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Background

Legionella in man-made water systems can amplify and be transmitted to susceptible hosts via aerosolized water droplets from systems such as whirlpool spas, showerheads, decorative fountains, and cooling towers, or, rarely, via aspiration of water. The following conditions in building water systems can promote the amplification and potential transmission of *Legionella* (1):

- Warm temperatures (77–108°F)
- Low residual disinfectant levels
- Water stagnation
- Presence of free-living protozoa
- Presence of biofilm, scale, and sediment in piping
- External factors such as changes in water pressure due to construction, water main breaks, or municipal water quality

The risk of acquiring Legionnaires' disease (LD), a type of pneumonia caused by *Legionella*, can be reduced through environmental control measures. Adequate maintenance of a building's water system through the implementation of a water management program could reduce risk for *Legionella* amplification and transmission (1).

Long-term care facility A (LTCF A) in Quincy, Illinois, is a 200-acre campus with 48 buildings, including seven residential buildings built from 1886–2011¹. LTCF A is a veterans' home, owned and managed by the state of Illinois but operating within the U.S. Department of Veterans Affairs system. The facility employs more than 500 employees and has greater than 100 volunteers. Nursing home care is provided to approximately 392 residents aged 50 and above, of whom some receive care for complex chronic medical conditions and dementia. Provided care ranges from independent living with minimal activities of daily living (ADL) support to total ADL support and skilled nursing care.

¹ Please refer to Appendix A for the specific year of construction for each campus building.

On July 27, 2015, the Illinois Department of Public Health (IDPH) consulted CDC after identification of the first lab-confirmed LD case at LTCF A. With the identification of four additional lab-confirmed LD cases at LTCF A, CDC was invited to assist in the ongoing field investigation on August 30, 2015. In collaboration with local and state public health officials, the investigation (Epi-Aid 2015-037) identified *Legionella* colonization in the potable water system and cooling tower. *Legionella pneumophila* serogroup 1 isolates cultured from the two-cell cooling tower and the potable water system of all resident buildings, Nielson dining hall, and decommissioned Andrew infirmary matched two available clinical isolates by sequence type (ST36). Between July 24 and September 20, 2015, there were a reported 47 cases of legionellosis and 12 deaths among residents and six cases among staff (2).

As a result of the outbreak, LTCF A hired a contractor with experience in *Legionella* testing and remediation. In September 2015, the water management team (clinical, facility, and administrative leadership from LTCF A; representatives from the Adams County Health Department (ACHD) and IDPH; a state-certified water operator; and the contractor with *Legionella* experience) developed and implemented a water management program for all campus water systems per ASHRAE Standard 188 (3). The cooling tower was cleaned and decontaminated in August 2015 and the potable water system was hyper chlorinated in September 2015. Supplemental disinfectant (chlorine and chlorine dioxide) was injected into the main campus water inlet until construction of an on-campus secondary disinfection chemical treatment plant was completed in June 2016. Water parameters were routinely monitored, and twice-monthly environmental sampling for *Legionella* was conducted.

As part of the implementation of the water management program, the LTCF A water system underwent extensive changes, with changes being implemented on an ongoing basis as the water management team identified new opportunities for system improvements. Between January 1 and August 11, 2016, changes to the water system included but were not limited to:

- Improvements to the potable water;
 - Removal of large sections of unused piping and the water tower from the water distribution system;
 - Consolidation of municipal water mains to one inlet delivering all potable water to the campus;

- Installation of dedicated recirculating hot water systems in each residential building and Smith Hall kitchen to significantly increase hot water temperatures;
- Installation of automatic flushing stations for on-campus water mains;
- Construction of an on-campus chemical treatment plant for injection of secondary disinfectant (12.5% sodium hypochlorite and chlorine dioxide) into the potable water under guidance of water and chemical treatment service provider;
- Installation of thermostatic mixing valves at sink faucet and shower fixtures, as well as 0.2 micron point-of-use filters for the removal of *Legionella* on all showerheads and hand-held sprayers on therapy tubs; and
- Daily flushing at all terminal fixtures per the water management program.
- Improvements to cooling towers' operation and maintenance, including automation of the biocide delivery system and chemical parameter monitoring, under the guidance of a water and chemical treatment service provider.

During this time, the water management team deployed various contingency responses (i.e., steps developed and implemented in response to identification of positive *Legionella* cultures or new conditions that promote *Legionella* growth). Contingency responses include activities such as isolating the affected riser pipes, superheating and flushing water through pipes at terminal fixtures, and resampling water for *Legionella* testing. This program also includes testing adjacent terminal fixtures once *Legionella* is detected at a particular fixture, and replacement of a fixture (e.g., sink faucet) if two consecutive water samples are positive for *Legionella* despite remediation.

LTCF A staff reported that increasing hot water temperatures in each residential building water system initially resulted in biofilm and sludge exiting terminal fixtures across the facility and clogging thermostatic mixing valves and point-of-use filters. Thermostatic mixing valves were checked when residents or staff noted decreased flow from fixtures, at which time clogging, or “fouling,” of the valve with sediment and biofilm was noted, requiring replacement or cleaning. Both thermostatic mixing valves and point-of-use filters had to be replaced frequently (e.g., initially, point-of-use filters were clogged after a few hours of use). By the end of June 2016, thermostatic

mixing valve cleaning/replacement still occurred, but with decreased frequency, and point-of-use filters were replaced every 31 days per the manufacturer's recommendations. Ongoing filter and mixing valve maintenance is outlined in the water management program as a contingency response.

On April 18, 2016, an LTCF A volunteer was diagnosed with LD. This volunteer reported using a dishwashing sprayer at LTCF A's Smith Hall within the 10 days before symptom onset. LTCF A was notified of the potential facility exposure by ACHD and instituted the following contingency responses on April 27, 2016:

- Removed dishwashing sink, sprayer head, and hose temporarily from service;
- Flushed system with hot water (148–150°F) for 30 minutes; and
- Reconfigured the hot water heater and added a second hot water heater to meet the demands of the Smith Hall hot water usage (maintained temperatures at 150–160°F).

On April 29, 2016, an additional flush was performed with cold water (duration: 30 minutes) and hot water at 151°F (duration: 5 minutes). Environmental sampling was done before volunteers or staff resumed use of the sink to determine if the potential risk of *Legionella* exposure was sufficiently addressed. Water sampling conducted on April 25, May 21, and July 6, 2016 at the dishwashing sink yielded negative results for *Legionella*.

On July 21, 2016, IDPH notified CDC of a second LD case in a LTCF A resident with multiple potential exposures and symptom onset on July 14, 2016. On July 25, 2016, IDPH notified CDC of a third LD case, diagnosed in a resident confined to one building at LTCF A with symptom onset on July 16, 2016. Given heightened concern regarding potential sources and transmission factors in the context of extensive improvements to the premise plumbing systems and cooling towers, an Epi-Aid was requested on July 27, 2016. The CDC Epi-Aid team was deployed August 8–11, 2016 to assist in the investigation.

Methods

Case finding and active surveillance

In collaboration with IDPH, ACHD, and LTCF A staff, the Epi-Aid team reviewed all case finding activities. Several measures had been implemented prospectively to identify cases among LTCF A residents, staff, volunteers, and visitors as well as the surrounding community.

1. Local hospital surveillance records were evaluated to assess trends in all-cause pneumonia diagnoses and to determine if there were increased pneumonia admission rates temporally associated with detection of LD cases at LTCF A. ACHD urged the hospital to proactively report LD cases.
2. LTCF A's prospective pneumonia surveillance of residents was reviewed to identify increases in pneumonia among residents at the facility.
3. Monthly LD case counts for all counties in the state were reviewed (July 2015–July 2016).

To review LTCF A's current protocol for rapid identification of residents with fever and early signs of pneumonia, as well as the facility's diagnostic testing practices for pneumonia, the Epi-Aid team interviewed the facility's medical director, director of nursing, and infection preventionist.

Case definitions

We defined the outbreak period as January 1–August 11, 2016 (the end date of the Epi-Aid investigation). During the Epi-Aid investigation, we used the following case definitions:

1. **Confirmed LD case:** an illness in an individual with (a) pneumonia diagnosed by chest x-ray, (b) laboratory confirmation of *Legionella* infection (a positive *Legionella* urinary antigen test [UAT] or lower respiratory specimen/tissue culture), and (c) exposure to LTCF A in the 10 days prior to symptom onset during the outbreak period.
2. **Definite healthcare-associated LD case:** Confirmed LD in a resident who spent the entire 10 days prior to onset of illness in a building at LTCF A during the outbreak period.
3. **Possible healthcare-associated LD case:** Confirmed LD in a resident, employee, volunteer, or visitor who spent part of the 10 days before symptom onset at LTCF A during the outbreak period.

Descriptive epidemiology

ACHD staff interviewed patients with confirmed LD regarding possible exposures and shared the information with IDPH and CDC's Respiratory Diseases Branch via the Research Electronic Data Capture (REDCap) database, a web application for building and sharing online surveys and databases².

