Drinking Water Quality Changes at a Middle School Under Low vs. Normal Water Use Conditions

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June 12, 2019
ACE 19

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Outline

- Building copper and lead monitoring in the past
- Background
- Results
  - Onsite water quality tests
  - Metal
  - Microbiology
- Other observations
- Conclusion/Recommendation
- Next Step

U.S building copper and lead monitoring

- Many studies focus on lead for drinking water quality
- A few studies that monitor both copper and lead on drinking water
- No “typical” U.S copper drinking water data for building water

Location (# of sample)	Range Cu (ppb)	Range Pb (ppb)	Note	Reference
School fountains (100)	BDL-10,200	BDL-135	After 10 min flush: Cu (BDL-7,800), Pb (BDL-74)	Murphy, 1993
5 different office building fountains (45)	2-5,043	BDL-210	Sampled 60mL, after 10sec flush	Cech et al. 2006

Other school copper and lead monitoring

Location (# of sample)	Range Cu (ppb)	Range Pb (ppb)	Note	Reference
5 different schools (48)	400-7,600	5.9-306	After 5 min flush: Cu (50-10,700), Pb (0.9-21.0)	Barn et al. 2014
3 different schools (130)	76.6-1,566	3.2-851	Volume equivalent to service line and internal plumbing was considered, and flushed 250mL	Dore et al. 2018

- Barn et al. 2014
  - Flushed 30 sec, 2 min, 5 min, longer flushing lowered both metals but effectiveness varied widely by locations
- Dore et al. 2018
  - Flush decreased metal concentration, but metal concentration rebounded within 30 minutes

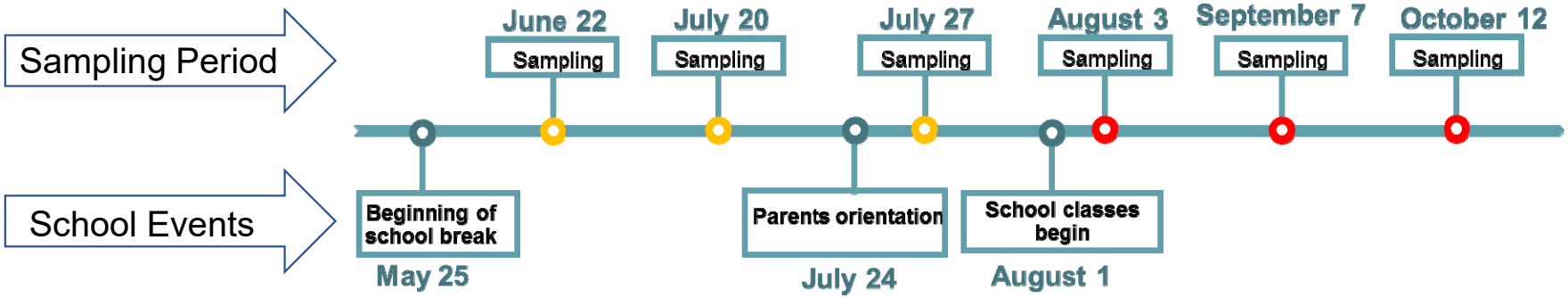
IDEM recommendation of Copper Exceedance

- Short Term Options (Not Permanent)
  - School wide flushing program of water outlets
  - School wide aerator cleaning program
  - Signs on problem locations for handwashing only

- Long Term/Permanent Options
  - Remove problem locations from service and cap location
  - Replace problem locations
  - Re-sampling of replaced sample locations

https://www.in.gov/idem/files/factsheet_owq_dw_gw_lead_copper.pdf

Sampling timeline & Background



Building Characteristics

- LEED certified, 7 Years Old
- 800 students
- Public water system: wellfield and river
- Chloraminated water
- Copper plumbing
- Hot water recirculation
- Water saving devices

Goal and Objectives

GOAL: to better understand how drinking water chemical and microbiological parameters change during the transition from Summer (low water use) to Fall (normal use) months

Objectives:

1. Determine chemical and microbiological water quality at 19 cold and hot water locations
2. Determine if there are relationships between water quality and distance from the (building entry-point)
3. Determine if water quality differed between Summer and Fall

