# Lead Levels in Drinking Water at Ripton Elementary School, Ripton, VT

Molly Costanza-Robinson, Ph.D* and Gabrielle Davis
Dept. of Chemistry & Biochemistry; Program for Environmental Studies, Middlebury College, Middlebury, VT. *Prof. of Environ. Chemistry, mcostanz@middlebury.edu
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## SUMMARY
Lead in drinking water was determined for all water outlets (n = 22) at Ripton Elementary School (RES) in Ripton, VT. Samples were collected according to the U.S. Environmental Protection Agency (EPA) guidance document *3Ts for Reducing Lead in Drinking Water in Schools*. First draw (FD) and flush (FL) samples were collected, acidified (pH<2), and turbidity verified to be <1 NTU prior to Pb determination. Lead concentrations in FD samples were evaluated relative to three standards: the administrative (not health-based) 15-ppb EPA action level for residential water, the health-based 1-ppb American Academy of Pediatrics (AAP) safety recommendation for drinking fountains in schools, and the anticipated Vermont state action level for drinking water in schools of 3 ppb. FL samples were used to determine the likely source of any lead in the water.

Most outlets (73%) produced FD samples with detectable lead, but in all but two cases, the lead was at 1 ppb or lower and, therefore, met the AAP recommended safety level. A kitchen sprayer produced a FD sample that exceeded the 15-ppb EPA action level (RD03, >50 ppb) and is considered a *highest priority* for remediation. The "source sample" (closest outlet to the water entry point in the school) produced a FD sample that exceeded the 1-ppb AAP safety level and the anticipated 3-ppb Vermont action level (RD01, 5 ppb). This outlet is not used for any regular purpose, nor do children or staff have access to it; for this reason, we consider this outlet to be a *low priority* for remediation. FL samples suggest that the predominant source of lead was the fixtures or their immediate connections, rather than more distal pipes or the incoming water supply, which may simplify potential remediation approaches.

Recommended permanent remedial actions include replacing fixtures with "lead-free" fixtures/solder with follow-up testing to verify remediation efficacy or removing outlets entirely. Additionally, we recommend that RES communicate the findings of this work and remediation updates with the school community, as well as post this report and remediation updates in a readily accessible location (e.g., school website). A sample letter describing the results for a general audience is provided.

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Molly Costanza-Robinson, Ph.D* and Gabrielle Davis
Dept. of Chemistry & Biochemistry; Program for Environmental Studies, Middlebury College, Middlebury, VT. *Prof. of Environ. Chemistry, mcostanz@middlebury.edu
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## BACKGROUND

Lead exposures derive from a variety of sources including dust from older lead-based paint, soil contamination from earlier leaded gasoline, and water contamination from leaded pipes, solder, and fixtures [1]. Dust from leaded paint is believed to be the dominant source of lead exposure, but the EPA estimates that ~20% of lead exposure is through drinking water [2]. Health effects of lead include irreversible developmental neurotoxicity [3], disruption of the endocrine and reproductive systems [4], and gastrointestinal and cardiovascular issues [5]. Even at low levels (<5 µg-Pb/dL-blood), lead has been known to decrease IQ scores [3]. Because of the health risks posed by lead, including that it can bioaccumulate, the U.S. Environmental Protection agency has set a non-enforceable health standard (Maximum Contaminant Level Goal, MLCG) for lead in drinking water of zero [2]. While no level of lead exposure is considered to be safe for anyone, lead exposure is a particular concern in children. Whereas children absorb >50% of Pb that they ingest, adults absorb ~35-50% [6]. Furthermore, lead's chemical similarity to calcium promotes uptake into children's bones, which can leach out over time and serve as a long-term source of Pb exposure [7]. The American Academy of Pediatrics recommends a maximum lead level in drinking water of 1 µg/L (referred to as "ppb") [8]. Because developing children spend much of their time at school and the effects are largely irreversible, exposure to lead through drinking water in schools is a critical issue [9, 10].