Environmental assessment

A timeline of changes to the campus water systems was created from information elicited during IDPH and LTCF A engineering staff interviews and review of documentation (Figure 1). The contractor's environmental sampling locations and culture results for *Legionella* were overlaid with the timeline of water system changes to identify events that may have precipitated *Legionella* amplification and transmission. Historical data on parameters of water collected at control points and documented contingency responses were reviewed. After synthesizing information from these sources, the team conducted an independent environmental assessment, including testing of water parameters (e.g., maximum hot water temperature, pH, free chlorine level, total chlorine level, and chlorine dioxide level) of the cooling tower and the potable water systems in select buildings to characterize the potential risk of *Legionella* amplification and transmission. The team compared LTCF A's written water management program to the best practices described in the CDC toolkit "Developing a Water Management Program to Reduce *Legionella* Growth and Spread in Buildings," a recently published (June 2016) adaption of ASHRAE Standard 188 (3,4).

Environmental sampling

Based on the team's environmental assessment, as well as a review of both epidemiologic and sampling data from the contractor, the CDC Epi-Aid team collected water samples for *Legionella* culture in select buildings and cooling towers.

Water sampling for *Legionella* was undertaken per previously published protocols (5). One-liter bulk water samples were collected from various points in potable water systems of select buildings, including the hot water

² <https://projectredcap.org/>

boiler, cold water fixture proximal to the main inlet, rooms of residents with LD, and common bathrooms. Water samples were collected from sites representing the water distribution in the potable water system (at least two resident rooms on each floor located distal to the riser pipes delivering hot water from the boiler/storage tank located in the basement)³. These samples were taken from showerheads, bathroom faucets, and/or resident room sinks. Showerhead point-of-use filters were removed before sampling to allow access to the piping interior. Bathroom sink faucet fixtures were easily accessible because all aerators had been removed since 2015. In two instances, samples were also collected from distal sinks bypassing the thermostatic mixing valve and one thermostatic mixing valve was inspected from the sink in the room of a resident with LD. Samples were also collected from the cooling tower.

Half a milliliter of 0.1N sodium thiosulfate was added to each 1-liter bottle to neutralize the disinfectant. In one instance, two samples were collected from a terminal fixture with a bottle including the disinfectant neutralizer and one without to determine if *Legionella* was present despite the presence of disinfectant. Biofilm swabs from the potable water system and cooling tower were collected with Dacron-tipped sterile swabs. Swabs were transported in 3–5 mL water with one drop of sodium thiosulfate. Bulk water samples and swabs were maintained in insulated coolers and sent to CDC's *Legionella* laboratory the day after sample collection.

Laboratory methods

Environmental samples

Environmental samples were cultured for *Legionella pneumophila* at CDC, and isolate serogroup was assessed by slide agglutination testing and direct fluorescence antibody testing (6, 7). Isolates were screened with monoclonal antibodies (MAb) 1 and 2 to determine if they were serogroup 1 and, if so, to provide additional strain-level typing information. All isolates were tested using a 7-gene sequence-based typing scheme to determine sequence type (ST) (8, 9).

³ Please refer to Appendix C for the sampled sites including representative sites from the potable water system.

Ten isolates previously cultured by the contractor and 2 collected from a nearby off-campus cooling tower (identified by ACHD) were sent to CDC for sequence-based typing and comparison.

Results

Case finding and active surveillance

A total of five confirmed LD cases and no deaths were identified in association with LTCF A during January 1–August 12, 2016 (three residents and two on-campus volunteers). In addition to the three cases (two possible healthcare-associated cases in a volunteer and resident and one definite healthcare-associated case in a resident) identified before the Epi-Aid, the team learned of two additional facility-linked cases after arriving:

1. During a review of all reported LD cases in Adams County (from January–July 2016) with ACHD and facility staff, a link to LTCF A was discovered in a previously confirmed LD case from the community. An astute administrator at LTCF A recognized the name of the community case — a current resident who had volunteered before seeking residence at the facility. Despite denying any association to the facility when interviewed by ACHD officials, a retrospective review of volunteer logbooks confirmed that this patient, in fact, volunteered at LTCF A. The volunteer reportedly used the dishwashing sprayer in Smith Hall in the 10 days before symptom onset on March 1, 2016. This case was determined to be the first possible healthcare-associated case for the 2016 outbreak.
2. An additional possible healthcare-associated resident case (with exposure to shower/sinks at off-campus, unoccupied home) was identified by the facility’s active surveillance. On August 1, 2016, the resident on immunosuppressive agents began experiencing fever, weakness, and fatigue, and was diagnosed with radiographically-confirmed pneumonia. This patient was not hospitalized for this illness. The Epi-Aid team was notified of a positive UAT result for this patient on August 9, 2016, during the investigation at the facility.

Based on surveillance data provided by the local hospital, primary and secondary pneumonia diagnoses made during the months of May through August increased each year from 2012 through 2015 (Figure 2).

Approximately one quarter of the hospital's pneumonia cases in August 2015 occurred in LTCF A residents with LD associated with the 2015 outbreak. Stable or declining pneumonia rates at the local hospital during May through July 2016 suggest that there was not a widespread LD outbreak at LTCF A during 2016.

However, pneumonia surveillance data from LTCF A show the number of residents with pneumonia in March 2016 and July 2016 exceeded one standard deviation above a baseline average for those months during the previous 8 years (Figure 3). Based on the increased number of pneumonia diagnoses at LTCF A and the identification of two confirmed LD cases in July 2016, the Epi-Aid team reviewed the facility's pneumonia surveillance for potentially unrecognized cases in this month. LTCF A had continued active clinical surveillance for LD among residents since the 2015 outbreak, which entailed ordering chest x-rays for residents with suspected pneumonia (i.e., those experiencing fever, respiratory signs/symptoms associated with pneumonia, or atypical symptoms such as diarrhea or abdominal pain) and UATs for all residents with radiographically-confirmed pneumonia. Infection prevention and nursing staff held weekly meetings to review all pneumonia cases. In July 2016, 20 residents with radiographically-confirmed pneumonia were identified via facility surveillance; 19 of these received UATs. The Epi-Aid team did not identify additional LD cases in the month of July beyond the two cases previously mentioned. The remaining 17 LTCF A residents with radiographically-confirmed pneumonia in July 2016 had the following diagnoses: gram-positive pathogens identified by sputum cultures (n=2), *Mycoplasma pneumoniae* identified by serology (n=1), and pneumonia/bronchitis not otherwise specified (n=14).

Although collection of lower respiratory tract specimens for *Legionella* culture was recommended by public health officials after the 2015 outbreak, the current practices of local healthcare providers have hindered implementation. For example, in July 2016, sputum cultures were obtained for only 2 of 20 residents diagnosed with pneumonia. Furthermore, LTCF A staff reported concern that perhaps UATs were not being ordered when indicated by local healthcare providers external to the facility. UAT continues to be unavailable locally; all urine specimens are tested at an out-of-state, contract laboratory, resulting in delayed clinical diagnosis, public health confirmation of disease (by 4–7 days) and, potentially, delayed outbreak recognition.

Descriptive epidemiology

Residents and volunteers with confirmed LD ranged in age from 78 to 94 years; four were male, two had an immunocompromising condition, and one had a chronic lung disease (Table 1).

Initial case investigations completed by ACHD indicated that each resident with LD was housed in a different building and had no obvious exposures in common (Figure 4). Two of three residents with LD had exposure to therapy tubs located in different buildings 10 days before their symptom onset. Upon review of previously obtained environmental sampling results, the Epi-Aid team found that a therapy tub had a positive *Legionella* culture within days of a possible exposure of one case resident. It was also noted that *Legionella* culture-positive results had been repeatedly obtained from a sink faucet in an unoccupied room adjacent to the room of another case resident. All three resident cases had exposures to their in-room sink faucets. Two of the three residents reported potential off-campus exposures 10 days before their symptom onset (Table 2).

Both facility volunteers with LD had possible exposures outside of campus, but also reported a shared exposure to the dishwasher's sprayer in Smith Hall (Table 2). Review of the water management team's sampling results indicated that the dishwashing sprayer grew *Legionella* on March 30, 2016 and April 12, 2016 (days before the second volunteer case's exposure) after testing negative in February and early March 2016.

Environmental assessment

The Epi-Aid team conducted environmental assessments on buildings that housed the 3 residents with LD, buildings with past *Legionella* positive cultures, Smith Hall, an additional building with predominantly negative water cultures, and the facility's cooling towers. The team's findings regarding key parameters related to potential *Legionella* growth and transmission were as follows:

Temperatures	Hot water temperatures in the buildings' recirculating systems were adequate: before the mixing valves (136–143°F) and at point-of-use after the mixing valves (97.9–108.5°F).
Disinfectant levels	Residual disinfectant in the potable water system were adequate: pH (5.5–7.0), free chlorine (0.7–4.5 mg/L), total chlorine (0.7–4.9 mg/L), and chlorine dioxide (0.0–0.4

mg/L). Data from the Epi-Aid team's testing and a review of previous parameter measurements indicated that free chlorine levels routinely exceeded 3.5 mg/L (the maximum limit of detection on the color-wheel test kit used by LTCF A staff). With disinfectant levels near the upper limit of the Environmental Protection Agency's (EPA) maximum contaminant level in the potable water, the potential for corrosion exists, particularly in buildings with old galvanized pipes. IDPH, in collaboration with Illinois EPA, monitors corrosive parameters (i.e., iron levels) periodically. Most recent results indicate normal corrosive parameters.