11,12. **B2C, B2H**: E207J [H119] P-6 Farthest bathroom sink to utility room (cold and hot)

WF3 F112 Water Fountain

ABS Backstage sink

WF4 F115 Water Fountain

SKD, SKF F102 Students' kitchen

13,14. **SKC, SKH**: F102 [G102] Students' kitchen (cold and hot)

Most used Bldg portion

Least used Bldg portion

ARRS F105 Art room sink

B9 A108M Bathroom

FK A108 Faculty Kitchen

B5 B103B Bathroom

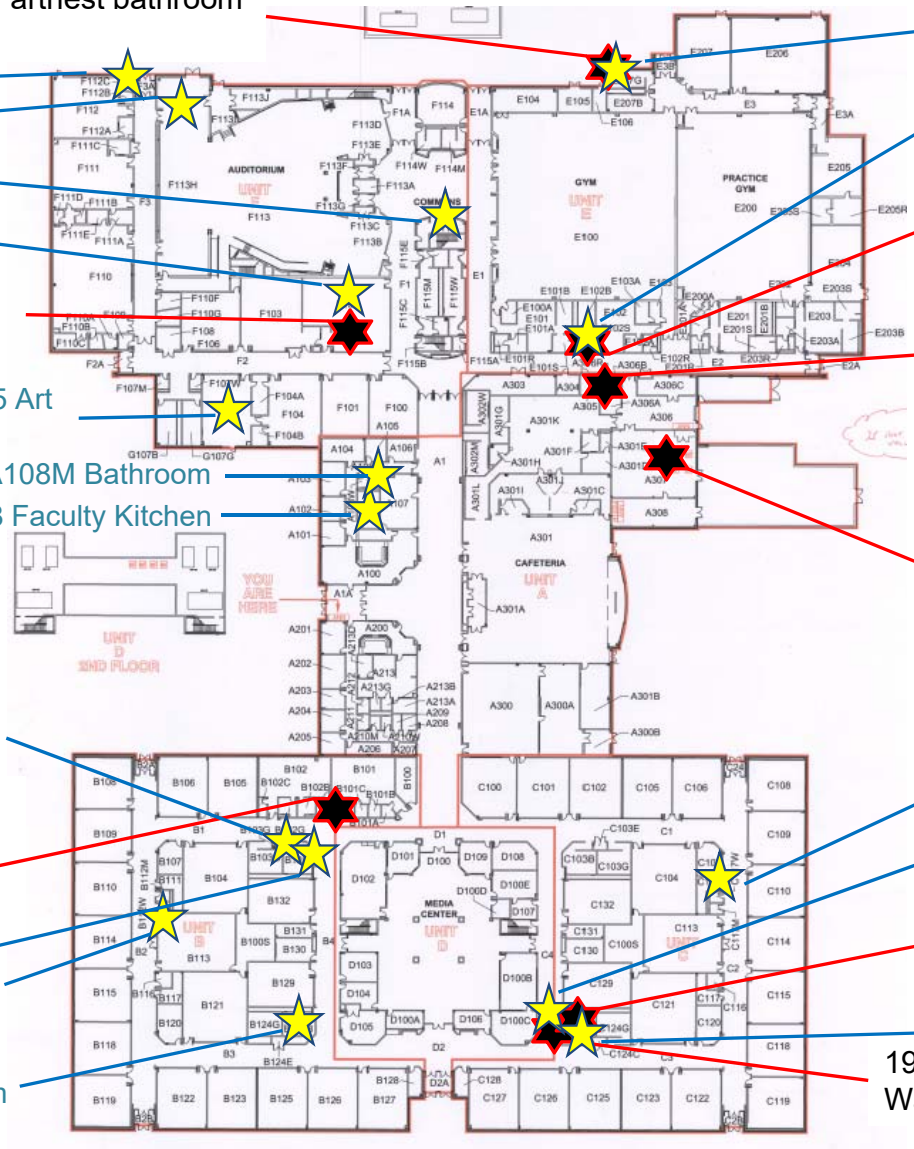
15,16. **TKC, TKH**: B102A [D110] P-10 Teachers' Kitchen sink (cold and hot)

WF5 B103B Water Fountain

NOT SHOWN
21,22. Trip Blank, Field Blank

B7 B112W Staff Bathroom

B6 B124B Bathroom



B2CR, B2CL E207J Farthest bathroom sinks

SRS, SLS locker room sinks

9,10. **SH1, SH2**: P-14, P-13 disabled, combined stand Showers (cold)

7,8. **B1C, B1H**: A306R [L123] Closest bathroom
sink to utility room (cold and hot)

UTILITY ROOM

1. **AM**: After water meter (cold)
2. **AS**: After softener (cold)
3. **BWH**: Before water heater (warm?)