In 1991, the United States Environmental Protection Agency (EPA) established the Lead and Copper Rule, which requires public water suppliers to monitor for lead in drinking water and sets an action level for the concentration of lead in drinking water to 15 parts per billion (ppb) and a maximum contaminant level *goal* of 0 ppb [11]. If lead concentrations exceed the 15 ppb action level in more than 10% of customer taps sampled, public water suppliers must take action to control corrosion and inform the public about steps they should take to protect their health. Importantly, this action level is used administratively to evaluate community exposure and is not a health-based standard. The American Academy of Pediatrics has issued a health-based recommendation that water fountains in schools not deliver water exceeding 1 ppb lead [8]. Currently, schools are not required to test for lead in drinking water unless they rely on a private water supply and serve more than 25 people daily [12]. This results in water being tested for lead in only ~8-11% of schools nationwide [13]. Previous national legislative efforts, including those by former Vermont Senator Jim Jeffords, to direct the EPA to require states to develop school testing programs and to address any problems found have been unsuccessful. While municipal water must be tested for lead at the site of distribution and at a small number of end-user (typically residential) outlets, lead can leach into the water at various points within the system, including from lead-containing pipes, solder, and individual outlet fixtures. The federal 1986 Safe Drinking Water Act limited the use of lead pipes and lead-containing solders in new drinking water systems, where "lead free" was defined as less than "0.2% lead for solders and fluxes and not more than 8% lead for pipes and pipe fittings" [14]. The amount of lead allowed in "lead-free" products installed after 2010 in Vermont [15] and after 2014 nationally was reduced through redefining "lead free" as products in which wetted surfaces of a pipe contain a weighted average of ≤0.25% lead and the wetted surfaces of solder and flux contain a weighted average of ≤0.2% lead. The 2011 federal revision also exempted from lead-free requirements certain products that are used exclusively for non-potable uses "such as irrigation, outdoor watering or any other uses where the water is not anticipated to be used for human consumption," as well as other products, including shower or water distribution main gate valves ≥2 inches in diameter [14]. Because of shifting "lead free" definitions, exemptions from lead-free requirements, and uncertainty regarding individual pipe and fixture composition and installation dates, direct testing of water from each outlet is the only way to understand the potential for lead exposure through drinking water.

Data from the Vermont State Health Lab in 2015 indicate that ~5% of blood samples from Vermont children age 2-and-under exceed Vermont's 5 μg/dL standard [16]. Approximately, 150 Vermont schools who are on their own drinking water supply regularly test some water outlets, but few schools have ever had all of their outlets tested. In 2017, the Vermont Department of Health (VDH) and Agencies of Education and Natural Resources launched a pilot project to test all drinking water outlets in 16 Vermont public schools that are on municipal water supplies [17]. Results of that pilot showed substantial differences across schools in the frequency of lead detection and in lead levels [18]. Schools ranged from having 0% up to 54% of outlets exceeding the EPA action level for lead, and from 3-88% of outlets exceeding AAP safety level of 1-ppb.[1] In response to the VDH pilot and with the support of the Governor, the Vermont legislature took up a bill in 2019 to require testing of school drinking water for lead. The Senate passed the bill in February 2019 that relies on a lead action level of 3 ppb; the House is expected to follow suit. In the current draft of the bill, the testing reflected in this report would be accepted as having fulfilled the requirements of testing.

Ripton Elementary School (RES) receives water through its own well and serves more than 25 people; consequently, it tests a handful of outlets for lead every three years [19]. Under Vermont state law, RES is also specifically required to tests water for lead in early education (preschool) classrooms [20]. The current study represents the first-time lead levels have been tested in water from all outlets at RES.

## METHODS

*Site Description*

Ripton Elementary School (RES) is located in the town of Ripton, VT and provides pre-kindergarten through 6th grade instruction [21]. RES is part of the Addison Central School District, which oversees public schools in the area. RES was constructed in 1988 with minor repairs and renovations since then. Any replacement of fixtures and other water infrastructure was performed in compliance with the lead-free requirements of the 1986 Safe Drinking Water Act. We worked with ACSD Facilities Manager, Eric Warren, on the study design, including completion of a plumbing questionnaire and mapping of flow paths.[2] All water outlets in the school (n = 22) were mapped by location and type. Outlets sampled at RES included a source sample, sinks (conventional and floor/utility), water fountains, bottle fillers, and a shower (**Figure 1**). Mapping included noting the flow path of water from the initial water entry point to the school. Knowledge of the water flow path is critical to the integrity of water sampling, as outlets need to be sampled in sequence from upstream to downstream to avoid inadvertent flushing of pipes and fixtures prior to sampling. We did not independently verify information provided regarding plumbing and water flow in the school.

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[1] The AAP health-based recommendation is made specifically for water fountains, but would reasonably be applied to any outlet used for direct consumption by children. Information regarding use of outlets for consumption was not publicly available for statewide pilot.

[2] EPA Plumbing Profile Questionnaire can be found on p 96 of (EPA 2006), and includes questions regarding pipe and fixture type and composition, building age, and dates of renovation, among other information.

