Attachment M.1 –
Summary of Testing and Mitigation for Arsenic

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Background

Arsenic is a regulated contaminant in public water supplies under the Safe Drinking Water Act, however there are no regulations or guidelines that require that arsenic be tested for and mitigated at taps within buildings, including schools. The USEPA recently lowered the maximum contaminant level for arsenic from 50 parts per billion (ppb) to 10 ppb. The two water sources used by Seattle Public Utilities (SPU) have extremely low background levels of arsenic, and nothing in SPU's treatment processes add to the arsenic levels of the treated water entering Seattle's water distribution system. Consequently, monitoring for arsenic was not included in Seattle Public School's Drinking Water Quality Improvement Program.

Discovery and Initial Evaluations of Arsenic Occurrences

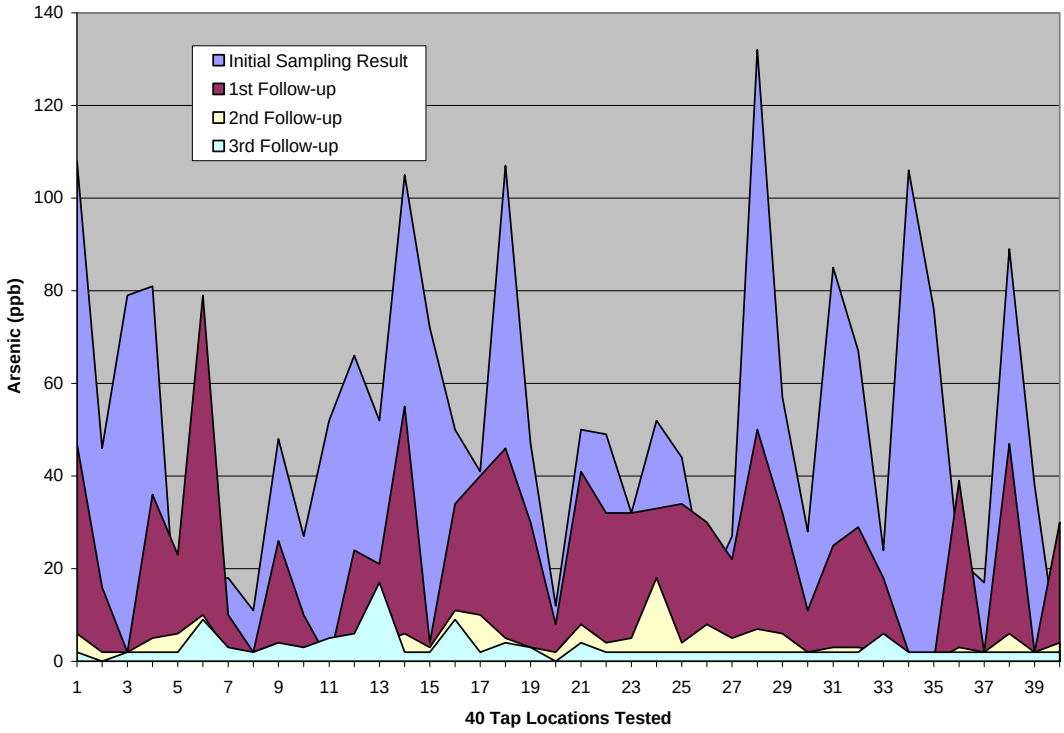
On April 5, 2006 the commercial laboratory (Test America, Inc.) that was under contract with SPS for water analyses noticed the appearance of arsenic in the analytical data as part of the routine laboratory QA/QC process. Further investigation revealed that a total of 40 drinking water source locations in different 22 schools were found to have arsenic above 10 ppb in water samples collected during March 2006. All of these locations had been repaired with new end-use plumbing in February or March, were flushed after the repair, and then had sat stagnant for some time prior to sampling. Therefore, the standard SPS sampling protocol had not been used for the samples collected during March 2006. The standard protocol is to flush each location for 2 minutes for two consecutive days prior to sampling, with the first-draw sample collected after 16 – 18 hours standing time.