4,5. **HWRa, HWRb**: Hot Water Recirculation (120, 140)

6. **AWH**: After water heater (hot)

B8 C112W Staff Bathroom

B3LS C124B Bathroom

17,18. **B3C, B3H**: C124B [A132] P-6 bathroom sink
(cold and hot)

B4 C124G Bathroom

19,20. **WF1, WF2**: C124B [A132] P-11, P-12 Water Fountains higher, lower (cold)

Sampling Process

Water sampling started 7:00-7:15am

- ✓ 150 mL for immediate analysis (pH, temperature, dissolved oxygen, total chlorine, free chlorine, free ammonia, monochloramine, total dissolved solid)

- ✓ **Metal** [125mL amber glass with 0.05 mL acid]
- ✓ **Metal** [125mL amber glass without acid]
- ✓ **Total Organic Carbon** (TOC) [250mL amber glass]
- ✓ **Alkalinity** [250mL amber glass]
- ✓ **Total trihalomethanes** (TTHM) [20mL glass vial x2]
- ✓ **Total Cell Counts** (TCC) [15mL falcon tube x2]
- ✓ **Heterotrophic Plate Count** (HPC) [1L HDPE bottle]
- ✓ **Quantitative polymerase chain reaction** (qPCR) [1L HDPE bottle]
- ✓ **Nitrification/Denitrification** [15mL bottles x2]

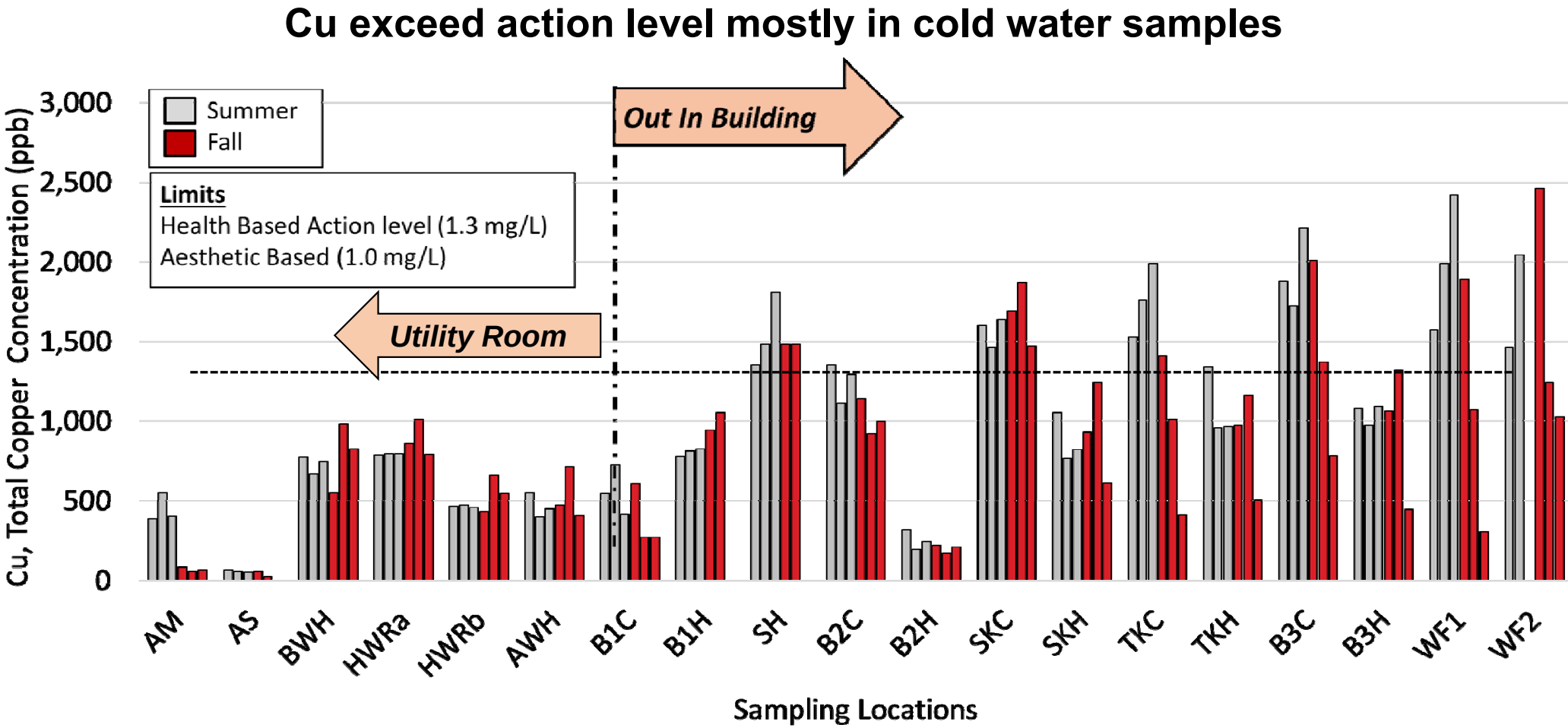
Onsite tests – Preliminary Data Summary [min-(median)-max]

