroxyphosphate compounds can form to limit the solubility of lead in equilibrium with the passivation film. This is illustrated in **Figure 20**. This figure shows that at lower values of pH and DIC the formation of the hydroxyphosphate compound can further reduce the equilibrium lead concentration as compared to the cerussite layer produced in the absence of orthophosphate. **Figure 20** also shows that the potential effectiveness of orthophosphate addition is reduced as the DIC is increased. The DIC increases as the alkalinity of the solution is increased.

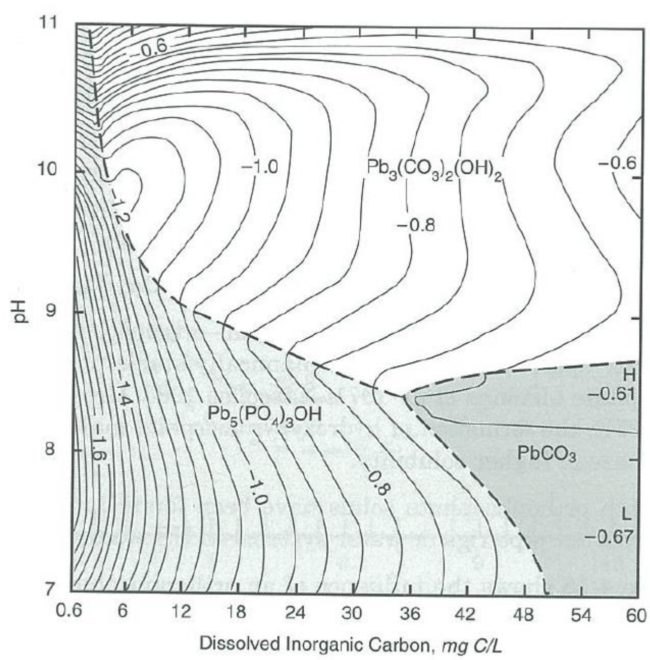
This relationship is further illustrated in **Figure 21** which shows the orthophosphate dose versus lead solubility for various values of alkalinity at pH 7.0. Since water within the distribution and plumbing systems generally do not remain in contact with the pipe surface, even during periods of nonuse, long enough to achieve complete equilibrium, a target lead solubility of 0.03 mg/L might be chosen to determine the initial orthophosphate dose. At an alkalinity of 50 mg/L an orthophosphate dose of approximately 1.8 mg/L would be required and at an alkalinity of 100 mg/L an orthophosphate dose of approximately 4.3 mg/L would be required. At an alkalinity of greater than 200 mg/L the dosing of orthophosphate would not be expected to exert a sufficient level of control to bring down the lead solubility to the target lead solubility, but would still limit the maximum lead solubility.

Figure 19. Contour Diagram of Lead Solubility vs pH and Inorganic Carbon*



NOTE: The boundary line position between the domains of the lead is approximate. Concentration units are log (mg Pb/L). Local high and low points are marked "L" and "H," respectively.

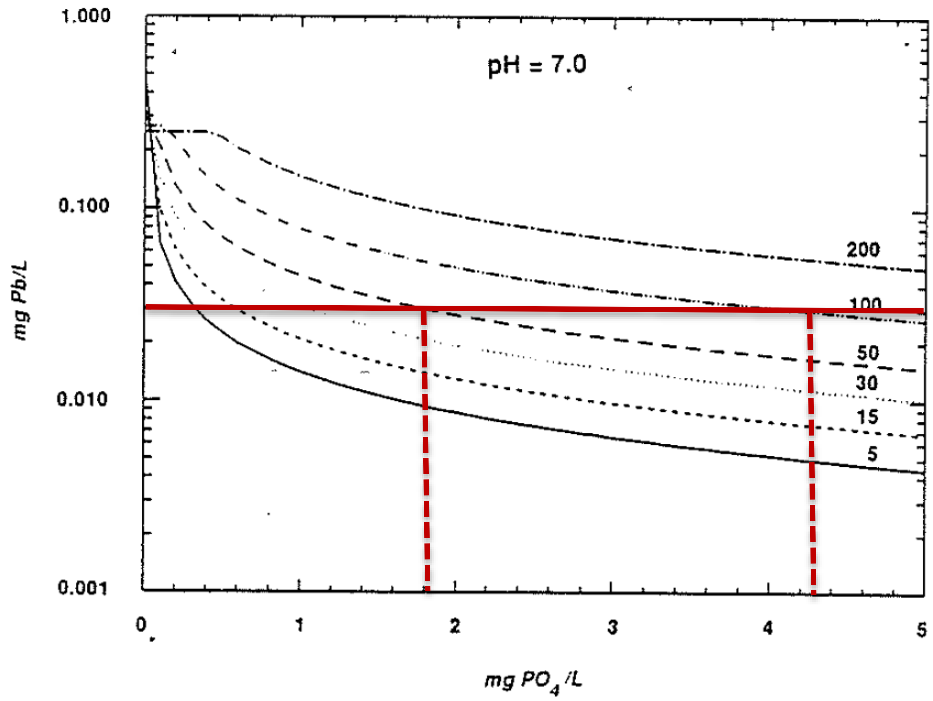
Figure 20. Contour Diagram of Lead Solubility in a System with 0.5 mg PO_4/L Orthophsphate*



NOTE: Concentration units are log (mg Pb/L). Local high and low points are indicated.

*Adapted from *Benjamin et al. (1996). Internal Corrosion of Water Distribution Systems. Denver, CO: Water Works Association Research Foundation*.

Figure 21. Lead Solubility vs Orthophosphate at Various Alkalinities*



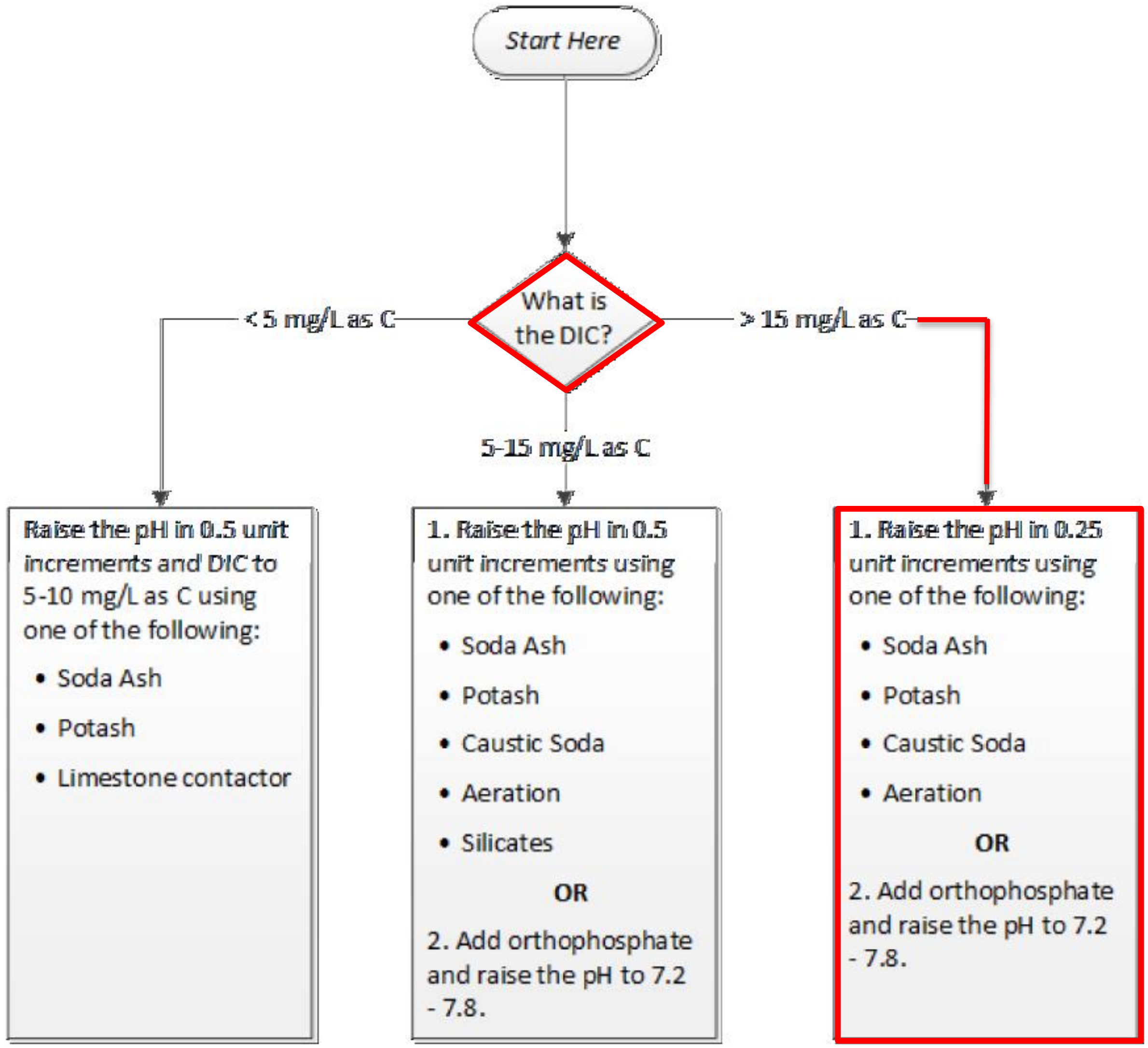
*Adapted from *American Water Works Association Research Foundation's Lead Control Strategies (1990)*.

Flow Chart Treatment Determinations

The Water Research Foundation (previously American Water Works Association Research Foundation) developed a "Lead Control Strategies" guidance manual in 1990 to provide water utilities information on how to approach lead concerns in drinking water, how to select water treatment alternatives, and how to determine the effectiveness of a lead control strategy (AWWARF 1990). This manual was later supplemented in 1997 by EPA's Guidance Manual for Selecting Lead and Copper Control Strategies, which was revised in 2003 and more recently updated in March, 2016 as Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems. Tetra Tech referred to these guidance manuals to identify treatment options for lead and copper control and to compare identified strategies to the City's current practices.

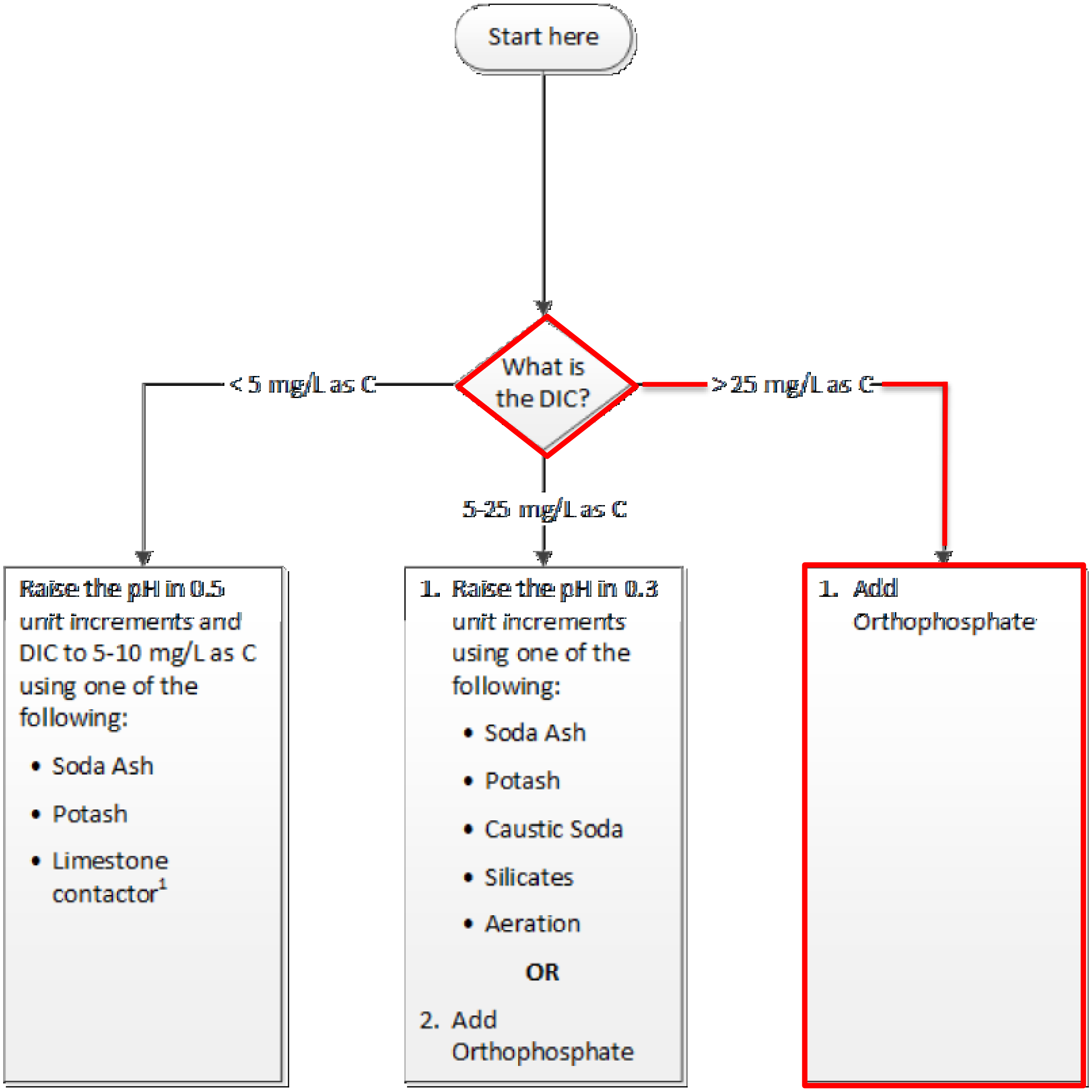
EPA's 2016 Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems includes flow charts for determining treatment approaches for mitigating lead and copper corrosion when the lead and/or copper ALs have been exceeded. Although the 90th percentile lead and copper levels throughout the City's water system are well below the lead and copper ALs, the City's desire to switch from sodium hexametaphosphate to a liquid, blended phosphate corrosion inhibitor requires consideration of optimum corrosion treatment for each station. The characteristics of the individual water supplies were used to select the flow chart in the manual that was most applicable for determining a recommended method of corrosion control. Therefore, EPA's pertinent flow charts, presented in **Figures 22** through **25**, were used to determine corrosion treatment approaches for the individual water pumping stations to aid in recommending a corrosion control management strategy.

Figure 22. Flow Chart 1a for Selecting Lead and Copper Corrosion Control Measures with pH < 7.2*



*Adapted from EPA's 2016 Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems.

Figure 23. Flow Chart 1b for Selecting Lead and/or Copper Corrosion Control Measures with pH from 7.2 to 7.8*

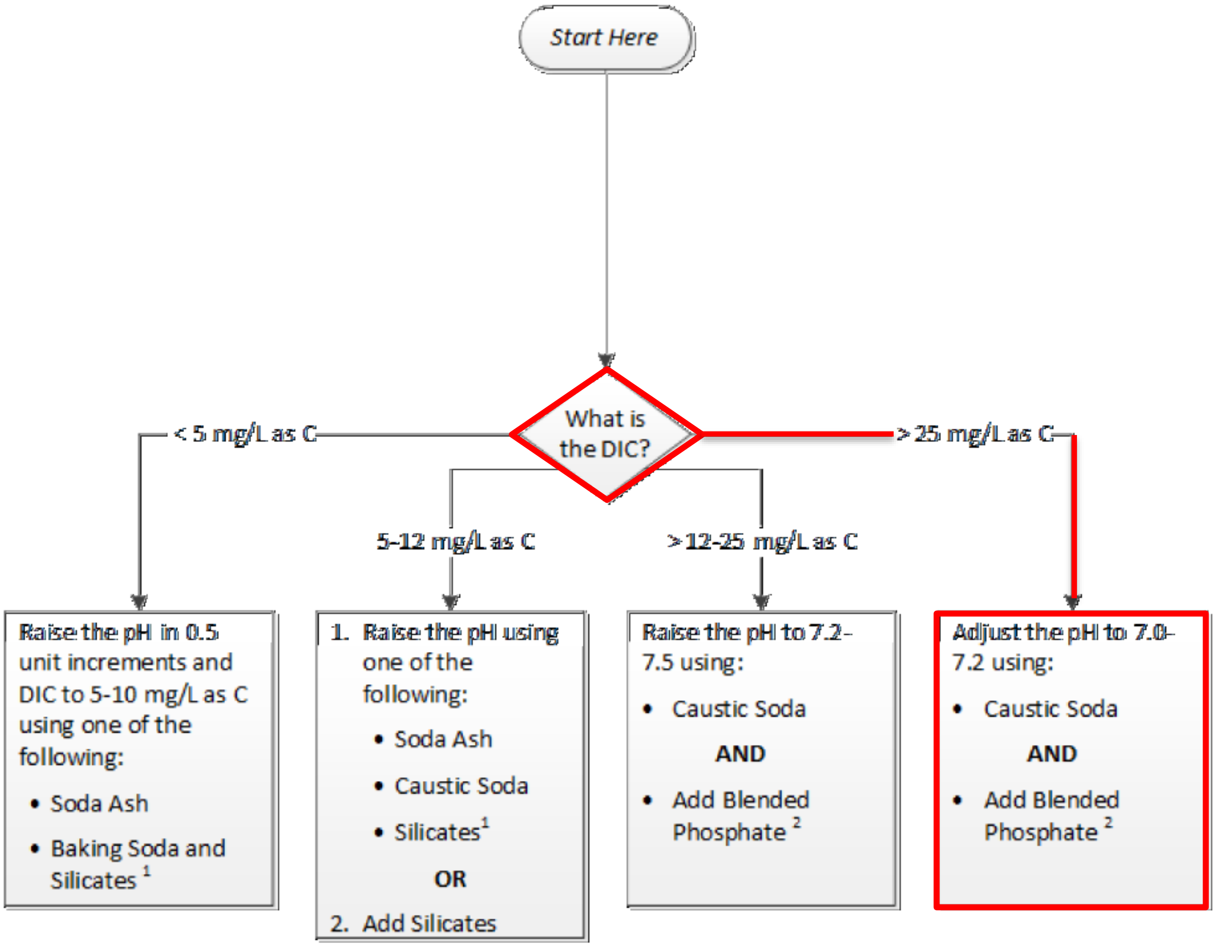


Notes:

1. Carbon dioxide feed before the limestone contactor may be necessary

*Adapted from EPA's 2016 Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems.

Figure 24. Flow Chart 3a for Selecting Lead and/or Copper Corrosion Control Measures with Iron and Manganese in Finished Water and pH <7.2*

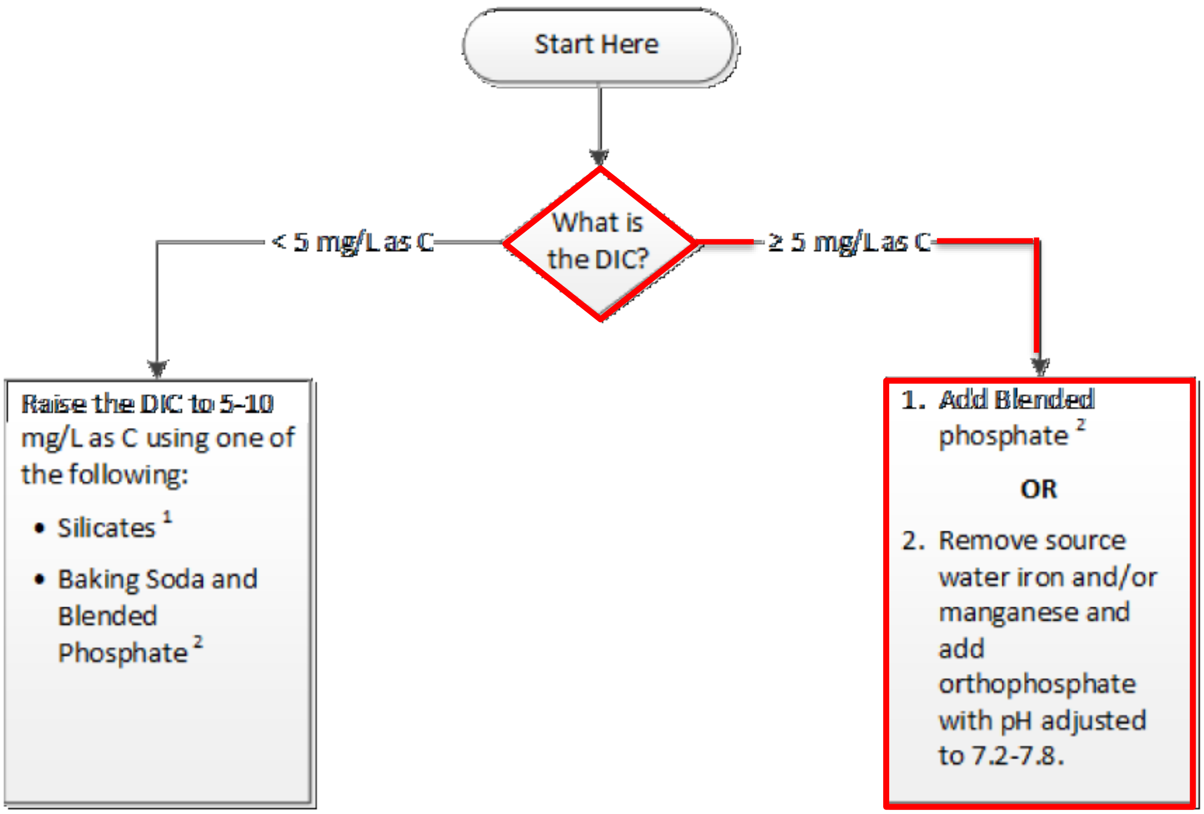


Notes:

1. Silicates are most effective when combined iron and manganese concentrations are less than 1.0 mg/L.
2. The effectiveness of blended phosphate varies based on the formulation. Additional evaluation and/or monitoring is recommended.

