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Project Comparison

Comparison of Monitoring Station and Residential Data

Project 1

Water Utility: North Shore Water Commission

Project Title: Navigating Major Water System Chemical Treatment Changes

Description: The North Shore Water Commission (NSWC) planned to switch the disinfectant used in the water distribution systems from free chlorine to chloramine. Experience from Washington, D.C.'s water system showed that such a switch could increase the lead concentration in the water. NSWC wanted to avoid or, at least, be alerted to such problems by using PRS Monitoring Stations. With these stations, lead concentrations as well as other water quality parameters can be tracked routinely; action can be taken and operational decisions made based on quantitative information in a timely manner.

Based on Washington's experience, the addition of a corrosion control chemical was helpful in creating a new protective barrier on the pipe walls after the production of the original protective layer of lead dioxide was prevented by using chloramine. To this end, NSWC wanted to re-evaluate their current corrosion control chemical against others and determine which chemical would perform best at such a critical time. The chemical comparison test is described in a separate report. Based on the test results, NSWC switched from a 50/50 polyphosphate/orthophosphate blend to 100% orthophosphate for corrosion control.

Goals: The goal of monitoring was to track and respond to changes in key water quality parameters in the distribution system, especially the release of lead into the water with a secondary focus on the biostability of the water.

Date Range: The monitoring was divided into three time periods –

Stage 1 (S1): Existing system – free chlorine and 50/50 polyphosphate/orthophosphate blend corrosion control chemical (April 2008 to September 2008)

Stage 2 (S2): Change of corrosion control chemical – continue with free chlorine and change to corrosion control chemical selected from chemical comparison tests (September 2008 to November 2008)

Stage 3 (S3): Change of disinfectant to chloramine – change to chloramine disinfection and continue with the new corrosion control chemical (November 2008 to April 2009)

Sampling Sites: Two PRS Monitoring Stations were installed. Monitoring Station #1 was installed at the entry point to the water distribution systems. Monitoring Station #2 was initially used to run corrosion control chemical comparison tests, but was then moved to an area of high water age in one of the distribution systems to perform routine monitoring in parallel to the station at the entry point. The stations include the following modules:

Monitoring Station	Sampling Point and Module ID	Metal Plates	Installation History
Entry Point	Inf 1or Entry		
	1-Cu-1	copper	April 2008 (new)
	1-Pb-1	lead	April 2008 (new)
	1-Pb-2	lead	April 2008 (new) September 2008 (new)
High Water Age Area	Inf 2 or HWA		
	2-Cu-1	copper	September 2008 (new) Module opened on 3/7/09 to check integrity of pipe insertion rack; all ok.
	2-Pb-1	lead	September 2008 (new)
	2-Pb-2	lead	This was formerly Pb 1-2 installed 4/08 and exposed to chlorine and 50/50 product; moved to new location in September 2008
	2-Pb-3	lead	This was formerly Pb 2-2 installed 4/08 and exposed to chloramine and 100% ortho; moved to new location in September 2008

Project 2

Water Utility: North Shore Water Commission

Project Title: Repeated Sampling at Residential Sites

Description: As a check against the PRS Monitoring Station data, four residences with historically high lead concentrations in the water were sampled every three or four months as the water system went through major chemical changes. Homes were sampled in a similar manner as for Lead and Copper Rule compliance sampling using a six hour water stagnation period. In contrast to the regulatory sampling, a water utility representative visited the site, allowed water from the water mains to fill the premise piping, took flowing water samples for background water quality, and then initiated the stagnation period. He returned six hours later for stagnation samples that were analyzed for a number of parameters representing possible chemical and microbiological reactions.

Goals: The goal of this study was to track water quality effects in residences as the water system went through major chemical changes. The data were also used to compare to PRS Monitoring Station data, determining if the monitoring station data were representative of water system responses.

Date Range: The residences have been sampled five times since the beginning of the monitoring efforts in April 2008.

- April 2008: Original water chemistry
- July 2008: Original water chemistry
- October 2008: After corrosion control chemical change
- December 2008: After disinfection change
- April 2009: After disinfection change

Sampling Sites: Four residences in the water distribution system were chosen based on the fact that they have historically had high lead concentrations as determined during Lead and Copper Rule sampling.

Water System Description

Project 1

Water Utility: North Shore Water Commission

Water Source: Lake Michigan

Water Treatment: Water treatment includes:

- Addition of potassium permanganate to control zebra mussels
- Addition of alum for coagulation
- Addition of activated carbon for adsorption of compounds causing taste and odor
- Sedimentation
- Rapid sand filtration using carbon, sand, and gravel
- Addition of chlorine for disinfection
- UV disinfection
- Addition of 50/50 polyphosphate/orthophosphate blend for corrosion control
- Fluoridation

Water System Configuration: North Shore Water Commission treats water for three water systems serving three suburban Milwaukee entities – Whitefish Bay, Glendale, and Fox Point. The population served is around 34,000.

Project 2

Water Utility: North Shore Water Commission – This project was performed in the same water system as Project 1.

Summary of Comparisons

Review the separate reports for each project for more detailed information. This report will only comment on the average and range graphs to quickly compare monitoring results between the PRS Monitoring Station data and data from four residential sites.

Influent Water Quality

Iron. Dissolved iron was found to be insignificant at all sampling times, system chemistries, and sampling sites.

Particulate iron increased at specific times that did not coincide with system chemistry changes. Instead, the appearance of particulate iron suggested some kind of singular disturbances in the water system. The following events were observed:

- In the original water system, particulate iron was insignificant at the entry point monitoring station. The residences out in the distribution system showed higher particulate iron than the entry. There was no high water age monitoring station to compare to at that time.

- About five months after the two chemical changes in the water system (March/April 2009), high particulate iron was seen at the entry point monitoring station suggesting that some kind of disturbance occurred at the water treatment plant. The high water age monitoring station experienced higher particulate iron at that time as did the residences.

Manganese. Total and dissolved manganese were measured at the entry point monitoring station in the original water system and deemed insignificant. There was no high water age monitoring station at that time. Residences showed a slightly higher concentration.

When the high water age monitoring station was installed, it was decided not to analyze water for manganese. However, it appears that the manganese levels (mostly in soluble form) have increased over time at the residences. Because of this, sampling for manganese at the high water age monitoring station will be reinstated.

Turbidity. Turbidity was measured during the last months of the projects. The results mirror the particulate iron results discussed previously. Again, the high water age monitoring station experiences similar influent water quality as the residences.

pH. Except for the initial residential sampling which occurred just before the monitoring stations were operational, the pH at the entry point is similar to that at the residences and the high water age monitoring station.

