2004 Annual Microbiological Monitoring Report

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Welcome to the 2004 Edition of the Annual Microbiological Report

The purpose of this report is to focus on:

▪ Total coliform and E. *coli* monitoring results
▪ Distribution system information
  ▪ Chlorine
  ▪ pH
  ▪ Temperature
  ▪ Electrical conductivity

INTRODUCTION

Approximately 98% of all Tucson Water customers receive their drinking water from the main drinking water system (10-112), which serves water to customers living in the Tucson area. The remaining 2% of Tucson Water's customers live outside of the Tucson area and are served by ten isolated systems, all of which are represented in this report.

DRINKING WATER REGULATIONS

In 1975, eighteen drinking water standards were adopted in response to the federal Safe Drinking Water Act. Today, there are more than 90 compounds that are regulated and water systems are also required to monitor for 12 unregulated compounds. The majority of these regulated contaminants are toxic metals or synthetic organic compounds (SOCs) that are not usually detected in any of our systems. Contamination of this sort is usually due to contamination at the source, rather than from the distribution system. Bacterial contamination, on the other hand, has the potential to enter the distribution system whenever failures of sanitary mechanisms occur. Therefore, bacterial monitoring for total coliforms is required and performed throughout the distribution system on a monthly basis. These standards for drinking water are set forth by the United States Environmental Protection Agency (USEPA) and are enforced statewide by the Arizona Department of Environmental Quality (ADEQ).

SOURCE WATER MONITORING[1]

All of the water supplied by Tucson Water is groundwater that is pumped from the underground aquifer. Some of this groundwater is currently being replenished by recharging Colorado River Water, also known as CAP water, in large constructed recharge basins, which are located in the Central Avra Valley west of the Tucson metropolitan area. This groundwater in turn supplies our distribution system through the use of approximately 200 deep wells. While most of the wells are pumped directly into the distribution system, some wells are combined together before entering the distribution system at what are called Points of Entry. In order to ensure compliance with all state and federal regulations, compliance monitoring is performed at approximately 175 Points of Entry (POEs). This information is not included within the scope of this report, but can be viewed in the Annual Consumer Confidence Report, better known as the Annual Water Quality Report, which is published and sent to every Tucson Water customer in June.

[1]Only samples collected from the distribution system are included within the scope of this report.

DISTRIBUTION SYSTEM MONITORING

In order to ensure a safe and sanitary water supply, extensive water quality monitoring is conducted throughout the year at all 262 dedicated sampling stations. These stations are located throughout the city, and have been an integral part of our monitoring program since 1997. They are effectively used to shield the sample point from environmental factors, such as rain, birds, and other animals, that may touch the sample point and cause false positives for total coliforms.

Currently, Tucson Water conducts monthly water quality monitoring at 246 dedicated sampling stations in the main system (system 10-112) and at 16 dedicated sampling stations in the isolated systems. Each system and the number of sampling stations within each system are shown in **Table 1**.

Table 1

System Number	System Name	Number of Sampling Stations
10-112	Main TW System	246
10-158	Valley View Acres	1
10-159	Diamond Bell	1
10-162	Silverbell West	1
10-169	Corona de Tucson	4
10-171	Catalina	2
10-173	Rancho Del Sol Lindo and White Fence Farms	3
10-179	Thunderhead	1
10-270	Sierrita Foothills	1
10-313	Police-Fire Academy	1
10-325	Sunset Ranch	1
Total Number of Sampling Stations		**262**

COMPLIANCE MONITORING

As part of the coliform monitoring requirement, Tucson Water is required to collect and analyze a minimum of 240 coliform samples per month from the main system, and at least one per month from each of the isolated systems depending on the size of the population being served. After sample collection, each sample is analyzed for total coliform and *E. coli* bacteria[2].

The current Maximum Contaminant Level (MCL) for coliform bacteria in a large water system, such as the TW main system, is "no more than 5% of the samples may be total coliform-positive" and "any fecal coliform-positive repeat sample or E. *coli*-positive repeat sample is an acute violation". Small or isolated water systems, which collect fewer than 40 samples per month, violate the standard if more than one sample is total coliform-positive. Anytime the coliform standard is exceeded, Tucson Water is required to notify the public as soon as possible. (Arizona Administrative Code, Title 18, Chapter 4)

Current drinking water regulations also require public water systems to monitor the chlorine residual of the water in the distribution system in order to minimize the production of disinfection by products[3]. Chlorine is a chemical disinfectant that is added to the water in order to control microbiological growth within the distribution system and to eliminate any microbiological contamination that might enter the system through a main break. It is an important aspect of maintaining the microbiological quality of the water being served and is tested regularly each time a coliform sample is collected.

Although, there is not a set MCL (Maximum Contaminant Level) for chlorine residual, there is a "**M**aximum **R**esidual **D**isinfectant **L**evel **G**oal" that has been set by the EPA at 4.0 mg/L. This is mentioned as a regulatory guideline because of its association with the production of disinfection by-products.

Tucson Water is also required to monitor for the presence of disinfection by-products within each system. These samples are collected from the main system on a quarterly basis at sixteen dedicated sampling stations, and from each of the isolated systems on an annual basis. The MCL for the trihalomethane (THM) contaminants is based on a running annual average and is 80 ppb. The MCL

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[2] Total coliforms and *E. coli* are indicator organisms that are used to indicate the presence of bacteria that can cause illness in humans. *E. coli* are bacteria whose presence indicate that the water may be contaminated with human or animal wastes. Water contaminated with such waste can cause illnesses that can range from a minor bout of diarrhea, cramps, nausea, or other symptoms to a much more serious illness, which can seriously threaten vulnerable individuals, i.e. the very young, the aged, and immunocompromised.

[3] Disinfection By-Products (trihalomethanes, THMs and haloacetic acids, HAAs) are contaminants that are formed when chlorine used for disinfection combines with organic matter that is naturally present in the water. These contaminants are of concern because some of these constituents are suspected to cause cancer and reproductive effects in humans.

for the haloacetic acid (HAA) contaminants is 60 ppb. Additional information regarding the results of this monitoring can be found in the Annual Water Quality Report that is published and sent to each Tucson Water customer in July.

COLIFORM MONITORING

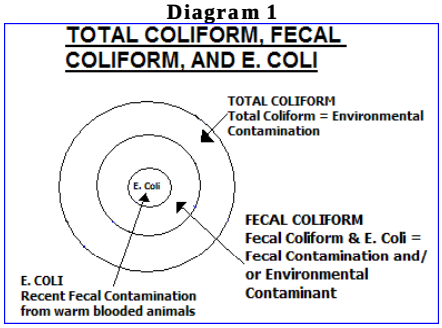
Coliform bacteria are common in the environment and are generally not harmful. However, the presence of these bacteria in drinking water is usually the result of a problem with the treatment system or the pipes distributing the water. The presence of Total Coliforms in drinking water suggests that the water may contain other bacteria that can cause illness, such as fecal coliforms and possibly E. coli. **Diagram 1** illustrates this correlation.

When a water sample is tested for coliform, the result is reported as either positive or negative. A positive result means that at least one coliform bacterium is present in a 100-milliliter sample. When this situation occurs, the original sample must be tested for the presence of *E. coli*, and a set of three more samples, known as "repeats," must be collected for each positive sample within the next 24 hours. This sampling must continue until all repeat samples are negative.

Each set of "repeats" must include 3 points for each positive sample collected in the main system and a total of 5 samples if from an isolated system. These sets must include:

1. The original point,
2. An upstream sample from within five water services,
3. A downstream sample collected within five water services,
4. And an additional two samples collected from other parts of the system in cases where the contamination is located in an isolated system.

Diagram 1



COLIFORM MONITORING RESULTS: SYSTEM 10-112 – TUCSON WATER MAIN SYSTEM[4]

In 2004, 2,976 coliform samples were collected from the main system. Seven of these samples tested positive for total coliforms and negative for E. coli. Additionally, all recollects for these samples tested negative for total coliforms and E. coli. **Table 2** summarizes these samples and shows the chlorine residual at the time of sample collection as well as the address and water quality zone. **Figure 1** at the end of this report summarizes the percentages of positive samples collected each month from 1997 to 2004.

Table 2

Positive Sample Points in 2004 (10-112)	Total Coliform Result (Pos/Neg)	Collection Date	WQ Zone	Address	Free Chlorine Residual
SP-732	Pos	5/10/2004	7	9233 E. 38TH ST.	0.75
SP-585	Pos	6/9/2004	6	9405 E. SIERRA ST.	0.67
SP-260	Pos	8/17/2004	2	6600 N. SWAN RD.	0.52
SP-290	Pos	8/17/2004	2	4732 E. CALLE BARRIL	0.61
SP-988	Pos	10/14/2004	10	9230 W. HENRY ST.	0.78
SP-988	Pos	10/15/2004	10	9230 W. HENRY ST.	0.61
SP-732	Pos	12/12/2004	7	9233 E. 38TH ST.	0.88

[4] In July 2004, the temperature of the incubator where the coliform samples are incubated fell out of range. As a result of this, eight coliform samples from the main system had to be recollected.