*Adapted from EPA's 2016 Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems.

Figure 25. Flow Chart 3b for Selecting Lead and Copper Corrosion Control Measures with Iron and Mangenese in Finished water and pH ≥7.2*



Notes:

1. Silicates are most effective when combined iron and manganese concentrations are less than 1.0 mg/L.
2. The effectiveness of blended phosphate varies based on the formulation. Additional evaluation and/or monitoring is recommended. Blended phosphates are less effective for controlling copper at DIC greater than 25 mg/L as C.

*Adapted from EPA's 2016 Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems.

If additional treatment were necessary to maintain lead and copper below their respective ALs, the following treatments would be recommended according to EPA's guidance manuals:

- Station No. 11:
    - Raise the pH in 0.25 unit increments using soda ash, potash, caustic soda, or aeration. Alternatively, add orthophosphate and raise pH to between 7.2 and 7.8.
- Station No. 1:
    - Add orthophosphate.
- Stations No. 5, 8, 9, 14, 17, 18, 24, 25, and 39:
    - Adjust the pH to 7.2 using caustic soda and add blended phosphate.
- Stations No. 2, 3, 4, 12, and 22:
    - Add blended phosphate. Alternatively, Remove source water iron and add orthophosphate with pH adjusted to between 7.2 and 7.8.

A comparison between these EPA recommended corrosion control treatments and currently applied treatments is included in **Table 7**.

Table 7. Comparison of EPA Recommended and Current Corrosion Control Treatments

Drinking Water Source	EPA Recommended	Currently Implemented
Station No. 11	• Raise the pH in 0.25 unit increments using soda ash, potash, caustic soda, or aeration; or • Add orthophosphate and raises pH to between 7.2 and 7.8	Currently adding sodium hexametaphosphate at about 1.0 to 1.5 mg/L
Station No. 1	• Add orthophosphate	Currently adding sodium hexametaphosphate at about 1.0 to 1.5 mg/L
Stations No. 5, 8, 9, 14, 17, 18, 24, 25, and 39	• Adjust the pH to 7.2 using caustic soda and add blended phosphate	Currently adding sodium hexametaphosphate at about 1.0 to 1.5 mg/L (2.0 to 2.5 mg/L is added to Station 24)
Stations No. 2, 3, 4, 12, and 22	• Add blended phosphate; or • Remove source water iron and add orthophosphate with pH adjusted to between 7.2 and 7.8.	Currently adding sodium hexametaphosphate at about 1.0 to 1.5 mg/L

REVIEW OF CORROSION INHIBITOR MANUFACTURER INFORMATION

Liquid, blended phosphate corrosion additives are primarily sold as proprietary formulations for which information must be obtained from the manufacturers and suppliers of these products. Product and dose recommendations were requested from three corrosion control chemical suppliers, including Carus Corporation, Sterling Water Technologies, and Shannon Chemical Corporation. We provided each supplier a summary of the City's water system data, including average capacity and water quality from each station. Additionally, we provided information regarding nearby stations and distribution system water mains. A summary of the recommended corrosion control strategies and products from each manufacturer are included in **Table 8**.

Table 8. Manufacturer Recommended Corrosion Control Management Strategies

Manufacturer	Recommended Corrosion Control Strategy
Carus Corporation	• At each water supply station, apply 1 to 1.5 mg/L of active CARUS™ 8100, which is a 34.5% active blended polyphosphate liquid product containing 70% polyphosphate and 30% orthophosphate.
Sterling Water Technologies	• At each water supply station, apply 4 equivalent parts of active polyphosphate as PO_4 for every mg/L of dissolved iron and manganese. • Recommended bended polyphosphate liquid product containing 90-85% polyphosphate and 10-15% orthophosphate. • At stations with pH < 7.2, adjust pH to between 7.2 to 7.6 pH units.
Shannon Chemical Corporation	• Continue feeding sodium hexametaphosphate for corrosion protection and sequestration of iron and manganese. • If converting to a liquid-based product is desired, it is recommended that 1.08 mg/L of active SLI-5225 be applied at each water supply station. SLI-5225 is a 36% active blended polyphosphate liquid product containing 75% polyphosphate and 25% orthophosphate.

SUMMARY AND DISCUSSION

All of the raw water supply stations for the City of Kalamazoo have high hardness and many have elevated levels of iron and manganese, which can lead to scaling, red, brown, yellow and black water, and staining. The system has historically fed sodium hexametaphosphate at each station which can effectively sequester calcium to prevent it from causing scale build up. More importantly, hexametaphosphate serves to sequester and prevent iron and manganese in the reduced +2 oxidation states from reacting with oxygen and chlorine to oxidize to the ferric (+3) and manganic (+3,4,6) oxidation states. These oxidation states form generally insoluble compounds that will impart turbidity and color to the water. The sequestration of calcium to prevent scaling does not appear to be as important in this system because most stations have a negative Langelier Index and negative calcium carbonate precipitation potential as a result of the lower pH. The sequestration of iron and manganese is a critical requirement of the phosphate inhibitor at those stations with iron greater than 300 ppb and manganese greater than 50 ppb to prevent aesthetics complaints.

An equivalent polyphosphate dose should be maintained at those stations that do not presently have treatment for iron removal. Hexametaphosphate at a neutral pH can prevent calcium carbonate from precipitating at a dose as low as 1 mg/L per 200 mg/L calcium hardness with potentially higher dosages up to 2-3 mg/L required for shorter chain polyphosphates. Calcium hardness ranges from 140 to 275 mg/L as $CaCO_3$, which would correspond to a dose of 0.7 to 1.38 mg/L. Pyrophosphates may be more effective at sequestering iron at dosages of 1 mg/L per mg/L of iron depending upon chain length up to dosages of 4 mg/L per mg/L of iron for metaphosphates. Therefore, it may be possible to somewhat reduce the polyphosphate doses where calcium sequestration is not essential and where only iron and manganese sequestration is required when using a product with straight chain polyphosphates.

Orthophosphate does not provide any appreciable benefits for sequestration but can build up passivation layers on the interior of pipe materials that reduce the rate of corrosion. Orthophosphate concentrations of 1 to 1.5 mg/L can be effective in creating and maintaining a corrosion barrier to reduce lead and copper corrosion. However, as described earlier in this report the effectiveness of orthophosphate is reduced as the alkalinity is increased and therefore, a higher dosage may be required to achieve significant reduction in metal release. There is a potential limit to the orthophosphate dose that can be applied to these raw waters because of the high calcium concentration.

Calcium phosphate is highly insoluble with a solubility product of 1×10^{-26} as compared to the calcite form of calcium carbonate which is 3.8×10^{-9}. The concentration of phosphate ion in the orthophosphate form is higher at higher pH and will tend to form turbidity and scale in the presence of high calcium concentration. Most of the stations have pH values that are neutral or slightly acidic so this should not be a problem. However, station 12 has a pH close to 8 and a higher orthophosphate dose at this station might lead to turbidity in the potable water.

The corrosion rate of copper is reduced and the effectiveness of orthophosphate is increased at pH values that are neutral to slightly alkaline. The orthophosphate component of blended phosphate inhibitors is often made using phosphoric acid and the pH of the solution will be very acidic. The addition of these products to the raw water will tend to cause the pH to drop slightly. At those stations where the pH after chemical addition is less than 7.0 consideration should be given to raising the pH both to reduce corrosion rates and to increase the effectiveness of the orthophosphate. However, raising the pH much above 8 should be avoided to prevent precipitation of calcium phosphate.

At stations 1 and 11 where iron removal is employed and if the calcium carbonate precipitation potential is low, a blended product with a high orthophosphate percentage (70-80%) would be appropriate as an initial product choice to provide an orthophosphate dose of 1 to 1.5 mg/L and lesser dose of polyphosphate to provide some control of corrosion products within the system and where blending with other sources occurs. At the remainder of the stations a product that has a higher percentage of polyphosphate (60-85%) would be appropriate as an initial product choice to provide an equivalent level of polyphosphate as the current sodium hexametaphosphate product and also providing an orthophosphate dose of 1 to 1.5 mg/L.

It is important not to significantly overdose or underdose polyphosphates. Overdosing can lead to the deflocculation of built-up corrosion byproducts, especially of iron, releasing particulate iron particles into the water system resulting in brown and red water complaints from consumers. Significantly underdosing of polyphosphates can provide inadequate sequestration and resistance to iron and manganese oxidation which can lead to brown and black water complaints as well as staining complaints from consumers as a result of the precipitation of insoluble iron and manganese oxidation products. This can also result in an additional chlorine demand upon the system which can lower chlorine residuals.

It is recommended that one or more products be tested with the raw water to determine the dosage of polyphosphate that provides for effective sequestering of iron and manganese. This testing can be performed by stain testing using a 0.45 micron filter. For the testing a sample of the raw water without chemical addition, a sample of the water after polyphosphate addition and two samples of the water after polyphosphate addition and chlorination should be collected. The first three samples will be filtered soon after chemical dosing and if the iron and manganese in the raw water are in the reduced state and the phosphate dose is sufficient these pads should be only lightly discolored. The fourth sample after chemical addition should be held for a day, measured for turbidity and then filtered. Filter pads should be retained for comparison purposes to compare different doses of a single product and to compare different products.

The corrosion control effectiveness of the orthophosphate portion of the blended phosphate corrosion inhibitor is best determined using coupon racks with copper, lead, brass and steel coupons. Side by side tests can be performed to determine optimum dosage and pH for maximum corrosion rate reduction. Side by side tests can also be performed to test different products and compare their effectiveness. Coupon test rigs can often be obtained from the chemical suppliers at no cost or a relatively low rental fee.

Some testing of the water quality in the distribution system is necessary after beginning the use of a blended orthophosphate product. Polyphosphates will over time, in the presence of calcium and at higher temperature tend to revert to orthophosphates as is currently occurring in the distribution system. At the water temperatures reported for the stations the reversion process is anticipated to occur very slowly. However, to ensure that the product being fed to the system maintains its effectiveness throughout the system it is recommended that samples be collected from the extremes of the system after the new product has been introduced into the system to measure the level of polyphosphates to verify that significant reversion is not occurring within the system that would compromise the effectiveness of this component. Samples should also be collected at the extremes of the system to check the orthophosphate concentration. Initially, there might be a higher orthophosphate demand in the system that would decrease the concentration as the travel time from the station increases. For the orthophosphate component to be effective for corrosion control a minimum concentration must be present. If measurements show that the concentration is significantly reduced in portions of the system, the dosage should be increased for a period of time until the orthophosphate concentration increases to near the feed concentration and then tapered back to a maintenance dosage level.

RECOMMENDATIONS

The system is currently operating within the requirements of the Lead and Copper Rule with lead and copper 90th percentile concentrations below their respective action levels. Therefore, further action is not required from a regulatory standpoint. However, the City wants to continue to implement improvements to the water quality that is delivered to its customers and further optimize operations of corrosion control treatment where possible.

Based upon the review and analysis of the compliance sampling results, source water quality, and manufacturer recommendations, the following recommendations are provided in **Table 9** to maintain system water quality and corrosion control within the distribution system.

Table 9. Recommended Corrosion Control Management Strategies

Water Pumping Station	Corrosion Control Method
Station No. 11	• Add blended phosphate (>70% orthophosphate) at a dose of 1.5-2.5 mg/L as active ingredient to provide 1-1.5 mg/L as orthophosphate and raise pH to between 7.2 and 7.8
Station No. 1	• Add blended phosphate (>70% orthophosphate) at a dose of of 1.5-2.5 mg/L as active ingredient to provide 1-1.5 mg/L as orthophosphate, adjust pH if necessary to between 7.2 and 7.8
Stations No. 5, 8, 9, 14, 17, 18, 24, 25, and 39	• Adjust the pH to 7.2 using caustic soda and add blended phosphate (>60% polyphosphate) at a dose of 2-3 mg/L as active ingredient to provide 1-1.5 mg/L as polyphosphate to match current dose and 0.5-1.0 mg/L as orthophosphate
Stations No. 2, 3, 4, 12, and 22	• Add blended phosphate (>60% polyphosphate) at a dose of 2-3 mg/L as active ingredient to provide 1-1.5 mg/L as polyphosphate to match current dose and 0.5-1.0 mg/L as orthophosphate

Additional considerations and recommendations for the corrosion control methods presented in **Table 9** are offered as follows:

- At start-up, it is recommended that the initial dose of the blended phosphate be adjusted to match the current polyphosphate concentration fed to the system to prevent rapid changes in distribution system water quality. The blended phosphate dosage would then be gradually increased to achieve the orthophosphate ranges recommended above.

- Collect lead and coper tap samples within six months after change to liquid inhibitor to confirm optimum corrosion control has been maintained.
- Shorter-chain polyphosphates are more effective in sequestering iron and manganese; therefore, longer-chain forms may require higher dosages.
- Continue to monitor water quality and review sampling results to compare pH, alkalinity, and orthophosphate levels to the sources of supply and verify that the water quality is not changing significantly in the distribution system.
- For further optimization of the corrosion control method, perform coupon studies to determine the best product and dosage to achieve minimum corrosion rates.

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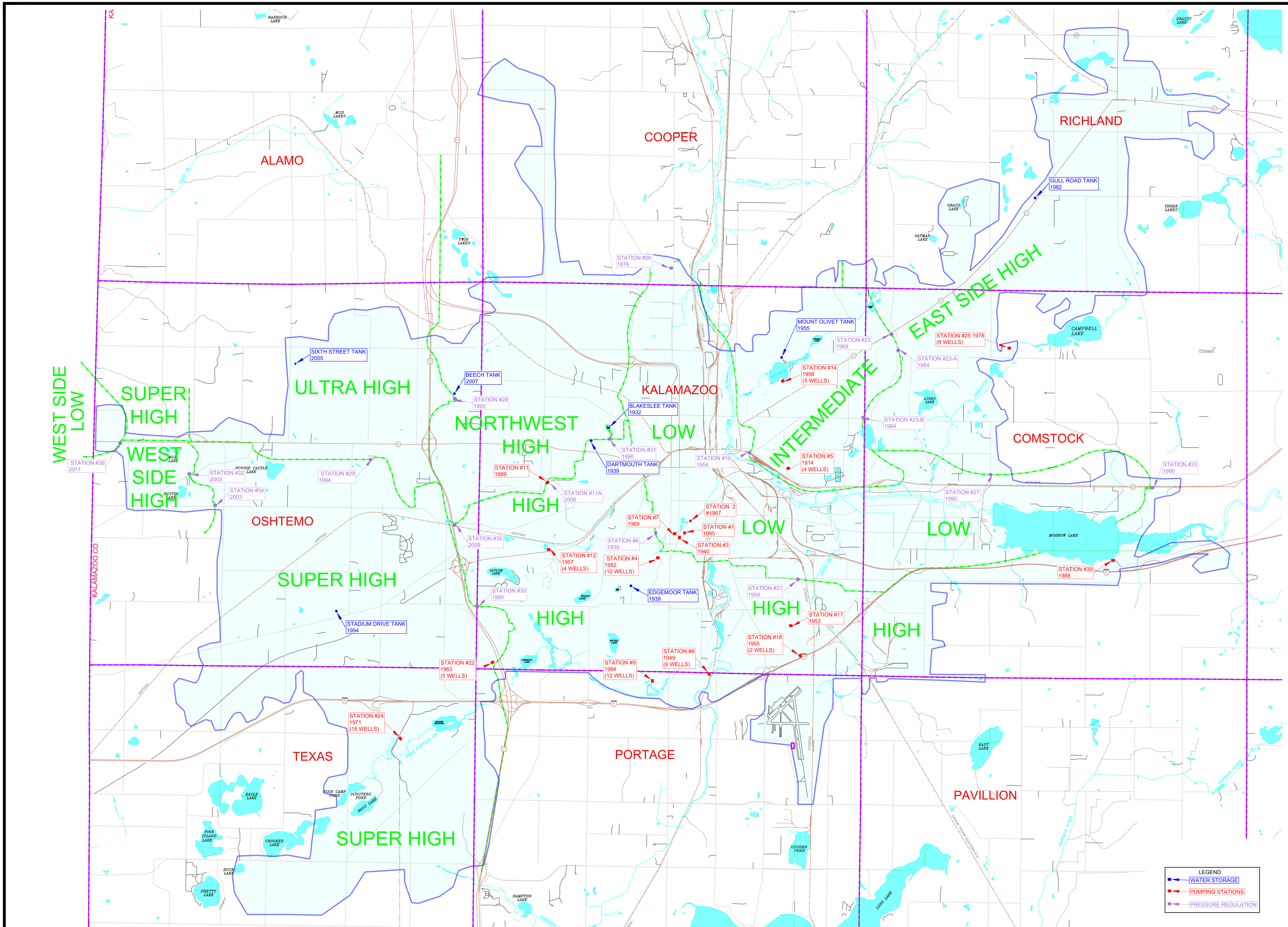
Attachment A

Kalamazoo Water System Data



DATE: 12/22/15

DRAWN BY: WEE

CITY OF KALAMAZOO WATER SERVICE AREA ~ 2015

CITY OF KALAMAZOO
Department Of Public Services
Engineering Division
415 STOCKBRIDGE AVE.
KALAMAZOO, MICHIGAN 49001
PH.# (269)-337-8601 FAX # (269)-337-8533

SHEET
1 OF 1

NO SCALE

Table A-1
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		1				2
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	311
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	308
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.08
Arsenic	ug/L	6.0	5.1	4.3	3.4	2.6
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	375
Calcium	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	110,150
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.44
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	37
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	110.13
Conductivity	umhos/cm	ND	#VALUE!	#VALUE!	#VALUE!	888
Copper	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	45.38
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	83.7
Dissolved Oxygen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	2.3
Fluoride	mg/L	0.98	0.88	0.79	0.69	0.59
Iron	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	877
Lead	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	2.64
Magnesium	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	35,500
Manganese	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	152
Nitrate Nitrogen	mg/L	0.44	0.41	0.39	0.37	0.34
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.09
pH	pH units	ND	#VALUE!	#VALUE!	#VALUE!	7.30
pH after Chem Add	pH units	ND	ND	ND	ND	7.28
Silicate	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	8,426
Sodium	ug/L	49,000	53,063	57,125	61,188	65,250
Sulfate	mg/L	45	47	49	52	54
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	14.0
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	57.1
TDS (calculated)	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	561
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	21.75
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	370.71
Zinc	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.45
CCPP		ND	ND	ND	ND	-27.6
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.69

Table A-2 Blending of Waters from Adjacent Stations						
Parameter	Unit	**A**				**B**
Station #		1				3
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Arsenic	ug/L	6.0	4.9	3.8	2.7	1.6
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Calcium	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	98,143
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	10.00
Conductivity	umhos/cm	ND	#VALUE!	#VALUE!	#VALUE!	878
Copper	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	20.00
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Dissolved Oxygen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	1.5
Fluoride	mg/L	0.98	#VALUE!	#VALUE!	#VALUE!	ND
Iron	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	930
Lead	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	3.00
Magnesium	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	32,014
Manganese	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	106
Nitrate Nitrogen	mg/L	0.44	#VALUE!	#VALUE!	#VALUE!	ND
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
pH	pH units	ND	#VALUE!	#VALUE!	#VALUE!	6.87
pH after Chem Add	pH units	ND	ND	ND	ND	ND
Silicate	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	5,271
Sodium	ug/L	49,000	45,836	42,671	39,507	36,343
Sulfate	mg/L	45	#VALUE!	#VALUE!	#VALUE!	ND
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	ND
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	ND
TDS (calculated)	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	555
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	ND
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	ND
Zinc	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	24
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
CCPP		ND	ND	ND	ND	ND
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!