For all water samples: **68% no disinfectant detected 83% contained free ammonia**

	After meter	Cold Water Lines	Hot Water Lines	SDWR[1]
pH	7.62 –(7.83)– 7.87	7.22 –(7.86)– 8.45	7.54 –(8.02)– 8.35	6.5-8.5[1]
Total Chlorine (mg/L)	0.14 –(0.17)– 0.43	BDL –(0.15)– 1.4	BDL –(0.1)– 1.0	0.2[2]
Monochloramine (mg/L)	0.18 –(0.26)– 0.94	BDL –(0.06)– 0.49	BDL –(0.05)– 0.7	4[3]
Free Ammonia (mg/L)	BDL –(0.085)– 0.48	BDL –(0.11)– 0.41	BDL –(0.13)– 0.84	N/A
Temperature (°C)	20.4 –(25.5)– 27.3	15.8 –(23.2)– 30.2	19.7 –(25.4)– 47.3*	N/A
DO (mg/L)	7.44 –(8.97)– 9.15	2.58 –(7.68)– 10.15	3.12 –(5.98)– 8.98	N/A

BDL: below detection limit
[1]Secondary Drinking Water Regulation BDL: below detection limit
[2]Indiana water quality standard for total chlorine residual
[3]Maximum contaminant Level of chloramine
*Temperature coolest in water bubblers, hot recirc system different than it was supposed to be (48.9°C line measured highest as 36.6°C, 60°C line measured highest as 47.3°C)

Chemical Water Quality Initial Results - Copper



Chemical Water Quality Initial Results - Copper

Routine Sampling Locations in October	1st grab (mg/L)	2nd grab (mg/L)	Our Experience with Locations
B2C	0.996	1.470	3 of 7 prior samples exceeded the AL
SKC	1.470	0.561	7 of 7 prior samples exceeded the AL

None of our other routine locations exceeded the copper AL during the October sampling event