A pungent odor from a combination of disinfectant cleaners (quaternary disinfectant cleaner and bleach) was noted by the Epi-Aid team while observing the process of disinfecting a therapy tub no longer in use; the facility was advised to follow the disinfectant manufacturer's recommendations, and if needed, consult with the chemical disinfectant supplier.

Water stagnation	Low resident occupancy noted in some buildings could contribute to increased risk of <i>Legionella</i> growth due to decreased water flow within the system. Per the contingency response first implemented in September 2015, the Epi-Aid team observed maintenance, housekeeping, or nursing staff perform daily flushing in low-occupancy floors and unoccupied resident buildings.
Presence of free-living protozoa, biofilm, scale, and sediment in piping	<p>Maintenance staff identified extensive sedimentation and biofilm in the 100+ year-old galvanized pipes. These pipes distribute potable water within the facility's residential buildings and continue to be associated with persistent positive <i>Legionella</i> culture results from point-of-use fixtures. Newer buildings with mostly negative culture results (e.g., Markwood and Fifer) have copper pipes.</p> <p>Sedimentation and biofilm were observed on the Smith Hall dishwashing sprayer hose, which had not been replaced since the previous outbreak. Interviews with maintenance staff ascertained that daily hot water flushing of the dishwasher sprayer occurred only on Mondays through Saturdays.</p>
External sources (e.g., construction)	Extensive changes to water systems occurred in response to the first outbreak and may have resulted in water pressure changes (see Introduction, page 4 for details).

Other findings Although therapy tubs were a possible source exposure for two of three case residents, they were not sampled because the facility had since discontinued use, eliminating the exposure risk going forward. To prevent water stagnation, daily flushing of therapy tubs continues until all tubs are replaced with new soaking tubs, which do not have jets that potentially aerosolize water.

LTCF A's written water management program aligned with the best practices identified in CDC's water management toolkit (4). Control measures, control limits, and control points, were routinely identified and corrective actions consistently taken. The program included contingency responses, verification and validation procedures, routine program review, and communication procedures. During the Epi-Aid investigation, the team observed the implementation of the program through daily flushing and disinfection checks by nursing and engineering staff and by auditing logbooks for evidence of cooling tower maintenance, daily flushing, disinfection, and point-of-use filter changes. The team further observed real-time application of contingency responses to potential exposure risks at facility after immediate identification of a resident case on August 9, 2016.

Laboratory results

All confirmed cases had positive UAT results tested at the contract private laboratory. Sputum cultures were not collected for any of the cases.

Of 42 bulk water samples and 27 swabs collected August 9–11, 2016, one bulk water sample from a resident room that was adjacent to a case resident's room was culture-positive for *Legionella pneumophila* serogroup 1, and also Mab-1 and Mab-2 positive. MAb reactivity provides additional typing information of serogroup 1 isolates⁴; all serogroup 1 isolates are MAb1 positive, and MAb2 is a marker for strains more often associated with LD outbreaks. *Legionella* did not grow from the water sample that did not include the sodium thiosulfate additive. The isolate's molecular sequence type (ST36) matched the ST isolated in clinical and environmental isolates from the 2015 outbreak. Ten previously cultured water sample isolates collected (April 25–July 19, 2016) by the

⁴ Please refer to Appendix B for final lab report of all environmental results from Epi-Aid investigation and from ten isolates provided by private contractor.

environmental contractor were also ST36, including a sample from the same adjacent resident room mentioned above³. An isolate recovered from the nearby off-campus cooling tower was ST1, similar to the only other ST found in one on-campus cooling tower from the 2015 outbreak. ST1 is the most common ST found in the environment, often causing sporadic LD cases; it is not among the STs most commonly associated with outbreaks in the United States (10).

Discussion

Since the 2015 outbreak, significant remediation efforts undertaken by LTCF A have substantially reduced the presence of *Legionella* in the potable water system. Based on observations during the Epi-Aid investigation, the water management program was fully implemented, followed, and continuously reviewed by the water management team to optimize the water systems.

In spite of the progress, the potable water system continued to pose a potential risk for *Legionella* growth and transmission. Although the sampling of the Smith Hall kitchen sprayer was negative before the first volunteer cases' exposure, epidemiologic and water sampling data raise the possibility that the two volunteers with confirmed LD may have been exposed to *Legionella* via the Smith Hall kitchen sprayer. It is also possible that 1 resident with confirmed LD may have been exposed to *Legionella* via a therapy tub. The two most recent LD cases, which included one definite healthcare-associated case, occurred in residents who had possible exposures to the potable water system via in-room sinks. Both residents lived in buildings that had older galvanized pipes and persistent *Legionella* positive results from sinks, despite adequate chlorination and hot water temperatures. We hypothesize that the sloughing of biofilm within the potable water systems was still occurring, given the evidence of extensive biofilm and sedimentation in old pipes and by the fouling of thermostatic mixing valves noted in their sink faucets.

The water management program, including contingency responses, should continue to be reviewed and modified to reduce the risk of *Legionella* amplification and transmission, especially when environmental samples taken from the same sampling location consistently test positive for *Legionella* or new cases occur. Engineering controls could be considered if indicated by concerning trends in clinical or environmental results. Furthermore,

active clinical surveillance should continue to be improved so that along with UATs, lower respiratory specimens are attempted/collected on all patients with symptoms suggestive of LD. It is important to partner with local hospitals and recommend enhanced capacity for UAT testing in order to reduce the time required to receive UAT results.

In conclusion, the 2016 Legionnaires' disease outbreak at LTCF A was likely attributable to conditions favorable to the amplification and transmission of *Legionella* in the potable water system. In the setting of a 100+ year-old facility, achieving non-detectable *Legionella* levels or completely eradicating *Legionella* is very challenging and optimal control will require time and persistence. To help prevent further cases, efforts to preemptively identify risks with the potable water system and establishment of contingency responses should continue.

Recommendations

The following recommendations are aimed at reducing the risk of *Legionella* growth in the potable water system, reducing the risk of transmission to residents, staff, volunteers or visitors, and improving the current active clinical surveillance and diagnostic practices at the facility.

Recommendations for ACHD

1. Consider providing training to local healthcare providers regarding Legionnaires' disease presentation and importance of collecting urine for UAT and lower respiratory specimens for culture (including induced sputum cultures, if necessary and when medically appropriate).
2. Facilitate the reduction in the time required to receive results of *Legionella* testing for pneumonia patients by recommending the local hospitals build capacity for on-site UAT (rapid antigen detection test) and culturing *Legionella* from lower respiratory specimens.
3. Continue rapidly investigating confirmed cases of legionellosis among Adams County residents to identify potential exposures at LTCF A.

Recommendations for IDPH

4. Facilitate the reduction in the time required to receive results of *Legionella* testing on pneumonia patients by recommending local hospitals build capacity for on-site UAT (rapid antigen detection test) and

culturing *Legionella* from lower respiratory specimens, or by pursuing collaboration opportunities with laboratories that offer reduced turnaround time for UAT results.

Clinical surveillance recommendations for LTCF A

5. Continue active clinical surveillance for Legionnaires' disease among residents for at least 2–6 months following identification of a possible healthcare-associated case at LTCF A.
 - a. Order chest x-rays in patients with symptoms compatible with Legionnaires' disease.
 - b. Conduct a daily review of ordered chest x-rays to rapidly identify patients with pneumonia.
6. Continue pneumonia surveillance on all persons with radiographically-confirmed pneumonia and update counts of new onsets of pneumonia among residents on a weekly basis; if an increase above baseline is observed:
 - a. Notify ACHD.
 - b. Conduct further diagnostic testing to identify the etiologic agent (i.e., sputum cultures, TaqMan array card [TAC] testing through the CDC's unexplained respiratory disease outbreak [URDO] program).
7. Reflexively order sputum (or other lower respiratory specimen) cultures and UAT for all patients with clinically- or radiographically-confirmed pneumonia among patients at risk (<https://www.cdc.gov/vitalsigns/pdf/2016-06-vitalsigns.pdf>). Lower quality sputum specimens (i.e., with epithelial cells) can still be used to culture *Legionella* if the receiving lab is notified.

Environmental recommendations to water management team

Water Management Program:

8. Continue adapting contingency responses to address identified risks for *Legionella* growth and transmission.
9. If concerning trends in clinical or environmental results are identified, consider implementation of additional engineering controls.
10. Continue weekly interdisciplinary water management team meetings including infection prevention staff.