Table A-3 Blending of Waters from Adjacent Stations						
Parameter	Unit	**A**				**B**
Station #		1				17
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	251
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	248
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.15
Arsenic	ug/L	6.0	5.6	5.1	4.7	4.3
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	302
Calcium	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	86,150
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.35
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	56
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	19.38
Conductivity	umhos/cm	ND	#VALUE!	#VALUE!	#VALUE!	543
Copper	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	22.10
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	74.8
Dissolved Oxygen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	1.6
Fluoride	mg/L	0.98	0.78	0.57	0.37	0.17
Iron	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	1,444
Lead	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	2.25
Magnesium	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	22,650
Manganese	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	359
Nitrate Nitrogen	mg/L	0.44	0.35	0.26	0.17	0.09
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.14
pH	pH units	ND	#VALUE!	#VALUE!	#VALUE!	7.24
pH after Chem Add	pH units	ND	ND	ND	ND	6.95
Silicate	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	6,205
Sodium	ug/L	49,000	38,615	28,230	17,845	7,460
Sulfate	mg/L	45	40	35	31	26
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	12.2
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	54.0
TDS (calculated)	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	344
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	20.25
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	346.88
Zinc	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	13
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	-0.66
CCPP		ND	ND	ND	ND	-25.30
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.22

Table A-4 Blending of Waters from Adjacent Stations						
Parameter	Unit	**A**				**B**
Station #		2				7
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	311	317	324	331	338
Alkalinity After Chem	mg CaCO3/L	308	315	321	328	335
Ammonia Nitrogen	mg/L	0.08	0.10	0.13	0.15	0.17
Arsenic	ug/L	2.6	2.4	2.3	2.1	2.0
Bicarbonate, calculated	mg/L	375	383	392	400	408
Calcium	ug/L	110,150	109,113	108,075	107,038	106,000
Carbonate, calculated	mg/L	0.44	0.28	0.24	0.21	0.23
CO2, calculated	mg/L	37	46	56	67	77
Chloride	mg/L	110.13	99.23	88.33	77.43	66.53
Conductivity	umhos/cm	888	895	902	909	916
Copper	ug/L	45.38	39.03	32.69	26.34	20.00
DIC, calculated	mg C/L	83.7	88.1	92.5	96.9	101.3
Dissolved Oxygen	mg/L	2.3	2.8	3.2	3.6	4.0
Fluoride	mg/L	0.59	0.48	0.36	0.25	0.13
Iron	ug/L	877	823	770	717	664
Lead	ug/L	2.64	2.73	2.82	2.91	3.00
Magnesium	ug/L	35,500	34,538	33,575	32,613	31,650
Manganese	ug/L	152	196	240	284	328
Nitrate Nitrogen	mg/L	0.34	0.51	0.67	0.84	1.00
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.09	0.09	0.09	0.10	0.10
pH	pH units	7.30	7.22	7.14	7.06	6.98
pH after Chem Add	pH units	7.19	7.10	7.02	6.96	6.91
Silicate	ug/L	8,426	10,145	11,863	13,582	15,300
Sodium	ug/L	65,250	57,344	49,438	41,531	33,625
Sulfate	mg/L	54	54	54	53	53
Temperature	C°	14.0	13.9	13.8	13.8	13.7
Temperature	F°	57.1	57.1	57.2	57.2	57.2
TDS (calculated)	mg/L	561	575	590	604	618
Total Hardness	grains/gal	21.75	23.06	24.38	25.69	27.00
Total Hardness	mg/L CaCO3	370.71	393.53	416.36	439.18	462.00
Zinc	ug/L		#VALUE!	#VALUE!	#VALUE!	20
Langelier Saturation Index		0.15	0.06	-0.02	-0.08	-0.13
CCPP		22.88	14.39	5.14	-2.46	-9.85
Larson Index		0.69	0.62	0.56	0.50	0.45

Table A-5
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		4				8
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	264
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	261
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.19
Arsenic	ug/L	7.4	8.1	8.8	9.5	10.2
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	318
Calcium	ug/L	82,557	83,813	85,069	86,324	87,580
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.23
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	38
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	65.12
Conductivity	umhos/cm	727	733	740	746	752
Copper	ug/L	20.86	20.69	20.53	20.36	20.20
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	72.9
Dissolved Oxygen	mg/L	1.9	2.3	2.7	3.1	3.5
Fluoride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.13
Iron	ug/L	1,797	1,688	1,579	1,469	1,360
Lead	ug/L	3.00	3.50	4.00	4.50	5.00
Magnesium	ug/L	28,586	29,054	29,523	29,991	30,460
Manganese	ug/L	231	232	233	235	236
Nitrate Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
pH	pH units	6.90	6.96	7.03	7.09	7.16
pH after Chem Add	pH units	7.19	7.10	7.02	6.96	7.12
Silicate	ug/L	7,214	9,461	11,707	13,954	16,200
Sodium	ug/L	27,614	27,086	26,557	26,029	25,500
Sulfate	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	44
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	12.5
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	54.6
TDS (calculated)	mg/L	460	470	480	491	501
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	24.40
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	417.20
Zinc	ug/L	43	40	36	32	29
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	-0.10
CCPP		ND	ND	ND	ND	-4.84
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.53

Table A-6
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		4				9
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	225
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	223
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.09
Arsenic	ug/L	7.4	7.0	6.6	6.2	5.8
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	271
Calcium	ug/L	82,557	78,774	74,991	71,208	67,425
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.07
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	92
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	52.95
Conductivity	umhos/cm	727	702	677	651	626
Copper	ug/L	20.86	20.73	20.60	20.46	20.33
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	78.5
Dissolved Oxygen	mg/L	1.9	1.8	1.8	1.7	1.6
Fluoride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.09
Iron	ug/L	1,797	1,868	1,939	2,010	2,081
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	28,586	27,585	26,585	25,584	24,583
Manganese	ug/L	231	221	212	202	193
Nitrate Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
pH	pH units	6.90	6.85	6.81	6.76	6.72
pH after Chem Add	pH units	7.19	7.10	7.02	6.96	6.68
Silicate	ug/L	7,214	5,414	3,613	1,812	12
Sodium	ug/L	27,614	27,819	28,024	28,229	28,433
Sulfate	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	21
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	12.8
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	55.1
TDS (calculated)	mg/L	460	439	419	398	378
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	18.92
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	ND
Zinc	ug/L	43	#VALUE!	#VALUE!	#VALUE!	ND
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	-0.69
CCPP		ND	ND	ND	ND	-81.09
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.43

Table A-7
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		4				11
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	258
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	255
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.24
Arsenic	ug/L	7.4	6.1	4.8	3.5	2.1
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	311
Calcium	ug/L	82,557	83,368	84,179	84,989	85,800
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.05
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	152
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	63.98
Conductivity	umhos/cm	727	731	734	738	741
Copper	ug/L	20.86	20.64	20.43	20.21	20.00
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	102.6
Dissolved Oxygen	mg/L	1.9	1.8	1.8	1.7	1.6
Fluoride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.13
Iron	ug/L	1,797	1,559	1,320	1,081	843
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	28,586	29,679	30,771	31,864	32,957
Manganese	ug/L	231	206	181	156	132
Nitrate Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
pH	pH units	6.90	6.81	6.72	6.63	6.54
pH after Chem Add	pH units	7.19	7.10	7.02	6.96	6.52
Silicate	ug/L	7,214	8,689	10,164	11,639	13,114
Sodium	ug/L	27,614	26,696	25,779	24,861	23,943
Sulfate	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	35
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	11.6
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	52.8
TDS (calculated)	mg/L	460	456	453	450	446
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	23.29
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	398.00
Zinc	ug/L	43	37	32	26	20
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	-0.72
CCPP		ND	ND	ND	ND	-113.78
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.50

Table A-8 Blending of Waters from Adjacent Stations						
Parameter	Unit	**A**				**B**
Station #		4				12
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	262
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	259
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.11
Arsenic	ug/L	7.4	7.5	7.6	7.7	7.8
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	313
Calcium	ug/L	82,557	80,068	77,579	75,089	72,600
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	1.44
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	6
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	27.58
Conductivity	umhos/cm	727	702	676	651	625
Copper	ug/L	20.86	21.27	21.68	22.09	22.50
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	63.5
Dissolved Oxygen	mg/L	1.9	2.0	2.1	2.2	2.3
Fluoride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.17
Iron	ug/L	1,797	1,514	1,231	948	665
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	28,586	28,639	28,693	28,746	28,800
Manganese	ug/L	231	189	147	105	64
Nitrate Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
pH	pH units	6.90	7.20	7.50	7.81	8.11
pH after Chem Add	pH units	7.19	7.10	7.02	6.96	7.91
Silicate	ug/L	7,214	5,415	3,615	1,816	16
Sodium	ug/L	27,614	23,342	19,070	14,797	10,525
Sulfate	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	35
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	12.9
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	55.2
TDS (calculated)	mg/L	460	434	409	384	359
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	21.50
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	367.50
Zinc	ug/L	43	37	32	26	20
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.64
CCPP		ND	ND	ND	ND	31.73
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.29

Table A-9
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		4				17
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	251
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	248
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.15
Arsenic	ug/L	7.4	6.6	5.8	5.1	4.3
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	302
Calcium	ug/L	82,557	83,455	84,354	85,252	86,150
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.35
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	56
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	19.38
Conductivity	umhos/cm	727	681	635	589	543
Copper	ug/L	20.86	21.17	21.48	21.79	22.10
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	74.8
Dissolved Oxygen	mg/L	1.9	1.8	1.7	1.7	1.6
Fluoride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.17
Iron	ug/L	1,797	1,709	1,621	1,532	1,444
Lead	ug/L	3.00	2.81	2.63	2.44	2.25
Magnesium	ug/L	28,586	27,102	25,618	24,134	22,650
Manganese	ug/L	231	263	295	327	359
Nitrate Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.09
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.14
pH	pH units	6.90	ND	ND	7.15	7.24
pH after Chem Add	pH units	ND	ND	ND	6.96	6.95
Silicate	ug/L	7,214	6,962	6,710	6,458	6,205
Sodium	ug/L	27,614	22,576	17,537	12,499	7,460
Sulfate	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	26
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	12.2
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	54.0
TDS (calculated)	mg/L	460	431	402	373	344
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	20.25
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	346.88
Zinc	ug/L	43	36	28	20	13
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	-0.27
CCPP		ND	ND	ND	ND	-25.25
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.22

Table A-10 Blending of Waters from Adjacent Stations						
Parameter	Unit	**A**				**B**
Station #		4				18
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	257
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	254
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.12
Arsenic	ug/L	7.4	6.2	5.0	3.7	2.5
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	310
Calcium	ug/L	82,557	82,018	81,479	80,939	80,400
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.13
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	62
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	33.75
Conductivity	umhos/cm	727	694	661	628	595
Copper	ug/L	20.86	20.64	20.43	20.21	20.00
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	77.8
Dissolved Oxygen	mg/L	1.9	2.2	2.5	2.8	3.2
Fluoride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.09
Iron	ug/L	1,797	1,618	1,439	1,259	1,080
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	28,586	27,364	26,143	24,921	23,700
Manganese	ug/L	231	210	190	170	150
Nitrate Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
pH	pH units	6.90	ND	ND	6.94	6.95
pH after Chem Add	pH units	ND	ND	ND	6.96	6.93
Silicate	ug/L	7,214	9,298	11,382	13,466	15,550
Sodium	ug/L	27,614	23,848	20,082	16,316	12,550
Sulfate	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	21
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	11.3
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	52.3
TDS (calculated)	mg/L	460	435	410	385	360
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	21.00
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	359.10
Zinc	ug/L	43	37	32	26	20
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	-0.33
CCPP		ND	ND	ND	ND	-32.50
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.27

Table A-10
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		5				14
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	338	325	312	298	285
Alkalinity After Chem	mg CaCO3/L	335	322	309	296	282
Ammonia Nitrogen	mg/L	0.17	0.14	0.11	0.09	0.06
Arsenic	ug/L	2.0	1.9	1.8	1.7	1.6
Bicarbonate, calculated	mg/L	408	393	377	360	344
Calcium	ug/L	106,000	104,460	102,920	101,380	99,840
Carbonate, calculated	mg/L	0.23	0.14	0.11	0.08	0.07
CO2, calculated	mg/L	77	96	114	133	152
Chloride	mg/L	66.53	69.88	73.23	76.59	79.94
Conductivity	umhos/cm	916	896	876	856	836
Copper	ug/L	20.00	20.00	20.00	20.00	20.00
DIC, calculated	mg C/L	101.3	103.3	105.3	107.3	109.3
Dissolved Oxygen	mg/L	4.0	4.3	4.5	4.8	5.1
Fluoride	mg/L	0.13	0.11	0.09	0.08	0.06
Iron	ug/L	664	567	470	372	275
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	31,650	31,068	30,485	29,903	29,320
Manganese	ug/L	328	281	234	187	139
Nitrate Nitrogen	mg/L	1.00	1.05	1.09	1.14	1.18
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	6.98	ND	ND	ND	6.59
pH after Chem Add	pH units	6.91	6.80	6.70	6.62	6.55
Silicate	ug/L	15,300	14,810	14,320	13,830	13,340
Sodium	ug/L	33,625	34,789	35,953	37,116	38,280
Sulfate	mg/L	53	48	43	38	33
Temperature	C°	13.7	13.6	13.4	13.3	13.1
Temperature	F°	57.2	56.8	56.4	56.0	55.6
TDS (calculated)	mg/L	618	598	579	559	539
Total Hardness	grains/gal	27.00	26.20	25.40	24.60	23.80
Total Hardness	mg/L CaCO3	462.00	#VALUE!	#VALUE!	#VALUE!	ND
Zinc	ug/L	20	#VALUE!	#VALUE!	#VALUE!	ND
Langelier Saturation Index		-0.13	-0.26	-0.38	-0.48	-0.58
CCPP		-9.85	-31.60	-54.42	-74.57	-93.96
Larson Index		0.45	0.46	0.48	0.50	0.52

Table A-12 Blending of Waters from Adjacent Stations						
Parameter	Unit	**A**				**B**
Station #		8				9
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	264	254	244	235	225
Alkalinity After Chem	mg CaCO3/L	261	251	242	232	223
Ammonia Nitrogen	mg/L	0.19	0.16	0.14	0.11	0.09
Arsenic	ug/L	10.2	9.1	8.0	6.9	5.8
Bicarbonate, calculated	mg/L	318	306	295	283	271
Calcium	ug/L	87,580	82,541	77,503	72,464	67,425
Carbonate, calculated	mg/L	0.23	0.15	0.11	0.09	0.07
CO2, calculated	mg/L	38	51	65	78	92
Chloride	mg/L	65.12	62.07	59.03	55.99	52.95
Conductivity	umhos/cm	752	720	689	657	626
Copper	ug/L	20.20	20.23	20.27	20.30	20.33
DIC, calculated	mg C/L	72.9	74.3	75.7	77.1	78.5
Dissolved Oxygen	mg/L	3.5	3.0	2.5	2.1	1.6
Fluoride	mg/L	0.13	0.12	0.11	0.10	0.09
Iron	ug/L	1,360	1,540	1,720	1,901	2,081
Lead	ug/L	5.00	4.50	4.00	3.50	3.00
Magnesium	ug/L	30,460	28,991	27,522	26,053	24,583
Manganese	ug/L	236	225	214	204	193
Nitrate Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	7.16	ND	ND	ND	6.72
pH after Chem Add	pH units	7.12	6.98	6.86	6.76	6.68
Silicate	ug/L	16,200	12,153	8,106	4,059	12
Sodium	ug/L	25,500	26,233	26,967	27,700	28,433
Sulfate	mg/L	44	38	32	27	21
Temperature	C°	12.5	12.6	12.7	12.8	12.8
Temperature	F°	54.6	54.7	54.8	55.0	55.1
TDS (calculated)	mg/L	501	470	439	409	378
Total Hardness	grains/gal	24.40	23.03	21.66	20.29	18.92
Total Hardness	mg/L CaCO3	417.20	#VALUE!	#VALUE!	#VALUE!	ND
Zinc	ug/L	29	#VALUE!	#VALUE!	#VALUE!	ND
Langelier Saturation Index		-0.10	-0.28	-0.43	-0.57	-0.69
CCPP		-4.84	-24.03	-43.84	-63.11	-80.68
Larson Index		0.53	0.51	0.48	0.46	0.43

Table A-13
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		8				18
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	264	262	260	259	257
Alkalinity After Chem	mg CaCO3/L	261	259	257	256	254
Ammonia Nitrogen	mg/L	0.19	0.17	0.16	0.14	0.12
Arsenic	ug/L	10.2	8.3	6.4	4.4	2.5
Bicarbonate, calculated	mg/L	318	316	314	312	310
Calcium	ug/L	87,580	85,785	83,990	82,195	80,400
Carbonate, calculated	mg/L	0.23	0.19	0.17	0.09	0.13
CO2, calculated	mg/L	38	44	50	89	62
Chloride	mg/L	65.12	57.27	49.43	41.59	33.75
Conductivity	umhos/cm	752	712	673	634	595
Copper	ug/L	20.20	20.15	20.10	20.05	20.00
DIC, calculated	mg C/L	72.9	74.1	75.3	76.5	77.8
Dissolved Oxygen	mg/L	3.5	3.4	3.3	3.2	3.2
Fluoride	mg/L	0.13	0.12	0.11	0.10	0.09
Iron	ug/L	1,360	1,290	1,220	1,150	1,080
Lead	ug/L	5.00	4.50	4.00	3.50	3.00
Magnesium	ug/L	30,460	28,770	27,080	25,390	23,700
Manganese	ug/L	236	214	193	171	150
Nitrate Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	7.16	ND	ND	ND	6.95
pH after Chem Add	pH units	7.12	7.06	7.01	6.76	6.93
Silicate	ug/L	16,200	16,038	15,875	15,713	15,550
Sodium	ug/L	25,500	22,263	19,025	15,788	12,550
Sulfate	mg/L	44	38	33	27	21
Temperature	C°	12.5	12.2	11.9	11.6	11.3
Temperature	F°	54.6	54.0	53.5	52.9	52.3
TDS (calculated)	mg/L	501	466	431	395	360
Total Hardness	grains/gal	24.40	23.55	22.70	21.85	21.00
Total Hardness	mg/L CaCO3	417.20	402.68	388.15	373.63	359.10
Zinc	ug/L	29	27	24	22	20
Langelier Saturation Index		-0.10	-0.17	-0.23	-0.49	-0.33
CCPP		-4.84	-12.41	-19.53	-59.87	-32.50
Larson Index		0.53	0.47	0.40	0.34	0.27

Table A-14 Blending of Waters from Adjacent Stations						
Parameter	Unit	**A**				**B**
Station #		9				12
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	225	234	243	252	262
Alkalinity After Chem	mg CaCO3/L	223	232	241	250	259
Ammonia Nitrogen	mg/L	0.09	0.09	0.10	0.11	0.11
Arsenic	ug/L	5.8	6.3	6.8	7.3	7.8
Bicarbonate, calculated	mg/L	271	282	293	304	313
Calcium	ug/L	67,425	68,719	70,013	71,306	72,600
Carbonate, calculated	mg/L	0.07	0.09	0.09	0.08	1.44
CO2, calculated	mg/L	92	70	75	94	6
Chloride	mg/L	52.95	46.61	40.26	33.92	27.58
Conductivity	umhos/cm	626	625	625	625	625
Copper	ug/L	20.33	20.88	21.42	21.96	22.50
DIC, calculated	mg C/L	78.5	74.7	71.0	67.2	63.5
Dissolved Oxygen	mg/L	1.6	1.8	2.0	2.1	2.3
Fluoride	mg/L	0.09	0.11	0.13	0.15	0.17
Iron	ug/L	2,081	1,727	1,373	1,019	665
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	24,583	25,638	26,692	27,746	28,800
Manganese	ug/L	193	161	128	96	64
Nitrate Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	6.72	ND	ND	ND	8.11
pH after Chem Add	pH units	6.68	6.81	6.80	6.72	7.91
Silicate	ug/L	12	13	14	15	16
Sodium	ug/L	28,433	23,956	19,479	15,002	10,525
Sulfate	mg/L	21	24	28	31	35
Temperature	C°	12.8	12.9	12.9	12.9	12.9
Temperature	F°	55.1	55.1	55.2	55.2	55.2
TDS (calculated)	mg/L	378	373	368	364	359
Total Hardness	grains/gal	18.92	19.56	20.21	20.85	21.50
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	367.50
Zinc	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	20
Langelier Saturation Index		-0.69	-0.53	-0.52	-0.58	0.64
CCPP		-80.68	-55.55	-56.23	-70.08	31.73
Larson Index		0.43	0.39	0.36	0.32	0.29

Table A-15
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		9				22
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	225	227	229	231	233
Alkalinity After Chem	mg CaCO3/L	223	224	226	228	230
Ammonia Nitrogen	mg/L	0.09	0.07	0.06	0.04	0.03
Arsenic	ug/L	5.8	4.8	3.8	2.8	1.8
Bicarbonate, calculated	mg/L	271	274	276	278	280
Calcium	ug/L	67,425	67,669	67,913	68,156	68,400
Carbonate, calculated	mg/L	0.07	0.08	0.08	0.06	0.28
CO2, calculated	mg/L	92	75	73	113	26
Chloride	mg/L	52.95	44.03	35.11	26.19	17.27
Conductivity	umhos/cm	626	600	575	549	524
Copper	ug/L	20.33	20.25	20.17	20.08	20.00
DIC, calculated	mg C/L	78.5	74.4	70.4	66.3	62.2
Dissolved Oxygen	mg/L	1.6	2.1	2.5	3.0	3.5
Fluoride	mg/L	0.09	0.09	0.10	0.10	0.11
Iron	ug/L	2,081	1,614	1,146	679	212
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	24,583	24,953	25,322	25,691	26,060
Manganese	ug/L	193	187	180	174	168
Nitrate Nitrogen	mg/L	0.10	0.34	0.58	0.82	1.06
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	6.72	ND	ND	ND	7.38
pH after Chem Add	pH units	6.68	6.78	6.80	6.62	6.50
Silicate	ug/L	12	3,299	6,586	9,873	13,160
Sodium	ug/L	28,433	22,810	17,187	11,563	5,940
Sulfate	mg/L	21	24	27	29	32
Temperature	C°	12.8	12.2	11.6	11.0	10.3
Temperature	F°	55.1	54.0	52.9	51.7	50.6
TDS (calculated)	mg/L	378	356	334	312	290
Total Hardness	grains/gal	18.92	18.99	19.06	19.13	19.20
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	328.40
Zinc	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	20
Langelier Saturation Index		-0.69	-0.60	-0.57	-0.74	-0.87
CCPP		-80.68	-62.71	-60.14	-97.43	-129.29
Larson Index		0.43	0.39	0.34	0.30	0.25