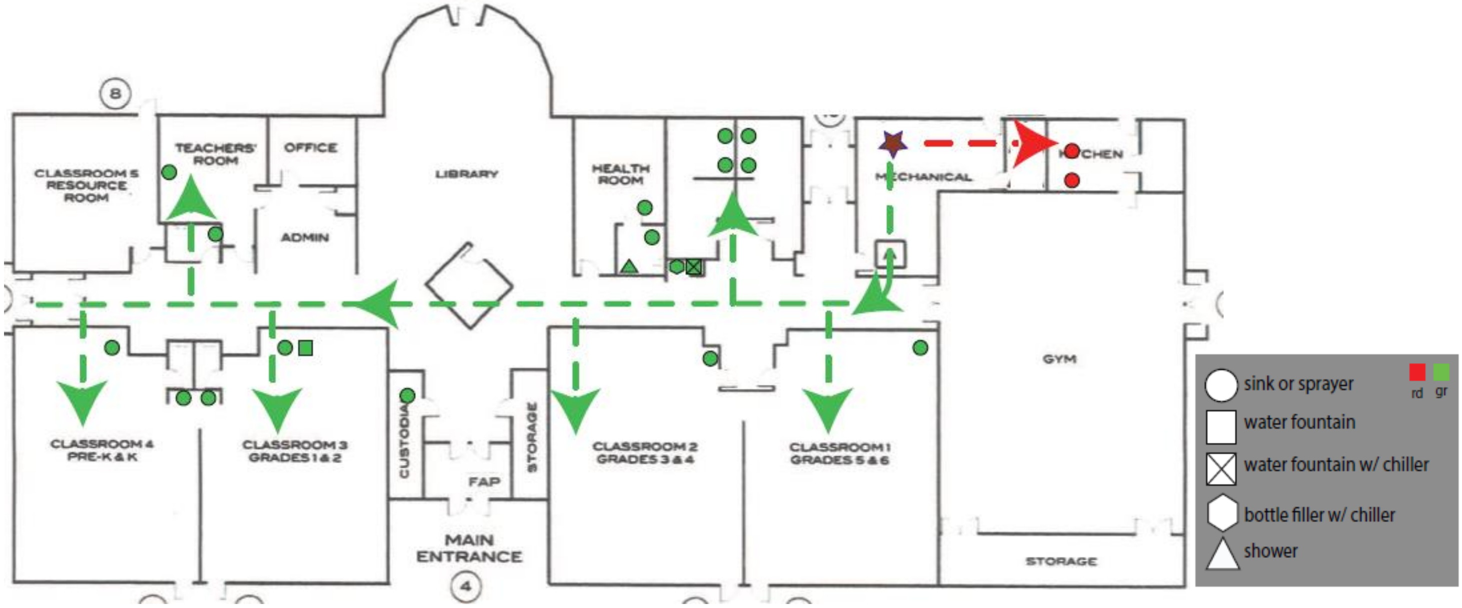


**Figure 1.** Ripton Elementary School floor plan showing water flow paths (arrows) and water outlet (sample) locations, with colors representing main branch lines. The location of water input to the school is in the marked with a star. Marker shapes indicate fixture type. The sample-naming scheme associated with outlets is provided in (**Appendix A**). The floor plan with outlet locations labeled by Outlet ID is provided in **Appendix B**.

*Sample Collection*

Water was sampled on a Saturday morning (January 12, 2019) during the regular school year and prior to any use for the day.[3] Water should ideally sit stagnant in the pipes and fixtures for least 8 h, but no more than 12 h before collection.[4] Water samples were collected in certified clean HDPE Nalgene bottles (250 mL).[5] Two types of samples were collected: first draw (FD) and flush samples (FL) (**Table 1**). The two types of samples collectively provide information on the source of lead in the water and therefore, on appropriate remediation measures. First draw (FD) samples were obtained by collecting the first 250 mL of water from each outlet. After all FD samples were collected, FL samples were obtained by flushing water out of the outlets for 30 seconds and then collecting another 250 mL. Two field blanks were collected at Middlebury College the day before sample collection using ultra-purified water and were exposed to the sampling conditions of RES. The sample naming scheme and RES floor plan showing outlet locations labeled by outlet ID are provided in **Appendix A** and **B**, respectively.

*Sample Preparation and Lead Analysis*

After collection, samples were placed in a cooler and within 48 hours were acidified to 0.5% (1.25 mL trace-metal grade $HNO_3$) for preservation. After 16 h or more, sample turbidity was verified to be <1 NTU and acidity pH<2. One sample had high turbidity and its lead level is considered a low

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[3]The U.S. EPA (2006) recommends against sampling during holidays or periods of time that the school is not in regular use in order to avoid collecting samples that have non-representative high levels of lead.

[4] Some outlets are used infrequently and had likely been sitting for longer than 8-12 h. We considered this to be in keeping with the goals of the EPA guidance in that our samples are representative of what a student might encounter at that particular outlet on a given day.