11. Consider checking thermostatic mixing valves for fouling following positive environmental test results from the associated fixture. If contamination is present, clean or replace mixing valve accordingly.
12. Continue follow-up and communication with all personnel to ensure staff are trained and implementing the flushing protocol per the water management program.
 - a. Encourage continued daily flushing of low flow buildings, particularly vacant rooms and unoccupied floors.
 - b. Consider adding Smith Hall to the Sunday flushing schedule.
13. Ensure the water management protocol is followed to sample adjacent fixtures of locations that have positive *Legionella* cultures to better characterize the risk in the building water system.
14. Ensure timely and appropriate documentation is maintained in logbooks and water management program database.
15. Continue improved operation and maintenance of cooling tower as observed during the investigation.

Water Sampling and Chemical Parameters:

16. Continue monitoring to ensure adequate residual disinfectant levels; also note the EPA maximum contaminant levels (MCL) for drinking water:
 - a. Chlorine: 4.0 mg/L
 - b. Chlorine dioxide: 0.8 mg/L
17. Continue monitoring corrosive parameters (i.e., iron levels) of pipes in campus water systems with IDPH and Illinois EPA instruction and support.
18. Consider use of extended range sampling method (0–10 mg/L) for free chlorine levels when color-wheel technique reaches 3.5 mg/L free chlorine (maximum reading capability).
19. Due to the possibility that fouling of thermostatic mixing valves (i.e., contamination with scale, sediment, and biofilm) may be a potential risk of *Legionella* transmission, consider modifying *Legionella* sampling procedure in the water management program to also include cold water samples with the mixing valve bypassed.

20. Consider measuring water parameters (residual disinfectant levels, pH, and temperature) at *Legionella* water sampling locations to allow for further analysis of sites with persistent positive cultures.
21. Consider adding more monitoring points (proximal and distal to water main) to ensure representative sampling in each building.
22. Consider capturing location description information for environmental samples as discrete variables (i.e., adding separate columns for building name, wing, room number, fixture type, hot vs. cold, bulk vs. swab, and whether associated with a potential exposure) in environmental sampling reports to allow for easier data/trend analysis.

Equipment:

23. Replace the dishwashing sprayer and hose at Smith Hall as the biofilm and sediment formation observed may increase risk of *Legionella* transmission; consider periodic evaluation of the Smith Hall sprayer hose for contamination and replace accordingly. Since the dishwashing sprayer is a recognized source of aerosolized water, persons at increased risk for developing Legionnaires' disease should be advised to avoid use.

People:

24. Continue inclusion of infection prevention staff in water management team to facilitate timely communication of potential exposure risks for patients diagnosed with pneumonia.
25. Continue training and routine audits to ensure staff are following procedures as instructed in the water management program.

Investigation collaborators

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Figures

Figure 1. Confirmed Legionnaires' disease cases by date of symptom onset with select dates of interventions shown — LTCF A, Quincy, Illinois, 2016

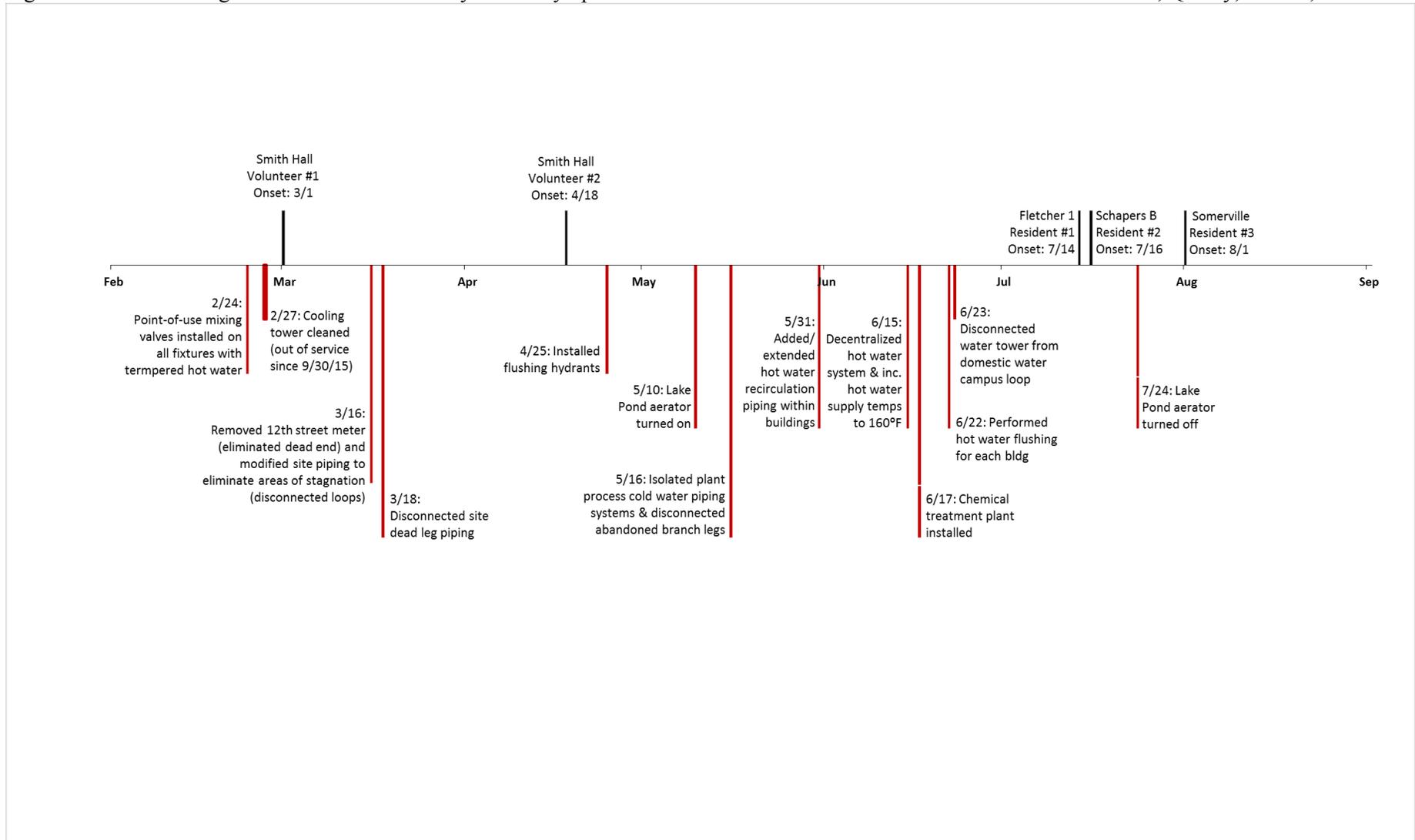
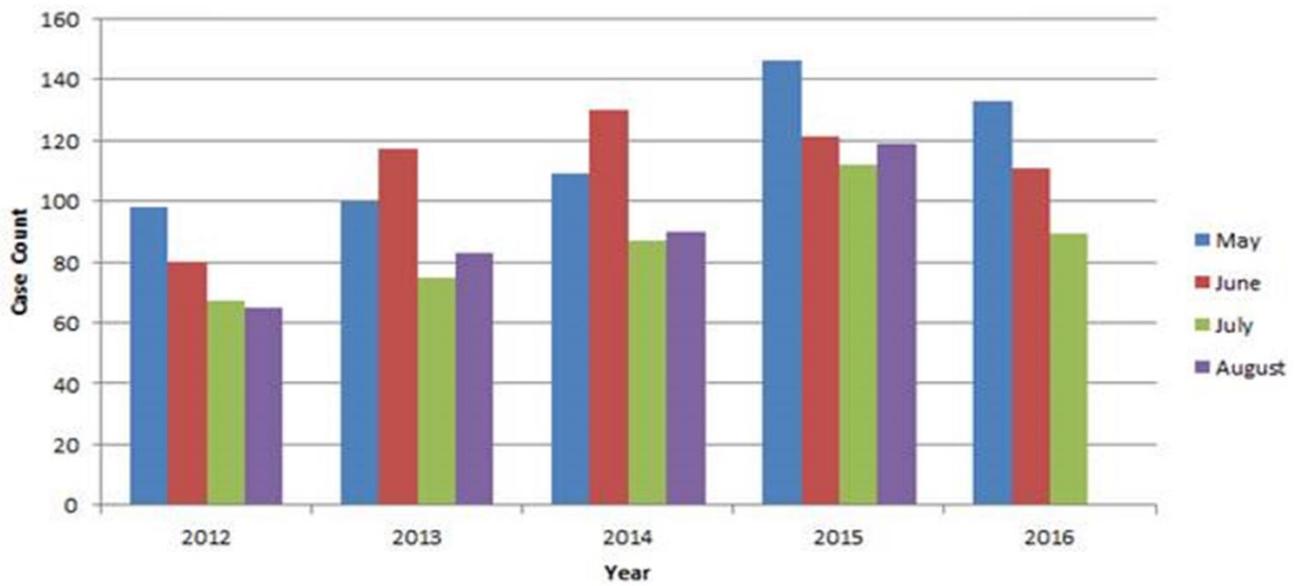