Table A-16 Blending of Waters from Adjacent Stations						
Parameter	Unit	**A**				**B**
Station #		11				12
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	258	259	260	261	262
Alkalinity After Chem	mg CaCO3/L	255	256	257	258	259
Ammonia Nitrogen	mg/L	0.24	0.21	0.18	0.15	0.11
Arsenic	ug/L	2.1	3.5	4.9	6.3	7.8
Bicarbonate, calculated	mg/L	311	312	313	314	313
Calcium	ug/L	85,800	82,500	79,200	75,900	72,600
Carbonate, calculated	mg/L	0.05	0.07	0.17	0.09	1.44
CO2, calculated	mg/L	152	115	47	87	6
Chloride	mg/L	63.98	54.88	45.78	36.68	27.58
Conductivity	umhos/cm	741	712	683	654	625
Copper	ug/L	20.00	20.63	21.25	21.88	22.50
DIC, calculated	mg C/L	102.6	92.8	83.0	73.3	63.5
Dissolved Oxygen	mg/L	1.6	1.8	2.0	2.2	2.3
Fluoride	mg/L	0.13	0.14	0.15	0.16	0.17
Iron	ug/L	843	798	754	709	665
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	32,957	31,918	30,879	29,839	28,800
Manganese	ug/L	132	115	98	81	64
Nitrate Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	6.54	ND	ND	ND	8.11
pH after Chem Add	pH units	6.52	6.65	7.04	6.77	6.50
Silicate	ug/L	13,114	9,840	6,565	3,291	16
Sodium	ug/L	23,943	20,588	17,234	13,879	10,525
Sulfate	mg/L	35	35	35	35	35
Temperature	C°	11.6	11.9	12.2	12.6	12.9
Temperature	F°	52.8	53.4	54.0	54.6	55.2
TDS (calculated)	mg/L	446	424	403	381	359
Total Hardness	grains/gal	23.29	22.84	22.39	21.95	21.50
Total Hardness	mg/L CaCO3	398.00	390.38	382.75	375.13	367.50
Zinc	ug/L	20	20	20	20	20
Langelier Saturation Index		-0.72	-0.60	-0.22	-0.49	-0.77
CCPP		-113.78	-82.26	-17.28	-58.60	-118.57
Larson Index		0.50	0.45	0.39	0.34	0.29

Table A-17
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		11				22
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	258	252	245	239	233
Alkalinity After Chem	mg CaCO3/L	255	249	243	236	230
Ammonia Nitrogen	mg/L	0.24	0.19	0.13	0.08	0.03
Arsenic	ug/L	2.1	2.1	2.0	1.9	1.8
Bicarbonate, calculated	mg/L	311	303	296	288	280
Calcium	ug/L	85,800	81,450	77,100	72,750	68,400
Carbonate, calculated	mg/L	0.05	0.06	0.12	0.06	0.28
CO2, calculated	mg/L	152	120	59	106	26
Chloride	mg/L	63.98	52.30	40.63	28.95	17.27
Conductivity	umhos/cm	741	687	633	578	524
Copper	ug/L	20.00	20.00	20.00	20.00	20.00
DIC, calculated	mg C/L	102.6	92.5	82.4	72.3	62.2
Dissolved Oxygen	mg/L	1.6	2.1	2.6	3.0	3.5
Fluoride	mg/L	0.13	0.12	0.12	0.11	0.11
Iron	ug/L	843	685	527	370	212
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	32,957	31,233	29,509	27,784	26,060
Manganese	ug/L	132	141	150	159	168
Nitrate Nitrogen	mg/L	0.10	0.34	0.58	0.82	1.06
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	6.54	ND	ND	ND	7.38
pH after Chem Add	pH units	6.52	6.62	6.93	6.67	6.42
Silicate	ug/L	13,114	13,126	13,137	13,149	13,160
Sodium	ug/L	23,943	19,442	14,941	10,441	5,940
Sulfate	mg/L	35	35	34	33	32
Temperature	C°	11.6	11.3	11.0	10.6	10.3
Temperature	F°	52.8	52.3	51.7	51.2	50.6
TDS (calculated)	mg/L	446	407	368	329	290
Total Hardness	grains/gal	23.29	22.26	21.24	20.22	19.20
Total Hardness	mg/L CaCO3	398.00	380.60	363.20	345.80	328.40
Zinc	ug/L	20	20	20	20	20
Langelier Saturation Index		-0.72	-0.65	-0.38	-0.67	-0.95
CCPP		-113.78	-91.33	-35.86	-85.45	-152.08
Larson Index		0.50	0.44	0.38	0.32	0.25

Table A-18 Blending of Waters from Adjacent Stations						
Parameter	Unit	**A**				**B**
Station #		12				22
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	262	254	247	240	233
Alkalinity After Chem	mg CaCO3/L	259	252	244	237	230
Ammonia Nitrogen	mg/L	0.11	0.09	0.07	0.05	0.03
Arsenic	ug/L	7.8	6.3	4.8	3.3	1.8
Bicarbonate, calculated	mg/L	313	305	298	289	280
Calcium	ug/L	72,600	71,550	70,500	69,450	68,400
Carbonate, calculated	mg/L	1.44	0.70	0.13	0.06	0.28
CO2, calculated	mg/L	6	11	57	105	26
Chloride	mg/L	27.58	25.00	22.42	19.85	17.27
Conductivity	umhos/cm	625	600	574	549	524
Copper	ug/L	22.50	21.88	21.25	20.63	20.00
DIC, calculated	mg C/L	63.5	63.2	62.9	62.6	62.2
Dissolved Oxygen	mg/L	2.3	2.6	2.9	3.2	3.5
Fluoride	mg/L	0.17	0.15	0.14	0.12	0.11
Iron	ug/L	665	552	439	325	212
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	28,800	28,115	27,430	26,745	26,060
Manganese	ug/L	64	90	116	142	168
Nitrate Nitrogen	mg/L	0.10	0.34	0.58	0.82	1.06
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	8.11	ND	ND	ND	7.38
pH after Chem Add	pH units	7.91	7.67	6.94	6.67	6.42
Silicate	ug/L	16	3,302	6,588	9,874	13,160
Sodium	ug/L	10,525	9,379	8,233	7,086	5,940
Sulfate	mg/L	35	34	34	33	32
Temperature	C°	12.9	12.3	11.6	11.0	10.3
Temperature	F°	55.2	54.1	52.9	51.8	50.6
TDS (calculated)	mg/L	359	342	324	307	290
Total Hardness	grains/gal	21.50	20.93	20.35	19.78	19.20
Total Hardness	mg/L CaCO3	367.50	357.73	347.95	338.18	328.40
Zinc	ug/L	20	20	20	20	20
Langelier Saturation Index		0.64	0.37	-0.38	-0.67	-0.95
CCPP		31.73	23.01	-35.84	-85.73	-152.08
Larson Index		0.29	0.28	0.27	0.26	0.25

Table A-19 Blending of Waters from Adjacent Stations						
Parameter	Unit	**A**				**B**
Station #		14				25
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	285	279	273	267	261
Alkalinity After Chem	mg CaCO3/L	282	276	270	264	258
Ammonia Nitrogen	mg/L	0.06	0.07	0.09	0.10	0.11
Arsenic	ug/L	1.6	1.5	1.3	1.2	1.0
Bicarbonate, calculated	mg/L	344	337	329	322	314
Calcium	ug/L	99,840	95,097	90,353	85,610	80,867
Carbonate, calculated	mg/L	0.07	0.08	0.26	0.11	0.26
CO2, calculated	mg/L	152	127	35	82	49
Chloride	mg/L	79.94	63.92	47.90	31.89	15.87
Conductivity	umhos/cm	836	776	716	657	597
Copper	ug/L	20.00	20.00	20.00	20.00	20.00
DIC, calculated	mg C/L	109.3	100.8	92.3	83.8	75.3
Dissolved Oxygen	mg/L	5.1	5.0	4.9	4.8	4.7
Fluoride	mg/L	0.06	0.06	0.07	0.08	0.08
Iron	ug/L	275	227	179	131	83
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	29,320	28,334	27,349	26,363	25,378
Manganese	ug/L	139	123	107	91	75
Nitrate Nitrogen	mg/L	1.18	1.22	1.26	1.30	1.34
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	6.59	ND	ND	ND	7.13
pH after Chem Add	pH units	6.55	6.62	7.17	6.79	6.49
Silicate	ug/L	13,340	13,458	13,576	13,693	13,811
Sodium	ug/L	38,280	30,838	23,396	15,953	8,511
Sulfate	mg/L	33	34	34	35	36
Temperature	C°	13.1	13.1	13.2	13.2	13.2
Temperature	F°	55.6	55.6	55.7	55.7	55.7
TDS (calculated)	mg/L	539	513	486	459	433
Total Hardness	grains/gal	23.80	22.93	22.07	21.20	20.33
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	ND
Zinc	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Langelier Saturation Index		-0.58	-0.54	-0.01	-0.42	-0.75
CCPP		-93.96	-79.20	4.00	-49.03	-118.89
Larson Index		0.52	0.45	0.38	0.31	0.23

Table A-20 Blending of Waters from Adjacent Stations						
Parameter	Unit	**A**				**B**
Station #		17				18
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	251	253	254	256	257
Alkalinity After Chem	mg CaCO3/L	248	250	251	253	254
Ammonia Nitrogen	mg/L	0.15	0.14	0.14	0.13	0.12
Arsenic	ug/L	4.3	3.8	3.4	2.9	2.5
Bicarbonate, calculated	mg/L	302	305	306	308	310
Calcium	ug/L	86,150	84,713	83,275	81,838	80,400
Carbonate, calculated	mg/L	0.35	0.13	0.15	0.08	0.13
CO2, calculated	mg/L	56	57	51	92	62
Chloride	mg/L	19.38	22.97	26.56	30.15	33.75
Conductivity	umhos/cm	543	556	569	582	595
Copper	ug/L	22.10	21.58	21.05	20.53	20.00
DIC, calculated	mg C/L	74.8	75.5	76.3	77.0	77.8
Dissolved Oxygen	mg/L	1.6	2.0	2.4	2.8	3.2
Fluoride	mg/L	0.17	0.15	0.13	0.11	0.09
Iron	ug/L	1,444	1,353	1,262	1,171	1,080
Lead	ug/L	2.25	2.44	2.63	2.81	3.00
Magnesium	ug/L	22,650	22,913	23,175	23,438	23,700
Manganese	ug/L	359	307	254	202	150
Nitrate Nitrogen	mg/L	0.09	0.09	0.09	0.10	0.10
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.14	0.13	0.12	0.11	0.10
pH	pH units	7.24	ND	ND	ND	6.95
pH after Chem Add	pH units	6.95	6.95	7.00	6.75	6.50
Silicate	ug/L	6,205	8,542	10,878	13,214	15,550
Sodium	ug/L	7,460	8,733	10,005	11,278	12,550
Sulfate	mg/L	26	25	24	22	21
Temperature	C°	12.2	12.0	11.8	11.5	11.3
Temperature	F°	54.0	53.6	53.2	52.8	52.3
TDS (calculated)	mg/L	344	348	352	356	360
Total Hardness	grains/gal	20.25	20.44	20.63	20.81	21.00
Total Hardness	mg/L CaCO3	346.88	349.93	352.99	356.04	359.10
Zinc	ug/L	13	15	16	18	20
Langelier Saturation Index		-0.27	-0.28	-0.24	-0.50	-0.76
CCPP		-25.25	-26.21	-20.70	-61.64	-121.48
Larson Index		0.22	0.23	0.25	0.26	0.27

Table A-21 Blending of Waters from Adjacent Stations						
Parameter	Unit	**A**				**B**
Station #		17				39
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	251	252	253	253	254
Alkalinity After Chem	mg CaCO3/L	248	249	250	251	251
Ammonia Nitrogen	mg/L	0.15	0.18	0.21	0.24	0.27
Arsenic	ug/L	4.3	4.3	4.3	4.3	4.3
Bicarbonate, calculated	mg/L	302	304	305	306	306
Calcium	ug/L	86,150	86,813	87,475	88,138	88,800
Carbonate, calculated	mg/L	0.35	0.14	0.15	0.08	0.23
CO2, calculated	mg/L	56	54	51	93	49
Chloride	mg/L	19.38	20.65	21.92	23.19	24.46
Conductivity	umhos/cm	543	563	583	603	623
Copper	ug/L	22.10	23.59	25.09	26.58	28.08
DIC, calculated	mg C/L	74.8	74.5	74.2	73.9	73.6
Dissolved Oxygen	mg/L	1.6	1.6	1.7	1.7	1.8
Fluoride	mg/L	0.17	0.16	0.16	0.15	0.15
Iron	ug/L	1,444	1,138	833	527	221
Lead	ug/L	2.25	2.43	2.60	2.78	2.95
Magnesium	ug/L	22,650	21,740	20,831	19,921	19,011
Manganese	ug/L	359	299	239	179	118
Nitrate Nitrogen	mg/L	0.09	0.42	0.74	1.07	1.40
Nitrite Nitrogen	mg/L	0.10	0.09	0.09	0.08	0.07
Ortho Phosphorous	mg/L	0.14	0.12	0.11	0.09	0.07
pH	pH units	7.24	ND	ND	ND	7.12
pH after Chem Add	pH units	6.95	6.97	7.00	6.73	6.48
Silicate	ug/L	6,205	6,628	7,050	7,472	7,894
Sodium	ug/L	7,460	9,334	11,207	13,081	14,955
Sulfate	mg/L	26	28	29	31	32
Temperature	C°	12.2	12.2	12.1	12.1	12.0
Temperature	F°	54.0	53.9	53.8	53.7	53.6
TDS (calculated)	mg/L	344	356	368	380	392
Total Hardness	grains/gal	20.25	19.46	18.67	17.88	17.09
Total Hardness	mg/L CaCO3	346.88	333.72	320.57	307.42	294.27
Zinc	ug/L	13	13	14	14	15
Langelier Saturation Index		-0.27	-0.25	-0.22	-0.49	-0.74
CCPP		-25.25	-22.37	-18.50	-61.04	-119.94
Larson Index		0.22	0.23	0.25	0.26	0.27

Table A-22
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		18				39
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	257	256	256	255	254
Alkalinity After Chem	mg CaCO3/L	254	253	253	252	251
Ammonia Nitrogen	mg/L	0.12	0.16	0.20	0.24	0.27
Arsenic	ug/L	2.5	2.9	3.4	3.8	4.3
Bicarbonate, calculated	mg/L	310	309	308	307	306
Calcium	ug/L	80,400	82,500	84,600	86,700	88,800
Carbonate, calculated	mg/L	0.13	0.13	0.16	0.08	0.23
CO2, calculated	mg/L	62	58	48	92	49
Chloride	mg/L	33.75	31.42	29.10	26.78	24.46
Conductivity	umhos/cm	595	602	609	616	623
Copper	ug/L	20.00	22.02	24.04	26.06	28.08
DIC, calculated	mg C/L	77.8	76.7	75.7	74.7	73.6
Dissolved Oxygen	mg/L	3.2	2.8	2.5	2.1	1.8
Fluoride	mg/L	0.09	0.10	0.12	0.13	0.15
Iron	ug/L	1,080	865	651	436	221
Lead	ug/L	3.00	2.99	2.98	2.96	2.95
Magnesium	ug/L	23,700	22,528	21,356	20,183	19,011
Manganese	ug/L	150	142	134	126	118
Nitrate Nitrogen	mg/L	0.10	0.43	0.75	1.08	1.40
Nitrite Nitrogen	mg/L	0.10	0.09	0.09	0.08	0.07
Ortho Phosphorous	mg/L	0.10	0.09	0.09	0.08	0.07
pH	pH units	6.95	ND	ND	ND	7.12
pH after Chem Add	pH units	6.93	6.95	7.03	6.74	6.48
Silicate	ug/L	15,550	13,636	11,722	9,808	7,894
Sodium	ug/L	12,550	13,151	13,752	14,353	14,955
Sulfate	mg/L	21	24	27	29	32
Temperature	C°	11.3	11.5	11.7	11.8	12.0
Temperature	F°	52.3	52.7	53.0	53.3	53.6
TDS (calculated)	mg/L	360	368	376	384	392
Total Hardness	grains/gal	21.00	20.02	19.05	18.07	17.09
Total Hardness	mg/L CaCO3	359.10	342.89	326.69	310.48	294.27
Zinc	ug/L	20	19	17	16	15
Langelier Saturation Index		-0.33	-0.30	-0.21	-0.49	-0.74
CCPP		-32.50	-28.38	-16.71	-60.70	-119.94
Larson Index		0.27	0.27	0.27	0.27	0.27

Table A-23 Blending of Waters from Adjacent Stations						
Parameter	Unit	A				B
Station #		22				24
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	233	224	215	206	197
Alkalinity After Chem	mg CaCO3/L	230	221	212	203	194
Ammonia Nitrogen	mg/L	0.03	0.06	0.10	0.14	0.18
Arsenic	ug/L	1.8	1.9	2.0	2.1	2.1
Bicarbonate, calculated	mg/L	280	270	259	248	237
Calcium	ug/L	68,400	65,098	61,797	58,495	55,193
Carbonate, calculated	mg/L	0.28	0.13	0.06	0.04	0.05
CO2, calculated	mg/L	26	44	84	135	100
Chloride	mg/L	17.27	16.95	16.63	16.31	15.98
Conductivity	umhos/cm	524	503	482	462	441
Copper	ug/L	20.00	20.00	20.00	20.00	20.00
DIC, calculated	mg C/L	62.2	65.2	68.1	71.0	73.9
Dissolved Oxygen	mg/L	3.5	3.0	2.5	2.0	1.5
Fluoride	mg/L	0.11	0.10	0.10	0.10	0.09
Iron	ug/L	212	407	601	796	990
Lead	ug/L	3.00	3.72	4.43	5.15	5.87
Magnesium	ug/L	26,060	24,437	22,813	21,190	19,567
Manganese	ug/L	168	136	105	73	42
Nitrate Nitrogen	mg/L	1.06	0.82	0.58	0.34	0.10
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	7.38	ND	ND	ND	6.67
pH after Chem Add	pH units	7.28	7.02	6.73	6.50	6.26
Silicate	ug/L	13,160	13,268	13,377	13,485	13,593
Sodium	ug/L	5,940	6,555	7,170	7,785	8,400
Sulfate	mg/L	32	28	24	20	15
Temperature	C°	10.3	10.7	11.1	11.5	11.8
Temperature	F°	50.6	51.3	52.0	52.6	53.3
TDS (calculated)	mg/L	290	288	287	286	284
Total Hardness	grains/gal	19.20	18.28	17.37	16.45	15.53
Total Hardness	mg/L CaCO3	328.40	#VALUE!	#VALUE!	#VALUE!	ND
Zinc	ug/L	20	#VALUE!	#VALUE!	#VALUE!	ND
Langelier Saturation Index		-0.09	-0.38	-0.71	-0.97	-1.24
CCPP		-3.53	-30.58	-76.35	-127.65	-197.30
Larson Index		0.25	0.24	0.23	0.21	0.20

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER LABORATORY
USEPA Region V Drinking Water Cert. No. MI00003
P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57140

Official Laboratory Report

Report To: CITY OF KALAMAZOO-SHANNAN DEAT
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	3000 STADIUM DR,KALAMAZOO	Source:	Other
Collected By:	MARY ALLEN	Site Code:	TP309 STATION 12
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016 09:02
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Other	Purpose:	Other

Sample Comment **LG57140** **Testing which has not been provided for test code CAS requires special containers. For residential wells contact the local county health dept. Otherwise, contact the MDEQ Drinking Water Unit: (517) 335-8184 (Lansing) or MDEQ UP District Office: (90**

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	34	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.52	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	297	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.4	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Matrix spike recovery was below the acceptance criteria due to the presence of residual chlorine in the sample. This does not affect the validity of the sample result.						
Sodium (automated)	12	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	30	07/01/2016	10		SM 4500 SO4E	14808-79-8

The analyses performed by the MDEQ Drinking Water Laboratory were conducted using methods approved by the U .S. Environmental Protection Agency in accordance with the Safe Drinking Water Act, 40 CFR parts 141-143, and other regulatory agencies as appropriate.