Operating Parameters

Disinfection. The disinfection concentration in terms of total and free chlorine and monochloramine is lower at the high water age monitoring station and the residences than

at the entry point. The high water age monitoring station data are similar to that found at the residences.

Phosphorus. The phosphorus concentration in terms of total phosphorus and orthophosphate is lower at the high water age monitoring station and the residences than at the entry point. The high water age monitoring station data are similar to that found at the residences.

Reactions

Presence of Microorganisms. The HPC data representing the presence of microorganisms is greatly variable. It was intended that the monitoring stations would magnify the microbiological growth because the water stagnates for twenty-three out of twenty-four hours a day. (Water samples are taken after six hours stagnation at the monitoring station just like the residences.) The monitoring station HPC data is typically higher than the residential data.

However, the monitoring station configuration was modified for the North Shore Water Commission installation from the original design of the Waukesha Water Utility installation. It is thought that the modification has caused the drawing in of microorganisms from the air that contaminated/inoculated the metal plates and modules. The existing monitoring stations and future monitoring stations will be reconfigured to the Waukesha design or will be outfitted with 0.1 micron air filters.

It is also thought that the modules' sample taps need more flow of chlorinated water to prevent the growth of microorganisms in the sample taps. Future operation of the monitoring stations will include periodic flushing of sample taps.

Finally, there is concern that the startup procedure of shock chlorinating the monitoring station and then re-opening the modules to install the alcohol-disinfected metal plates caused a breech in the sterility of the initial system. For future startup procedures, brief final shock chlorination will be performed after the installation of the plates.

Nitrification. No signs of nitrification, based on the concentration of nitrogen compounds, nitrite and nitrate, were found in the entry point monitoring station, the high water age monitoring station, or the residences.

Lead. The lead concentrations (and in copper modules, the copper concentrations) are expected to be exaggerated in the monitoring stations from that of the residences. This is because there is more exposed metal surface area to a given volume of water in the monitoring station than in a building's plumbing system, typically. Also, like HPC data, what are important are data trends. The lead, copper, or HPC concentrations are expected to rise and fall in the same way as data from residences, given a systemic cause of an increase or decrease.

For example, if a chemical is added to the water to suppress the release of lead into the water, that trend should be seen in both the monitoring station and the residences. The advantage of the monitoring station is that the trend is measured in a uniformly configured apparatus, making the data more dependable as representing the effect of the chemical and not the effect of a localized factor.

Also, a trend of dissolved versus particulate lead is expected to be similar between the high water age monitoring station and the residences. Based on previous monitoring data

observations, the production of particulate lead can come from some inherent chemistry of the water or from contributions of iron and manganese particulates (or any particles that can adsorb lead and other metals) from the distribution system.

The comparison between lead data from the monitoring station versus residential data at North Shore Water Commission shows that lead concentrations can be greatly variable at all sampling sites and that the variability is caused by the presence of particulate lead. In this way, the monitoring station data reflects the same residential trend in the North Shore system.

In addition, the main goal of using the monitoring station in North Shore Water Commission was to track changes in lead concentration should the two major chemical changes influence such a change. Neither the monitoring station data nor the residential data showed any change throughout and after the chemical transitions. Therefore, the monitoring station data correctly represented the fact that the system made the transitions without a deterioration of water quality in terms of lead.

It is interesting to note that the one major increase in lead at a residence occurred in October 2008 because of the remodeling of a kitchen. This is just an example of how an individual residential site cannot properly provide the controls to testing conditions that a standard monitoring station can. Such residential data that can skew lead concentrations because of site conditions are not representative of the ability of the system to release lead into water. That data merely represents a site-specific physical disturbance to the premise piping system.

Copper. The description of copper data from a monitoring station versus residential data follows the same discussion as that of lead data.

The North Shore Water Commission copper data show that the high water age monitoring station and the residences follow the same trends in that copper is higher in the distribution system than at the entry point monitoring station. Even though the copper concentration is higher, it is still greatly below the regulatory Action Level. Nevertheless, one should be on-guard as to the reasons that copper is higher at some locations as this can lead to preventing a larger water quality issue from occurring.

The copper seen in the distribution system (both at the residences and at the high water age monitoring station) includes a percentage of particulate copper, whereas the entry point copper concentration is low and in soluble form.

The high water age monitoring station copper levels stay higher than the entry point copper levels. This contrast in concentration between the entry point and the area of high water age needs to be watched closely and defined. It may be because of the metal plates were newer; it may be because increased microbiological activity from operational contamination; it may be from an actual water quality issue.

Conclusions

The influent water quality and operating parameters to the high water age monitoring station and to the residences are similar.

The response to the water quality and operating parameters are exaggerated in the monitoring station data, but follow the same trends as the residences in terms of concentration changes and in the dissolved/particulate nature of metals.

The data from both types of sites show that lead levels did not increase or decrease because of the corrosion control and disinfection chemical changes and that spikes of lead particulates are possible in the system.

The data from both types of sampling sites show that copper concentration is possibly higher in the distribution system than at the entry point. There is a portion of the total copper concentration at the distribution system sites that is in particulate form in contrast to mostly soluble copper at the entry point. While the copper concentrations are considered relatively low and raise no alarms of pushing the water system out of compliance with the Lead and Copper Rule, this is an early warning sign that must be tracked and the trend reversed.

Looking back to past Lead and Copper Rule sampling results, it is seen that the monitoring station data and the special residential sampling data shed light on mechanisms at work, at least for recent Lead and Copper Rule sampling. Figure 1 shows that North Shore Water Commission's 90th percentile lead concentration has hovered close to the Action Level with high maximum concentrations at some sites. Most likely, this phenomenon is due to the presence of particulate lead stored in the piping and is not a direct result of uniform corrosion. This phenomenon has been observed in other Process Research Solutions water quality investigations and has been remedied by uni-directional flushing of water mains and flushing of some water service lines in hydraulically critical areas.

Also, as depicted by the monitoring station data and from the special residential sampling data, the copper levels are considered low and not of a regulatory concern. Nevertheless, the Lead and Copper Rule data in Figure 2 show that some sites have insignificant levels of copper while others have about 200 µg/L. When the continuing monitoring studies can better define why this is occurring, the trend can be reversed.