COLIFORM MONITORING RESULTS: ISOLATED SYSTEMS[5]

With the exception of the Diamond Bell Isolated System, 10-159, none of the isolated systems had any detections of either total coliforms or E. coli in 2004. This is shown in **Table 3** below. The Diamond Bell Isolated System had a total of 6 samples test positive for total coliforms and E. coli. This is explained below in the following section of this report.

Table 3

System Number	System Name	Number of Total Coliform Positive Samples	Number of E. Coli Positive Samples
10-158	Valley View Acres	0	0
10-159	Diamond Bell	6	6
10-162	Silverbell West	0	0
10-169	Corona de Tucson	0	0
10-171	Catalina	0	0
10-173	Rancho Del Sol Lindo and White Fence Farms	0	0
10-179	Thunderhead	0	0
10-270	Sierrita Foothills	0	0
10-313	Police-Fire Academy	0	0
10-325	Sunset Ranch	0	0

SYSTEM 10-159 – DIAMOND BELL ISOLATED SYSTEM

VIOLATION OF DRINKING WATER STANDARD FOR BACTERIA

In January of this year, the microbiological drinking water standard was violated in the Diamond Bell Isolated System (system # 10-159) when a routine sample from this system tested positive for total coliforms and E. *coli*. As required by the Arizona Department of Environmental Quality, "repeat" samples were collected within 24 hours. These samples ultimately tested positive for total coliforms and E. *coli* as well, and public notifications were provided to customers to not drink the water until there was sufficient evidence that the problem had been eliminated. Subsequent monitoring of the chlorine residual and bacteria was conducted throughout the system until all samples tested negative for total coliforms.

As a precautionary measure, additional chlorine residual monitoring was conducted every third week of each month at specified dead-end[6] locations within the system. This monitoring continued until the third week of November 2004, and was discontinued only after several months of data showed continuous satisfactory chlorine residual at each dead end location.

The following table (**Table 4**) represents all of the microbiological samples that were collected from the Diamond Bell Isolated System for this event as well as the coliform monitoring results and the free chlorine residuals that were measured in the field.

As you can see from the information presented in **Table 4**, on the following page – a total of 36 coliform samples were collected from the Diamond Bell Isolated System between January 27th and February 24th of 2004. Of these 36 samples collected, the initial **6** samples tested positive for total coliforms and E. *coli*. All of these 6 initial samples had chlorine residuals that were significantly below Tucson Water's internal standard of 0.40 mg/L of free chlorine, and 5 out of these 6 positive samples had a chlorine residual that was below the detection of field instrumentation, <0.05 mg/L free chlorine. This failure to maintain an adequate chlorine residual significantly contributed to contamination within the system.

[5] In July 2004, the temperature of the incubator where the coliform samples are incubated fell out of range. As a result of this, six coliform samples from the three isolated systems (10-162, 10-171, 10-173) had to be recollected.

[6] A dead end location in the system is a place in the system where water can become trapped if there is little water usage in the area. This can cause problems with stagnation if the level of chlorine is not maintained.

Table 4						
Date	**Sample Point**	**Total Coliform Result (Pos/Neg)**	**E. coli Result (Pos/Neg)**	**Cl_2F, mg/L**		**Sample Point Address/Field Comments**
1/27/2004	SR-259	POS	POS	<	0.05	15710 W. Diamond Bell Rd. Called Bob/Central for Cl, Entrained air - reran NTU
1/28/2004	SR-259	POS	POS		0.05	15710 W. Diamond Bell Rd.
1/28/2004	SR-259 E	POS	POS		0.05	15700 W. Diamond Bell Rd.
1/28/2004	SR-259 D	POS	POS		0.11	15710 W. Diamond Bell Rd.
1/28/2004	SR-259 X	POS	POS	<	0.05	15720 W. Diamond Bell Rd.
1/29/2004	SR-259 X	NEG	NEG		0.42	16102 W. Pinacate Ave.
1/29/2004	SR-259 X	NEG	NEG	<	0.05	16465 W. Cinnabar (Kitchen Tap)
1/29/2004	SR-259 X	NEG	NEG		0.38	16151 Larkdale St.
1/29/2004	SR-259	NEG	NEG		0.48	15710 W. Diamond Bell Rd.
1/29/2004	SR-259 X	NEG	NEG		0.34	16101 Killarney Ave.
1/29/2004	SR-259 X	NEG	NEG		0.55	16432 Larkdale St.
1/29/2004	SR-259 X	NEG	NEG		0.61	Diamond Bell (F-G Booster)
1/29/2004	SR-259 X	POS	POS	<	0.05	16465 W. Cinnabar (Inlet)
1/29/2004	SR-259 X	NEG	NEG		0.35	16332 W. Cinnabar
1/29/2004	SR-259 X	NEG	NEG		0.29	16433 W. Pinacate Ave.
1/29/2004	SR-259 X	NEG	NEG		0.40	15825 Killarney Ave.
1/30/2004	SR-259 X	NEG	NEG		Not Analyzed	15921 Killarney Ave.
1/30/2004	SR-259 X	NEG	NEG		0.77	Diamond Bell (F-G) Booster [Sample Spigot]
1/30/2004	SR-259 X	NEG	NEG		0.65	Diamond Bell (F-G) Booster [Pressure Tank]
1/30/2004	SR-259 X	NEG	NEG		Not Analyzed	15921 Killarney Ave. (RO Tap)
1/31/2004	SR-259 X	NEG	NEG		0.40	16230 Killarney Ave.
1/31/2004	SR-259	NEG	NEG		0.64	15710 W. Diamond Bell Rd.
1/31/2004	SR-259 X	NEG	NEG		0.70	15900 W. Ridgemoor Ave.
1/31/2004	SR-259 X	NEG	NEG		0.60	14550 Stagecoach
1/31/2004	SR-259 X	NEG	NEG		0.73	15879 W. Ravina Ave.
1/31/2004	SR-259 X	NEG	NEG		0.75	16005 W. Ravina Ave.
1/31/2004	SR-259 X	NEG	NEG		0.52	16532 W. Larkdale
1/31/2004	SR-259 X	NEG	NEG		0.34	14082 Poston
1/31/2004	SR-259 X	NEG	NEG		0.37	14045 Chino
1/31/2004	SR-259 X	NEG	NEG		0.45	14160 Olman
1/31/2004	SR-259 X	NEG	NEG		0.34	14142 Mica
1/31/2004	SR-259 X	NEG	NEG		0.69	16465 W. Cinnabar
1/31/2004	SR-259 X	NEG	NEG		0.80	15909 Lynette
2/24/2004	SR-259	NEG	NEG		0.56	15710 W. Diamond Bell Rd. Initial chlorine residual analysis was low – 0.22 ppm; flushed SP for ~60 min – resulted in a better Cl2F residual
2/24/2004	SR-259 D	NEG	NEG		0.39	15700 W. Diamond Bell Rd.
2/24/2004	SR-259 E	NEG	NEG		0.72	15720 W. Diamond Bell Rd.
2/24/2004	SR-259 X	NEG	NEG		0.70	15825 W. Killarney Ave.
2/24/2004	SR-259 Y	NEG	NEG		0.83	15892 W. Killarney Ave.

MONITORING RESULTS

CHEMICAL DISINFECTION – CHLORINE: ALL SYSTEMS

In order to maintain assurance that any microbiological growth is controlled, Tucson Water has instituted a self-imposed target range and minimum standard for chlorine in the system. The target chlorine residual for all systems ranges from 0.60 - 1.00 mg/L, however, this residual can be higher or lower than this target due to usage and demand in the field. In cases where the chlorine residual drops below the target, a minimum of 0.40 ppm of free chlorine residual in the distribution system is required. If the chlorine residual falls below this minimum standard or increases to levels that are above the upper standard, the result is reported to the Central operators who then respond by having the problem investigated in the field by the appropriate field crew.

Table 5

Chlorine Residual Range, mg/L	Percent of Samples	Number of Samples
≤0.05	0.3	11
0.06 to 0.39	2.3	73
0.40 to 0.59	16.5	527
0.60 to 1.00	78.2	2499
>1.00	2.7	86

Table 5 shows the percent distribution of samples within each range of chlorine residual detected and the number of samples detected within each range for all systems in 2004. As you can see from the table, over seventy-eight percent of the samples collected had chlorine residuals that were within the target range of 0.60% to 1.00%, and over 16% had chlorine residuals that were between 0.40 and 0.59 mg/L. **Figure 2** at the end of this report illustrates this distribution using various colors to represent the different ranges of chlorine residual that were measured throughout the year.