[5] School samples are smaller than the 1-L sample collected by public water suppliers for compliance with the Lead and Copper Rule. A smaller sample is more effective at identifying the sources of lead at an outlet because lead sample is also more representative of water per serving consumed by a child. (EPA 2006)

estimate of actual total lead.[6] Samples were analyzed for lead using inductively coupled plasma mass spectrometry, manufacturer-recommended conditions, and conventional quality control and quality assurance methods.[7] Lead concentrations are reported to the nearest part-per-billion (ppb, i.e., μg-Pb/L-water) for samples at/above the limit of quantification (LOQ, 0.5 ppb); as <0.5 ppb for samples with detectable lead below the LOQ; and as non-detect (n.d.) for samples with lead levels below the limit of detection (0.1 ppb)

A health-based prioritization of outlet remediation (highest, high, or moderate priority) is made based on the measured lead levels in FD samples and the potential use of the outlet for direct consumption. Lead levels are evaluated relative to three standards: the administrative (not health-based) EPA action level for lead of 15-ppb, the American Academy of Pediatrics health-based safety standard for school water fountains of 1 ppb, and the anticipated Vermont state action level for drinking water in schools of 3 ppb.

**Table 1**. Types, descriptions, and rationale for samples collected.

| Sample Type | Description and Rationale |
|---|---|
| **First Draw (FD)** | First 250 mL of water to exit outlet after sitting stagnant in pipes for 8-12 hours (see footnote 2 on p. 3). Provides information on Pb in the drinking water from all sources, including water coming in to the school, water pipes, and the outlet fixtures and connections. |
| **Flush (FL)** | First 250 mL of water to exit outlet after sitting stagnant in pipes for 8-12, having taken a FD sample, and *subsequently having been flushed for 30 seconds*. Provides information on Pb in the drinking from all sources *excluding* the outlet fixtures and immediate connections (i.e., from more distant connections, pipes, and/or incoming water). |

## RESULTS & DISCUSSION

*Lead Level Summary*

Water from 22 outlets was sampled, including collecting one FD and one FL sample from each outlet. FD samples are used to evaluate lead exposures, while FL samples are used to evaluate the potential source of any lead found. Complete sample data are provided in **Appendix C**. Summary results for FD samples are shown in **Figure 2**. Most outlets produced FD samples with detectable lead (73%), but in all but two cases, the lead was at 1 ppb or lower and, therefore, meets the AAP recommended safety level. One outlet produced an FD sample that exceeded the AAP recommendation and the anticipated VT action level, and another exceeded the 15-ppb EPA action level (**Figure 3**). The potential health concerns posed, and therefore, the prioritization of outlets for remedial action, depend on the measured lead concentration and the potential use of the outlet for direct consumption.

The outlet that produced a FD sample that exceed the administrative EPA action level of 15 ppb was the kitchen sprayer (>50 ppb, RD03). The RD03 FD sample had high turbidity (i.e., particulate matter) that was not reduced upon acidification and extended time. Because lead may be contained within the undissolved particulate and only the dissolved fraction is measured, 50 ppb is considered a lower limit for the actual lead concentration produced. High turbidity samples are often

[6] The FD sample from the kitchen sprayer (RD03) had high turbidity (2 NTU) that was not reduced upon acidification and extended time. This sample was filtered (0.2 μm nylon) prior to lead determination and, therefore, represents a lower limit for its total lead content.

[7] Reliability was ensured by use of a 7-point calibration ($r^2>0.999$) with use of internal standards; analysis of field and calibration blank samples; analysis in triplicate (±10%); and Pb recovery for a National Institutes of Standards and Technology certified reference material (±10%) after every 10 samples.

associated with infrequent use/flushing of the fixture and proximate pipes. This outlet is considered as *highest priority* outlets for remedial action due to its location within the kitchen.

The outlet that produced an FD lead levels that exceeded the AAP recommendation and the anticipated Vermont action level was the source sample. This fixture is not used for any regular purpose, nor do children or staff have access to this outlet. For this reason, we consider this outlet as a *low priority* for remediation. Priority outlets for remediation are summarized and appropriate remedial actions are discussed below in the *Summary & Recommendations* section.