Two rounds of follow-up sampling for arsenic of the 40 locations were performed in mid-April. Samples in the first round reflected water that had stood stagnant since they were tested in March. After the first round of sampling, the locations were then flushed per standard SPS protocol. The following morning they were sampled again so that the samples collected represented water that had stood for about 24 hours. The arsenic results for these 40 sources are shown in Table 1.

Historical Results

An evaluation of the arsenic concentrations in water samples collected and analyzed for other metals between September 2005 and February 2006 was also performed. Testing results were available for 818 samples, which includes first-draw and 30-second flush samples at each location, so this data set represents over 400 sources. Of these, there were 17 samples with arsenic above the 2 ppb detection limit (or 2% of this group of samples) and only one sample with arsenic above 10 ppb. These data strongly indicate that arsenic had not been a water quality concern prior to March 2006.

Table 1. Initial Arsenic Testing Results



Comprehensive Arsenic Testing Program

Approach

Based on the initial arsenic testing results, and because the cause and/or source of the arsenic had not been determined from the initial evaluations, SPS decided to carryout a comprehensive arsenic testing program for all drinking water sources in all schools, including kitchen taps and classroom sinks. This testing program was started in May and was completed in June 2006. All drinking water sources were turned off and bottled water was provided at all schools pending the results of the arsenic testing. Each drinking water location was flushed for 2 minutes the afternoon prior to sampling. Samples collected at each location consisted of a first-draw 250 mL sample followed by a 30-second flush 250 mL sample. Samples were also collected at the service entry to each school after a 2-minute flush.

Results

A summary of the results from the comprehensive arsenic testing program are shown in Table 2.

Table 2. Results of Comprehensive Arsenic Testing in May/June 2006

Number of Schools / Buildings Tested	93
Total Number of Locations (Sources) Tested	3526
Number (%) Locations with As < 2 ppb	3460 (98.1%)
Number (%) Locations with As 2 to 10 ppb	45 (1.3%)
Number (%) Locations with As > 10 ppb	21 (0.6%)

Of the 40 sources that had arsenic above 10 ppb in samples collected in March and/or April 2006, the arsenic concentrations in the May testing were less than 2 ppb for all but 10 of these sources, and only one source was above 10 ppb (see Table 1). There were only about 21 sources in 13 schools that had arsenic results above 10 ppb - approximately 0.6% (see Table 2). Of these 21 results, 8 of them were at one school (Denny Middle School). One other school had 2 sources with arsenic above 10 ppb and the rest of the high results were from a single source in a school.

Return of Schools to Service

Based on the comprehensive testing program results, all schools that had no more than two sources with arsenic above 10 ppb were returned to regular water service after the necessary public notifications had been completed.

Additional Testing for Arsenic in Water Samples

Results of Water Standing Over a Weekend

As part of the comprehensive arsenic testing in May 2006, SPS also evaluated the effect of water standing time on arsenic levels at several locations in two schools (Graham Hill and Van Asselt) that had elevated arsenic levels in the March 2006 data. The results from the stagnation testing at Graham Hill show that 2 of the 7 sources tested had arsenic above detection limits after both 2 days and 4 days of stagnant standing time; the other 5 sources at this school had no arsenic levels above 2 ppb in either the 2 or 4-day samples. For the Graham Hill source that had previously exhibited the highest arsenic levels, after 2 days of stagnation the highest measured level was 4.8 ppb and after 4 days of stagnation it increased to 6.5 ppb. The other Graham Hill source with measurable arsenic levels showed a similar trend: 3.3 ppb after 2 days and 5.8 ppb after 4 days of stagnation. The arsenic levels measured at the second school (Van Asselt) were all less than 2 ppb for all sources tested after both 2 days and 4 days of stagnation.

Water Testing at Denny Middle School

Denny Middle School had 8 of the 21 locations with arsenic above 10 ppb in the comprehensive testing program. Because this school had the greatest number of locations with high arsenic, additional, focused water quality testing was performed. Each of the locations with high arsenic was in a portion of the school where piping refurbishments had been done in summer 2005. As part of this work, the end-use plumbing components had been completely replaced with new components at all failing locations.