Table 5 also illustrates the following information:

- 94.7% of the samples collected (3,026 samples) had chlorine residuals that were between 0.4 and 1.00 mg/L;
- 2.6% of samples (84 samples) had chlorine residuals that were below 0.40 mg/L;
- 2.7% of samples (86 samples) had chlorine residuals that were above the upper limit of the target range (1.00 mg/L).

Table 6

Month (2004)	Average Chlorine Residual	Number of Samples Collected
January	0.70	289
February	0.68	263
March	0.72	260
April	0.61	260
May	0.67	263
June	0.71	263
July	0.67	274
August	0.71	268
September	0.70	261
October	0.69	268
November	0.66	262
December	0.77	265
Total Number of Samples Collected in All Systems		3,196

Table 6 shows the average monthly chlorine residuals for the main and isolated systems for all samples collected in 2004 as well as the total number of chlorine residual samples collected from all systems. From this table you can see that:

- The lowest average, 0.61 mg/L, occurred in April.
- The highest average, 0.77 mg/L, occurred in December.

This information is also illustrated in **Figure 3** at the end of this report.

CHEMICAL DISINFECTION – CHLORINE: MAIN SYSTEM INFORMATION (10-112)

Table 7

Chlorine Residual Range, mg/L	Percent of Samples	Number of Samples
≤0.05	0.07	2
0.06 to 0.39	1.61	48
0.40 to 0.59	16.59	494
0.60 to 1.00	79.45	2366
>1.00	2.28	68

In 2004, Tucson Water collected 2,978 chlorine residual samples from the Main System. The majority of these samples had chlorine residual values that were within the target range of 0.60 to 1.00 mg/L. This is illustrated in **Table 7**, which shows the percent distribution of the chlorine residuals in the samples collected. From this table you can see that:

- Approximately 96% of the samples collected (2,860 samples) had chlorine residuals that were between 0.40 and 1.00 mg/L;

- Only 0.07% of the samples collected (2 samples) had residuals that were below the instrument detection limit, 0.05 mg/L, and only 1.61% had residuals that were below the minimum standard of 0.40 mg/L;
- Approximately 2.3% of samples (68 samples) had residuals that were above Tucson Water's upper limit of 1.00 mg/L.

Table 8

Month (2004)	Chlorine Residual (mg/L)			Number of Samples Collected
	Average	Maximum	Minimum	
January	0.73	1.18	0.43	245
February	0.67	1.38	0.18	245
March	0.72	1.35	0.30	246
April	0.61	1.09	0.13	246
May	0.67	1.09	0.24	249
June	0.71	1.47	0.38	249
July	0.67	1.07	0.22	254
August	0.71	1.10	0.25	252
September	0.70	0.99	<0.05	245
October	0.69	1.24	0.19	252
November	0.76	1.36	0.41	246
December	0.77	1.16	<0.05	249
Total Number of Samples Collected from the Main Tucson Water System (10-112) in 2004				2,978

Table 8 shows the monthly chlorine residual average, minimum, and maximum as well as the number of samples collected for each month. From this table you can see that:

- The lowest monthly average in the Main System was 0.61 mg/L;
- The highest monthly average was 0.77 mg/L;
- The highest chlorine residual detected was 1.38 mg/L and occurred in February.
- The lowest chlorine residuals seen in the main system were below the instrument detection limit, <0.05 mg/L. This occurred only two times in 2004: once in September and once in December.

The average chlorine residual for each Water Quality Zone in the main Tucson Water system is illustrated in **Figure 4**. This chart shows the average residual for each zone for the past four years. From this chart, you can see that the average chlorine residual has decreased for nine out of the ten zones in the main system. Zone 1 is the only WQZ in the main system that had a slight increase in chlorine residual in 2004 as compared to 2003. This zone increased from 0.71 mg/L in 2003 to 0.73 mg/L in 2004.

The highest average chlorine residual for each of the WQ Zones in 2004 was 0.73 mg/L, whereas, the lowest average for each WQ Zone in 2004 was 0.67 mg/L.

CHEMICAL DISINFECTION – CHLORINE: ISOLATED SYSTEM INFORMATION

Table 9

Month (2004)	Average Chlorine Residual (mg/L)										Number of samples collected from isolated systems each month
	10-158	10-159	10-162	10-169	10-171	10-173	10-179	10-270	10-313	10-325	
January	1.80	0.42	0.74	0.38	0.86	0.62	0.70	0.25	0.77	0.41	44
February	1.61	0.64	0.82	0.84	0.55	0.79	0.66	1.32	0.66	0.33	18
March	1.26	0.45	0.81	0.83	0.69	0.81	0.79	0.91	0.70	0.44	14
April	0.28	0.53	0.78	0.76	0.38	0.90	1.03	0.08	0.33	0.43	14
May	0.41	0.39	1.09	0.79	0.78	0.83	1.01	0.35	0.68	0.51	14
June	0.71	1.07	0.83	0.80	0.56	0.89	0.77	<0.05	0.61	0.11	14
July	<0.05	0.47	0.61	0.79	0.60	0.93	0.74	0.62	0.66	0.31	20
August	0.94	0.89	0.43	0.78	0.39	1.01	0.90	0.48	0.50	0.53	16
September	1.11	0.29	0.55	0.77	0.51	0.76	0.85	1.39	0.55	0.32	16
October	0.94	0.75	0.88	0.85	0.84	0.80	0.90	0.25	0.60	0.47	16
November	0.40	1.05	1.15	0.73	0.99	0.79	0.76	0.78	0.66	0.63	16
December	1.80	0.77	1.02	0.69	0.85	0.67	0.23	0.90	0.79	0.63	16
Annual Average	0.94	0.50	0.79	0.75	0.66	0.82	0.78	0.62	0.63	0.43	Annual Isolated System Avg. = 0.69
Number of samples collected from each system in 2004	12	46	13	34	26	39	12	12	12	12	218

Table 9 shows the average chlorine residuals for each of the small systems, the number of samples collected from each system in 2004, and the number of samples collected from all isolated systems per month.

VALLEY VIEW ACRES (10-158)

- Three out of the 12 samples collected from this system had chlorine residual values that were within the target range of 0.60 to 1.00 mg/L.
- Chlorine residuals above the upper standard of 1.00 mg/L were detected five times in this system.
  - January – 1.80 mg/L
  - February – 1.61 mg/L
  - March – 1.26 mg/L
  - September – 1.11 mg/L
  - December – 1.80 mg/L
- Low chlorine residuals were detected in this system four times:
  - April – 0.28 mg/L
  - May – 0.41 mg/L
  - July – <0.05 mg/L
  - November – 0.40 mg/L

DIAMOND BELL (10-159)

Please see the special section on the Diamond Bell Isolated System on pages 4 and 5 of this report for complete information.

SILVERBELL WEST (10-162)

- Seven out of the 13 samples collected from this system had chlorine residual values that were within the target range of 0.60 to 1.00 mg/L.
- Three out of the 13 samples collected had chlorine residuals that were between 0.40 and 0.60 mg/L.
- Chlorine residuals above the upper standard of 1.00 mg/L were detected three times in this system.
  - May – 1.09 mg/L
  - November – 1.15 mg/L
  - December – 1.02 mg/L
- The lowest chlorine residual detected in this system, 0.43 mg/L, was detected in August.
- In July, the coliform sample collected from this system was invalidated due to a quality control (QC) failure. (The temperature of the incubator where the samples were kept fell out of range while the samples were being incubated.)
  - This resulted in an extra chlorine sample being collected from this system in July.

CORONA DE TUCSON (10-169)

- **Table 10** shows the average, maximum, and minimum chlorine residuals that were detected in this system.
- Two new dedicated system sample points were added to this system in August due to a rapid population increase.
- All but one sample collected from this system had chlorine residual values that were within the target range of 0.60 to 1.00 mg/L.
- The highest chlorine residual seen in this system was 0.95 mg/L.
- The lowest chlorine residual for this system occurred in January and was 0.15 mg/L.

Table 10

Month (2004)	10-169 Chlorine Residual (mg/L) Average	Maximum	Minimum	Number of Samples Collected
January	0.38	0.61	0.15	2
February	0.84	0.85	0.82	2
March	0.83	0.87	0.79	2
April	0.76	0.76	0.75	2
May	0.79	0.81	0.76	2
June	0.80	0.94	0.65	2
July	0.79	0.82	0.76	2
August	0.78	0.95	0.67	4
September	0.77	0.81	0.73	4
October	0.85	0.87	0.82	4
November	0.73	0.81	0.68	4
December	0.69	0.70	0.65	4

- This was the only sample from this system that was below the minimum standard of 0.40 mg/L.