Figure 1. North Shore Water Commission: Lead Trends in Lead and Copper Rule Sampling Data

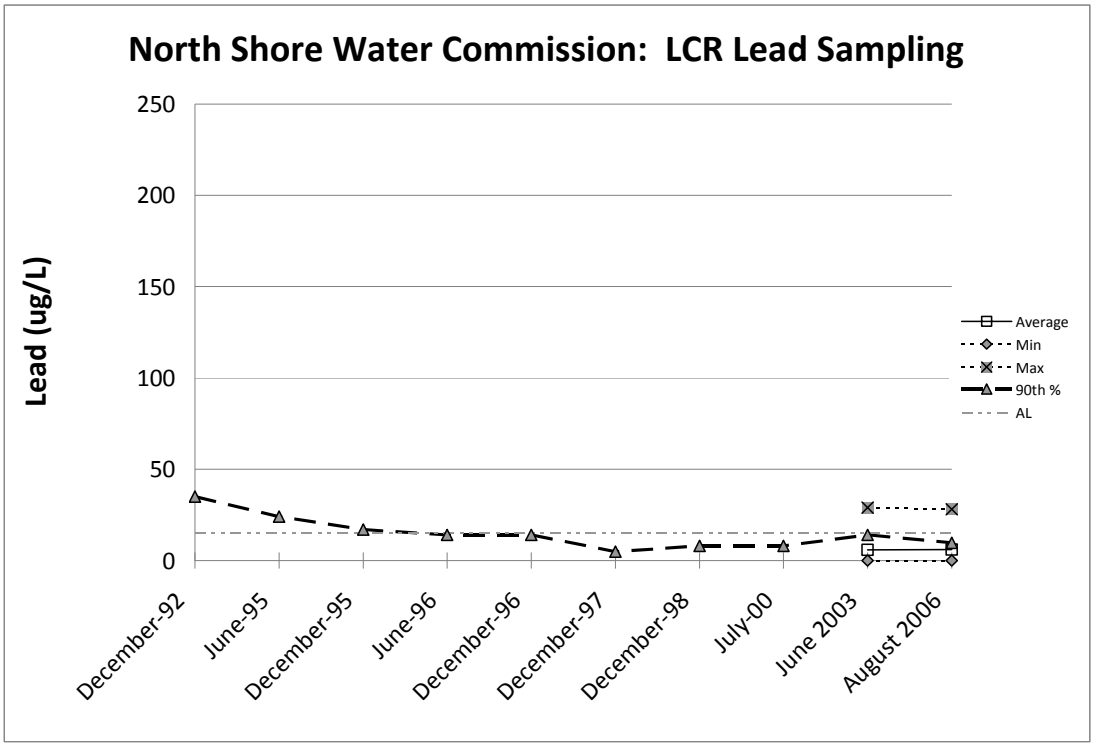
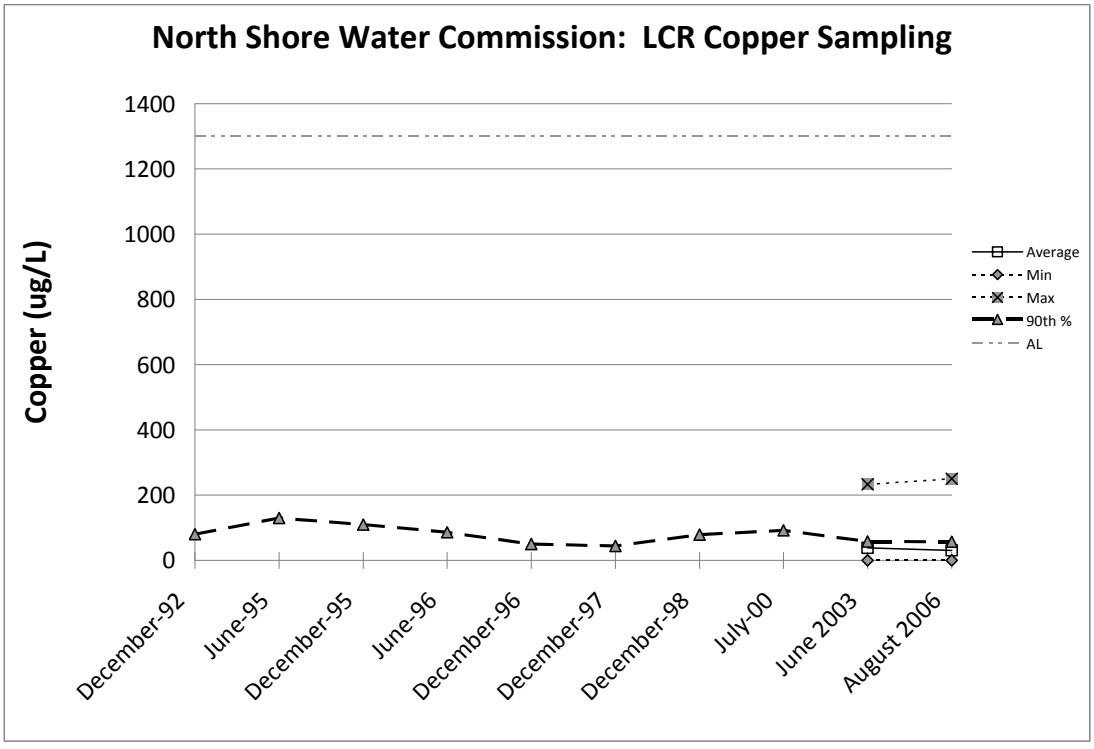


Figure 2. North Shore Water Commission: Copper Trends in Lead and Copper Rule Sampling Data



Recommendations

The monitoring and comparisons will continue as this technique is now an operational tool of North Shore Water Commission.

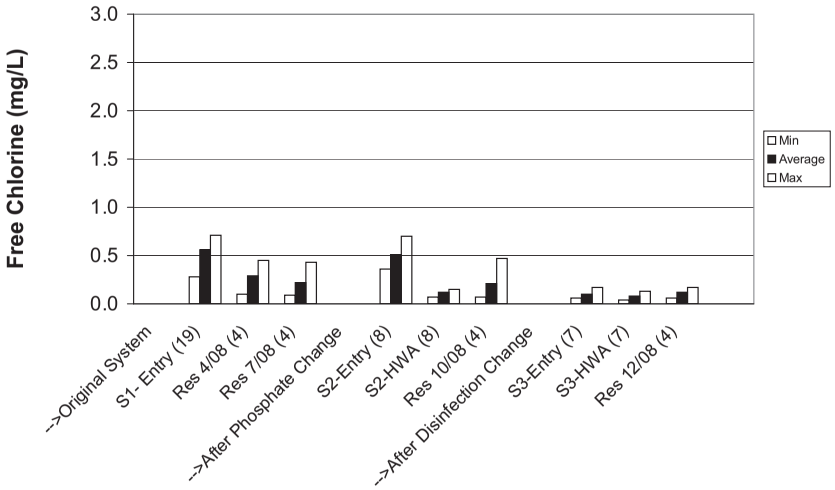
The questions and concerns about microbiological contamination of the monitoring station will be addressed and a fresh start given to the monitoring efforts. A closer look will be given to the biostability of the water and the effect of microbiological presence on metals concentrations, especially on copper levels.