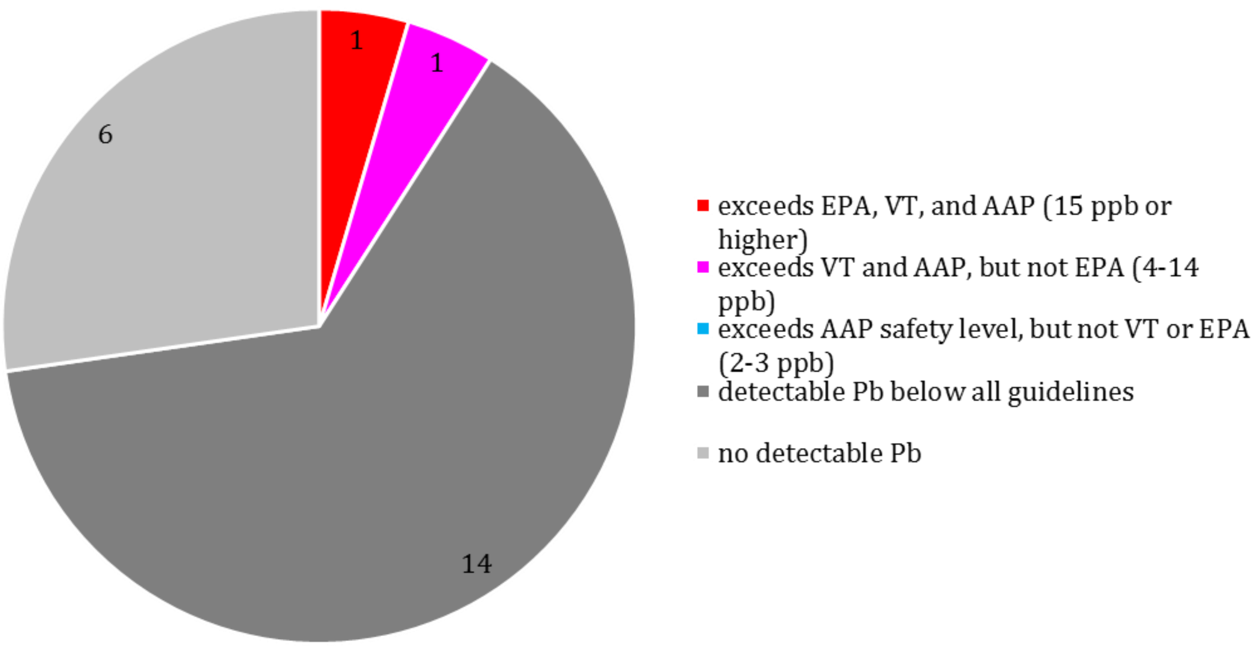


**Figure 2.** Summary of lead levels in Ripton Elementary School FD samples. Numbers represent the number of outlets producing FD samples in each lead concentration category. No FD samples exceeded the AAP safety level without also violating either the VT or EPA levels (blue in legend).

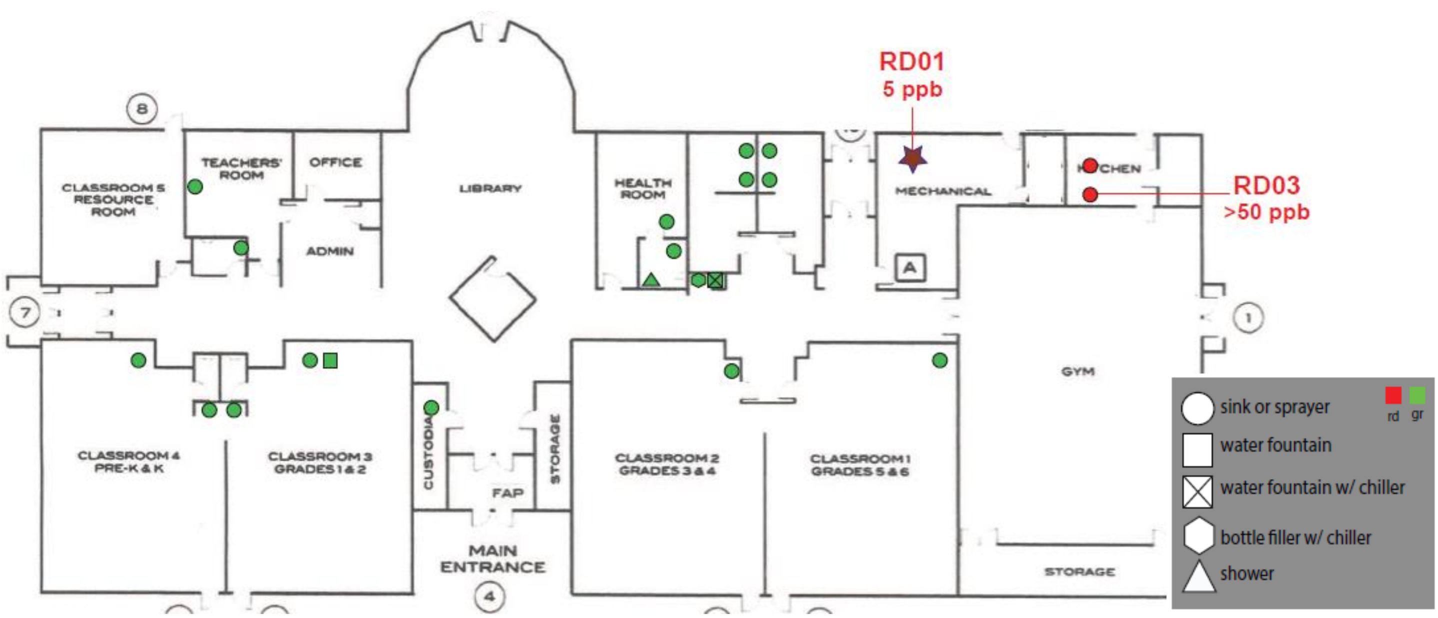


**Figure 3.** Floor plan showing locations and lead levels for Ripton Elementary School outlets that exceeded the American Academy of Pediatrics recommended safety level of 1 ppb or other guidelines.