CATALINA (10-171)

- **Table 11** shows the average, maximum, and minimum monthly chlorine residuals that were detected in this system.
- 17 out of the 26 samples collected from this system had chlorine residuals that were within the target range of 0.60 to 1.00 mg/L.
- Five samples collected from this system had chlorine residuals that were between 0.40 and 0.60 mg/L.
- Only one sample collected from this system had a chlorine residual that was above the upper standard of 1.00 mg/L.
  - July – 1.09 mg/L
- Three samples from this system had chlorine residuals that were below the minimum standard of 0.40 mg/L.
  - April – 0.08 mg/L
  - July – <0.05 mg/L
  - August – 0.09 mg/L

Table 11

Month (2004)	10-171 Chlorine Residual (mg/L) Average	Maximum	Minimum	Number of Samples Collected
January	0.86	0.86	0.86	2
February	0.55	0.60	0.49	2
March	0.69	0.73	0.65	2
April	0.38	0.67	0.08	2
May	0.78	0.83	0.73	2
June	0.56	0.56	0.55	2
July	0.60	1.09	<0.05	4
August	0.39	0.69	0.09	2
September	0.51	0.53	0.48	2
October	0.84	0.88	0.89	2
November	0.99	1.00	0.98	2
December	0.85	0.86	0.83	2

- In July, the two coliform samples collected from this system were invalidated due to a quality control (QC) failure. (The temperature of the incubator where the samples were kept fell out of range while the samples were being incubated.)
  - This resulted in two extra chlorine samples being collected from this system in July.

RANCHO DEL SOL LINDO AND WHITE FENCE FARMS (10-173)

- **Table 12** shows the average, maximum, and minimum monthly chlorine residuals that were detected in this system.
- 35 out of the 39 samples collected from this system had chlorine residuals that were within the target range of 0.60 to 1.00 mg/L.
- Only two samples collected from this system had chlorine residuals that were between 0.40 and 0.60 mg/L.
- Only two samples collected had chlorine residuals that were above the upper standard of 1.00 mg/L.
  - July – 1.07 mg/L
- The lowest chlorine residual, 0.56 mg/L, was detected in September.
- In July, the coliform sample collected from this system was invalidated due to a quality control (QC) failure. (The temperature of the incubator where the samples were kept fell out of range while the samples were being incubated.)
  - This resulted in three extra chlorine samples being collected

Table 12

Month (2004)	10-173 Chlorine Residual (mg/L) Average	Maximum	Minimum	Number of Samples Collected
January	0.62	0.64	0.59	3
February	0.79	0.85	0.74	3
March	0.81	0.85	0.75	3
April	0.90	0.93	0.86	3
May	0.83	0.94	0.71	3
June	0.89	0.97	0.79	3
July	0.93	1.07	0.81	6
August	1.01	1.03	0.98	3
September	0.76	0.90	0.56	3
October	0.80	0.82	0.76	3
November	0.79	0.88	0.73	3
December	0.67	0.70	0.63	3

from this system in July.

THUNDERHEAD (10-179)

- Nine out of the 12 samples collected from this system had chlorine residuals that were within the target range of 0.60 to 1.00 mg/L.
- Only two samples showed chlorine residuals that were above the upper standard of 1.00 mg/L.
  - April – 1.03 mg/L
  - May – 1.01 mg/L
- Only one sample had a chlorine residual that was below the minimum standard of 0.40 mg/L
  - December – 0.23 mg/L

SIERRITA FOOTHILLS (10-270)

- Four out of the 12 samples collected from this system had chlorine residuals that were within the target range of 0.60 to 1.00 mg/L.
- Only one sample collected from this system had a chlorine residual between 0.40 and 0.60 mg/L.
- Two of the samples collected from this system had chlorine residuals that were above the upper standard of 1.00 mg/L.
  - February – 1.32 mg/L
  - September – 1.39 mg/L
- Five samples collected from this system had chlorine residuals that were below the minimum standard of 0.40 mg/L.
  - January – 0.25 mg/L
  - April –0.08 mg/L
  - May – 0.35 mg/L
  - June – <0.05 mg/L
  - October – 0.25 mg/L

POLICE-FIRE ACADEMY (10-313)

- Nine out of the 12 samples collected from this system had chlorine residuals that were within the target range of 0.60 to 1.00 mg/L.
- Only two samples collected from this system had chlorine residuals that were between 0.40 and 0.60 mg/L.
- None of the samples collected from this system had chlorine residuals that exceeded the upper limit of 1.00 mg/L.
- Only one sample had a chlorine residual that was below the minimum standard of 0.40 mg/L.
  - April - 0.33 mg/L

SUNSET RANCH (10-325)

- Only two out of the 12 samples collected from this system had chlorine residuals that were within the target range of 0.60 to 1.00 mg/L.
- Six samples collected from this system had chlorine residuals that were between 0.40 and 0.60 mg/L.
- None of the samples collected from this system had chlorine residuals that exceeded the upper limit of 1.00 mg/L.
- Four samples had chlorine residuals that were below the minimum standard of 0.40 mg/L. These occurred in:
  - February – 0.33 mg/L
  - June – 0.11 mg/L
  - July – 0.31 mg/L
  - September – 0.32 mg/L

DISCRETIONARY MONITORING

ADDITIONAL MEASUREMENTS AND EXTENDED PARAMETERS

In addition to monitoring for compliance purposes, Tucson Water also performs discretionary monitoring throughout the year that is not mandated by laws or regulations and is not reported to the state. This information is collected every three months in order to provide the public with water quality information on unregulated parameters such as water hardness and mineral content. In addition to this, important system information is collected in the field to monitor the temperature, pH, electrical conductivity, and turbidity at each of the dedicated stations.

Table 13 to your right shows the individual analytes that are monitored as part of this discretionary monitoring program. These "Quarterly Extended Parameters" are analytes that are monitored on a quarterly basis at each of the 262 dedicated sampling stations. This information is available in a separate report entitled, "2004 Major Water Quality Parameter Results for the Dedicated Sample Points."

Table 13

QUARTERLY EXTENDED PARAMETERS		
ALKALINITY	HARDNESS	POTASSIUM
CALCIUM	IRON	SODIUM
CHLORIDE	MANGANESE	SILICON
COPPER	NITRATE	SULFATE
FLUORIDE	NITRITE	ZINC
TOTAL ORGANIC CARBON (TOC)		
TOTAL DISSOLVED SOLIDS (TDS)		

Temperature

Several factors contribute to the variability in water temperature that is seen in the distribution system. This variability in the temperature can be attributed to several different factors such as the location of the sample point within the Tucson area, the time of year, the groundwater's depth below the surface, and the geology of the aquifer surrounding the wells.

The 2004 average monthly temperature of the water in the distribution system is illustrated in **Figure 5**. From this chart, you can see that:

- The highest temperature seen in the system, 88.2 °F (Fahrenheit), was found during July when outside temperatures regularly exceed 100 °F.
- The lowest temperature, 70.5 °F, occurred in February, one of the coldest months of the year.

The average temperature of the water in each Water Quality Zone from 2001 to 2004 is shown in **Figure 6**. From this chart, you can see that the average water temperature within each zone does not change much from year to year.

pH

The pH of water is a measure of the water's hydrogen ion activity. A pH of 7 Standard Units (SU) is considered neutral. Lower pH values represent water that is more acidic; whereas, higher pH values represent water that is more basic or alkaline. Water in the Tucson basin is slightly alkaline and averages between 7.5 and 8.0 SU throughout all TW systems. This is primarily due to the natural presence of carbonates and bicarbonates in our groundwater aquifer, which tend to increase the pH of natural waters.

Although pH is not listed as a regulated parameter under the National Primary Drinking Water Standards, it is listed under the USEPA National Secondary Drinking Water Regulations and has a secondary standard that has been set at a pH range of 6.5 – 8.5 SU.

The highest annual pH value that was measured in 2004 was 8.33 SU. This occurred in Water Quality Zone 6 at SP-375, which is located at 4633 N. Rockliff Rd. The average pH at this location was 7.98 SU in 2004, and the minimum value detected was 7.60 SU.

Table 14

	Annual Max & Min pH, SU	Sample Point	System Number	System Name
Highest Annual pH	8.33	SP-375	10-112	TW Main System
Lowest Annual pH	6.44	SR-278	10-179	Thunderhead

The lowest annual pH value measured in 2004 was 6.44 SU and occurred in the Thunderhead Isolated System (10-179) at SR-278 which is located at 6260 S. Mesquite Trail. The average and the maximum pH measured at this location in 2004 were 6.83 SU and 7.60 SU respectively.

The highest and lowest pH values measured in 2004 and their locations are shown in **Table 14** above.

A graph of the average pH of each Water Quality Zone within the TW distribution system from 2001 to 2004 is shown in **Figure 7** at the end of this report. From this chart and **Table 15** you can see that the pH of all zones, with the exception of Zones 5 and 6, have been declining over the past four years. **Table 15** shows this decline as well as the 4-year average of each zone.

- The zone with the lowest pH value in 2004 was Zone 8 with a pH of approximately 7.5 SU;
- The highest average pH in 2004 was seen in Zone 2 where the average was approximately 7.9 SU;
- The zone with the lowest consistent pH over the last four-year period is Zone 1. The 4-year pH average for this zone was 7.56.
- The zone with the highest consistent pH from 2001 to 2003 was Zone 2. The 4-year pH average for this zone was 7.92.