Also to address the representation of biostability in the monitoring station, refer to similar project summary and comparison reports of the Waukesha Water Utility.

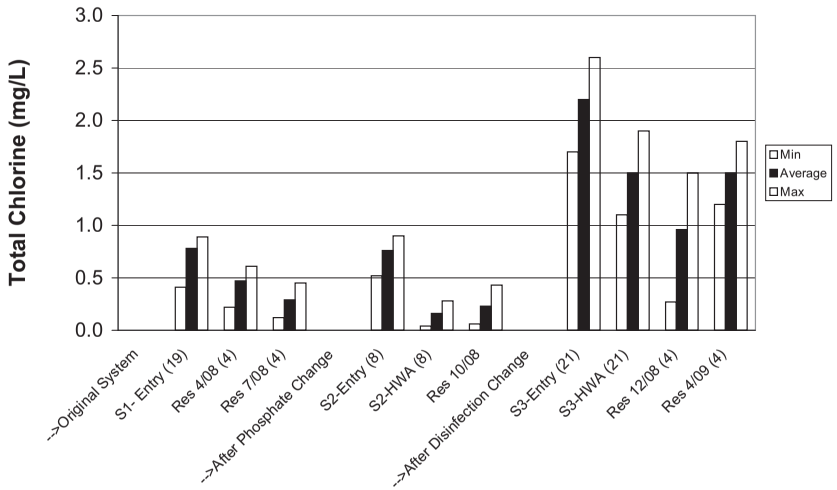
Future efforts of North Shore Water Commission will focus on cleaning debris and particulates from the water system by efficient flushing and on better defining and improving the biostability of the water system by flushing and setting appropriate disinfection levels as well as cutting back on nutrients, such as phosphorus added to the system. These efforts will be guided by the monitoring station data.

Appendix A: Average and Range Graphs

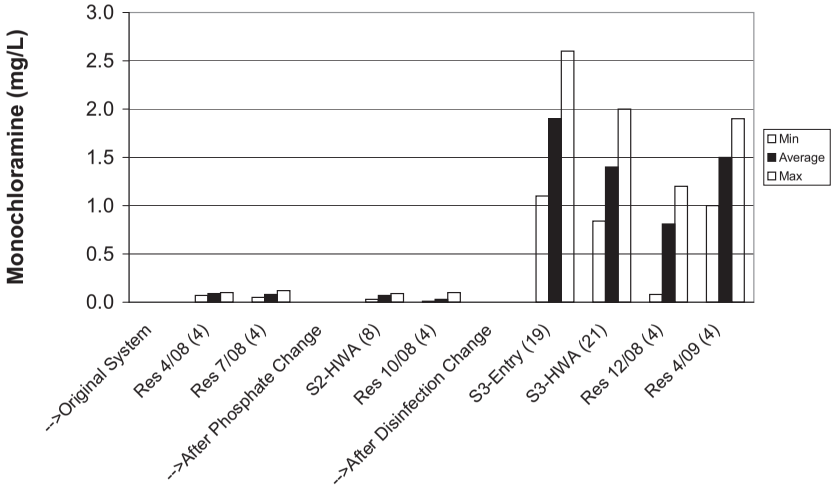
North Shore Water Commission: Comparison of Disinfection

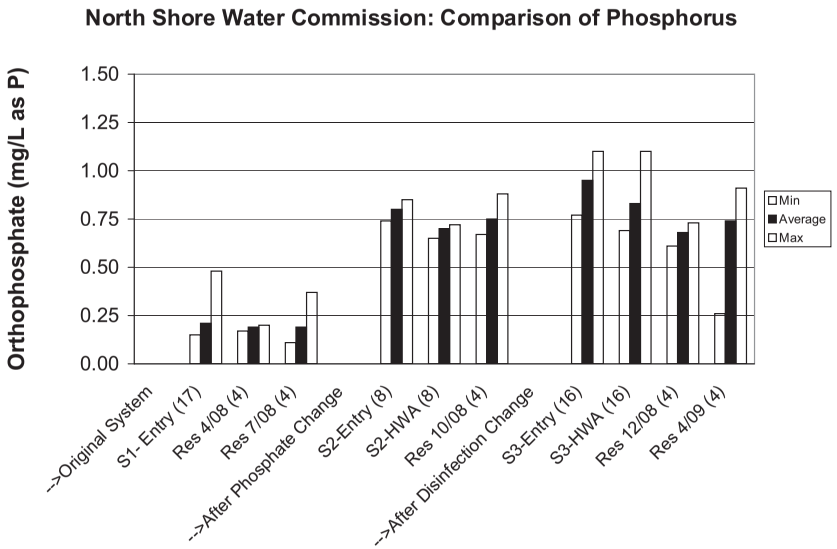


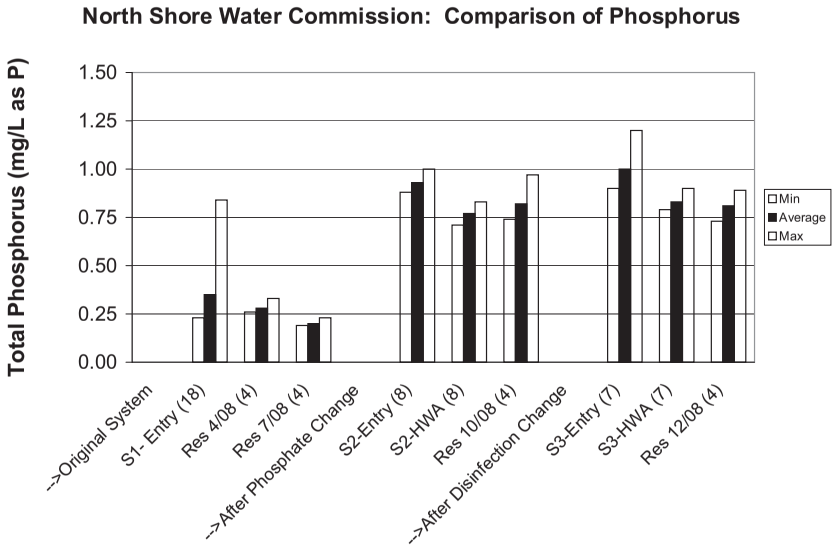
North Shore Water Commission: Comparison of Disinfection