Figure 2. Pneumonia diagnoses at local hospital — Quincy, Illinois, 2012–2016



*Graph obtained from local hospital

Figure 3. Monthly pneumonia diagnoses at LTCF A — Quincy, Illinois, January 2009–July 2016

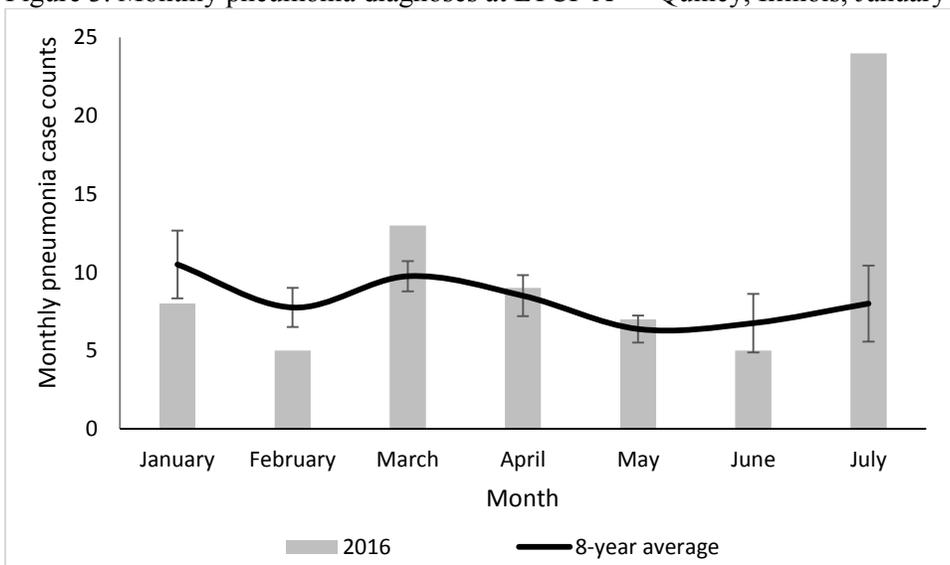
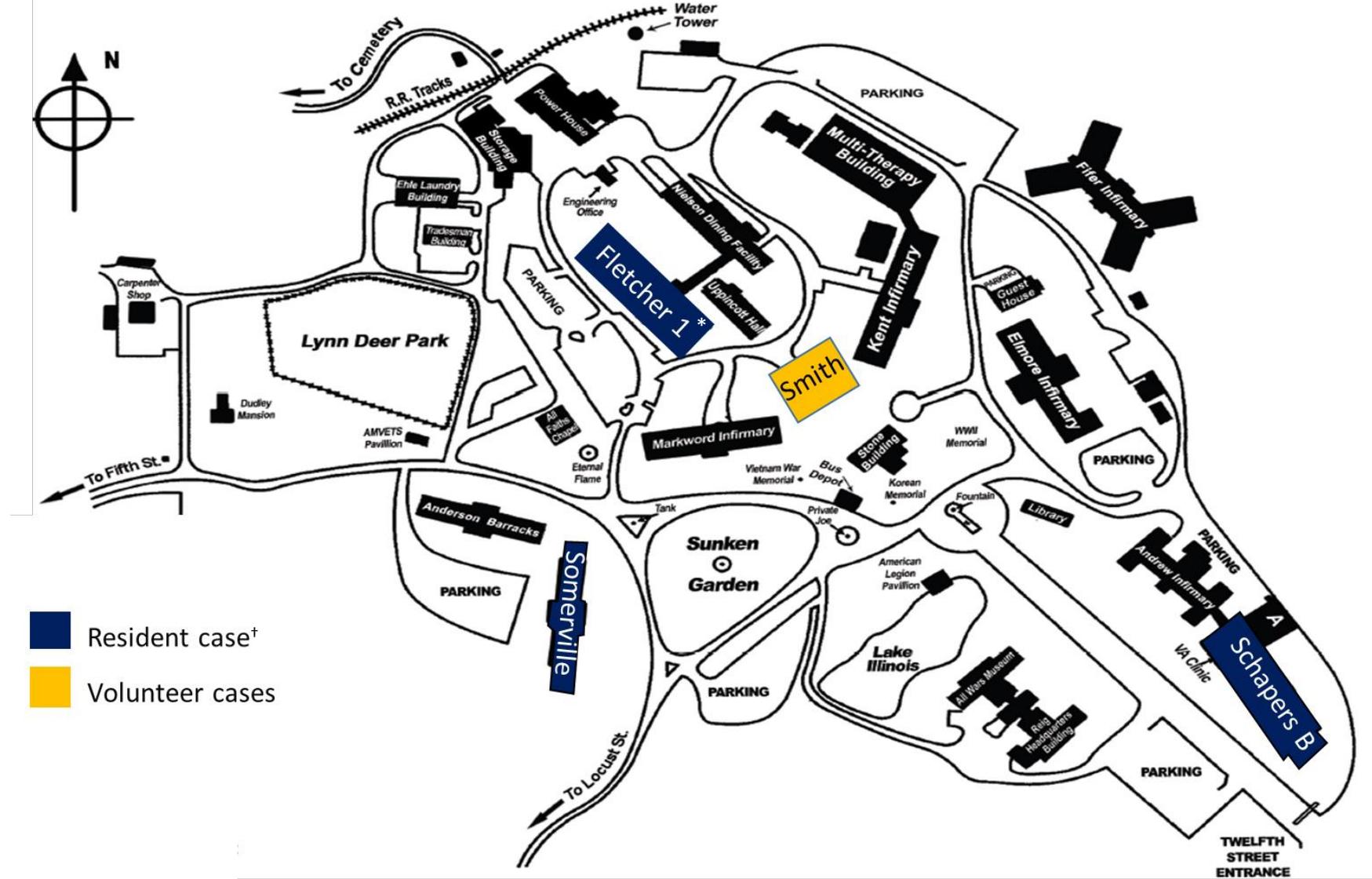


Figure 4. Relative location of facility buildings by presence of resident and staff Legionnaires' disease cases at LTCF A — Quincy, Illinois, 2016



* Fletcher 1 represents the first floor of the building

† 2 case-volunteers reported a common exposure to a dishwasher sprayer in Smith Hall

Tables

Table 1. Select characteristics of confirmed Legionnaires' disease (LD) cases — LTCF A, Quincy, Illinois, January 1, 2016–August 12, 2016

Characteristic	LD Case N (%)
Total cases	5
Age in years, range	78–94
Male	4 (80)
Immunocompromised*	2 (40)
Chronic lung disease†	1 (20)
Current smoker	0
Difficulty swallowing	0
Hospitalization	4 (80)
Death	0

*Immunocompromised hosts are people with cancer, diabetes, kidney failure, and drugs that suppress the immune system

†Chronic lung disease includes chronic obstructive pulmonary disease and emphysema

Table 2. Legionnaires' disease case possible exposure history during 2–10 days before symptom onset — LTCF A, Quincy, Illinois, 2016

Case	Date of symptom onset	Building of residence/ exposure	Tub	Room sink	Shower	Nebulizer treatment	Off-campus
Volunteer 1	03/01/16	Smith	No	Yes	No	No	Yes
Volunteer 2	04/18/16	Smith	No	Yes	No	No	Yes
Resident 1	07/14/16	Fletcher 1	Yes	Yes	No	No	Yes
Resident 2	07/16/16	Schapers B	Yes	Yes	No	No	No
Resident 3	08/01/16	Somerville	No	Yes	Yes	No	Yes

Table 3. Source of *L. pneumophila* in environmental samples and characterization of isolates — LTCF A, Quincy, Illinois, August 2016

Sample Location* (no. of positive samples)	<i>L. pneumophila</i> serogroup	Sequence type (ST)
Somerville (3)	1	36
Fletcher 1† (5)	1	36
Fletcher 2† (1)	1	36
Schapers B (1)	1	36
Smith Hall (1)	1	36
Off-campus cooling tower	1	1

* 10 of 11 of positive samples collected by private contractor with *Legionella* experience

† Fletcher 1 represents the 1st floor of the Fletcher residential building and Fletcher 2 represents the 2nd floor

References

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Appendix A. LTCF A campus buildings' characteristics