Table 15

WQ Zone	2001 Average pH	2004 Average pH	Change in pH from 2001 to 2004	4 yr. Average pH
Zone 1	7.61	7.52	-0.09	7.52
Zone 2	7.99	7.90	-0.09	7.92
Zone 3	7.88	7.73	-0.15	7.78
Zone 4	7.91	7.78	-0.13	7.83
Zone 5	7.73	7.74	+0.01	7.72
Zone 6	7.76	7.81	+0.05	7.77
Zone 7	7.82	7.74	-0.08	7.75
Zone 8	7.78	7.45	-0.33	7.56
Zone 9	7.93	7.65	-0.28	7.76
Zone 10	7.98	7.65	-0.33	7.77

Electrical Conductivity

The electrical conductivity, or EC, of water is a measure of its ability to carry an electric current. An increase in EC corresponds to an increase in the amount of total dissolved solids (TDS) that are present in a sample. Because of this relationship, the amount of total dissolved solids (TDS) present in a sample can be estimated using the measured EC value and a simple calculation[7].

The average EC for each WQ Zone from 2001 to 2004 is shown in **Figure 8.** This chart illustrates the differences between the zones as they relate to EC and TDS. As you can see from the chart, the EC values for each of the WQ Zones have been increasing over the past four years. The following table, **Table 16**, presents data that shows the estimated TDS values for each WQZ as well as the changes in EC and TDS over time.

The zone with the highest EC and TDS in 2004 was Zone 1.

- Average EC = 640 umhos/cm
- Average TDS = 410 mg/L
- Four-year EC average = 626 umhos/cm
- Four-year TDS average = 400 mg/L

The lowest averages for EC and TDS were measured in Zone 10.

- Average EC = 365 umhos/cm
- Average TDS = 234 mg/L
- Four-year EC average = 349 umhos/cm
- Four-year TDS average = 223 mg/L

Table 16

WQ Zone	2001 Average EC	2004 Average EC	Estimated TDS, 2004, mg/L	Change in EC from 2001 to 2004	Estimated Change in TDS from 2001 to 2004, mg/L
Zone 1	622	640	410	+18	+12
Zone 2	423	488	312	+65	+42
Zone 3	480	499	319	+19	+12
Zone 4	369	415	266	+46	+29
Zone 5	377	445	285	+68	+44
Zone 6	367	447	286	+80	+51
Zone 7	341	383	245	+42	+27
Zone 8	486	568	363	+82	+53
Zone 9	447	473	303	+26	+17
Zone 10	343	365	234	+22	+14

[7] EC x 0.64 = estimated TDS mg/L

Figure 9 is a map of the Tucson area illustrating the locations for all dedicated taps within the Tucson Water distribution system. The green circles (●) represent dedicated sampling stations within the main system, and the green triangles (▲) represent dedicated sampling stations within the ten isolated systems. The red circles (●) and red triangles (▲) represent locations where total coliform samples tested positive during 2004. The purple circles (●) and purple triangles (△) on this map represent locations where samples had a chlorine residual at or below 0.05 mg/L.

Additional information concerning the above parameters is available from:

1. The Tucson Water automated phone line at 791-4227
2. The Tucson Water website: http://www.ci.tucson.az.us/water/
2. The Tucson Water, Customer Liaison, Dave Schodroski, at 791–5945.

For information on this report please contact Tom Jefferson or Mohsen Belyani at the Water Quality Management Division: 791-5252.