The purpose of the additional water quality testing at Denny was to determine the impact on arsenic levels of using the fountains on a regular basis (i.e. keeping the fountains in regular water service). Water was tested under stagnant (30 day standing time) conditions, then flushed and tested each of the next four days. The results are shown in Table 3. These results indicate that, for those locations that had elevated arsenic in previous testing, longer stagnation time results in arsenic levels above 10 ppb; and that arsenic levels drop significantly with each successive day that the location is sampled to below detection levels by the fourth day. Based on these results, more frequent passage of water through the

fountains will greatly reduce and/or eliminate the presence of arsenic at those locations that had higher initial arsenic levels.

Another round of follow-up water testing was conducted at Denny after the testing described above was completed. In this round of testing, the 8 locations that had arsenic greater than 10 ppb in the comprehensive testing in May 2006 were allowed to sit stagnant (without use) for about 3 weeks. Each location was then flushed for 2 minutes on two consecutive days (a Thursday and a Friday), then allowed to sit stagnant over the weekend and sampled Monday morning (approximately 72 hours stagnation time) and again Tuesday morning (about 24 hours stagnation time). All results were at or below the analytical detection limit of 2 ppb. These results indicate that periodic flushing of locations that have exhibited elevated arsenic is very effective for keeping arsenic levels low, even after a 3-week stagnation period.

It was also noted that at Denny, while nearly all the recently installed drinking fountains in the hallways had high arsenic, the 10 sinks in the home economics classroom (all of which had the new work, including the same brass nipple/galvanized steel pipe connection) all were found to have arsenic below detection levels. The difference is that the home economics classroom sinks were used regularly during the 2005/2006 school year until April 2006, while the hallway drinking fountains had remained out-of-service and stagnant since October 2005. This provides further confirmation that galvanic corrosion due to improper dissimilar metal connections was the cause of high arsenic at Denny, and that regular use of locations that have these conditions is effective for keeping arsenic to very low levels.

Components and Materials Testing

In addition to the water quality sampling evaluations, SPS carried out a more detailed investigation of the potential for arsenic leaching from plumbing components, piping, plumbing materials, and cleansers. A total of 28 different components (pipes, bubblers, nipples, filters, hoses and couplings) and materials (sealants, tape and cleansers) used or potentially used in repaired fixtures were tested for arsenic content. The methods and results of these evaluations are described in Appendix A. In general, the results of these evaluations indicated that arsenic was found at trace levels in some of the components and materials, but was not present at levels great enough to result in arsenic levels in the water in contact with the components to be above analytical detection limits (2 ppb).

More detailed investigations of piping components and materials were conducted at Denny MS, which had the greatest number of locations with elevated arsenic in the comprehensive testing in May 2006. It was found that there were numerous places in the refurbished plumbing where there was a direct connection of dissimilar metals, e.g. old galvanized steel pipe connected to new brass or copper fittings. The piping refurbishment work done in the summer of 2005. Galvanic corrosion occurs when dissimilar metals are brought into contact, thereby creating a “battery effect” whereby electrons from one metal (the anode) move to the other metal (the cathode) dissolving the anode. With a copper or copper alloy (brass) connection to galvanized steel, the galvanized steel will preferentially (and rapidly) corrode. To prevent galvanic corrosion, a dielectric union, which acts as an electrical insulator, is commonly placed between the connections of two dissimilar metals. SPS plumbing construction specifications require the use of dielectric unions. At Denny, however, at nearly every dissimilar metal connection point the contractor had inserted a copper nipple between the dielectric union and the iron pipe, thereby defeating

the purpose of the dielectric union. SPS plumbers have indicated this is often done to prevent leaks from over-tightening of the joint.

Laboratory testing was performed for sections of the piping and fittings of some of these dissimilar metal connections found at Denny MS. The results demonstrate that the corrosion scales in galvanized pipe removed near new copper pipe contained up to 5.4 ppm (5400 ppb) or arsenic. This indicates that arsenic has accumulated in the corrosion scales within old galvanized piping at or near the points of dissimilar metals connections. These corrosion scales, left undisturbed, would generally be stable. However the galvanic corrosion is leading to local dissolution. Two additional sections of galvanized pipe to copper pipe connections were also removed and examined. Both of these sections had visible localized corrosion near the galvanized/copper connection, as well as high arsenic levels in the corrosion scales near the connections.