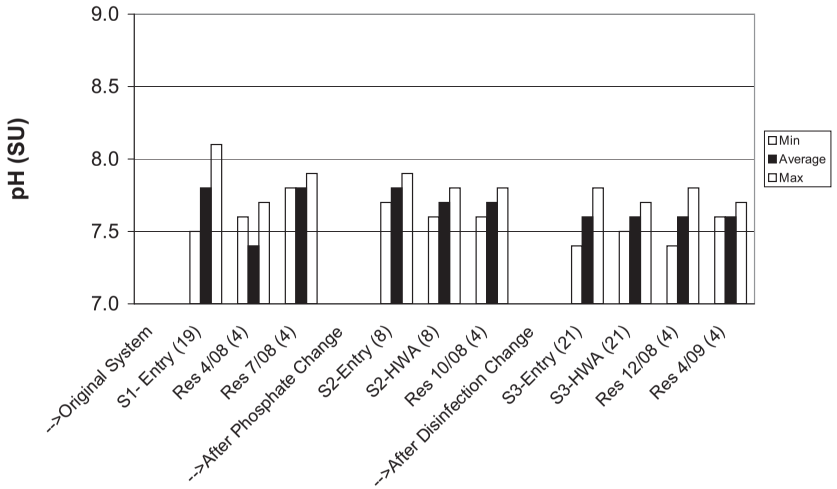
North Shore Water Commission: Comparison of Disinfection



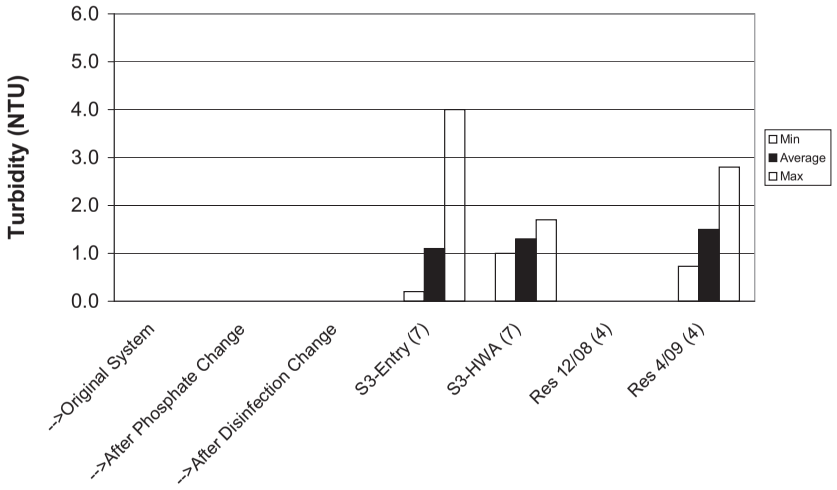

North Shore Water Commission: Comparison of Phosphorus
Orthophosphate (mg/L as P)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Min
Average
Max
-->Original System
S1- Entry (17)
Res 4/08 (4)
Res 7/08 (4)
-->After Phosphate Change
S2-Entry (8)
S2-HWA (8)
Res 10/08 (4)
-->After Disinfection Change
S3-Entry (16)
S3-HWA (16)
Res 12/08 (4)
Res 4/09 (4)

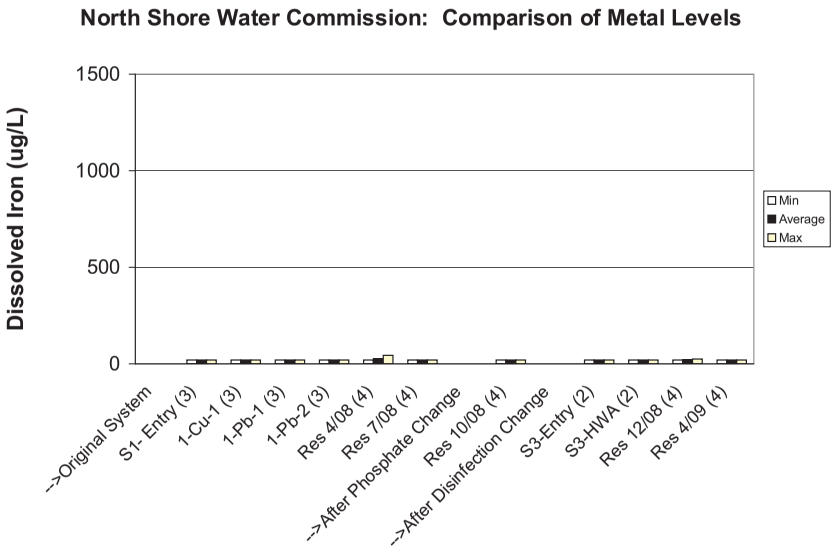

North Shore Water Commission: Comparison of Phosphorus
Total Phosphorus (mg/L as P)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Min
Average
Max
-->Original System
S1- Entry (18)
Res 4/08 (4)
Res 7/08 (4)
-->After Phosphate Change
S2-Entry (8)
S2-HWA (8)
Res 10/08 (4)
-->After Disinfection Change
S3-Entry (7)
S3-HWA (7)
Res 12/08 (4)

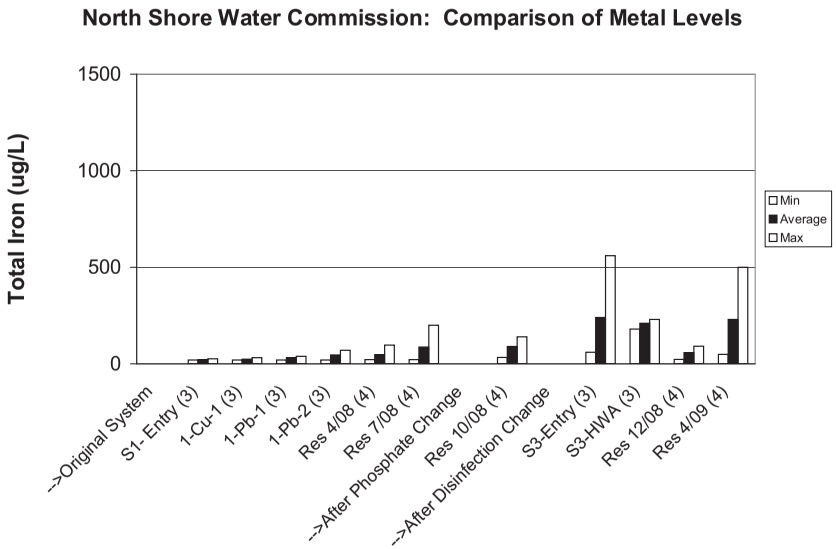
North Shore Water Commission: Comparison of pH