*Source of Lead in Water*

FL samples had lower lead levels as compared to their associated FD sample and none exceeded the AAP safety level, which suggests that the predominant source of the lead in FD samples is the outlet fixtures or immediate connections (e.g., solder), rather than incoming water or pipes within the school.

## SUMMARY & RECOMMENDATIONS

Most outlets produced FD samples with detectable lead, but all but two met the AAP safety level. One FD sample, the kitchen sprayer, exceeded the EPA action level and is considered a *highest priority* for remediation based on lead levels and the likelihood and frequency of direct consumption (**Table 2)**. The source sample was considered a *low priority* for remediation because it is not used for any regular purpose and neither students nor staff have access to the outlet.

**Table 2.** Summary of Ripton Elementary School outlets that exceeded the EPA or anticipated Vermont action level or AAP recommended safety level (i.e., "priority outlets"), with prioritization for remediation based on lead level and likelihood and frequency of use for consumption.

| Priority level | Concern | Rationale | Outlet ID | Outlet type & location | First Draw (ppb) | Flush (ppb) |
|---|---|---|---|---|---|---|
| Highest | Exceeds EPA action level | Likely & frequent use for direct consumption | RD03 | Kitchen sink sprayer | 50 | 1 |
| Low | Exceeds AAP safety level and anticipated Vermont action level | Virtually no student/staff access; low potential use for direct consumption | BL22 | Source outlet within mechanical closet | 5 | 1 |

Results suggest that the predominant source of the lead in the FD samples is the outlet fixtures or immediate connections (e.g., solder), rather than incoming water or pipes within the school.

We recommend that RES pursue the following *permanent* remediation approaches for priority outlets:

1) replace with "lead-free" fixture/solder or remove the outlet entirely
2) if replaced, verify remediation efficacy via follow-up lead testing

Until the priority outlets are permanently remediated, we suggest the following *temporary* approaches:

1) disconnect water supply to the kitchen sprayer (RD03), if at all possible
2) If kitchen sprayer water *is* needed for non-consumption uses, place signage instructing against its use for consumption or food preparation and with educational outreach regarding the policy and its rationale

Finally, we recommend that RES communicate the findings of this work and remediation updates with the school community, as well as post this report and remediation updates in a readily accessible location (e.g., school website). A draft letter describing the results for a general audience is provided as **Appendix D**.