STATE ID	INH ID	BUILDING NAME	DATE BUILT	GRS SQ. FEET	FLOORS	BELOW GRADE	INSPECTED FM
W0600	37	LIPPINCOTT HALL	1939	19,924	3	1	
W0601	5	BUS STATION	1935	264	1		
W0602	47	HOUSEMAN'S QUARTERS	1886	152	1		
W0603	31	NORTHERN GUEST HOUSE	1886	6,949	2		
W0604	35	OLD ADMINISTRATION	1886	17,115	4	1	
W0605	41	EQUIPMENT STORAGE	1886	24,889	4	1	
W0606	30	LIBRARY	1905	5,910	2		
W0607	37	8TH STREET GATEHOUSE	1935	370	1		
W0608	11	ROLAND BARRACKS	1907	5,825	2		
W0610	20	SOMERVILLE DOMICILIARY	1909	38,680	4	1	
W0611	21	FOGG BARRACKS	1935	4,395	2		
W0612	22	ANDERSON BARRACKS	1909	38,680	4	1	
W0613	36	SMITH HALL	1935	18,288	2	1	
W0614	34	MEDICAL STAFF BUILDING	1912	3,464	3	1	
W0615	40	POWER PLANT	1886	17,004	2	1	
W0616	33	6-BAY GARAGE	1946	1,885	1		
W0617	29	REIC - ADMINISTRATION	1936	20,188	2	1	
W0618	26	FLETCHER	1954	32,922	3	1	
W0621	28	ANDREW BARRACKS	1936	20,188	2	1	
W0622	43	SUPERINTENDENT'S RESIDENCE	1886	9,203	3	1	
W0623	42	TRADESMAN WORKSHOP	1948	3,805	1		
W0624	50	GREENHOUSE	1886	50	1		
W0626	54	STORAGE BUILDING	1955	1,036	1		
W0627	49	CARPENTER SHOP	1955	7,104	2		
W0628	53	LUMBER SHED	1940	2,858	1		
W0631	48	5TH STREET GATEHOUSE	1886	190	1		
W0632	31	STORAGE/CAVE	1885	767	1	1	
W0635	58	NEW TRUCK GARAGE	2011	6,000	1		
W0639		SEXTON'S BUILDING	1885	184	2	1	DEMOLISHED
W0634	38	ENGINEERING BUILDING	1911	2,825	3	1	
W0637	24	8-BAY GARAGE	1951	924	1		
W0638	30	BUS GARAGE	1951	764	1		
W0641	46	DEER FEED SHED			1		
W0643	92	NELSON DINING/KITCHEN/STORE	1963	40,929	3	1	
W0644	93	SCHAPERS HOSPITAL	1963	35,716	2	1	
W0645	89	EHLE LAUNDRY	1963	9,120	2	1	
W0646	94	ELMORE INFIRMARY	1963	34,128	3	1	
W0647	90	MARKWORD INFIRMARY	1964	27,504	3	1	
W0649	97	ALL FAITHS CHAPEL	1972	5,357	1		
W0650	91	KENT INFIRMARY	1972	58,850	4	1	
W0651	59	KOCH CEMETERY BUILDING	1986	2,048	1		
W0652	45	CONDENSATE PUMP HOUSE	1955	49	1		
W0653	32	SECURITY ANNEX	1927	4,800	3	1	
W0654	39	LAWN GARAGE	1886	4,169	1		
W0655	26&92	INTERCONNECT		853	1		
W0656		TUNNEL SYSTEM	1885	27,250	1	1	
W0657		WOOD FRAME STORAGE		156	1		
W0658	98	AMERICAN LEGION RECREATION BUILDING	1989	2,960	1		
W0659	99	AMVETS DEER PARK PAVILLION	1989	736	1		
W0660	100	MULTI-PURPOSE THERAPY BUILDING	1995	41,100	2	1	
W0661	101	FIFER SKILLED CARE FACILITY	2002	43,077	2	1	

Appendix B. Environmental sample results from Epi-Aid and select specimens from environmental contractor



Centers for Disease Control & Prevention Legionella



Outbreak: IL16-1

Project ID	DASH #	Collected	Processed	Sample Data Description	Test Results	Specimen Type	Comments
F-4605	3015353005	07/19/2016	08/10/2016	Isolate-Somerville 203 Sink Hot/ PASL# 141362	F-4605-c1 Final Identification = LP 1, [2]=pos		
F-4606	3015353006	07/19/2016	08/10/2016	Isolate-Fletcher 2 Left Sink Hot/ PASL# 141353	F-4606-c1 Final Identification = LP 1, [2]=pos		
F-4607	3015353007	06/14/2016	08/10/2016	Isolate-Fletcher Fl 1 Rm 7 R Sink Hot/ PASL# 136648	F-4607-c1 Final Identification = LP 1, [2]=pos		
F-4608	3015353008	06/14/2016	08/10/2016	Isolate-Fletcher Fl 1 Rm 5 R Sink Hot/ PASL# 136639R	F-4608-c1 Final Identification = LP 1, [2]=pos		
F-4609	3015353009	06/14/2016	08/10/2016	Isolate-Fletcher Fl 1 Rm 3 Sink Hot/ PASL# 136635	F-4609-c1 Final Identification = LP 1, [2]=pos		
F-4610	3015353010	06/14/2016	08/10/2016	Isolate-Fletcher Fl 1 Rm 2 L Sink Hot/ PASL# 136626	F-4610-c1 Final Identification = LP 1, [2]=pos		
F-4611	3015353011	06/07/2016	08/10/2016	Isolate-Somerville 118 Sink Cold/ PASL# 135613R	F-4611-c1 Final Identification = LP 1, [2]=pos		
F-4612	3015353012	06/07/2016	08/10/2016	Isolate-Smith Hall 1 Well Sink Cold/ PASL# 135543	F-4612-c1 Final Identification = LP 1, [2]=pos		
F-4613	3015353013	05/24/2016	08/10/2016	Isolate-Schapers B Tub Hot/ PASL# 133481	F-4613-c1 Final Identification = LP 1, [2]=pos		
F-4614	3015353014	04/25/2016	08/10/2016	Broth-Elmore 127 Sink Hot/PASL# 127471	Final Identification = No Legionella Isolated		The broth submitted for culture is non-vit
IL16-1-001	3015352951	08/09/2016	08/11/2016	Sommerville, 202, sink, hot blended (case)	Final Identification = No Legionella Isolated	Water	
IL16-1-002	3015352952	08/09/2016	08/11/2016	Sommerville, 202, sink, cold blended (case)	Final Identification = No Legionella Isolated	Water	
IL16-1-003	3015352953	08/09/2016	08/11/2016	Sommerville, 202, sink	Final Identification = No Legionella Isolated	Swab	



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Legionella**



Outbreak: IL16-1

<u>Project ID</u>	<u>DASH #</u>	<u>Collected</u>	<u>Processed</u>	<u>Sample Data Description</u>	<u>Test Results</u>	<u>Specimen Type</u>	<u>Comments</u>
IL16-1-004	3015352954	08/09/2016	08/11/2016	Sommerville, 2nd fl, womens bathrm, showerhead, pre-filter	Final Identification = No <i>Legionella</i> Isolated	Water	
IL16-1-005	3015352955	08/09/2016	08/11/2016	Sommerville, 2nd fl, womens bathrm, showerhead, post-filter	Final Identification = No <i>Legionella</i> Isolated	Water	
IL16-1-006	3015352956	08/09/2016	08/11/2016	Sommerville, 2nd fl, womens bathrm, showerhead, distal hose	Final Identification = No <i>Legionella</i> Isolated	Swab	
IL16-1-007	3015352957	08/09/2016	08/11/2016	Sommerville, 2nd fl, womens bathrm, showerhead, filter	Final Identification = No <i>Legionella</i> Isolated	Swab	
IL16-1-008	3015352958	08/09/2016	08/11/2016	Sommerville, 2nd fl, womens bathrm, showerhead, spigot	Final Identification = No <i>Legionella</i> Isolated	Swab	
IL16-1-009	3015352959	08/09/2016	08/11/2016	Sommerville, 2nd fl, womens bathrm, L sink, hot blend	Final Identification = No <i>Legionella</i> Isolated	Water	
IL16-1-010	3015352960	08/09/2016	08/11/2016	Sommerville, 203, sink, hot blend, + thio (previous +)		Water	
IL16-1-010			08/11/2016		IL16-1-010-c1 Final Identification = LP 1, [2]=pos	Water	
IL16-1-011	3015352961	08/09/2016	08/11/2016	Sommerville, 203, sink, hot blend, - thio (previous +)	Final Identification = No <i>Legionella</i> Isolated	Water	
IL16-1-012	3015352962	08/09/2016	08/11/2016	Sommerville, 203, sink (replaced), (previous +)	Final Identification = No <i>Legionella</i> Isolated	Swab	
IL16-1-013	3015352963	08/09/2016	08/11/2016	Sommerville, 132, sink, hot blend	Final Identification = No <i>Legionella</i> Isolated	Water	
IL16-1-014	3015352964	08/09/2016	08/11/2016	Sommerville, 132, sink	Final Identification = No <i>Legionella</i> Isolated	Swab	
IL16-1-015	3015352965	08/09/2016	08/11/2016	Sommerville, 203, sink cold	Final Identification = No <i>Legionella</i> Isolated	Water	
IL16-1-016	3015352966	08/09/2016	08/11/2016	Sommerville, hot water storage tank #1	Final Identification = No <i>Legionella</i> Isolated	Water	
IL16-1-017	3015352967	08/09/2016	08/11/2016	Sommerville, basement, cold proximal to main	Final Identification = No <i>Legionella</i> Isolated	Water	
IL16-1-018	3015352968	08/09/2016	08/11/2016	Anderson, 101, sink, hot blend	Final Identification = No <i>Legionella</i> Isolated	Water	
IL16-1-019	3015352969	08/09/2016	08/11/2016	Anderson, 101, sink	Final Identification = No <i>Legionella</i> Isolated	Swab	
IL16-1-020	3015352970	08/09/2016	08/11/2016	Anderson, 203, sink, cold, bypass mixer	Final Identification = No <i>Legionella</i> Isolated	Water	
IL16-1-021	3015352971	08/09/2016	08/11/2016	Anderson, hot water storage tank	Final Identification = No <i>Legionella</i> Isolated	Water	