FIGURE 1

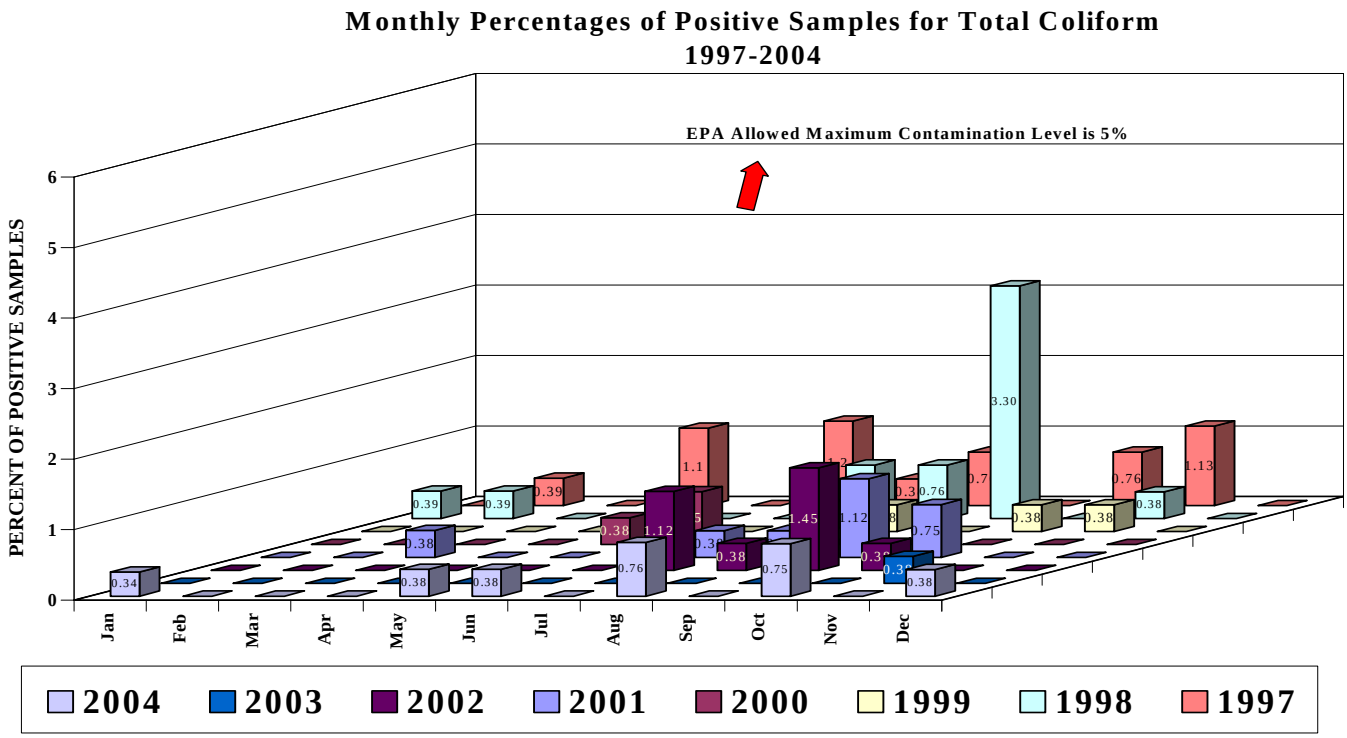


FIGURE 2

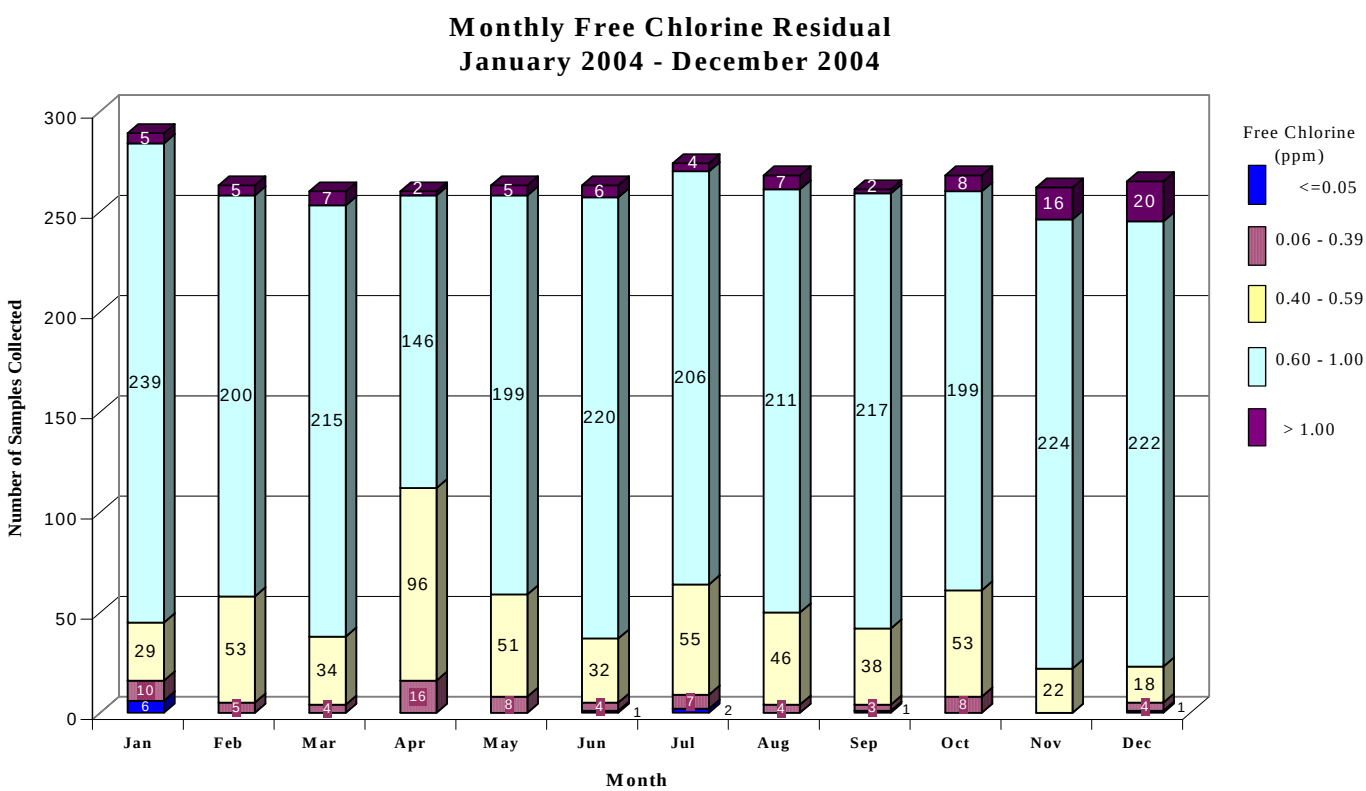


FIGURE 3

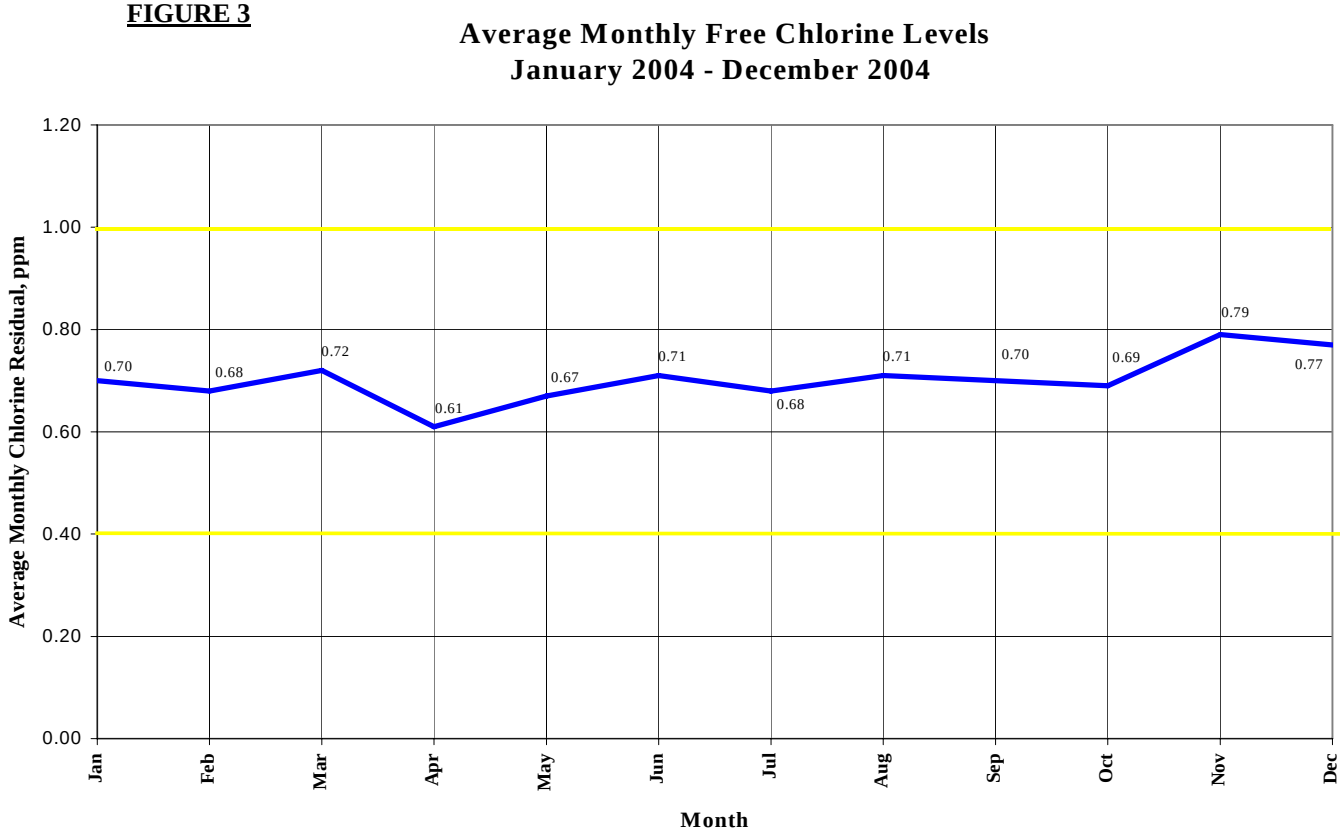


FIGURE 4

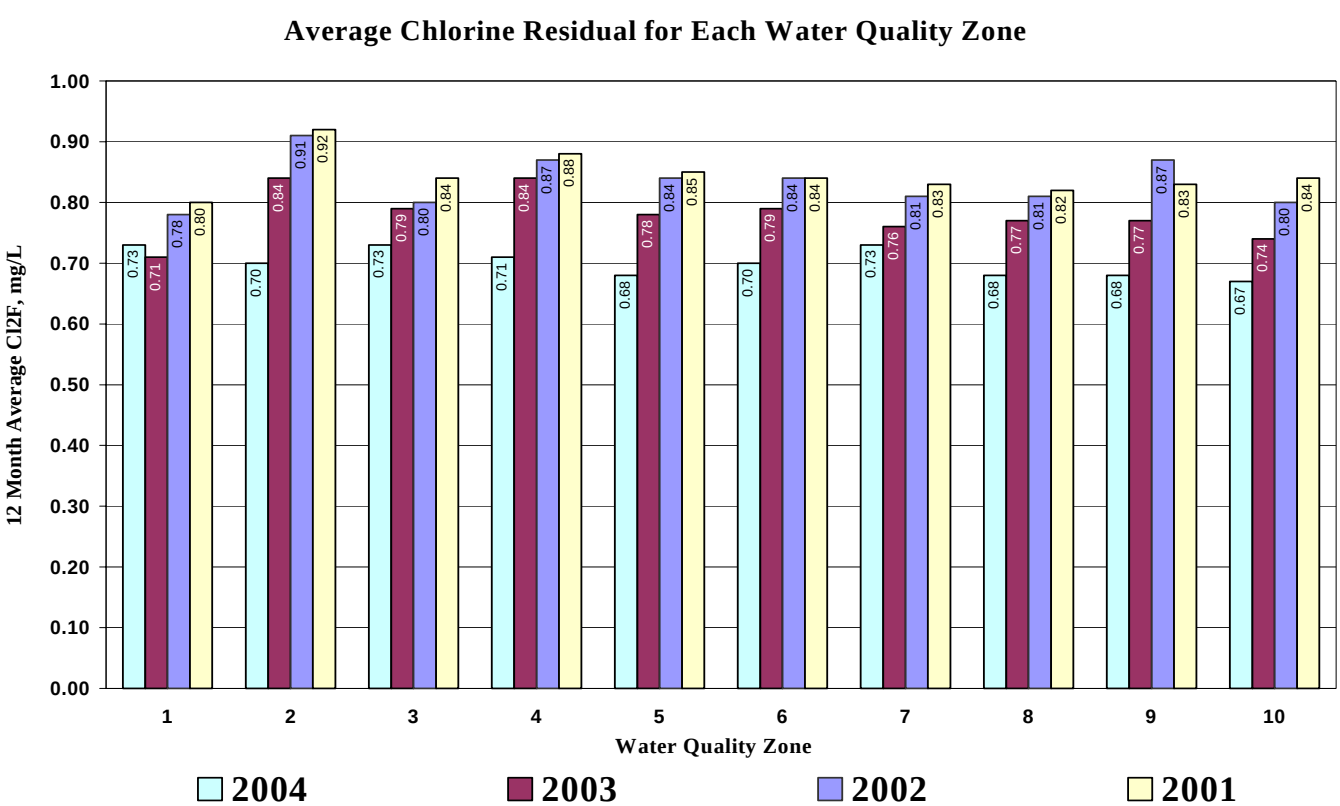


FIGURE 5

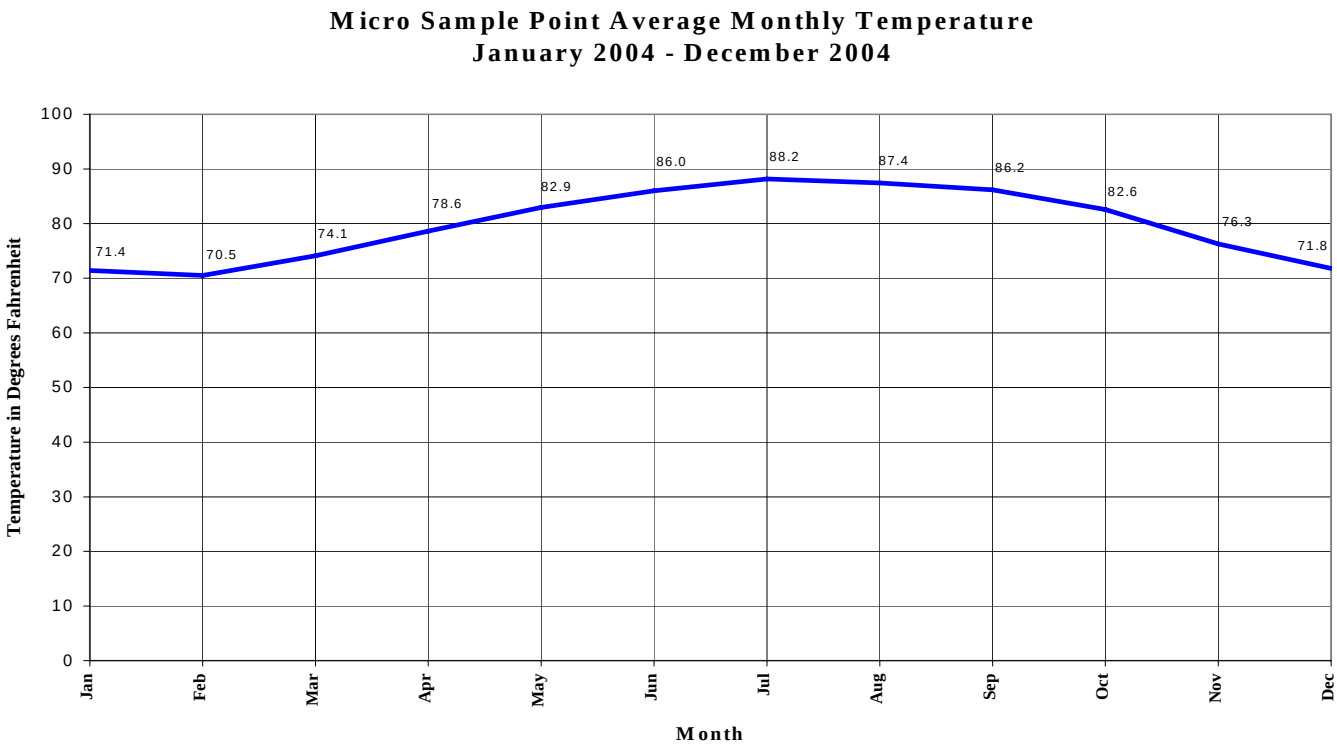


FIGURE 6

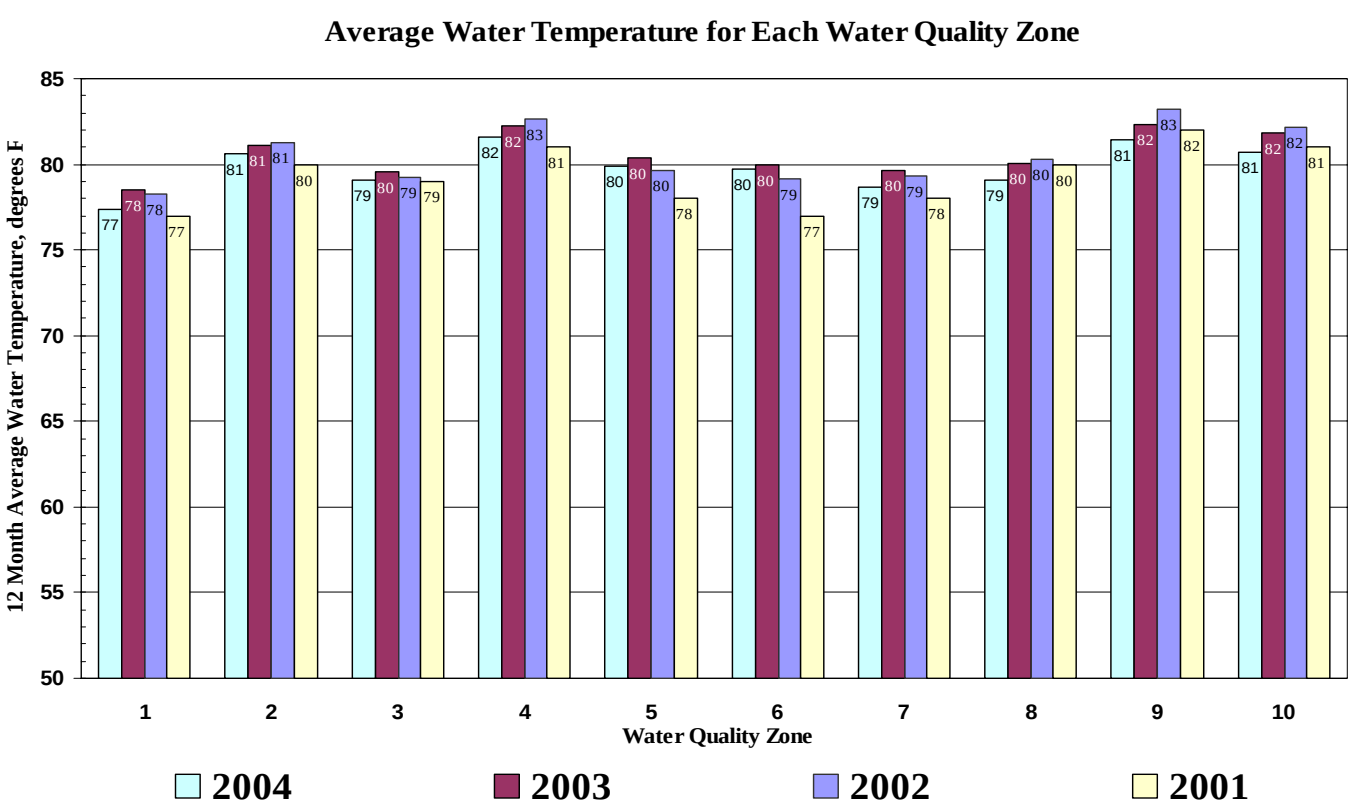


FIGURE 7

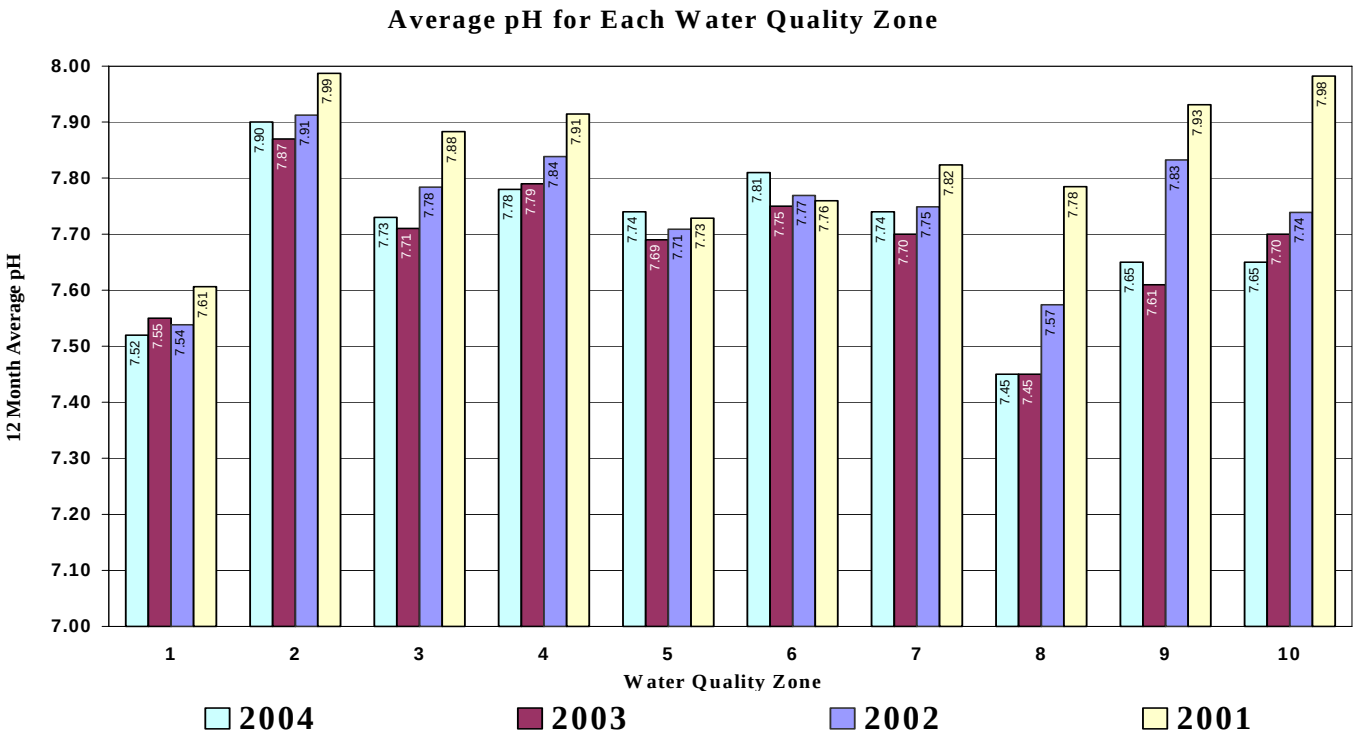