## ACKNOWLEDGEMENTS
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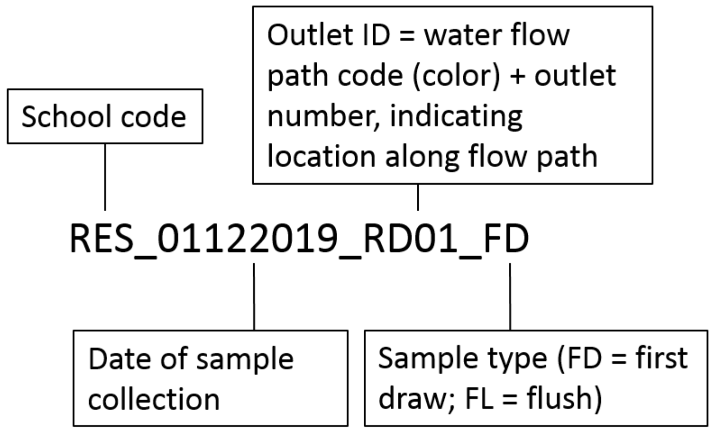
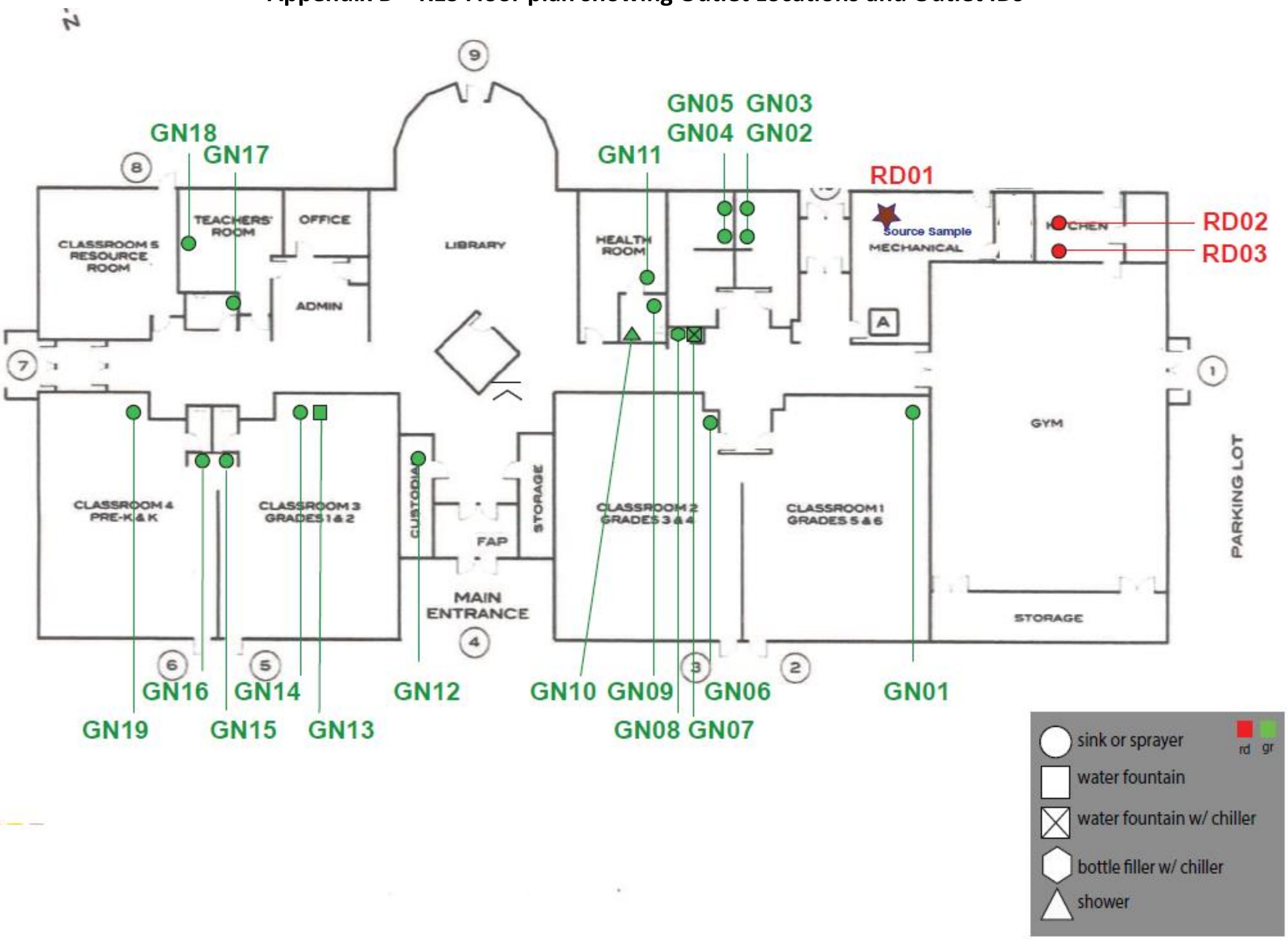
**Appendix A – Sample Naming Scheme**

Samples collected at RES were assigned unique sample IDs as presented below. The IDs are composed of the school code, sampling date, flow path identification, outlet ID, and the type of sample.



**Appendix B – RES Floor plan showing Outlet Locations and Outlet IDs**



**Appendix C – Complete Lead Concentration Results for RES**

Samples were collected as described in the Methods; sample names are as described and located in **Appendix A** and **B**, respectively. Lead concentrations are reported in parts-per-billion (ppb, i.e., µg-Pb/L-water) for samples at/above the limit of quantification (LOQ, 0.5 ppb); as <0.5 ppb for samples with detectable lead below the LOQ; and as non-detect (n.d.) for samples with lead levels below the limit of detection (i.e., <0.1 ppb). Samples that exceed the EPA action level are shown in red; those that exceed the anticipated Vermont action level, but not the EPA level, are shown in pink.