Your local health department has detailed information about the quality of drinking water in your area. If you have concerns about the health risks related to the test results of your sample, please contact the Environmental Health Section through the address and telephone number listed below:

Kalamazoo County Human Services Dept.
3299 Gull Rd.
Nazareth, MI 49048
269 373-5200

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminant Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Julia Pieper
Systems Mgmt. Unit Mgr: George Krisztian

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER LABORATORY

USEPA Region V Drinking Water Cert. No. MI00003
P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57141

Official Laboratory Report

Report To: CITY OF KALAMAZOO-SHANNAN DEAT
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	4419 SIESTA,KALAMAZOO	Source:	Other
Collected By:	MARY ALLEN	Site Code:	TP313 STATION 22
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016 11:27
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Other	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	13	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.53	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	274	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	Not detected	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	0.8	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	7	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	37	07/01/2016	10		SM 4500 SO4E	14808-79-8

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269 373-5200

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MCL : Maximum Contaminant Level
AL : Action Level
RL : Reporting Limit

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ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Julia Pieper
Systems Mgmt. Unit Mgr: George Krisztian

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P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57142

Official Laboratory Report

Report To: CITY OF KALAMAZOO-SHANNAN DEAT
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	7275 EAST H STREET,KALAMAZOO	Source:	Other	
Collected By:	MARY ALLEN	Site Code:	TP314 STATION 25	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	13:40
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Other	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	20	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.31	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	284	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	Not detected	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	2.1	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	10	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	33	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Kalamazoo County Human Services Dept.
3299 Gull Rd.
Nazareth, MI 49048
269 373-5200

CAS# : Chemical Abstract Service Registry Number
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AL : Action Level
RL : Reporting Limit

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ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Julia Pieper
Systems Mgmt. Unit Mgr: George Krisztian

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DRINKING WATER LABORATORY

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P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57143

Official Laboratory Report

Report To: SHANNAN DEATER
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	331 BALCH ST,KALAMAZOO	Source:	Other
Collected By:		Site Code:	TP303 STATION 3
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016 08:00
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Other	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	79	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.54	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	348	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	2.7	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	35	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	41	07/01/2016	10		SM 4500 SO4E	14808-79-8

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MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
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Systems Mgmt. Unit Mgr: George Krisztian

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P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57144

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	3531 KONKLE,KALAMAZOO	Source:	Other
Collected By:		Site Code:	TP311 STATION 17
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016 10:12
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Other	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	38	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.15	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	294	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	1.1	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	17	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	27	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Your local health department has detailed information about the quality of drinking water in your area. If you have concerns about the health risks related to the test results of your sample, please contact the Environmental Health Section through the address and telephone number listed below:

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3299 Gull Rd.
Nazareth, MI 49048
269 373-5200

CAS# : Chemical Abstract Service Registry Number
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AL : Action Level
RL : Reporting Limit

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ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Julia Pieper
Systems Mgmt. Unit Mgr: George Krisztian

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER LABORATORY
USEPA Region V Drinking Water Cert. No. MI00003
P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57145

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	200 EAST KILGORE,KALAMAZOO	Source:	TYPE I
Collected By:	MARY ALLEN	Site Code:	TP306 STATION 8
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016 12:38
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Treated Public Distribution System	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	80	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.48	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	334	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.9	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	27	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	45	07/01/2016	10		SM 4500 SO4E	14808-79-8

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MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
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Systems Mgmt. Unit Mgr: George Krisztian

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P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
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Sample Number
LG57146

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	4131 PENWAY ST,KALAMAZOO	Source:	Other
Collected By:		Site Code:	TP312 STATION 18
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016 09:41
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Other	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	53	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.48	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	293	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.6	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	22	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	26	07/01/2016	10		SM 4500 SO4E	14808-79-8

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269 373-5200

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Laboratory Contacts
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Sample Number
LG57147

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
415 STOCKBRIDGE
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	5999 S 9TH ST,KALAMAZOO	Source:	Other
Collected By:		Site Code:	TP315 STATION 24
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016 11:06
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Other	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	12	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.34	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	202	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.6	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	8	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	11	07/01/2016	10		SM 4500 SO4E	14808-79-8

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MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
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Sample Number
LG57148

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	2000 W CROSSTOWN MAPLE ST,KALAMA	Source:	Other
Collected By:		Site Code:	TP304 STATION 4
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Other	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	63	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.31	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	314	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.6	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	30	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	35	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Kalamazoo County Human Services Dept.
3299 Gull Rd.
Nazareth, MI 49048
269 373-5200

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminant Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Julia Pieper
Systems Mgmt. Unit Mgr: George Krisztian

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER LABORATORY
USEPA Region V Drinking Water Cert. No. MI00003
P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57149

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	432 KENDALL,KALAMAZOO	Source:	Other
Collected By:		Site Code:	TP308 STATION 11
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016 09:10
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Other	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	79	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.52	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	328	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.2	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	26	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	35	07/01/2016	10		SM 4500 SO4E	14808-79-8

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269 373-5200

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MCL : Maximum Contaminant Level
AL : Action Level
RL : Reporting Limit

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ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

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TEL: (517) 335-8184
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Sample Number
LG57150

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	8801 MILLER ROAD,KALAMAZOO	Source:	Other
Collected By:	MARY ALLEN	Site Code:	TP316 STATION 39
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016 13:05
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Other	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	38	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.65	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	288	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.7	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	1.6	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	19	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	26	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Lansing, MI 48909
TEL: (517) 335-8184
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Sample Number
LG57151

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	112 CROSSTOWN-BOUN CT,KALAMAZOO	Source:	Other
Collected By:	MARY ALLEN	Site Code:	TP302 STATION 2
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016 08:17
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Other	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	199	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.13	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	385	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	1.0	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	94	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	45	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Laboratory Contacts
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Lansing, MI 48909
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Sample Number
LG57152

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	2300 HENSON AVE,KALAMAZOO	Source:	Other
Collected By:	MARY ALLEN	Site Code:	TP310 STATION 14
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016 14:00
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Other	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	91	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.39	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	338	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	Not detected	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	1.2	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	41	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	32	07/01/2016	10		SM 4500 SO4E	14808-79-8

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269 373-5200

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Sample Number
LG57153

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	215 W STOCKBRIDGE,KALAMAZOO	Source:	Other
Collected By:	MARY ALLEN	Site Code:	TP201 CENTRAL/STATION 1
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016 07:45
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Other	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	145	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.52	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	371	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	Not detected	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	0.6	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	63	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	39	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57154

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	813 WEST KILGORE,KALAMAZOO	Source:	Other
Collected By:	MARY ALLEN	Site Code:	TP307 STATION 9
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016 12:18
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:44
Water System:	Other	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Antimony	Not detected	07/06/2016	0.0006	0.006	EPA 200.8	7440-36-0
Arsenic	0.003	07/06/2016	0.002	0.010	EPA 200.8	7440-38-2
Barium	0.09	07/06/2016	0.01	2	EPA 200.8	7440-39-3
Beryllium	Not detected	07/06/2016	0.0004	0.004	EPA 200.8	7440-41-7
Cadmium	Not detected	07/06/2016	0.0003	0.005	EPA 200.8	7440-43-9
Chloride	77	07/01/2016	4		SM 4500-Cl E	7647-14-5
Chromium	Not detected	07/06/2016	0.01	0.1	EPA 200.8	7440-47-3
Fluoride	0.48	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	261	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.2	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Lead	Not detected	07/06/2016	0.001	0.015	EPA 200.8	7439-92-1
Mercury	Not detected	07/06/2016	0.0001	0.002	EPA 200.8	7439-97-6
Nickel	Not detected	07/06/2016	0.01	0.1	EPA 200.8	7440-02-0
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Selenium	Not detected	07/06/2016	0.001	0.05	EPA 200.8	7782-49-2
Sodium (automated)	34	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	Not detected	07/01/2016	10		SM 4500 SO4E	14808-79-8
Thallium	Not detected	07/06/2016	0.0002	0.002	EPA 200.8	7440-28-0

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Sample Number
LG57154

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #

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CITY OF KALAMAZOO PUBLIC SERVICES LABORATORY REPORT
WATER QUALITY MONITORING

Date	SEQ	Location	pH	Ortho-Phos	Hexameta-Phos
5/16/2016	31	STA 1	8.08	0.34	1.88
5/16/2016	39	STA 9	7.49	<0.10	1.98
5/16/2016	41	STA 11	7.83	0.24	1.65
5/16/2016	42	STA 12	7.43	<0.10	1.96
5/16/2016	44	STA 14	7.03	<0.10	2.05
5/16/2016	54	STA 24	7.28	0.11	3.94
5/16/2016	55	STA 25	7.29	<0.10	1.96
5/16/2016	69	STA 39	7.19	0.10	2.49
5/31/2016	31	STA 1	7.56	0.22	1.28
5/31/2016	41	STA 11	7.31	0.25	1.79
5/31/2016	44	STA 14	6.80	<0.10	1.96
5/31/2016	48	STA 18	6.89	<0.10	1.81
5/31/2016	52	STA 22	6.97	<0.10	2.30
5/31/2016	55	STA 25	6.86	<0.10	1.47
5/31/2016	69	STA 39	6.95	<0.10	2.04

Total Samples	pH	Ortho-Phos	Hexameta-Phos
15.00	15.00	15.00	15.00

UNITS: mg/L
Acceptable Limits for pH: 6.5 - 8.5
Acceptable Limits for Total Phos: .5 - 4.0

CITY OF KALAMAZOO PUBLIC SERVICES LABORATORY REPORT
WATER QUALITY MONITORING

Date	SEQ	Location	pH	Ortho-Phos	Hexameta-Phos
6/13/2016	31	STA 1	7.88	0.21	1.07
6/13/2016	34	STA 4	7.16	<0.10	1.60
6/13/2016	41	STA 11	7.38	0.21	1.53
6/13/2016	42	STA 12	7.22	<0.10	1.56
6/13/2016	44	STA 14	7.06	<0.10	1.61
6/13/2016	54	STA 24	7.31	<0.10	1.73
6/13/2016	55	STA 25	7.12	<0.10	2.02
6/27/2016	31	STA 1	7.83	0.15	1.10
6/27/2016	39	STA 9	7.25	<0.10	2.24
6/27/2016	41	STA 11	7.67	0.22	1.82
6/27/2016	42	STA 12	7.22	<0.10	2.00
6/27/2016	44	STA 14	7.05	<0.10	2.17
6/27/2016	54	STA 24	7.29	<0.10	1.73
6/27/2016	55	STA 25	7.16	<0.10	0.55

Total Samples	pH	Ortho-Phos	Hexameta-Phos
14.00	14.00	14.00	14.00

UNITS: mg/L
Acceptable Limits for pH: 6.5 - 8.5
Acceptable Limits for Total Phos: .5 - 4.0

June 2016

Water - Phos Samp Pt

	Daily Com	54111 FS2 - Total Phos mg/L	54113 FS2 - Total Phos Dup mg/L	54117 FS2 - Total Phos Spike mg/L	54121 FS2 - Ortho Phos mg/L	54123 FS2 - Ortho Phos Dup mg/L	54127 FS2 - Ortho Phos Spike mg/L	54211 FS3 - Total Phos mg/L	54213 FS3 - Total Phos Dup mg/L	54217 FS3 - Total Phos Spike mg/L	54221 FS3 - Ortho Phos mg/L	54223 FS3 - Ortho Phos Dup mg/L
1 Wed												
2 Thu												
3 Fri												
4 Sat												
5 Sun												
6 Mon												
7 Tue					0.24						0.18	
8 Wed												
9 Thu												
10 Fri												
11 Sat												
12 Sun												
13 Mon												
14 Tue					0.31						0.20	
15 Wed												
16 Thu												
17 Fri												
18 Sat												
19 Sun												
20 Mon												
21 Tue					0.18						0.23	
22 Wed												
23 Thu												
24 Fri												
25 Sat												
26 Sun												
27 Mon					0.18						0.26	
28 Tue												
29 Wed												
30 Thu												
MIN		-	-	-	0.18	-	-	-	-	-	0.18	-
MAX		-	-	-	0.31	-	-	-	-	-	0.26	-
AVG		-	-	-	0.23	-	-	-	-	-	0.22	-
SUM		-	-	-	0.91	-	-	-	-	-	0.87	-

Water - Phos Samp Pt

	Daily Com	54227 FS3 - Ortho Phos Spike mg/L	54311 FS6 - Total Phos mg/L	54313 FS6 - Total Phos Dup mg/L	54317 FS6 - Total Phos Spike mg/L	54321 FS6 - Ortho Phos mg/L	54323 FS6 - Ortho Phos Dup mg/L	54327 FS6 - Ortho Phos Spike mg/L	54411 Peoples Church - Total Phos mg/L	54413 Peoples Church - Total Phos Dup mg/L	54417 Peoples Church - Total Phos Spike mg/L	54421 Peoples Church - Ortho Phos mg/L
1 Wed												
2 Thu												
3 Fri												
4 Sat												
5 Sun												
6 Mon												
7 Tue						0.19						
8 Wed												
9 Thu												
10 Fri												
11 Sat												
12 Sun												
13 Mon												
14 Tue						0.11						
15 Wed												
16 Thu												
17 Fri												
18 Sat												
19 Sun												
20 Mon												
21 Tue						<0.10						
22 Wed												
23 Thu												
24 Fri												
25 Sat												
26 Sun												
27 Mon						0.14						
28 Tue												
29 Wed												
30 Thu												
MIN		-	-	-	-	<0.10	-	-	-	-	-	-
MAX		-	-	-	-	0.19	-	-	-	-	-	-
AVG		-	-	-	-	<0.14	-	-	-	-	-	-
SUM		-	-	-	-	<0.54	-	-	-	-	-	-

Water - Phos Samp Pt

	Daily Com	55013 BLAKSLEE - Total Phos Dup mg/L	55017 BLAKSLEE - Total Phos Spike mg/L	55021 BLAKSLEE - Ortho Phos mg/L	55023 BLAKSLEE - Ortho Phos Dup mg/L	55027 BLAKSLEE - Ortho Phos Spike mg/L	55111 Gull Road - Total Phos mg/L	55113 Gull Road - Total Phos Dup mg/L	55117 Gull Road - Total Phos Spike mg/L	55121 Gull Road - Ortho Phos mg/L	55123 Gull Road - Ortho Phos Dup mg/L	55127 Gull Road - Ortho Phos Spike mg/L
1 Wed												
2 Thu												
3 Fri												
4 Sat												
5 Sun												
6 Mon												
7 Tue										0.27		
8 Wed												
9 Thu												
10 Fri												
11 Sat												
12 Sun												
13 Mon												
14 Tue										0.13		
15 Wed												
16 Thu												
17 Fri												
18 Sat												
19 Sun												
20 Mon												
21 Tue										0.20		
22 Wed												
23 Thu												
24 Fri												
25 Sat												
26 Sun												
27 Mon										0.20		
28 Tue												
29 Wed												
30 Thu												
MIN		-	-	-	-	-	-	-	-	0.13	-	-
MAX		-	-	-	-	-	-	-	-	0.27	-	-
AVG		-	-	-	-	-	-	-	-	0.20	-	-
SUM		-	-	-	-	-	-	-	-	0.80	-	-

		Drinking Water\F Cl2 Bac-T										
	Daily Com	55523 STA32 - Ortho Phos Dup mg/L	55527 STA32 - Ortho Phos Spike mg/L	55611 Stadium - Total Phos mg/L	55613 Stadium - Total Phos Dup mg/L	55617 Stadium - Total Phos Spike mg/L	55621 Stadium - Ortho Phos mg/L	55623 Stadium - Ortho Phos Dup mg/L	55627 Stadium - Ortho Phos Spike mg/L	55711 6THST - Total Phos mg/L	55713 6THST - Total Phos Dup mg/L	55717 6THST - Total Phos Spike mg/L
1 Wed												
2 Thu												
3 Fri												
4 Sat												
5 Sun												
6 Mon												
7 Tue							0.21					
8 Wed												
9 Thu												
10 Fri												
11 Sat												
12 Sun												
13 Mon												
14 Tue							0.14					
15 Wed												
16 Thu												
17 Fri												
18 Sat												
19 Sun												
20 Mon												
21 Tue												
22 Wed												
23 Thu												
24 Fri												
25 Sat												
26 Sun												
27 Mon							0.15					
28 Tue												
29 Wed												
30 Thu												
MIN		-	-	-	-	-	0.14	-	-	-	-	-
MAX		-	-	-	-	-	0.21	-	-	-	-	-
AVG		-	-	-	-	-	0.17	-	-	-	-	-
SUM		-	-	-	-	-	0.50	-	-	-	-	-

July 2016

Water - Ortho Phos - HACH

		Drinking Water\F Cl2 Bac-T									
	Daily Com	54135 FS2 - Ortho Phos HACH Kit mg/L	54235 FS3 - Ortho Phos HACH Kit mg/L	54335 FS6 - Ortho Phos HACH Kit mg/L	54435 Peoples Church - Ortho Phos HACH Kit mg/L	54535 Markin Park - Ortho Phos HACH Kit mg/L	54635 Miller Road - Ortho Phos HACH Kit mg/L	54735 Dartmouth - Ortho Phos HACH Kit mg/L	54835 Edgemor - Ortho Phos HACH Kit mg/L	54935 Mt.Olivet - Ortho Phos HACH Kit mg/L	55035 BLAKSLEE - Ortho Phos HACH Kit mg/L
1 Fri											
2 Sat											
3 Sun											
4 Mon											
5 Tue				0.31	0.86	0.77			0.34		0.58
6 Wed		0.46	0.44				0.34	0.81		0.11	
7 Thu											
8 Fri											
9 Sat											
10 Sun											
11 Mon				0.29	0.79			0.91	0.32		0.75
12 Tue		0.63	0.56			0.84	0.74			0.51	
13 Wed				0.26	1.02			0.89	0.52		0.68
14 Thu		0.56	0.46			0.88	0.42			0.26	
15 Fri											
16 Sat											
17 Sun											
18 Mon		0.72	0.32			0.80	0.37			0.21	
19 Tue				0.72	0.54			0.47	0.35		0.31
20 Wed		0.80	0.86			0.87	0.32			0.52	
21 Thu											
22 Fri											
23 Sat											
24 Sun											
25 Mon				0.23	0.67			0.93	0.29		1.18
26 Tue		0.71	0.77			0.94	0.30			0.11	
27 Wed				0.28	0.55			0.97	0.39		0.61
28 Thu											
29 Fri											
30 Sat											
31 Sun											
MIN		0.46	0.32	0.23	0.54	0.77	0.30	0.47	0.29	0.11	0.31
MAX		0.80	0.86	0.72	1.02	0.94	0.74	0.97	0.52	0.52	1.18
AVG		0.65	0.57	0.35	0.74	0.85	0.42	0.83	0.37	0.29	0.69
SUM		3.88	3.41	2.09	4.43	5.10	2.49	4.98	2.21	1.72	4.11

Water - Ortho Phos - HACH

	Daily Com	55135 Gull Road - Ortho Phos HACH Kit mg/L	55235 Richland/Parker - Ortho Phos HACH Kit mg/L	55335 28th Saginaw - Ortho Phos HACH Kit mg/L	55435 Candlewyck - Ortho Phos HACH Kit mg/L	55535 STA32 - Ortho Phos HACH Kit mg/L	55635 Stadium - Ortho Phos HACH Kit mg/L	55735 6THST - Ortho Phos HACH Kit mg/L	55835 TXTWP - Ortho Phos HACH Kit mg/L	55935 PSSTA - Ortho Phos HACH Kit mg/L	56035 Beech - Ortho Phos HACH Kit mg/L
1 Fri											
2 Sat											
3 Sun											
4 Mon											
5 Tue						0.92	0.40	1.14	0.32		
6 Wed		0.52	1.14	0.36	0.22					0.87	
7 Thu											
8 Fri											
9 Sat											
10 Sun											
11 Mon						1.14	0.72	1.02	0.38		
12 Tue		0.58	0.91	0.33	0.23					0.74	
13 Wed						1.15	0.63	1.05	0.33		
14 Thu		0.47	0.90	0.44	0.38					0.80	
15 Fri											
16 Sat											
17 Sun											
18 Mon		0.64	0.83	0.38	0.30					0.87	
19 Tue						0.80	1.89	1.74	0.25		
20 Wed		1.07	1.05	0.36	0.24					1.31	
21 Thu											
22 Fri											
23 Sat											
24 Sun											
25 Mon						0.78	0.68	1.02	0.22		
26 Tue		0.62	0.43	0.41	0.20					0.76	
27 Wed						1.37	0.50	0.98	0.29		
28 Thu											
29 Fri											
30 Sat											
31 Sun											
MIN		0.47	0.43	0.33	0.20	0.78	0.40	0.98	0.22	0.74	-
MAX		1.07	1.14	0.44	0.38	1.37	1.89	1.74	0.38	1.31	-
AVG		0.65	0.88	0.38	0.26	1.03	0.80	1.16	0.30	0.89	-
SUM		3.90	5.26	2.28	1.57	6.16	4.82	6.95	1.79	5.35	-

		Drinking Water\F Cl2 Bac-T									
	Daily Com	56135 Service Master - Ortho Phos HACH Kit mg/L	59035 FS7 - Ortho Phos HACH Kit mg/L	59135 Comstock Fire Sta - Ortho Phos HACH Kit mg/L	59235 Speedway - Ortho Phos HACH Kit mg/L	59335 Kal Twp Hall - Ortho Phos HACH Kit mg/L	59435 Borgess Hospital - Ortho Phos HACH Kit mg/L	59535 Env Health Dept - Ortho Phos HACH Kit mg/L	59635 Harding`s Eastwood - Ortho Phos HACH Kit	59735 Eastwood Fire Sta. - Ortho Phos HACH Kit mg/L	59835 Westwood FS4 - Ortho Phos HACH Kit mg/L
1 Fri											
2 Sat											
3 Sun											
4 Mon											
5 Tue		0.85									
6 Wed											
7 Thu											
8 Fri											
9 Sat											
10 Sun											
11 Mon		0.81									
12 Tue											
13 Wed		0.84									
14 Thu											
15 Fri											
16 Sat											
17 Sun											
18 Mon											
19 Tue		0.33									
20 Wed											
21 Thu											
22 Fri											
23 Sat											
24 Sun											
25 Mon		0.38									
26 Tue											
27 Wed		0.78									
28 Thu											
29 Fri											
30 Sat											
31 Sun											
MIN		0.33	-	-	-	-	-	-	-	-	-
MAX		0.85	-	-	-	-	-	-	-	-	-
AVG		0.67	-	-	-	-	-	-	-	-	-
SUM		3.99	-	-	-	-	-	-	-	-	-