FIGURE 8

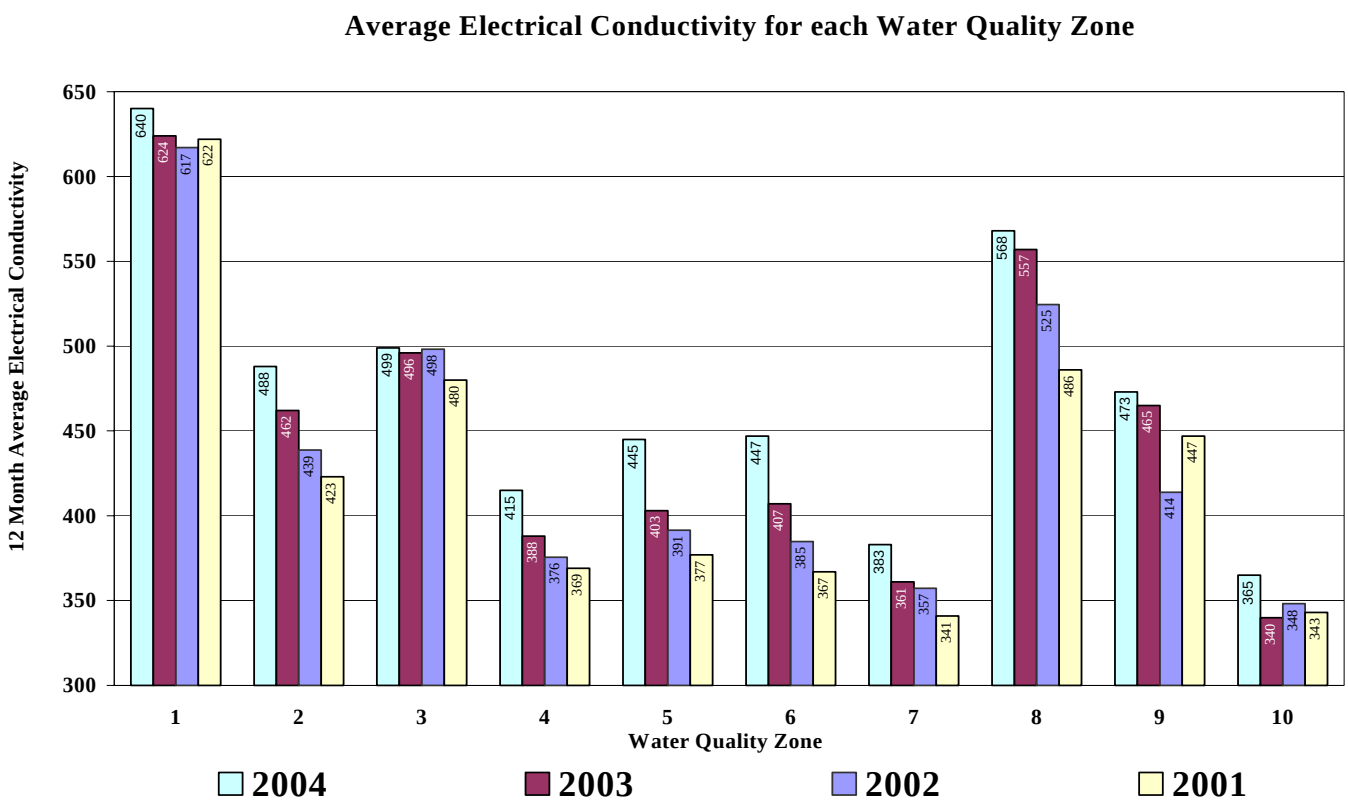
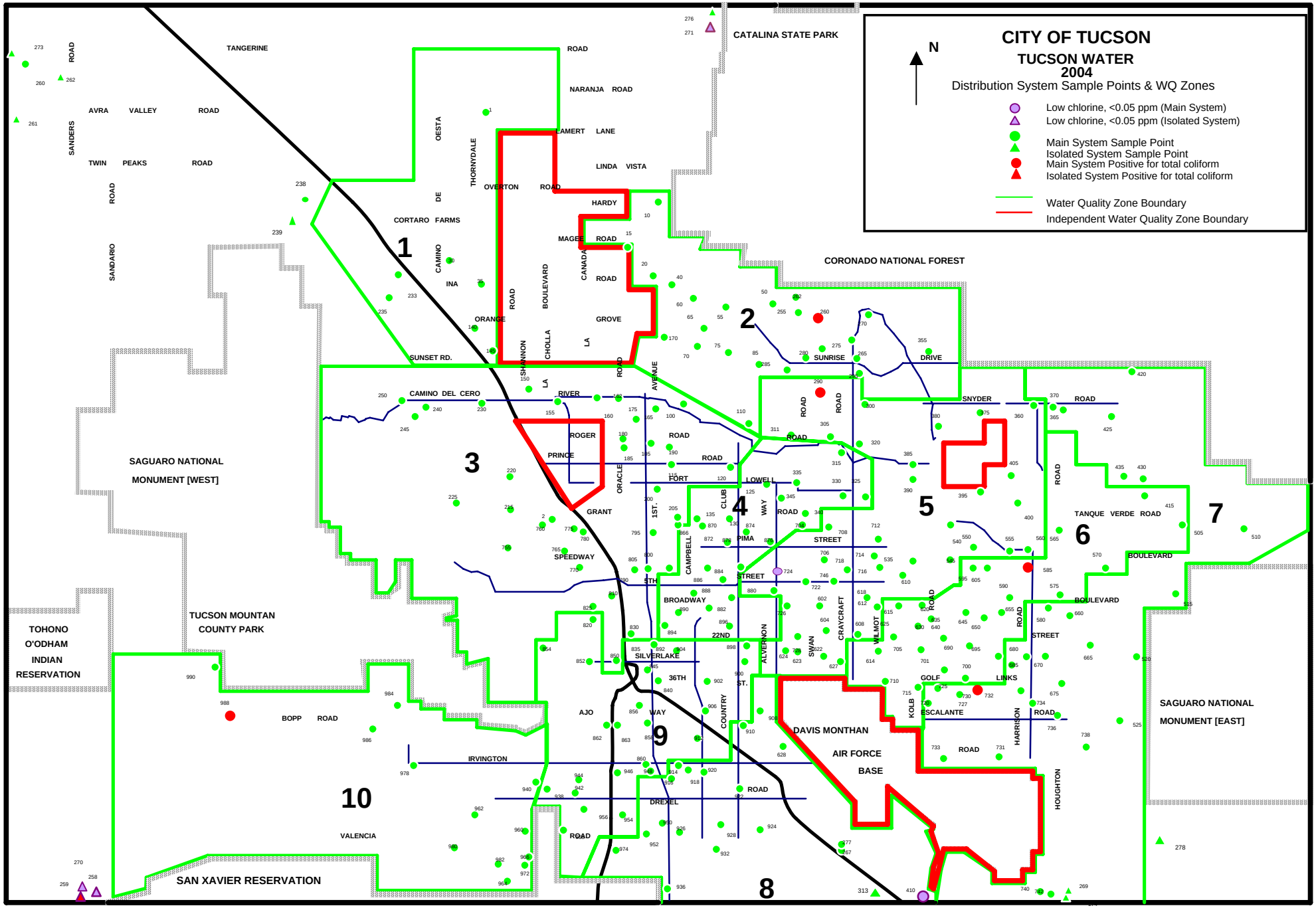


Figure 9


CITY OF TUCSON
TUCSON WATER
2004
Distribution System Sample Points & WQ Zones
N
Low chlorine, <0.05 ppm (Main System)
Low chlorine, <0.05 ppm (Isolated System)
Main System Sample Point
Isolated System Sample Point
Main System Positive for total coliform
Isolated System Positive for total coliform
Water Quality Zone Boundary
Independent Water Quality Zone Boundary
CATALINA STATE PARK
CORONADO NATIONAL FOREST
SAGUARO NATIONAL MONUMENT [WEST]
SAGUARO NATIONAL MONUMENT [EAST]
TUCSON MOUNTAN COUNTY PARK
TOHONO O'ODHAM INDIAN RESERVATION
SAN XAVIER RESERVATION
DAVIS MONTHAN AIR FORCE BASE
1
2
3
4
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