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Outbreak: IL16-1

<u>Project ID</u>	<u>DASH #</u>	<u>Collected</u>	<u>Processed</u>	<u>Sample Data Description</u>	<u>Test Results</u>	<u>Specimen Type</u>	<u>Comments</u>
IL16-1-022	3015352972	08/09/2016	08/11/2016	Anderson, basement, cold proximal to main	Final Identification = No Legionella Isolated	Water	
IL16-1-023	3015352973	08/10/2016	08/11/2016	Schapers B lobby mens bathrm sink hot blended	Final Identification = No Legionella Isolated	Water	
IL16-1-024	3015352974	08/10/2016	08/11/2016	Schapers B lobby mens bathrm sink hot blended	Final Identification = No Legionella Isolated	Swab	
IL16-1-025	3015352975	08/10/2016	08/11/2016	Schapers B107, sink, cold bypass mixer (previous +)	Final Identification = No Legionella Isolated	Water	
IL16-1-026	3015352976	08/09/2016	08/11/2016	Anderson, 203, sink, hot blend	Final Identification = No Legionella Isolated	Water	
IL16-1-027	3015352977	08/09/2016	08/11/2016	Anderson, 203, sink	Final Identification = No Legionella Isolated	Swab	
IL16-1-028	3015352978	08/10/2016	08/11/2016	Schapers B107, sink, hot blended (previous +)	Final Identification = No Legionella Isolated	Water	
IL16-1-029	3015352979	08/10/2016	08/11/2016	Schapers B107, sink	Final Identification = No Legionella Isolated	Swab	
IL16-1-030	3015352980	08/10/2016	08/11/2016	Schapers B120, hot blended (case)	Final Identification = No Legionella Isolated	Water	
IL16-1-031	3015352981	08/10/2016	08/11/2016	Schapers B120 (case)	Final Identification = No Legionella Isolated	Swab	
IL16-1-032	3015352982	08/10/2016	08/11/2016	Schapers A1, sink, blended hot	Final Identification = No Legionella Isolated	Water	
IL16-1-033	3015352983	08/10/2016	08/11/2016	Schapers A1, sink	Final Identification = No Legionella Isolated	Swab	
IL16-1-034	3015352984	08/10/2016	08/11/2016	Schapers basement, hot water heater	Final Identification = No Legionella Isolated	Water	
IL16-1-051	3015352985	08/10/2016	08/11/2016	Smith, dishwasher sink hot blended	Final Identification = No Legionella Isolated	Water	
IL16-1-052	3015352986	08/10/2016	08/11/2016	Smith, #3 well sink, hot blended	Final Identification = No Legionella Isolated	Water	
IL16-1-053	3015352987	08/10/2016	08/11/2016	Smith, dishwasher sink (proximal end)	Final Identification = No Legionella Isolated	Swab	
IL16-1-054	3015352988	08/10/2016	08/11/2016	Smith, #3 well sink	Final Identification = No Legionella Isolated	Swab	
IL16-1-055	3015352989	08/10/2016	08/11/2016	Smith, #1 well sink	Final Identification = No Legionella Isolated	Swab	



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Legionella**



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<u>Project ID</u>	<u>DASH #</u>	<u>Collected</u>	<u>Processed</u>	<u>Sample Data Description</u>	<u>Test Results</u>	<u>Specimen Type</u>	<u>Comments</u>
IL16-1-056	3015352990	08/10/2016	08/11/2016	Smith, #3 well sink, cold blended	Final Identification = No Legionella Isolated	Water	
IL16-1-057	3015352991	08/10/2016	08/11/2016	Smith, #1 well sink, cold bypass mixer	Final Identification = No Legionella Isolated	Water	
IL16-1-058	3015352992	08/10/2016	08/11/2016	Smith, #1 well sink, hot blended	Final Identification = No Legionella Isolated	Water	
IL16-1-059	3015352993	08/10/2016	08/11/2016	Smith, Basement, hot water heater (Left)	Final Identification = No Legionella Isolated	Water	
IL16-1-060	3015352994	08/10/2016	08/11/2016	Smith, Basement, hot water heater (Right)	Final Identification = No Legionella Isolated	Water	
IL16-1-061	3015352995	08/10/2016	08/11/2016	Fletcher, 1-2, bathrm, sink, left, hot blended	Final Identification = No Legionella Isolated	Water	
IL16-1-062	3015352996	08/10/2016	08/11/2016	Fletcher, 1-2, bathrm, sink, left (hot faucet)	Final Identification = No Legionella Isolated	Swab	
IL16-1-063	3015352997	08/10/2016	08/11/2016	Fletcher, 1-2, bathrm, shower, pre-filter, hot	Final Identification = No Legionella Isolated	Water	
IL16-1-064	3015352998	08/10/2016	08/11/2016	Fletcher, 1-2, bathrm, shower, pre-filter	Final Identification = No Legionella Isolated	Swab	
IL16-1-065	3015352999	08/10/2016	08/11/2016	Fletcher, 1-2, bathrm, sink, right (hot faucet)	Final Identification = No Legionella Isolated	Swab	
IL16-1-066	3015353000	08/10/2016	08/11/2016	Fletcher, 2-12, bathrm, sink, right, hot blended	Final Identification = No Legionella Isolated	Water	
IL16-1-067	3015353001	08/10/2016	08/11/2016	Fletcher, 2-12, bathrm, sink, right (hot faucet)	Final Identification = No Legionella Isolated	Swab	
IL16-1-068	3015353002	08/10/2016	08/11/2016	Fletcher, 2-16, bathrm, sink, right, hot	Final Identification = No Legionella Isolated	Water	
IL16-1-069	3015353003	08/10/2016	08/11/2016	Fletcher, 2-16, bathrm, sink, right, hot faucet	Final Identification = No Legionella Isolated	Swab	
IL16-1-070	3015353004	08/10/2016	08/11/2016	Fletcher, basement, hot water storage tank	Final Identification = No Legionella Isolated	Water	
IL16-1-101	3015353034	08/10/2016	08/12/2016	Markword Basement (L) Hot water heater 1551M003528	Final Identification = No Legionella Isolated	Water	
IL16-1-102	3015353035	08/10/2016	08/12/2016	Markword Basement (R) Hot water heater 1551M003533	Final Identification = No Legionella Isolated	Water	
IL16-1-103	3015353036	08/10/2016	08/12/2016	Markword room 205/203 shared sink	Final Identification = No Legionella Isolated	Water	



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<u>Project ID</u>	<u>DASH #</u>	<u>Collected</u>	<u>Processed</u>	<u>Sample Data Description</u>	<u>Test Results</u>	<u>Specimen Type</u>	<u>Comments</u>
IL16-1-104	3015353037	08/10/2016	08/12/2016	Markword room 205/203 shared sink	Final Identification = No Legionella Isolated	Water	
IL16-1-105	3015353038	08/10/2016	08/12/2016	Markword room 205/203 shared sink	Final Identification = No Legionella Isolated	Swab	
IL16-1-106	3015353039	08/10/2016	08/12/2016	Markword Nurses Lounge sink	Final Identification = No Legionella Isolated	Water	
IL16-1-107	3015353040	08/10/2016	08/12/2016	Markword Nurses Lounge sink	Final Identification = No Legionella Isolated	Water	
IL16-1-108	3015353041	08/10/2016	08/12/2016	Markword Nurses Lounge sink	Final Identification = No Legionella Isolated	Swab	
IL16-1-109	3015353042	08/11/2016	08/12/2016	Smith Hall Kitchen Dishwaster sink-hard plumbing behind hose	Final Identification = No Legionella Isolated	Swab	
IL16-1-110	3015353043	08/11/2016	08/12/2016	Anderson Room 230 Resident room sink	Final Identification = No Legionella Isolated	Swab	
IL16-1-111	3015353044	08/11/2016	08/12/2016	Fletcher 3 tubroom sink mixing valve	Final Identification = No Legionella Isolated	Swab	
IL16-1-112	3015353045	08/11/2016	08/12/2016	C.T. U110560301-2	Final Identification = No Legionella Isolated	Water	
IL16-1-113	3015353046	08/11/2016	08/12/2016	C.T. (no number)	Final Identification = No Legionella Isolated	Water	
IL16-1-114	3015353047	08/11/2016	08/12/2016	C.T. U110560301-2 scum line on reservoir water line	Final Identification = No Legionella Isolated	Swab	
IL16-1-115	3015353048	08/11/2016	08/12/2016	C.T. (no number) scum line on reservoir water line	Final Identification = No Legionella Isolated	Swab	