August 2016

Water - Ortho Phos - HACH

	Daily Com	Drinking Water\F Cl2 Bac-T									
		54135 FS2 - Ortho Phos HACH Kit mg/L	54235 FS3 - Ortho Phos HACH Kit mg/L	54335 FS6 - Ortho Phos HACH Kit mg/L	54435 Peoples Church - Ortho Phos HACH Kit mg/L	54535 Markin Park - Ortho Phos HACH Kit mg/L	54635 Miller Road - Ortho Phos HACH Kit mg/L	54735 Dartmouth - Ortho Phos HACH Kit mg/L	54835 Edgemor - Ortho Phos HACH Kit mg/L	54935 Mt.Olivet - Ortho Phos HACH Kit mg/L	55035 BLAKSLEE - Ortho Phos HACH Kit mg/L
1 Mon											
2 Tue			0.93	0.76	1.11			3.33	0.65		0.97
3 Wed		>3.30	1.33			1.43	0.73			>3.30	
4 Thu											
5 Fri											
6 Sat											
7 Sun											
8 Mon				0.30	0.82			0.85	0.42		0.91
9 Tue		0.78	0.54			0.57	0.61			0.99	
10 Wed				0.24	0.98			0.93	0.31		0.70
11 Thu											
12 Fri											
13 Sat											
14 Sun											
15 Mon		0.50	0.80			0.78	0.38			1.16	
16 Tue		0.98	0.87	1.66	0.93	0.87	0.43	0.87	0.34	1.29	0.69
17 Wed		3.33	0.71			1.08	0.83			1.38	
18 Thu											
19 Fri											
20 Sat											
21 Sun											
22 Mon											
23 Tue		0.52	0.51			0.39	0.48			0.59	
24 Wed				0.97	0.87			1.22	0.71		0.68
25 Thu											
26 Fri											
27 Sat											
28 Sun											
29 Mon											
30 Tue				0.57	1.19			0.92	0.56		0.68
31 Wed		0.73	0.97			0.95	0.13			1.51	
MIN		0.50	0.51	0.24	0.82	0.39	0.13	0.85	0.31	0.59	0.68
MAX		3.33	1.33	1.66	1.19	1.43	0.83	3.33	0.71	>3.30	0.97
AVG		>1.45	0.83	0.75	0.98	0.87	0.51	1.35	0.50	>1.46	0.77
SUM		>10.14	6.66	4.50	5.90	6.07	3.59	8.12	2.99	>10.22	4.63

Water - Ortho Phos - HACH

	Daily Com	55135 Gull Road - Ortho Phos HACH Kit mg/L	55235 Richland/Parker - Ortho Phos HACH Kit mg/L	55335 28th Saginaw - Ortho Phos HACH Kit mg/L	55435 Candlewyck - Ortho Phos HACH Kit mg/L	55535 STA32 - Ortho Phos HACH Kit mg/L	55635 Stadium - Ortho Phos HACH Kit mg/L	55735 6THST - Ortho Phos HACH Kit mg/L	55835 TXTWP - Ortho Phos HACH Kit mg/L	55935 PSSTA - Ortho Phos HACH Kit mg/L	56035 Beech - Ortho Phos HACH Kit mg/L
1 Mon											
2 Tue						1.83	0.67	1.09	0.27		
3 Wed		2.94	2.18	0.67	0.40					>3.30	
4 Thu											
5 Fri											
6 Sat											
7 Sun											
8 Mon						1.04	0.45	1.08	0.34		
9 Tue		0.65	0.72	0.50	0.15					0.65	
10 Wed						1.06	0.52	0.93	0.28		
11 Thu											
12 Fri											
13 Sat											
14 Sun											
15 Mon		0.51	0.44	0.55	0.41					0.74	
16 Tue				0.68	0.26	0.04	0.68		0.17	0.85	
17 Wed		0.44	0.90	0.59	0.13					0.68	
18 Thu											
19 Fri											
20 Sat											
21 Sun											
22 Mon											
23 Tue		0.61	0.43	0.64	0.16					0.77	
24 Wed						1.00	0.63	0.95	0.30		
25 Thu											
26 Fri											
27 Sat											
28 Sun											
29 Mon											
30 Tue						0.87	0.59	2.25	0.19		
31 Wed		0.91	0.94	0.55	0.34					0.88	
MIN		0.44	0.43	0.50	0.13	0.04	0.45	0.93	0.17	0.65	-
MAX		2.94	2.18	0.68	0.41	1.83	0.68	2.25	0.34	>3.30	-
AVG		1.01	0.94	0.60	0.26	0.97	0.59	1.26	0.26	>1.12	-
SUM		6.06	5.61	4.18	1.85	5.84	3.54	6.30	1.55	>7.87	-

	Daily Com	Drinking Water\F Cl2 Bac-T									
		56135 Service Master - Ortho Phos HACH Kit mg/L	59035 FS7 - Ortho Phos HACH Kit mg/L	59135 Comstock Fire Sta - Ortho Phos HACH Kit mg/L	59235 Speedway - Ortho Phos HACH Kit mg/L	59335 Kal Twp Hall - Ortho Phos HACH Kit mg/L	59435 Borgess Hospital - Ortho Phos HACH Kit mg/L	59535 Env Health Dept - Ortho Phos HACH Kit mg/L	59635 Harding`s Eastwood - Ortho Phos HACH Kit	59735 Eastwood Fire Sta. - Ortho Phos HACH Kit mg/L	59835 Westwood FS4 - Ortho Phos HACH Kit mg/L
1 Mon											
2 Tue		1.03									
3 Wed											
4 Thu											
5 Fri											
6 Sat											
7 Sun											
8 Mon		0.70									
9 Tue											
10 Wed		0.63									
11 Thu											
12 Fri											
13 Sat											
14 Sun											
15 Mon											
16 Tue		0.67	1.06	0.43	0.38	1.38	0.44	1.02	1.38	0.96	0.68
17 Wed											
18 Thu											
19 Fri											
20 Sat											
21 Sun											
22 Mon											
23 Tue											
24 Wed		0.72									
25 Thu											
26 Fri											
27 Sat											
28 Sun											
29 Mon											
30 Tue		0.83									
31 Wed											
MIN		0.63	1.06	0.43	0.38	1.38	0.44	1.02	1.38	0.96	0.68
MAX		1.03	1.06	0.43	0.38	1.38	0.44	1.02	1.38	0.96	0.68
AVG		0.76	1.06	0.43	0.38	1.38	0.44	1.02	1.38	0.96	0.68
SUM		4.58	1.06	0.43	0.38	1.38	0.44	1.02	1.38	0.96	0.68

Water - Ortho Phos - HACH

		Drinking Water\F Cl2 Bac-T									
	Daily Com	54135 FS2 - Ortho Phos HACH Kit mg/L	54235 FS3 - Ortho Phos HACH Kit mg/L	54335 FS6 - Ortho Phos HACH Kit mg/L	54435 Peoples Church - Ortho Phos HACH Kit mg/L	54535 Markin Park - Ortho Phos HACH Kit mg/L	54635 Miller Road - Ortho Phos HACH Kit mg/L	54735 Dartmouth - Ortho Phos HACH Kit mg/L	54835 Edgemor - Ortho Phos HACH Kit mg/L	54935 Mt.Olivet - Ortho Phos HACH Kit mg/L	55035 BLAKSLEE - Ortho Phos HACH Kit mg/L
1 Thu											
2 Fri											
3 Sat											
4 Sun											
5 Mon											
6 Tue				0.21	0.91			0.99	0.37		0.86
7 Wed		0.88	0.39			0.98	0.16			1.06	
8 Thu				0.30	0.90			0.96	0.61		0.85
9 Fri											
10 Sat											
11 Sun											
12 Mon		0.22	0.50			0.79	0.24			0.91	
13 Tue				0.41	0.93			1.24	0.56		1.09
14 Wed		0.58	0.93			1.05	0.22			0.98	
15 Thu											
16 Fri											
17 Sat											
18 Sun											
19 Mon				0.36	0.98			0.75	0.53		0.84
20 Tue		0.27	0.65			0.82	0.50			0.96	
21 Wed				0.26	1.13			0.96	0.54		0.87
22 Thu											
23 Fri											
24 Sat											
25 Sun											
26 Mon		0.55	0.39			0.74	0.60			0.82	
27 Tue				0.46	0.91			0.97	0.24		0.70
28 Wed		0.35	0.38			0.79	0.37			1.01	
29 Thu											
30 Fri											
MIN		0.22	0.38	0.21	0.90	0.74	0.16	0.75	0.24	0.82	0.70
MAX		0.88	0.93	0.46	1.13	1.05	0.60	1.24	0.61	1.06	1.09
AVG		0.48	0.54	0.33	0.96	0.86	0.35	0.98	0.48	0.96	0.87
SUM		2.85	3.24	2.00	5.76	5.17	2.09	5.87	2.85	5.74	5.21

Water - Ortho Phos - HACH

	Daily Com	55135 Gull Road - Ortho Phos HACH Kit mg/L	55235 Richland/Parker - Ortho Phos HACH Kit mg/L	55335 28th Saginaw - Ortho Phos HACH Kit mg/L	55435 Candlewyck - Ortho Phos HACH Kit mg/L	55535 STA32 - Ortho Phos HACH Kit mg/L	55635 Stadium - Ortho Phos HACH Kit mg/L	55735 6THST - Ortho Phos HACH Kit mg/L	55835 TXTWP - Ortho Phos HACH Kit mg/L	55935 PSSTA - Ortho Phos HACH Kit mg/L	56035 Beech - Ortho Phos HACH Kit mg/L
1 Thu											
2 Fri											
3 Sat											
4 Sun											
5 Mon											
6 Tue						0.88	0.40	1.08	0.28		
7 Wed		0.63	0.93	0.61	0.23					1.00	
8 Thu						0.86	0.29	0.93	0.24		
9 Fri											
10 Sat											
11 Sun											
12 Mon		0.43	0.88	0.81	0.35					1.28	
13 Tue						1.17	0.63	1.11	0.33		
14 Wed		0.67	0.81	1.32	0.34					1.46	
15 Thu											
16 Fri											
17 Sat											
18 Sun											
19 Mon						0.92	0.27	1.20	0.36		
20 Tue		0.69	0.75	0.70	0.20					0.70	
21 Wed						0.81	0.65	1.00	0.30		
22 Thu											
23 Fri											
24 Sat											
25 Sun											
26 Mon		0.65	0.71	0.66	0.28					0.99	
27 Tue						0.85	0.46	1.84	0.22		
28 Wed		0.52	1.03	0.53	0.07					1.46	
29 Thu											
30 Fri											
MIN		0.43	0.71	0.53	0.07	0.81	0.27	0.93	0.22	0.70	-
MAX		0.69	1.03	1.32	0.35	1.17	0.65	1.84	0.36	1.46	-
AVG		0.60	0.85	0.77	0.25	0.92	0.45	1.19	0.29	1.15	-
SUM		3.59	5.11	4.63	1.47	5.49	2.70	7.16	1.73	6.89	-

		Drinking Water\F Cl2 Bac-T									
	Daily Com	56135 Service Master - Ortho Phos HACH Kit mg/L	59035 FS7 - Ortho Phos HACH Kit mg/L	59135 Comstock Fire Sta - Ortho Phos HACH Kit mg/L	59235 Speedway - Ortho Phos HACH Kit mg/L	59335 Kal Twp Hall - Ortho Phos HACH Kit mg/L	59435 Borgess Hospital - Ortho Phos HACH Kit mg/L	59535 Env Health Dept - Ortho Phos HACH Kit mg/L	59635 Harding`s Eastwood - Ortho Phos HACH Kit	59735 Eastwood Fire Sta. - Ortho Phos HACH Kit mg/L	59835 Westwood FS4 - Ortho Phos HACH Kit mg/L
1 Thu											
2 Fri											
3 Sat											
4 Sun											
5 Mon											
6 Tue		1.01									
7 Wed											
8 Thu		0.94									
9 Fri											
10 Sat											
11 Sun											
12 Mon											
13 Tue		0.99									
14 Wed											
15 Thu											
16 Fri											
17 Sat											
18 Sun											
19 Mon		1.10									
20 Tue											
21 Wed		0.98									
22 Thu											
23 Fri											
24 Sat											
25 Sun											
26 Mon											
27 Tue		0.78									
28 Wed											
29 Thu											
30 Fri											
MIN		0.78	-	-	-	-	-	-	-	-	-
MAX		1.10	-	-	-	-	-	-	-	-	-
AVG		0.97	-	-	-	-	-	-	-	-	-
SUM		5.80	-	-	-	-	-	-	-	-	-

October 2016

Water - Ortho Phos - HACH

		Drinking Water\F Cl2 Bac-T									
	Daily Com	54135 FS2 - Ortho Phos HACH Kit mg/L	54235 FS3 - Ortho Phos HACH Kit mg/L	54335 FS6 - Ortho Phos HACH Kit mg/L	54435 Peoples Church - Ortho Phos HACH Kit mg/L	54535 Markin Park - Ortho Phos HACH Kit mg/L	54635 Miller Road - Ortho Phos HACH Kit mg/L	54735 Dartmouth - Ortho Phos HACH Kit mg/L	54835 Edgemor - Ortho Phos HACH Kit mg/L	54935 Mt.Olivet - Ortho Phos HACH Kit mg/L	55035 BLAKSLEE - Ortho Phos HACH Kit mg/L
1 Sat											
2 Sun											
3 Mon				0.67	0.83			0.89	0.28		0.77
4 Tue		0.54	0.83			0.89	0.52			0.90	
5 Wed				0.53	0.88			0.93	0.72		0.80
6 Thu											
7 Fri											
8 Sat											
9 Sun											
10 Mon		0.81	0.69			0.73	0.59			0.83	
11 Tue				0.52	1.19			0.78	0.22		0.69
12 Wed		0.52	0.48			0.80	0.48			1.08	
13 Thu											
14 Fri											
15 Sat											
16 Sun											
17 Mon				0.75	1.38			0.91	0.45		0.70
18 Tue		0.68	0.50			0.78	0.37			0.74	
19 Wed				0.61	1.35			0.87	0.42		0.67
20 Thu											
21 Fri											
22 Sat											
23 Sun											
24 Mon											
25 Tue											
26 Wed											
27 Thu											
28 Fri											
29 Sat											
30 Sun											
31 Mon											
MIN		0.52	0.48	0.52	0.83	0.73	0.37	0.78	0.22	0.74	0.67
MAX		0.81	0.83	0.75	1.38	0.89	0.59	0.93	0.72	1.08	0.80
AVG		0.64	0.63	0.62	1.13	0.80	0.49	0.88	0.42	0.89	0.73
SUM		2.55	2.50	3.08	5.63	3.20	1.96	4.38	2.09	3.55	3.63

October 2016

Water - Ortho Phos - HACH

	Daily Com	55135 Gull Road - Ortho Phos HACH Kit mg/L	55235 Richland/Parker - Ortho Phos HACH Kit mg/L	55335 28th Saginaw - Ortho Phos HACH Kit mg/L	55435 Candlewyck - Ortho Phos HACH Kit mg/L	55535 STA32 - Ortho Phos HACH Kit mg/L	55635 Stadium - Ortho Phos HACH Kit mg/L	55735 6THST - Ortho Phos HACH Kit mg/L	55835 TXTWP - Ortho Phos HACH Kit mg/L	55935 PSSTA - Ortho Phos HACH Kit mg/L	56035 Beech - Ortho Phos HACH Kit mg/L
1 Sat											
2 Sun											
3 Mon						0.90	0.62	0.84	0.31		
4 Tue		0.66	1.17	0.85	0.34					0.80	
5 Wed						2.85	0.69	0.83	0.34		
6 Thu											
7 Fri											
8 Sat											
9 Sun											
10 Mon		0.85	0.71	0.66	0.45					0.77	
11 Tue						1.84	0.56	1.91	0.22		
12 Wed		0.47	1.17	0.60	0.09					0.72	
13 Thu											
14 Fri											
15 Sat											
16 Sun											
17 Mon						1.18	0.56	0.93	0.34		
18 Tue		0.89	1.32	0.70	0.27					0.65	
19 Wed						1.29	0.49	0.92	0.28		
20 Thu											
21 Fri											
22 Sat											
23 Sun											
24 Mon											
25 Tue											
26 Wed											
27 Thu											
28 Fri											
29 Sat											
30 Sun											
31 Mon											
MIN		0.47	0.71	0.60	0.09	0.90	0.49	0.83	0.22	0.65	-
MAX		0.89	1.32	0.85	0.45	2.85	0.69	1.91	0.34	0.80	-
AVG		0.72	1.09	0.70	0.29	1.61	0.58	1.09	0.30	0.74	-
SUM		2.87	4.37	2.81	1.15	8.06	2.92	5.43	1.49	2.94	-

October 2016

Water - Ortho Phos - HACH

	Daily Com	Drinking Water\F Cl2 Bac-T									
		56135 Service Master - Ortho Phos HACH Kit mg/L	59035 FS7 - Ortho Phos HACH Kit mg/L	59135 Comstock Fire Sta - Ortho Phos HACH Kit mg/L	59235 Speedway - Ortho Phos HACH Kit mg/L	59335 Kal Twp Hall - Ortho Phos HACH Kit mg/L	59435 Borgess Hospital - Ortho Phos HACH Kit mg/L	59535 Env Health Dept - Ortho Phos HACH Kit mg/L	59635 Harding`s Eastwood - Ortho Phos HACH Kit	59735 Eastwood Fire Sta. - Ortho Phos HACH Kit mg/L	59835 Westwood FS4 - Ortho Phos HACH Kit mg/L
1 Sat											
2 Sun											
3 Mon		0.70									
4 Tue											
5 Wed		0.84									
6 Thu											
7 Fri											
8 Sat											
9 Sun											
10 Mon											
11 Tue		0.75									
12 Wed											
13 Thu											
14 Fri											
15 Sat											
16 Sun											
17 Mon		0.82									
18 Tue											
19 Wed		0.70									
20 Thu											
21 Fri											
22 Sat											
23 Sun											
24 Mon											
25 Tue											
26 Wed											
27 Thu											
28 Fri											
29 Sat											
30 Sun											
31 Mon											
MIN		0.70	-	-	-	-	-	-	-	-	-
MAX		0.84	-	-	-	-	-	-	-	-	-
AVG		0.76	-	-	-	-	-	-	-	-	-
SUM		3.81	-	-	-	-	-	-	-	-	-

November 2016

Water - Ortho Phos - HACH

		Drinking Water\F Cl2 Bac-T									
	Daily Com	54135 FS2 - Ortho Phos HACH Kit mg/L	54235 FS3 - Ortho Phos HACH Kit mg/L	54335 FS6 - Ortho Phos HACH Kit mg/L	54435 Peoples Church - Ortho Phos HACH Kit mg/L	54535 Markin Park - Ortho Phos HACH Kit mg/L	54635 Miller Road - Ortho Phos HACH Kit mg/L	54735 Dartmouth - Ortho Phos HACH Kit mg/L	54835 Edgemor - Ortho Phos HACH Kit mg/L	54935 Mt.Olivet - Ortho Phos HACH Kit mg/L	55035 BLAKSLEE - Ortho Phos HACH Kit mg/L
1 Tue		0.68	1.42			1.03	0.48			1.25	
2 Wed				0.89	1.34			1.15	0.75		1.23
3 Thu											
4 Fri											
5 Sat											
6 Sun											
7 Mon		0.54	0.84			1.42	1.87			0.98	
8 Tue											
9 Wed		0.85	0.86			1.19	0.27			1.33	
10 Thu		0.80	1.07	0.59	1.12	1.38	0.56	1.33	0.51	1.57	1.25
11 Fri											
12 Sat											
13 Sun											
14 Mon											
15 Tue											
16 Wed											
17 Thu											
18 Fri											
19 Sat											
20 Sun											
21 Mon											
22 Tue											
23 Wed											
24 Thu											
25 Fri											
26 Sat											
27 Sun											
28 Mon											
29 Tue											
30 Wed											
MIN		0.54	0.84	0.59	1.12	1.03	0.27	1.15	0.51	0.98	1.23
MAX		0.85	1.42	0.89	1.34	1.42	1.87	1.33	0.75	1.57	1.25
AVG		0.72	1.05	0.74	1.23	1.26	0.80	1.24	0.63	1.28	1.24
SUM		2.87	4.19	1.48	2.46	5.02	3.18	2.48	1.26	5.13	2.48