| School | Outlet ID | Outlet Type | Outlet Description/Location | First Draw Lead Conc (ppb) | Flush Lead Conc (ppb)[a] |
|---|---|---|---|---|---|
| RES | RD01 | source | source | 5 | 1 |
| RES | RD02 | kitchen sink or sprayer | kitchen sink | n.d. | <0.5 |
| RES | RD03 | kitchen sink or sprayer | kitchen hand wash sink | >50[b] | 1 |
| RES | GN01 | classroom/office sink | classroom 1 (grades 5+6) sink | <0.5 | n.d. |
| RES | GN02 | bathroom sink | boys' bathroom (near health room) | <0.5 | n.d. |
| RES | GN03 | bathroom sink | boys' bathroom (near health room) | <0.5 | <0.5 |
| RES | GN04 | bathroom sink | girls' bathroom (near health room) | <0.5 | n.d. (hot); n.d. (cold) |
| RES | GN05 | bathroom sink | girls' bathroom (near health room) | <0.5 | n.d. (hot); n.d. (cold) |
| RES | GN06 | classroom/office sink | classroom 2 (grades 3+4) sink | <0.5 | n.d. |
| RES | GN07 | water fountain or bottle filler | water fountain near health office | n.d. | n.d. |
| RES | GN08 | water fountain or bottle filler | bottle filler near health office | n.d. | n.d. |
| RES | GN09 | bathroom sink | health office bathroom sink | n.d. | n.d. (hot); n.d. (cold) |
| RES | GN10 | other | health office shower | <0.5 | <0.5 |
| RES | GN11 | classroom/office sink | health office sink | 1 | <0.5 (hot); n.d. (cold) |
| RES | GN12 | utility sink | utility sink in custodial closet | 1 | <0.5 |
| RES | GN13 | water fountain or bottle filler | classroom 3 (grades 1+2) water fountain (on sink) | 1 | <0.5 |
| RES | GN14 | classroom/office sink | classroom 3 (grades 1+2) sink | n.d. | <0.5 |
| RES | GN15 | classroom/office sink | classroom 3/4 (grades preK-2) sink | n.d. | <0.5 |
| RES | GN16 | classroom/office sink | classroom 3/4 (grades preK-2) sink | <0.5 | n.d. |
| RES | GN17 | bathroom sink | bathroom sink (near teachers' room) | <0.5 | n.d. |
| RES | GN18 | classroom/office sink | teachers' room sink | <0.5 | <0.5 |
| RES | GN19 | classroom/office sink | classroom 4 (preK+K) sink | <0.5 | n.d. |

[a] hot/cold water lines were reversed for some outlets, leading to hot samples inadvertently being collected for some outlets; cold samples were subsequently collected. Data for both hot and cold lines are provided.

[b] this sample had high turbidity (2 NTU) even after acidification for an extended time; thus, this value is considered as a low estimate of total lead concentration.

## Appendix D – Sample Letter to the RES Community Regarding Study Results

We provide here a sample letter for sharing the study results with the school community.

Dear Parents,

As we shared earlier this year, Ripton Elementary School (RES) partnered with students and faculty researchers from Middlebury College to test all the sources of drinking water at RES for lead, including water from water fountains, bottle fillers, sinks, and showers -- a total of 22 outlets.

**Why is it important to screen to test the school's drinking water for lead?**

Although most lead exposure occurs when people eat paint chips and inhale dust, the U.S. Environmental Protection Agency (EPA) estimates that up to 20% of lead exposure may come from drinking water. Even though the public water supply to the school meets EPA's lead standards, lead can still get into a school's drinking water. As water moves through a school's plumbing system, lead can leach into the drinking water from plumbing materials and fixtures that contain lead. Testing is the best way to know if there are elevated levels of lead in the school's drinking water.

**What were the results of the study?**

Nearly all (91%) outlets met the American Academy of Pediatrics (AAP) recommended safety level of 1 ppb for lead in school drinking water. A kitchen sink sprayer (>50 ppb) exceeded the EPA action level (15 ppb) and is considered a *highest priority* for remediation. One outlet within the mechanical closet (5 ppb) exceeded the 1-ppb American Academy of Pediatrics safety level and the anticipated Vermont action level, standards defined for outlets potentially used for consumption. This outlet is not used for any regular purpose and neither students nor staff have access to it; consequently, this outlet is considered a *low priority* for remediation. Testing suggests that the predominant source of lead is the fixtures or their immediate connections, rather than more distal pipes or the incoming water supply.

**What comes next?**

We have accepted the researchers' recommendations that we:

(1) replace the kitchen sink sprayer with a new lead-free spray fixture

(2) verify remediation efficacy via follow-up lead testing after fixture replacement

[INSERT LANGUAGE ON TIMELINE FOR RESPONSE/IMPLEMENTATION AND OF FOLLOWUP AFTER CHANGES HAVE BEEN MADE/IMPLEMENTED]

**Where can I get more information?**

For more information regarding the testing project or sampling results:

- Call Bruce MacIntire at 802-382-1500
- Access the full report at [INSERT URL FOR ACCESSING THE FULL REPORT]

For information about the health effects of lead:

- Call the Health Department at 800-439-8550
- Visit http://healthvermont.gov/drinking-water/lead
- Visit http://healthvermont.gov/environment/children/prevent-lead-poisoning -parents

To request a drinking water test kit:

- Call the Health Department Laboratory at 802-338-4736 or 800-660-9997