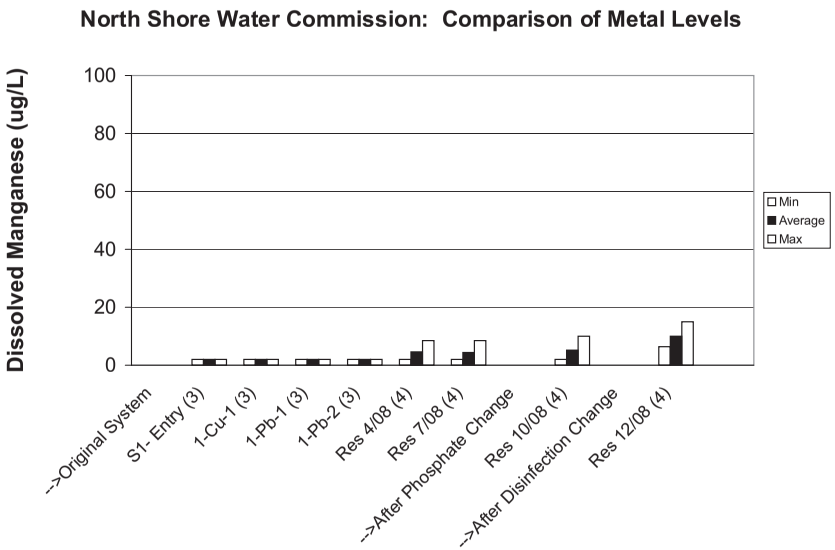


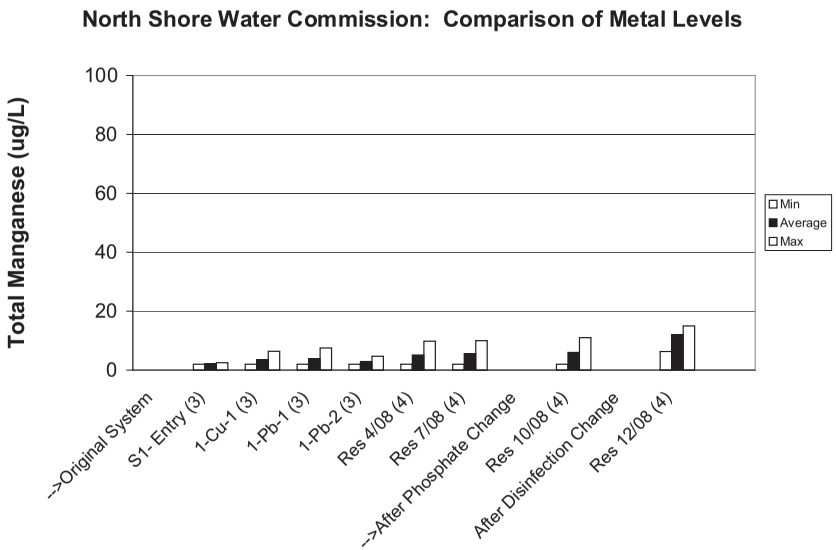
North Shore Water Commission: Comparison of Turbidity



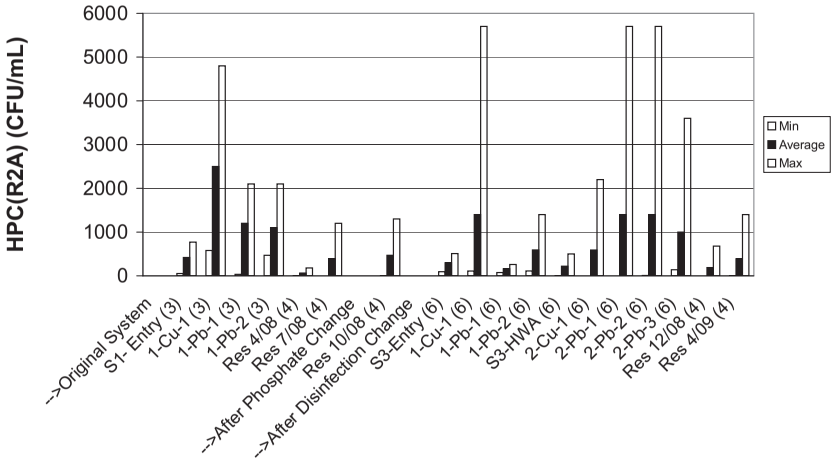

North Shore Water Commission: Comparison of Metal Levels
Dissolved Iron (ug/L)
1500
1000
500
0
Min
Average
Max
-->Original System
S1- Entry (3)
1-Cu-1 (3)
1-Pb-1 (3)
1-Pb-2 (3)
Res 4/08 (4)
Res 7/08 (4)
-->After Phosphate Change
Res 10/08 (4)
-->After Disinfection Change
S3-Entry (2)
S3-HWA (2)
Res 12/08 (4)
Res 4/09 (4)


North Shore Water Commission: Comparison of Metal Levels
Total Iron (ug/L)
1500
1000
500
0
Min
Average
Max
-->Original System
S1- Entry (3)
1-Cu-1 (3)
1-Pb-1 (3)
1-Pb-2 (3)
Res 4/08 (4)
Res 7/08 (4)
-->After Phosphate Change
Res 10/08 (4)
-->After Disinfection Change
S3-Entry (3)
S3-HWA (3)
Res 12/08 (4)
Res 4/09 (4)