There were 13 other locations at 12 other schools that had arsenic above 10 ppb in the May 2006 comprehensive testing. Examination of several of these locations was performed to see if there were dissimilar metal connections like those found at Denny. None were found, however, because the piping to the locations is often behind walls or under floors, it was not possible to identify whether dissimilar metal connections are present of not. For example, at Olympic Hills (a school with 2 of the 13 locations), it is known that there is both galvanized steel and copper piping present in the building, but the connections between the copper and steel pipe segments are hidden behind walls with asbestos material and therefore could not and will not be examined.

Elevated arsenic was also present at isolated locations in some schools that are believed to have only copper piping. Leschi Elementary, which had 5 locations with high arsenic in the March 2006 data, is one such school and was examined in some detail. This school was rebuilt in 1988 and is believed to have only copper piping. A visual examination of the 5 locations did not reveal any dissimilar metal connections, so it cannot be determined if the galvanic corrosion effect with galvanized steel and copper/brass is the cause of the elevated arsenic levels that were measured. However, it is clear that with each successive water sampling at Leschi, the arsenic levels have decreased (see Table 1). As can be seen, arsenic levels dropped to below detection limits in all but two locations in the building, and the highest of those readings was 4 ppb.

Conclusions from the Arsenic Investigations

1. Based on the comprehensive arsenic testing program of all drinking water sources in SPS, arsenic is not present above EPA maximum contaminant level of 10 ppb in 99.4% of the District's drinking water sources.

2. For those locations where elevated arsenic levels were initially found, arsenic was most often detected in subsequent sampling, although almost always at lower levels than was in the previous sample, as described in Conclusion #2 below. The vast majority of locations tested did not exhibit any arsenic above detection levels, but there were some specific locations in some schools had measurable arsenic, while locations directly adjacent to the location with arsenic did not have arsenic. Therefore, arsenic, when found, is highly localized to specific water fixture locations, which indicates that the source of arsenic is within or very near to the end-use plumbing of the water fixture.

3. The majority of the locations that were found to have elevated arsenic levels had had end-use plumbing repair / replacement work done within about 6 months of the finding of arsenic. Of the total of 63 drinking water sources that had arsenic over 10 ppb at any time, 56 were recently repaired sources.

4. For those locations where elevated arsenic was present, the length of the stagnation time prior to sampling has a direct impact on the concentration of arsenic in the water samples. The 40 locations that were initially found to have arsenic above 10 ppb in samples collected in March 2006 data had been sampled after extended stagnation times of up to 2 or more months. However, when samples were collected from these same 40 locations after a stagnation time of only 16-18 hours (the standard SPS sampling protocol), the vast majority of drinking water sources did not have arsenic above the analytical detection limit of 2 ppb. Of the 63 sources that had arsenic over 10 ppb at any time, over 50 were turned off for a lengthy period of time prior to the test. Therefore, the water sampling results demonstrate that the general trend is that arsenic levels diminish and remain at or near the detection limit of 2 ppb when water is flushed through the fixture at more frequent intervals of up to approximately 4 days. However, extensive stagnation periods of weeks or months can result in elevated arsenic levels at locations that had previously exhibited high arsenic levels.

5. The one identified condition that can result in elevated arsenic is the galvanic corrosion effect at the connection of dissimilar metals, in this case galvanized steel and brass or copper, based on the investigations conducted at Denny MS. This effect can be avoided by proper installation of approved plumbing materials and dielectric unions, as well as relatively frequent water use at fixtures.

Recommended Approach for Arsenic Mitigation

1. Future plumbing installations will be made without any brass/steel or copper/steel connections to preclude galvanic corrosion effects.

2. Where arsenic does appear at a drinking water location, it is quickly flushed out by regular, repeated water use as normally occurs for an in-service water source. Regular water use prevents any arsenic from accumulating, and short stagnant periods of 2-4 days do not result in significant accumulations of arsenic.

Recommendations for Long-Term Testing for Arsenic

SPS will need to make decisions for the most appropriate approach for testing for arsenic throughout all its schools. Given the extremely low frequency of elevated arsenic, it remains an open question whether routine arsenic testing is justified. Our current intention is to evaluate this issue after another year of testing experience. In the interim, we will test for arsenic whenever we test for lead. This includes the several schools undergoing work this summer, as well as any individual fountain replacements.