November 2016

Water - Ortho Phos - HACH

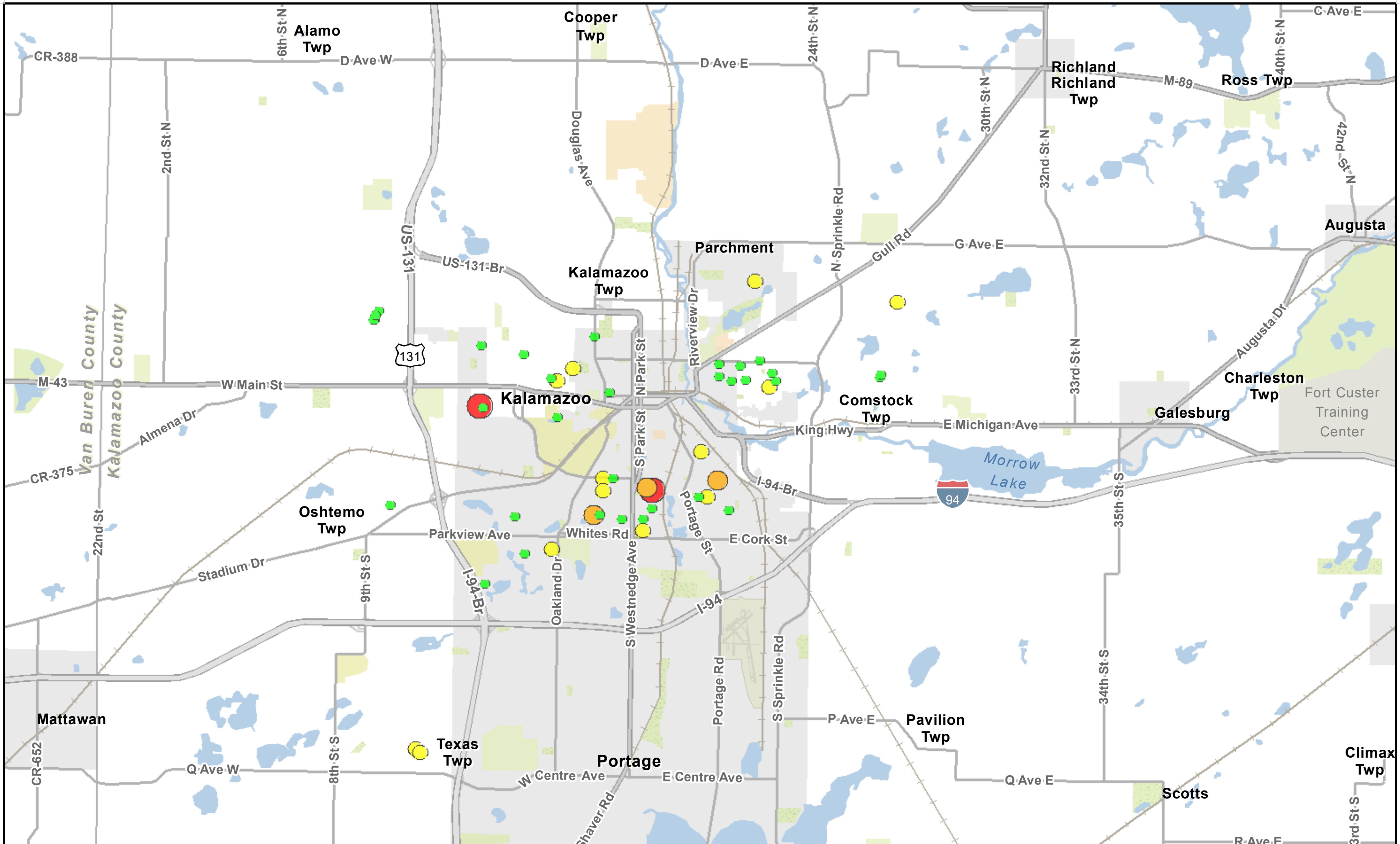
	Daily Com	55135 Gull Road - Ortho Phos HACH Kit mg/L	55235 Richland/Parker - Ortho Phos HACH Kit mg/L	55335 28th Saginaw - Ortho Phos HACH Kit mg/L	55435 Candlewyck - Ortho Phos HACH Kit mg/L	55535 STA32 - Ortho Phos HACH Kit mg/L	55635 Stadium - Ortho Phos HACH Kit mg/L	55735 6THST - Ortho Phos HACH Kit mg/L	55835 TXTWP - Ortho Phos HACH Kit mg/L	55935 PSSTA - Ortho Phos HACH Kit mg/L	56035 Beech - Ortho Phos HACH Kit mg/L
1 Tue		0.66	1.16	0.75	0.61					1.47	
2 Wed						1.02	0.39	1.04	0.15		
3 Thu											
4 Fri											
5 Sat											
6 Sun											
7 Mon		0.78	1.02	0.75	0.53					1.65	
8 Tue											
9 Wed		0.46	3.03	0.68	0.12					1.25	
10 Thu				0.86	0.25	0.80	0.67	0.75	0.15	1.46	
11 Fri											
12 Sat											
13 Sun											
14 Mon											
15 Tue											
16 Wed											
17 Thu											
18 Fri											
19 Sat											
20 Sun											
21 Mon											
22 Tue											
23 Wed											
24 Thu											
25 Fri											
26 Sat											
27 Sun											
28 Mon											
29 Tue											
30 Wed											
MIN		0.46	1.02	0.68	0.12	0.80	0.39	0.75	0.15	1.25	-
MAX		0.78	3.03	0.86	0.61	1.02	0.67	1.04	0.15	1.65	-
AVG		0.63	1.74	0.76	0.38	0.91	0.53	0.90	0.15	1.46	-
SUM		1.90	5.21	3.04	1.51	1.82	1.06	1.79	0.30	5.83	-

Water - Ortho Phos - HACH

		Drinking Water\F Cl2 Bac-T									
	Daily Com	56135 Service Master - Ortho Phos HACH Kit mg/L	59035 FS7 - Ortho Phos HACH Kit mg/L	59135 Comstock Fire Sta - Ortho Phos HACH Kit mg/L	59235 Speedway - Ortho Phos HACH Kit mg/L	59335 Kal Twp Hall - Ortho Phos HACH Kit mg/L	59435 Borgess Hospital - Ortho Phos HACH Kit mg/L	59535 Env Health Dept - Ortho Phos HACH Kit mg/L	59635 Harding`s Eastwood - Ortho Phos HACH Kit	59735 Eastwood Fire Sta. - Ortho Phos HACH Kit mg/L	59835 Westwood FS4 - Ortho Phos HACH Kit mg/L
1 Tue											
2 Wed		0.85									
3 Thu											
4 Fri											
5 Sat											
6 Sun											
7 Mon											
8 Tue											
9 Wed											
10 Thu		0.87	0.98	0.49	0.46	1.58	1.05	1.03	1.67	0.82	0.64
11 Fri											
12 Sat											
13 Sun											
14 Mon											
15 Tue											
16 Wed											
17 Thu											
18 Fri											
19 Sat											
20 Sun											
21 Mon											
22 Tue											
23 Wed											
24 Thu											
25 Fri											
26 Sat											
27 Sun											
28 Mon											
29 Tue											
30 Wed											
MIN		0.85	0.98	0.49	0.46	1.58	1.05	1.03	1.67	0.82	0.64
MAX		0.87	0.98	0.49	0.46	1.58	1.05	1.03	1.67	0.82	0.64
AVG		0.86	0.98	0.49	0.46	1.58	1.05	1.03	1.67	0.82	0.64
SUM		1.72	0.98	0.49	0.46	1.58	1.05	1.03	1.67	0.82	0.64

Attachment B

Lead and Copper Aerial Maps



LEGEND

Lead Concentration (ppb) - 2002

- > 0 - 3.9
- 4 - 9.9
- 10 - 14.9
- 15 - 49.9
- Greater than 50

N

0 2.25

Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

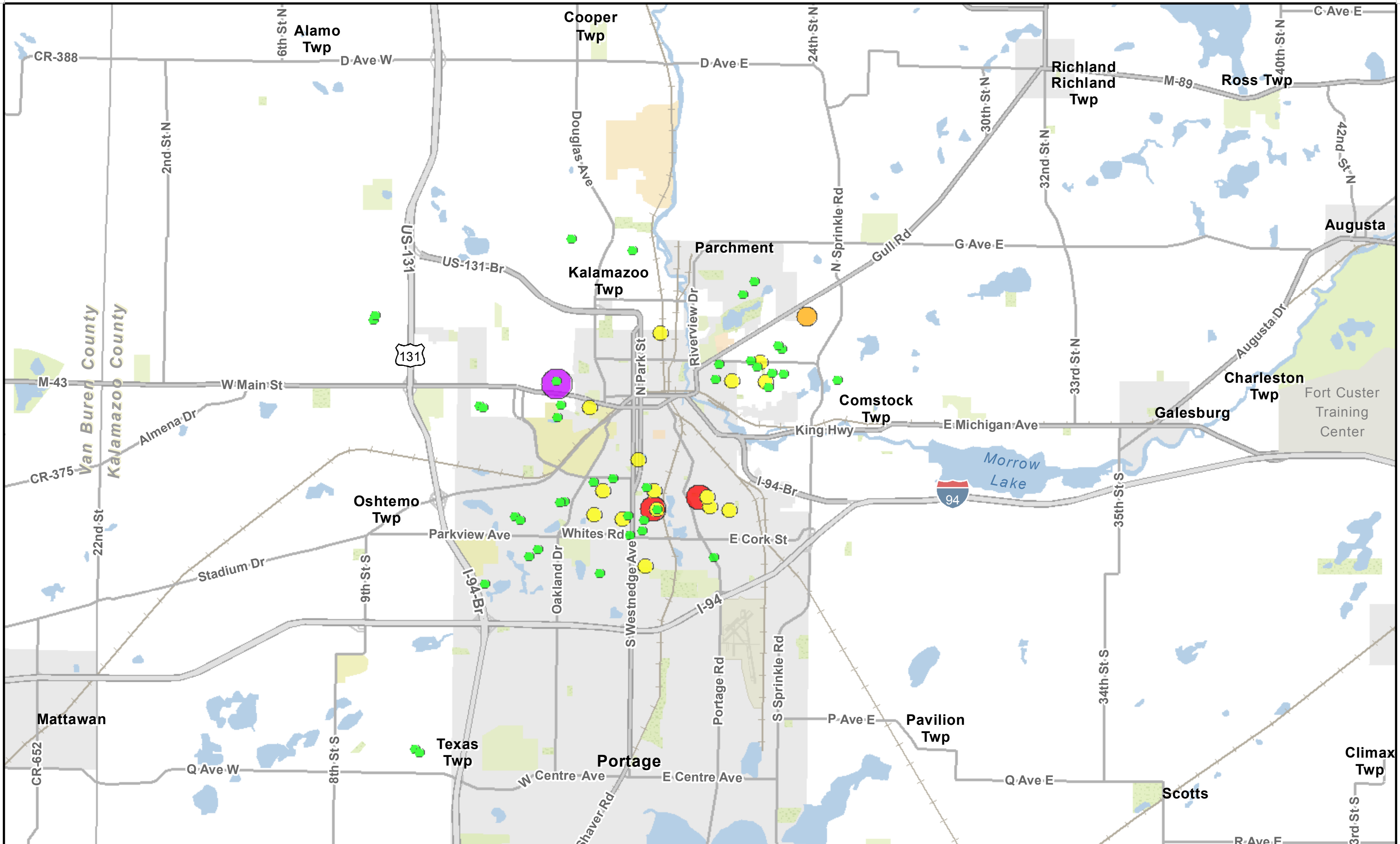
LEAD CONCENTRATION

TETRA TECH

FIGURE 1

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Pb_2002.mxd [alex.montalvo 8/25/2016]



LEGEND

Lead Concentration (ppb) - 2005

- \> 0 - 3.9
- 4 - 9.9
- 10 - 14.9
- 15 - 49.9
- Greater than 50

N

0 2.25

Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

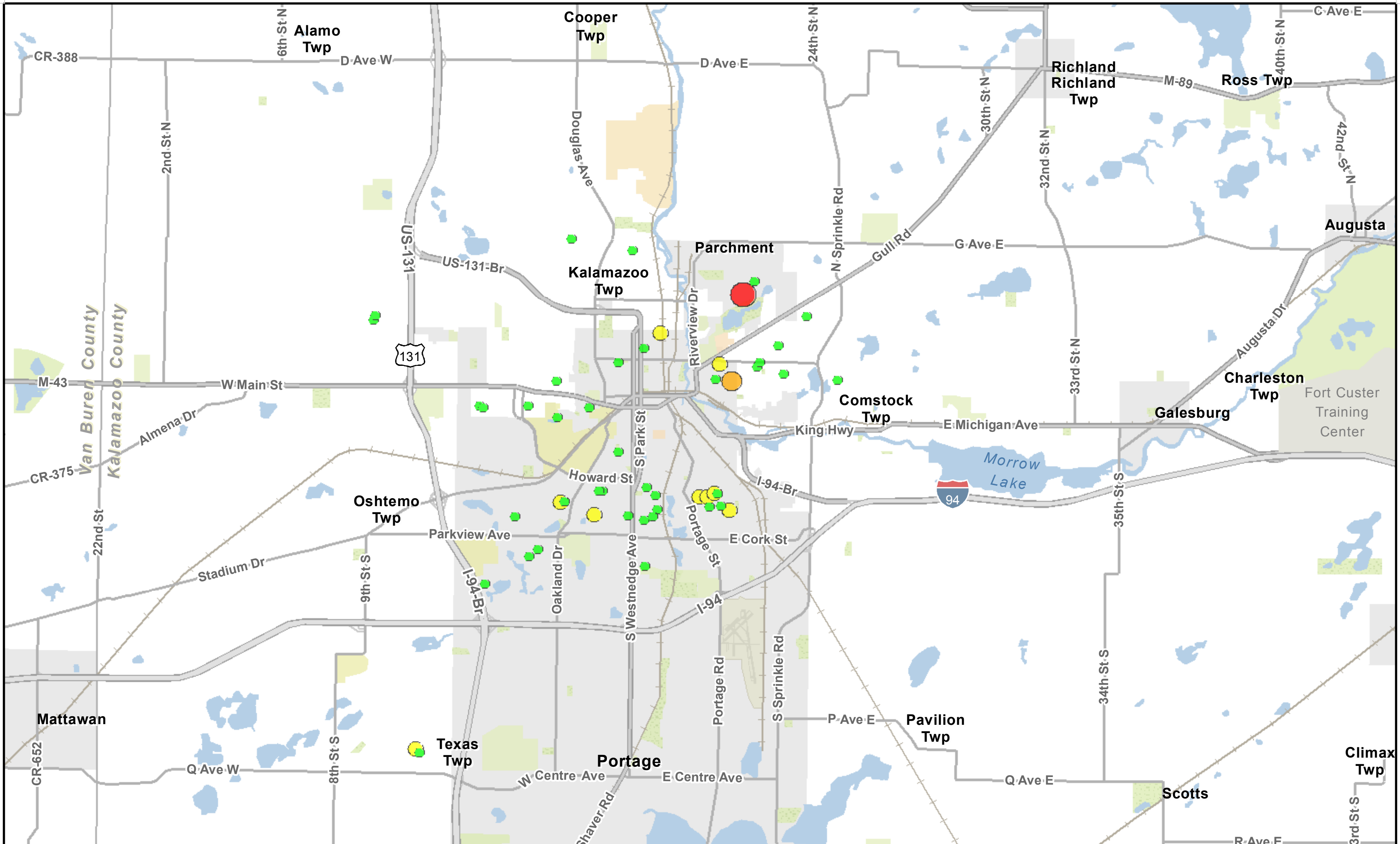
LEAD CONCENTRATION

TETRA TECH

FIGURE 2

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Pb_2005.mxd [alex.montalvo 8/25/2016]



LEGEND

Lead Concentration (ppb) - 2008

- > 0 - 3.9
- 4 - 9.9
- 10 - 14.9
- 15 - 49.9
- Greater than 50

N

0 2.25

Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

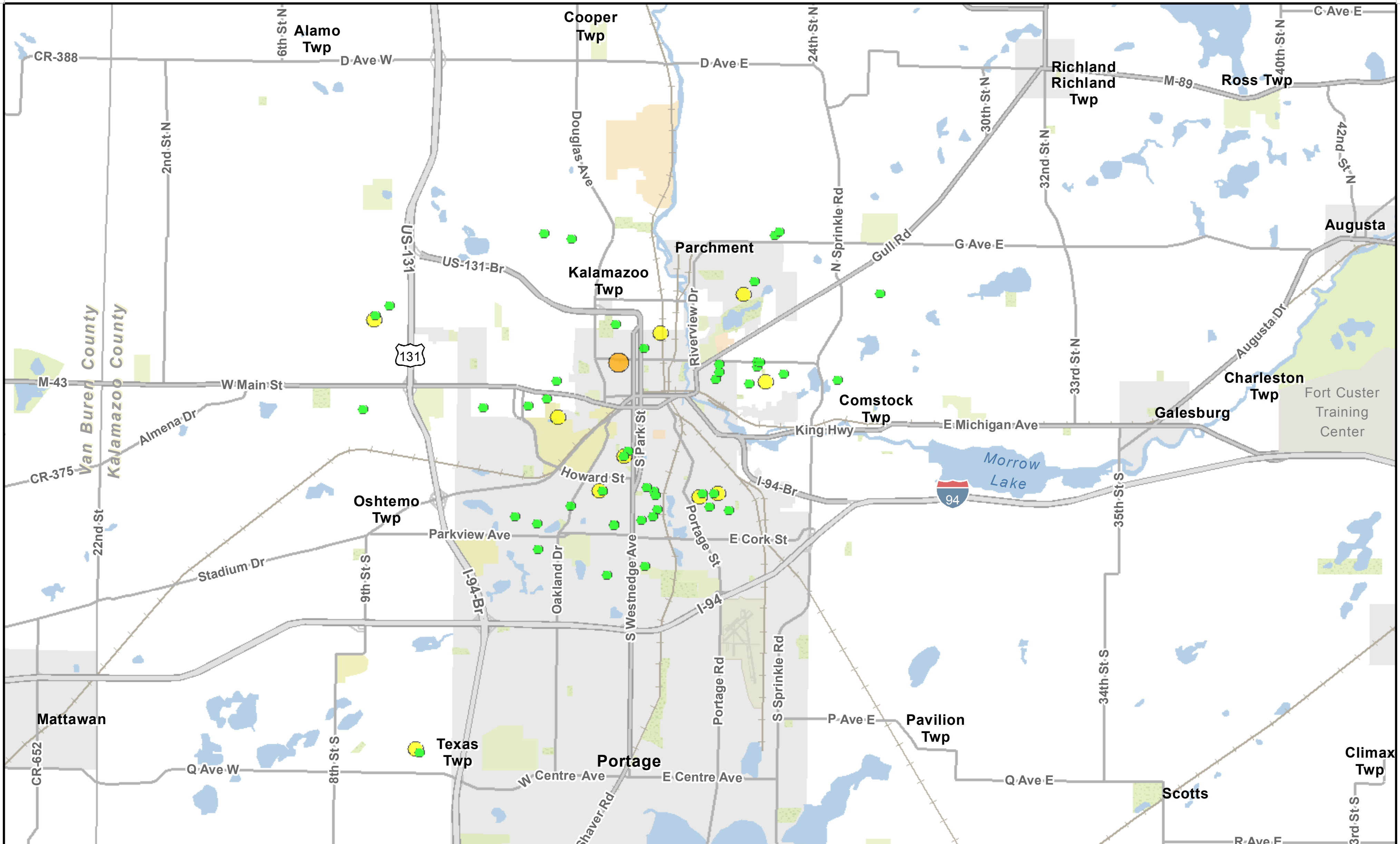
LEAD CONCENTRATION

TETRA TECH

FIGURE 3

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Pb_2008.mxd [alex.montalvo 8/25/2016]



LEGEND

Lead Concentration (ppb) - 2011

- > 0 - 3.9
- 4 - 9.9
- 10 - 14.9
- 15 - 49.9
- Greater than 50

N

0 2.25

Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

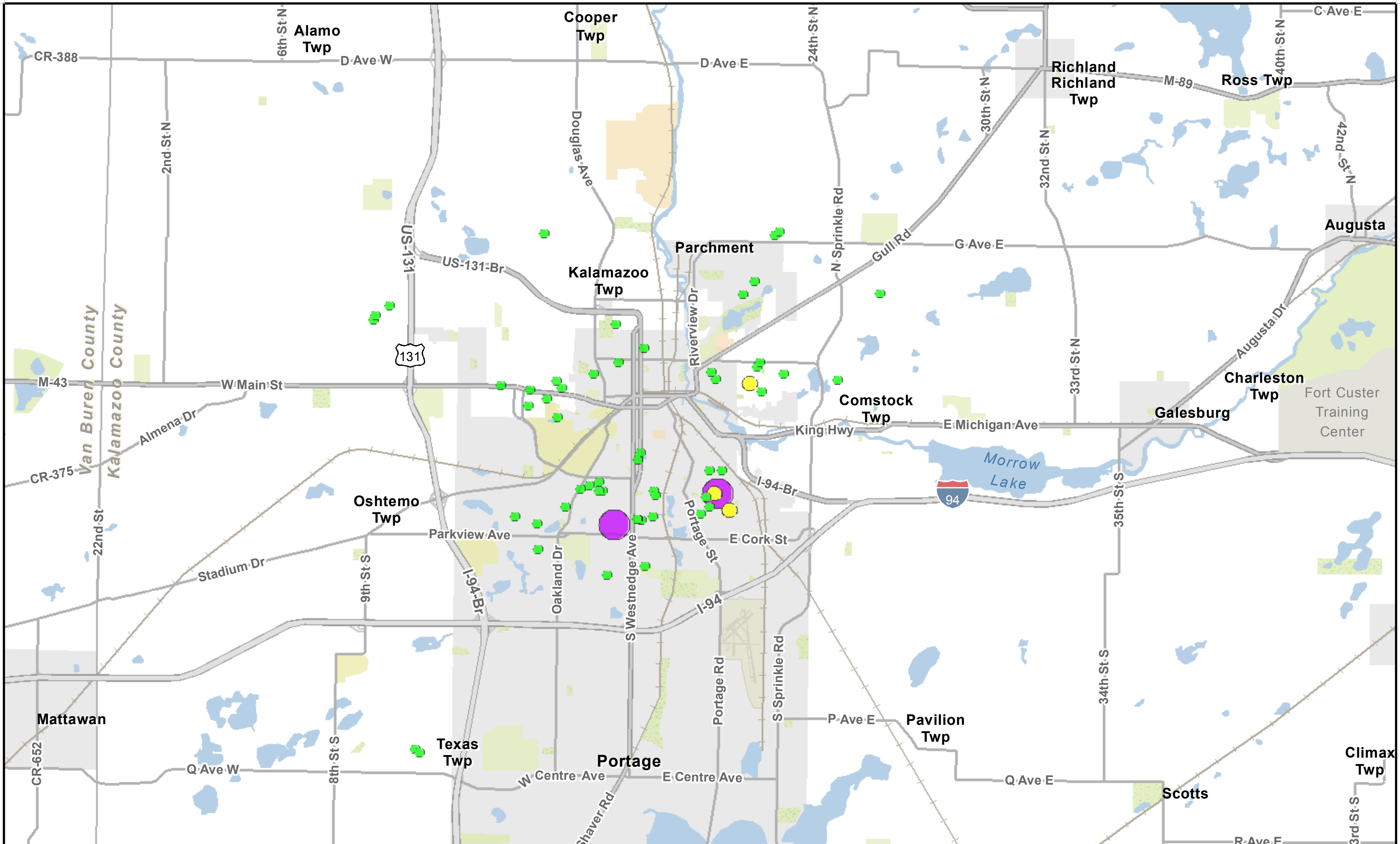
LEAD CONCENTRATION

TETRA TECH

FIGURE 4

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Pb_2011.mxd [alex.montalvo 8/25/2016]