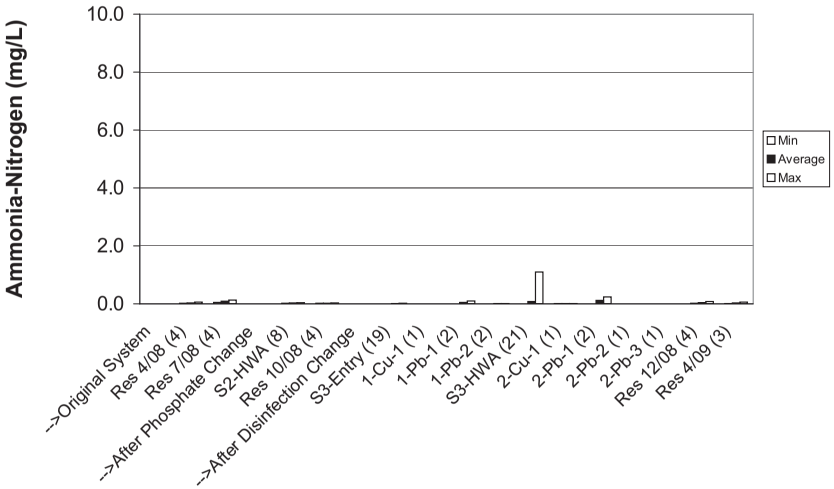

North Shore Water Commission: Comparison of Metal Levels
Dissolved Manganese (ug/L)
100
80
60
40
20
0
Min
Average
Max
-->Original System
S1- Entry (3)
1-Cu-1 (3)
1-Pb-1 (3)
1-Pb-2 (3)
Res 4/08 (4)
Res 7/08 (4)
-->After Phosphate Change
Res 10/08 (4)
-->After Disinfection Change
Res 12/08 (4)


North Shore Water Commission: Comparison of Metal Levels
Total Manganese (ug/L)
100
80
60
40
20
0
Min
Average
Max
-->Original System
S1- Entry (3)
1-Cu-1 (3)
1-Pb-1 (3)
1-Pb-2 (3)
Res 4/08 (4)
Res 7/08 (4)
-->After Phosphate Change
Res 10/08 (4)
After Disinfection Change
Res 12/08 (4)

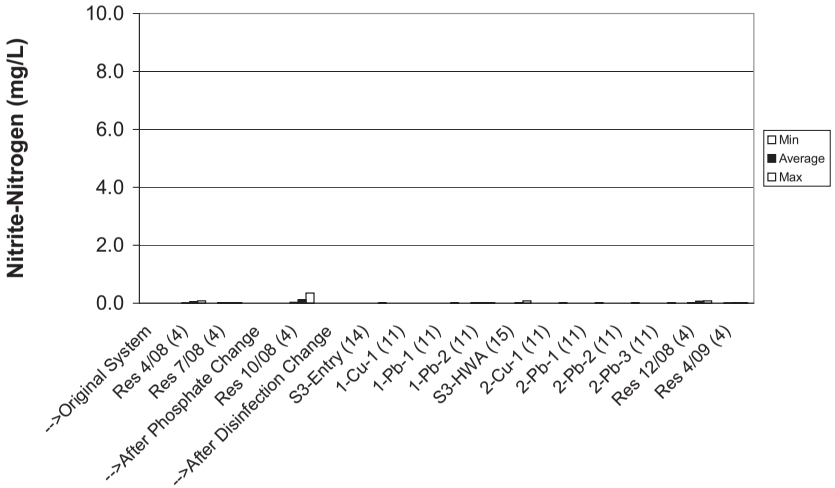
North Shore Water Commission: Comparison of Microbiological Activity



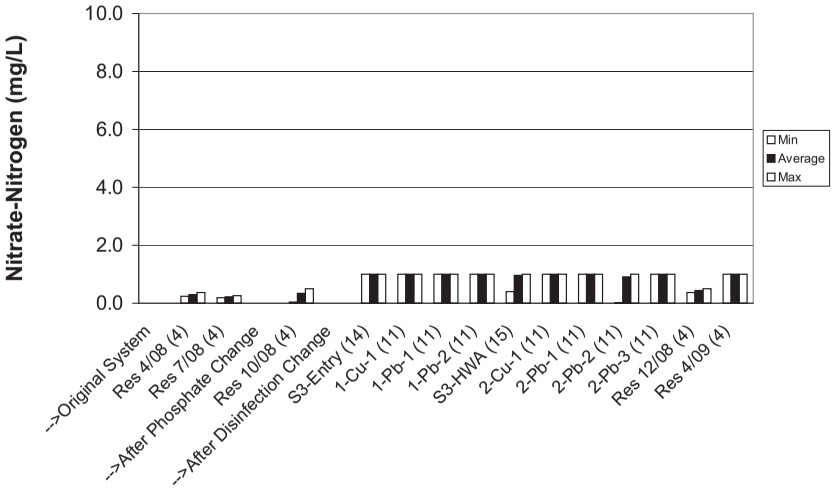
North Shore Water Commission: Comparison of Nitrogen

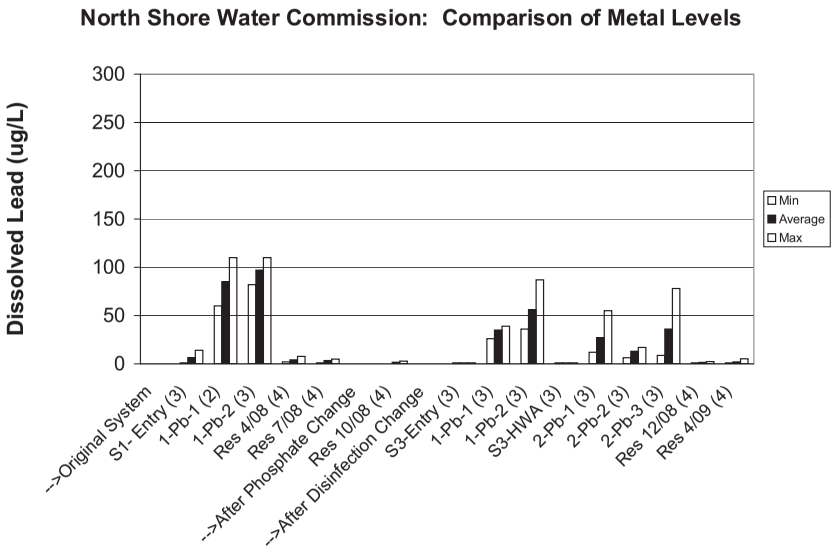


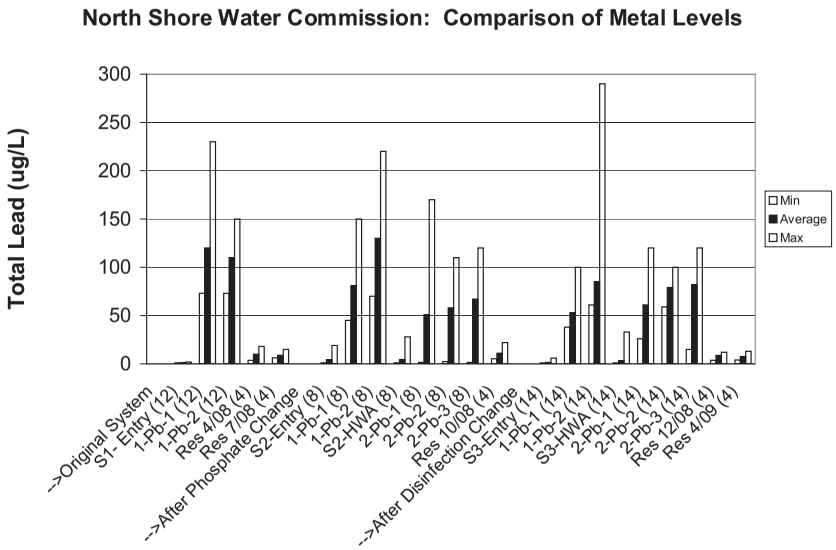
North Shore Water Commission: Comparison of Nitrogen