Appendix C. Water parameter testing conducted by Epi-Aid team in select buildings and cooling tower

Sample ID	Date Collected	Specimen Type	Sample Description	pH	Temp	Total Cl2	Free Cl2	TS
1216-1-001	8/8/2016	Bulk water - HOT	Blended Hot Somerville, Rm 202, Resident sink (Case patient)	7.0	108.5°F	5.5	3.5	0.14
1216-1-002	8/8/2016	Bulk water - Cold (Blended)	Somerville, Rm 202, Resident sink (Case patient)			9.6/3.5	7.4/2.5	0.11
1216-1-003	8/8/2016	SWAB	Somerville, Room 202, sink faucet fixture (Case)					
1216-1-004	8/8/2016	BW - HOT (Blended)	Somerville, Floor 2, women's restroom showerhead	7.0	107°F	5.2/1.2	3.5/0.5	0.11
1216-1-005	8/8/2016	BW - HOT Blended	Somerville, Floor 2, women's restroom post-filter showerhead					
1216-1-006	8/8/2016	SWAB	Somerville, Floor 2, women's restroom spray-end of shower hose, women's restroom					
1216-1-007	8/8/2016	SWAB	Somerville, floor 2, Pall filter, women's restroom					
1216-1-008	8/8/2016	SWAB	Somerville, Floor 2, shower hose spigot, women's restroom					
1216-1-009	8/8/2016	BW - HOT Blended	Somerville, Floor 2, Common sink faucet (Blended HOT) women's restroom	7.0	95.5	6.1	6.0	
	8/8/2016	cold	Somerville, Floor 2, left common sink faucet			8.9	6.0	
	8/8/2016	HOT - HOT water	Somerville, Floor 2, middle faucet, women's restroom		86°F			
	8/8/2016	HOT - HOT water	Somerville, Floor 2, middle faucet, women's restroom		143°F			
	8/8/2016	Blended cold water	Somerville, Floor 2, women's restroom, shower			7.4	6.8	0.2
1216-1-010	8/9/16	Hot Blended	Somerville, Floor 2, Room 203 (preexisting) sink	7.0	105°F	1.4.7	1.5 3.8	0.0
1216-1-011	8/9/16	Hot blended	Somerville, Floor 2, Room 203 sink on Phlegmatics testing					
1216-1-012	8/9/16	swab	Somerville, Fl 2, Room 203 sink on 8/10 (faucet replaced)					
	8/9/16	cold - Blended	" "			3.5/7.9	2.3 6.7	0.2
1216-1-013	8/9/16	Blended Hot BW	Somerville, FL 1, Rm. 132, stair sink, resident Rm.	7.0	102.5°F	5.5	4.4	0.2
1216-1-014	8/9/16	swab	Somerville, FL 1, Rm. 132 sink fixture, resident Rm.					
1216-1-015	8/9/16	cold-cold BW	Somerville, FL 2, Rm. 203, Resident sink		78.0°F			
	8/9/16	cold-blended	Somerville, FL 1, Rm. 132, sink, resident Rm.			4/4.7	2/6.6	0.3
1216-1-016	8/9/16	BW - HOT - HOT	Somerville, Basement, Hot water tank #1		141.5°F			
1216-1-017	8/9/16	cold cold BW	Somerville, Basement, cold water, resident faucet to main	7.0	78.9	5.10/7.4	3.3/7.0	0.2

Sample ID	Date Collected	Specimen Type	Sample Description	pH	Temp	Total Cl2	Free Cl2	ClO ₂
IL-16-1-018	8/9/16	BW-hot blended	Anderson, Rm #101 (resident room) sink	7	111.3°F	2.4	1.8	0.0
IL-16-1-019	8/9/16	swab - hot	Anderson, Rm #101 (resident) sink					
	8/9/16	blended cold	Anderson, Rm #101 (resident) sink			4.2	3.5	0.1
IL-16-1-020	8/9/16	BW hot blended	Anderson, Rm #230 (resident) sink	7	107°F	1.5	1.7	0.0
IL-16-1-021	8/9/16	swab	Anderson, Rm #230 (resident) sink					
	8/9/16	blended cold	Anderson, Rm #230 (resident) sink			4.3	2.2	0.2
IL-16-1-020	8/9/16	cold-cold BW bypass thermal mixer	Anderson, Rm #230 (resident) sink	-	-	-	-	-
IL-16-1-021	8/9/16	BW Hot storage	Anderson basement		138.7°F			
IL-16-1-022	8/9/16	cold proximal to main BW	Anderson basement			0.5	0.6	0.0
IL-16-1-023	8/10/16	BW Blended hot	Schapers B lobby men's RR sink	7	101.4°F	1.8/2.0	2.5	0.0
IL-16-1-024	8/10/16	swab	Schapers B lobby men's RR sink					
	8/10/16	cold	Schapers B lobby men's RR sink			4.9	2.7	.13
IL-16-1-025	8/10/16	cold-cold BW bypass	Schapers B rm 107 sink (persistent pos)	-	-	-	-	-
IL-16-1-028	8/10/16	blended BW (Hot-discolored)	Schapers B rm 107 sink (persistent pos)	7	103.7°F	-	2.1	.12
	8/10/16	blended cold	Schapers B rm 107 sink (" ")	-	-	-	4.2/4.4	.28
IL-16-1-029	8/10/16	swab	Schapers B rm 107 sink (" ")					
IL-16-1-030	8/10/16	BW Blended hot	Schapers B rm 120 sink (case pt)	7	101.1°F		2.8	.13
IL-16-1-031	8/10/16	swab	Schapers B rm 120 sink (case pt)					
	8/10/16	blended cold	Schapers B rm 120 sink (case pt)				4.5	.17
IL-16-1-032	8/10/16	BW Blended hot	Schapers A rm 1 behind nurses station sink	7	98.6°F		0.2/1.5	.05
IL-16-1-033	8/10/16	swab	Schapers A rm 1 behind nurses station sink					
	8/10/16	blended cold	Schapers A rm 1 behind nurses station sink				3.8	.40
034	8/10/16	BW Hot	Schapers Basement A+B Hot water heater		143°F			

Sample ID	Date Collected	Specimen Type	Sample Description						
051	8/9/16	BW blended hot	Smith Hall Dishwasher Sink (Kitchen)	6	177.3°F	1.0	1.1	.06	
052	8/10/16	BW Blended hot	Smith Hall #3 well Sink hot (Kitchen)	6	123.8°F	0.9	1.2	.00	
053	8/10/16	swab	Smith Hall Dishwasher Sink (Kitchen) Proximal end						
054	8/10/16	Swab	Smith Hall #3 well sink (Kitchen)						
055	8/10/16	Swab	Smith Hall #4 well sink (Kitchen)						
056	8/10/16	BW Blended cold	Smith Hall #3 well Sink cold (Kitchen)			3.3	3.5	.23	
057	8/10/16	BW cold-cold bypass	Smith Hall #1 well sink cold-cold (Kitchen)			4.1	4.1	.08	
058	8/10/16	BW Blended cold Hot	Smith Hall #4 well sink (Kitchen)	6	103°F	2.6	2.3	.06	
059	8/10/16	BW Hot	Smith Hall Basement Water heater (Left)						
060	8/10/16	BW Hot	Smith Hall Basement Water heater (right)						
061	8/10/16	BW blended hot	Fletcher Floor 1/Rm 2 RR left sink	6	101°F	1.6	1.8	0.0	
062	8/10/16	swab (hot)	Fletcher Floor 1/Rm 2 RR left sink						
	8/10/16	Blended cold	Fletcher Floor 1/Rm 2 RR left sink			3.0	3.5	0.0	
063	8/10/16	BW Hot Pre Fall	Fletcher Floor 1/Rm 2 RR shower			—	2.2	0.0	
064	8/10/16	swab Pre Fall	Fletcher Floor 1/Rm 2 RR shower						
065	8/10/16	swab (hot)	Fletcher Floor 1/Rm 2 RR right sink (old fixtures)						
	8/10/16	Cold Pre-Fall Blended	Fletcher Floor 1/Rm 2 RR shower			—	3.1	0.0	
066	8/10/16	BW blended hot	Fletcher Floor 2/Rm 212 RR right sink	5.5	104°F	—	0.8	.09	
067	8/10/16	swab (hot)	Fletcher Floor 2/Rm 212 RR right sink			—			
068	8/10/16	Distal BW (hot)	Fletcher Floor 2/Rm 216 RR right sink	5.5	106.7°F		1.5	0.0	
069	8/10/16	Distal Swab (hot)	Fletcher Floor 2/Rm 216 RR right sink hot faucet						
	8/10/16	Blended cold	Fletcher Floor 2/Rm 12 RR right sink			—	2.9	.10	
	8/10/16	Blended cold	Fletcher Floor 2/Rm 16 RR right sink				2.1	.2	
070	8/10/16	Hot	Fletcher Basement Water heater storage tank		135.3				