LEGEND

Lead Concentration (ppb) - 2014

- > 0 - 3.9
- 4 - 9.9
- 10 - 14.9
- 15 - 49.9
- Greater than 50

N

0 2.25

Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

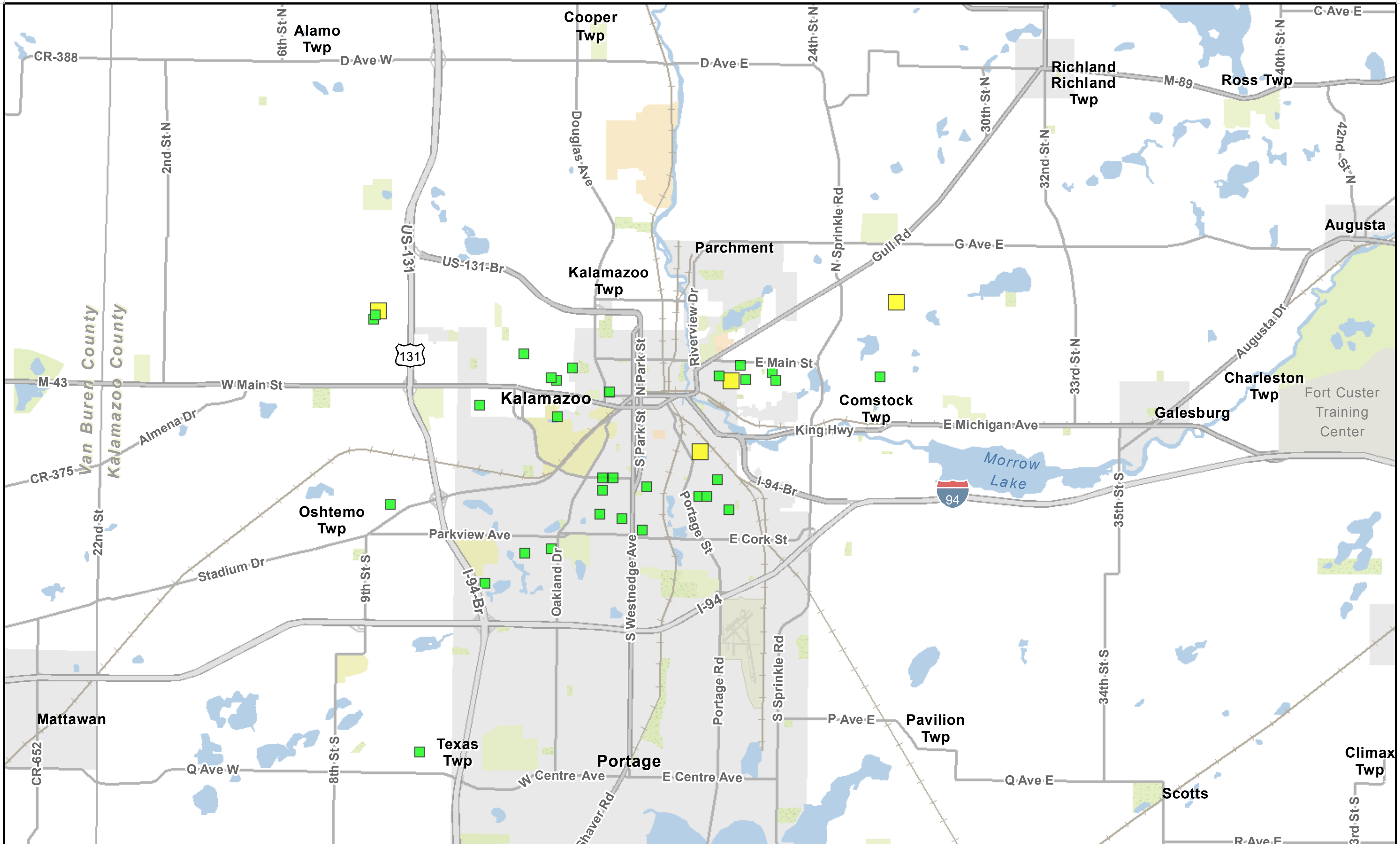
LEAD CONCENTRATION

TETRA TECH

FIGURE 5

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Pb_2014.mxd [alex.montalvo 8/25/2016]



LEGEND

Copper Concentration (ppb) - 2002

- > 0 - 399
- 400 - 799
- 800 - 1299
- Greater than 1300

N

0 2.25

Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

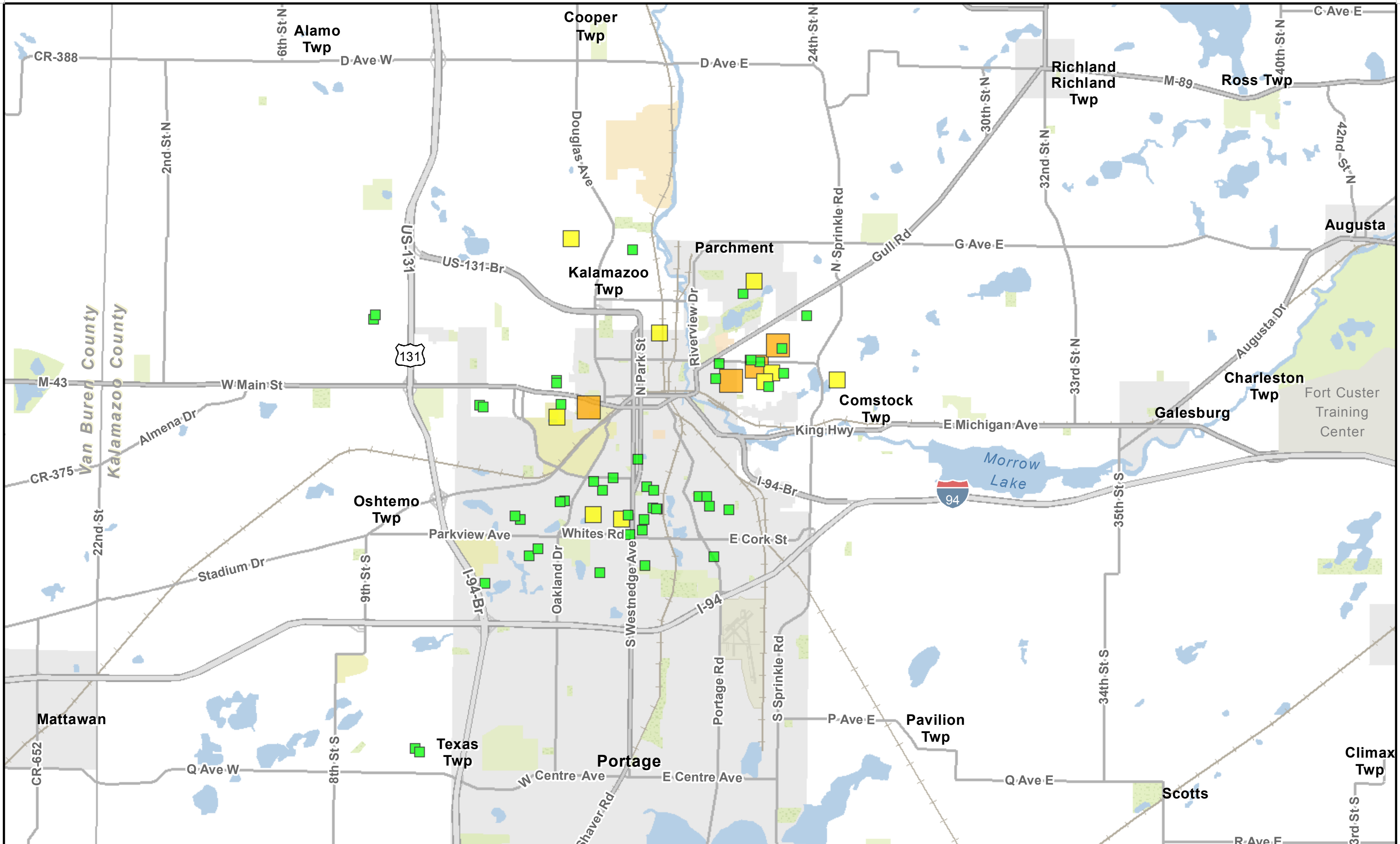
COPPER CONCENTRATION

TETRA TECH

FIGURE 6

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Cu_2002.mxd [alex.montalvo 8/25/2016]



LEGEND

Copper Concentration (ppb) - 2005

- > 0 - 399
- 400 - 799
- 800 - 1299
- Greater than 1300

N

0 2.25

Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

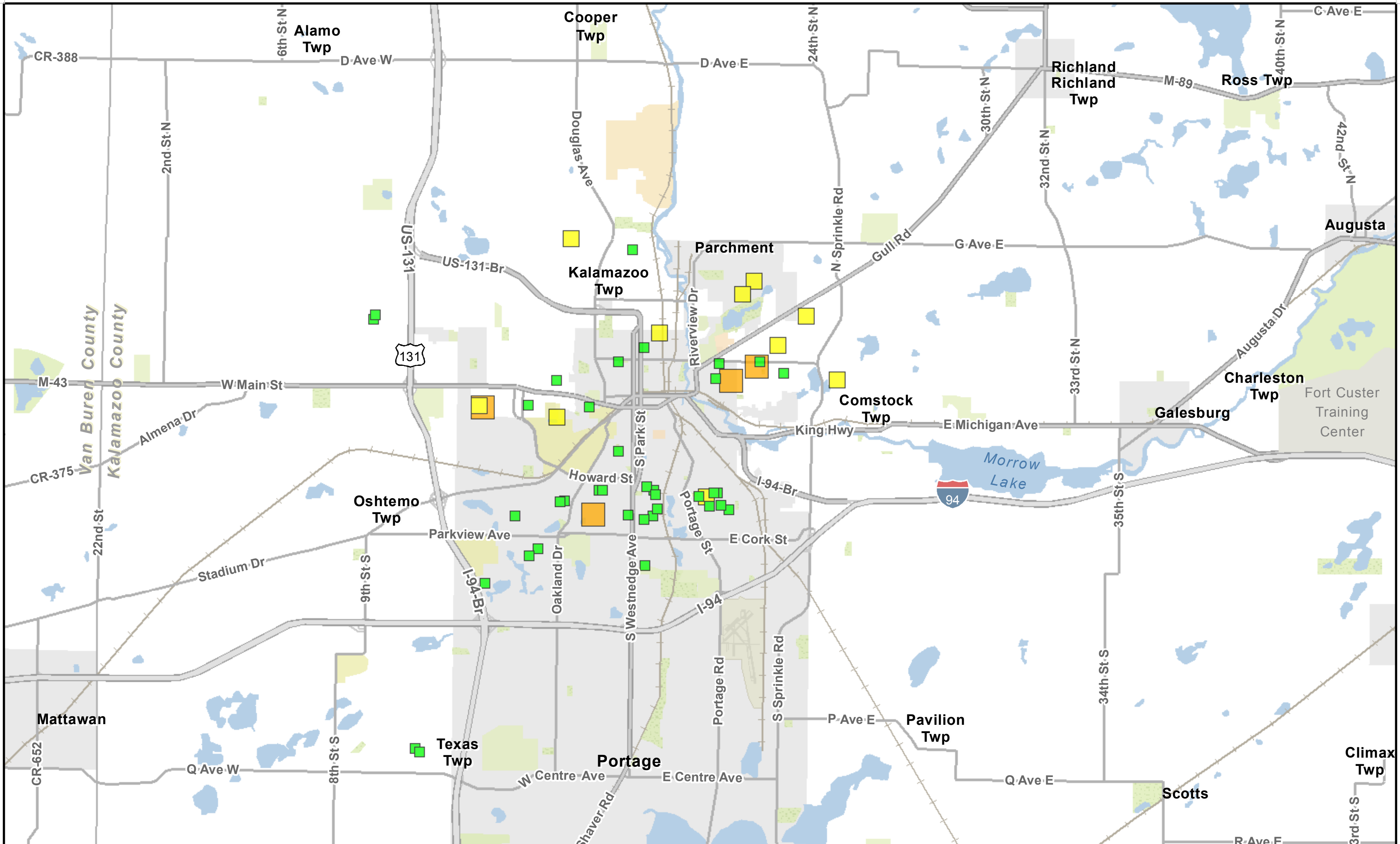
COPPER CONCENTRATION

TETRA TECH

FIGURE 7

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Cu_2005.mxd [alex.montalvo 8/25/2016]



LEGEND

Copper Concentration (ppb) - 2008

- > 0 - 399
- 400 - 799
- 800 - 1299
- Greater than 1300

N

0 2.25

Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

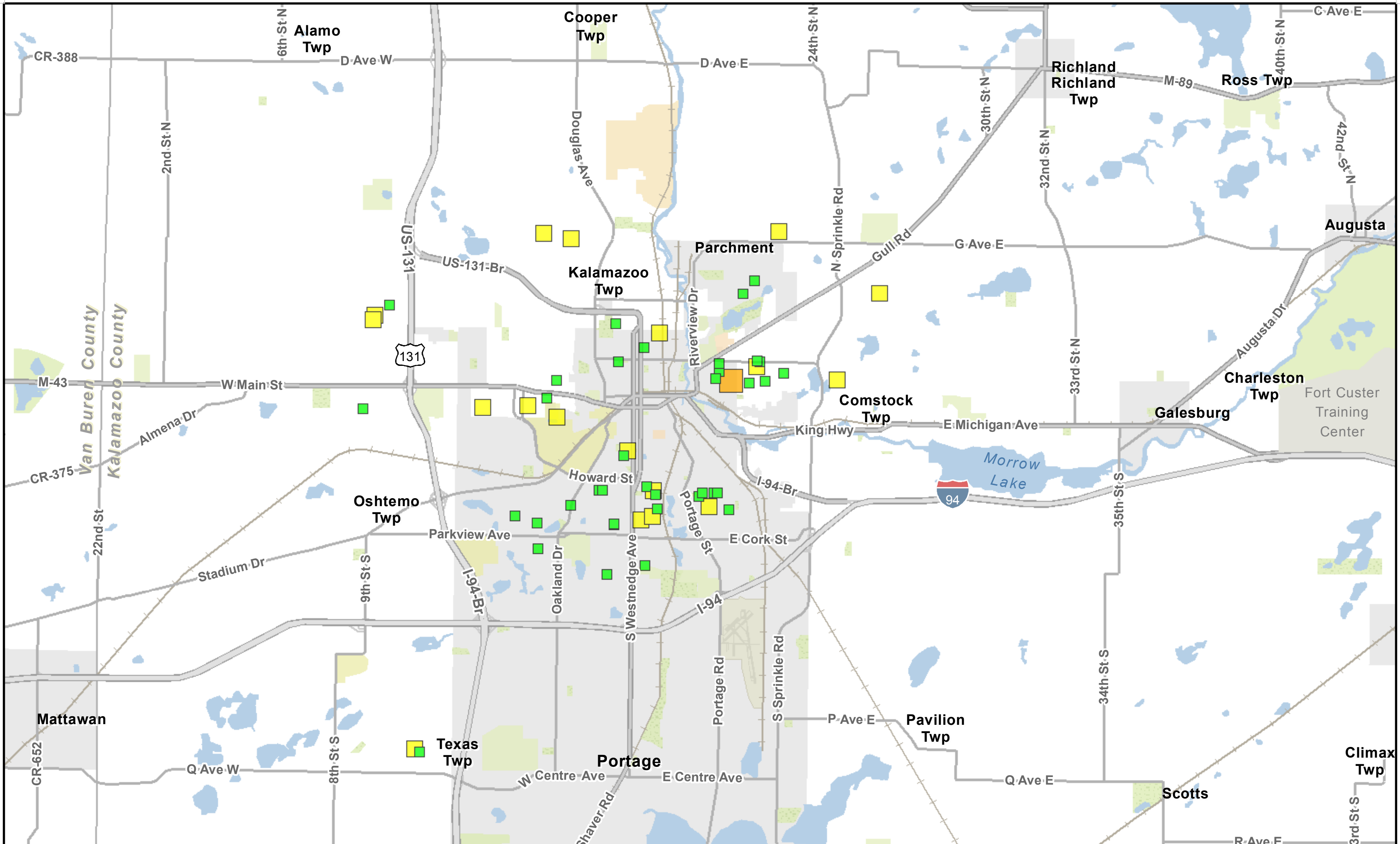
COPPER CONCENTRATION

TETRA TECH

FIGURE 8

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Cu_2008.mxd [alex.montalvo 8/25/2016]



LEGEND

Copper Concentration (ppb) - 2011

- > 0 - 399
- 400 - 799
- 800 - 1299
- Greater than 1300

N

0 2.25

Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

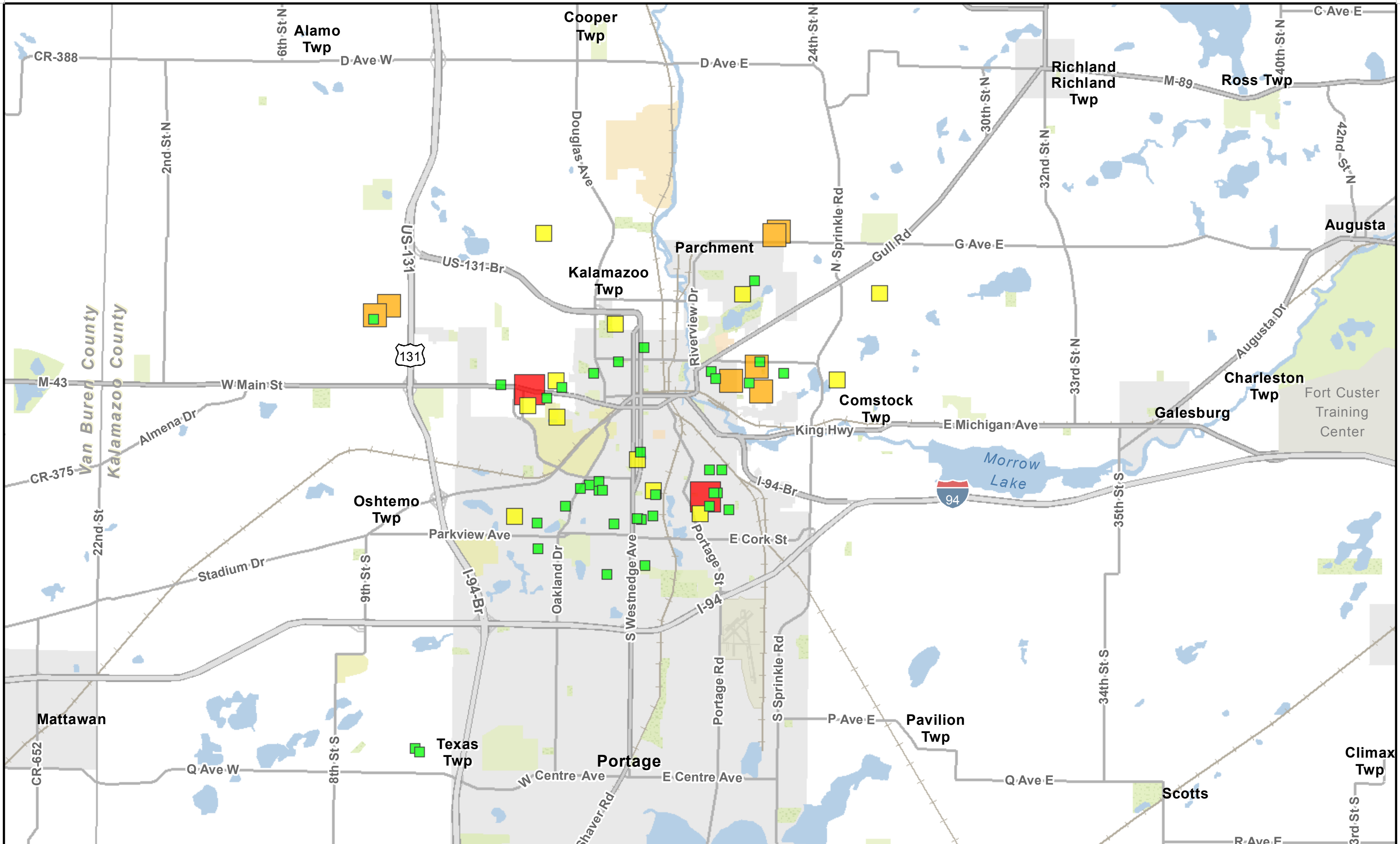
COPPER CONCENTRATION

TETRA TECH

FIGURE 9

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Cu_2011.mxd [alex.montalvo 8/25/2016]



LEGEND

Copper Concentration (ppb) - 2014

- > 0 - 399
- 400 - 799
- 800 - 1299
- Greater than 1300

N

0 2.25

Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

COPPER CONCENTRATION

TETRA TECH

FIGURE 10

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Cu_2014.mxd [alex.montalvo 8/25/2016]