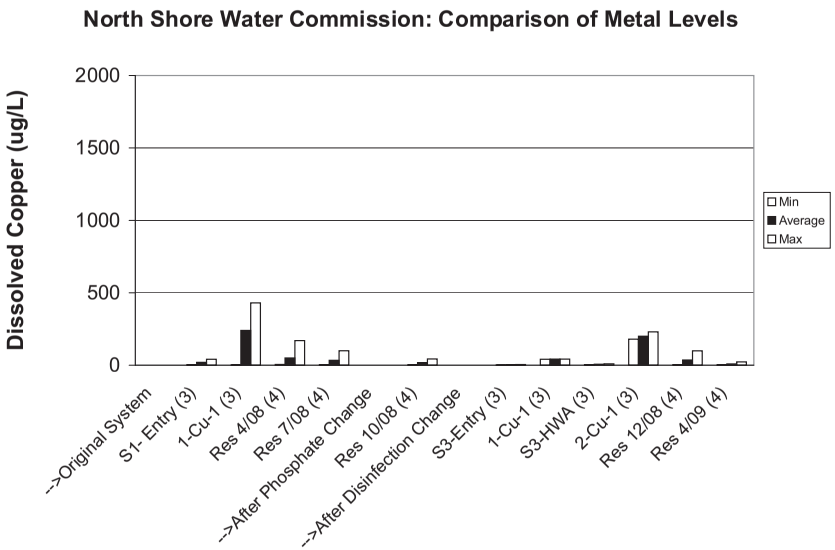


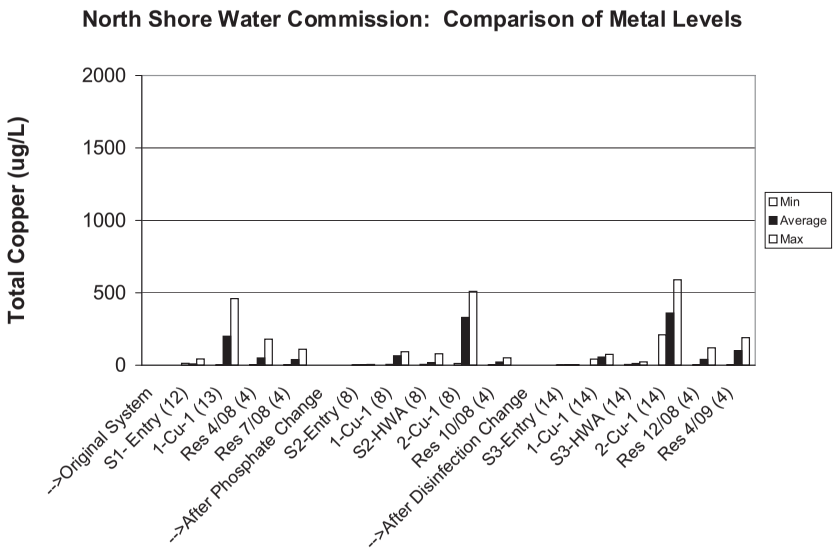
North Shore Water Commission: Comparison of Nitrogen




North Shore Water Commission: Comparison of Metal Levels
Dissolved Lead (ug/L)
300
250
200
150
100
50
0
Min
Average
Max
-->Original System
S1- Entry (3)
1-Pb-1 (2)
1-Pb-2 (3)
Res 4/08 (4)
Res 7/08 (4)
-->After Phosphate Change
Res 10/08 (4)
-->After Disinfection Change
S3-Entry (3)
1-Pb-1 (3)
1-Pb-2 (3)
S3-HWA (3)
2-Pb-1 (3)
2-Pb-2 (3)
2-Pb-3 (3)
Res 12/08 (4)
Res 4/09 (4)


North Shore Water Commission: Comparison of Metal Levels
Total Lead (ug/L)
300
250
200
150
100
50
0
Min
Average
Max
-->Original System
S1- Entry (12)
1-Pb-1 (12)
1-Pb-2 (12)
Res 4/08 (4)
Res 7/08 (4)
-->After Phosphate Change
S2-Entry (8)
1-Pb-1 (8)
1-Pb-2 (8)
S2-HWA (8)
2-Pb-1 (8)
2-Pb-2 (8)
2-Pb-3 (8)
Res 10/08 (4)
-->After Disinfection Change
S3-Entry (14)
1-Pb-1 (14)
1-Pb-2 (14)
S3-HWA (14)
2-Pb-1 (14)
2-Pb-2 (14)
2-Pb-3 (14)
Res 12/08 (4)
Res 4/09 (4)


North Shore Water Commission: Comparison of Metal Levels
Dissolved Copper (ug/L)
2000
1500
1000
500
0
Min
Average
Max
-->Original System
S1- Entry (3)
1-Cu-1 (3)
Res 4/08 (4)
Res 7/08 (4)
-->After Phosphate Change
Res 10/08 (4)
-->After Disinfection Change
S3-Entry (3)
1-Cu-1 (3)
S3-HWA (3)
2-Cu-1 (3)
Res 12/08 (4)
Res 4/09 (4)


North Shore Water Commission: Comparison of Metal Levels
Total Copper (ug/L)
2000
1500
1000
500
0
Min
Average
Max
-->Original System
S1- Entry (12)
1-Cu-1 (13)
Res 4/08 (4)
Res 7/08 (4)
-->After Phosphate Change
S2-Entry (8)
1-Cu-1 (8)
S2-HWA (8)
2-Cu-1 (8)
Res 10/08 (4)
-->After Disinfection Change
S3-Entry (14)
1-Cu-1 (14)
S3-HWA (14)
2-Cu-1 (14)
Res 12/08 (4)
Res 4/09 (4)