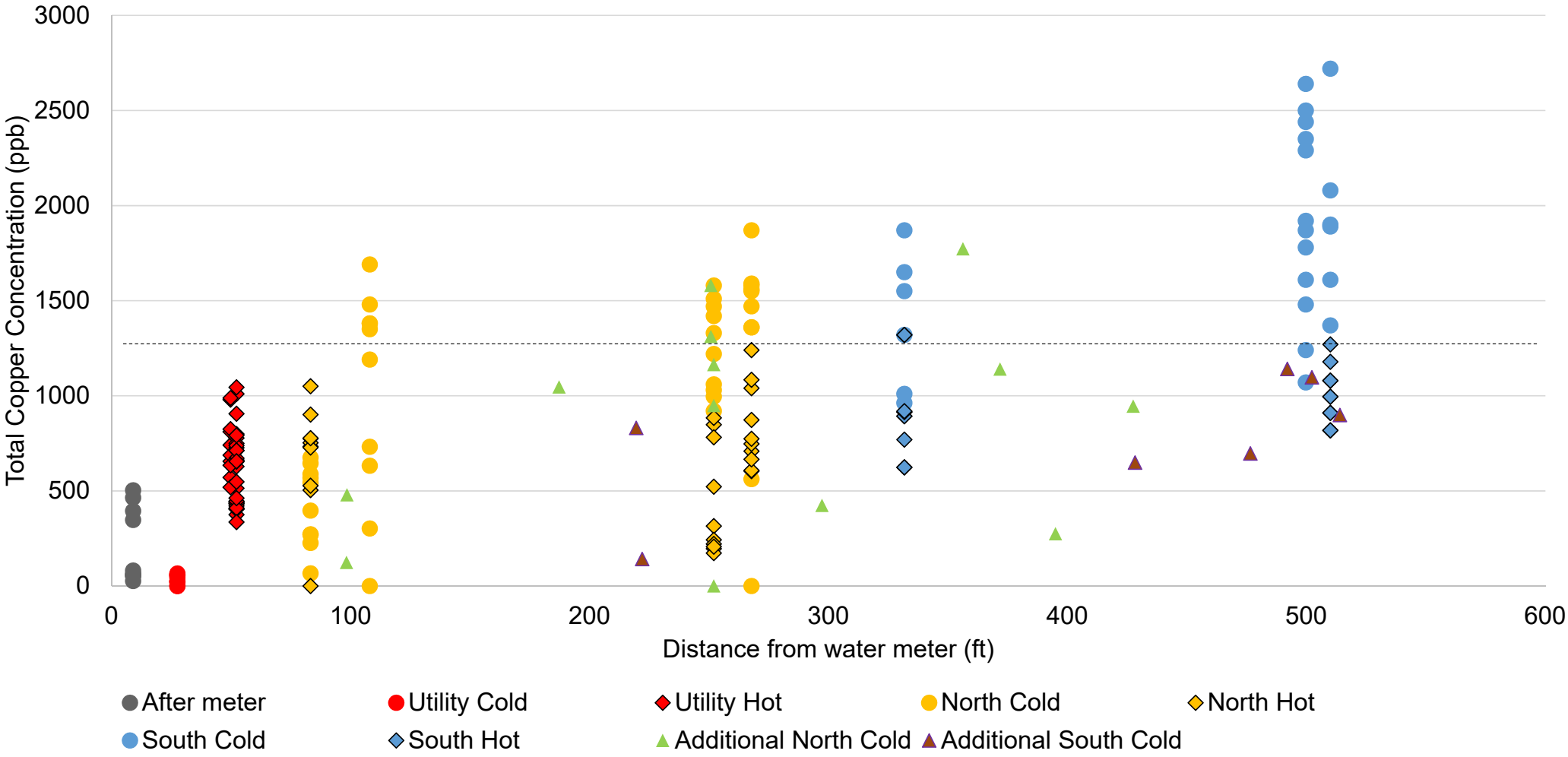
of 19 Routine Sampling Locations

Copper Action Level 1.3 mg/L

+ 19 New Sampling Locations

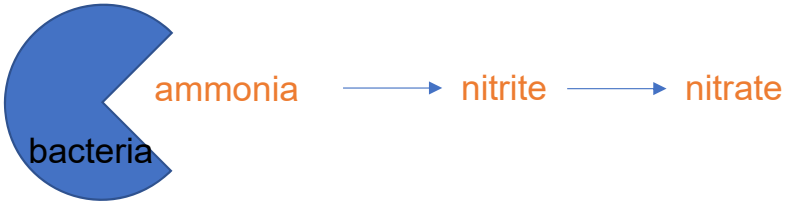
New Sampling Locations in October	1st grab (mg/L)	2nd grab (mg/L)
SRS - shower room right sink	0.123	0.149
SLS - shower room left sink	0.479	0.164
B2CR - bathroom 2 cold right	0.949	1.403
B2CL - bathroom 2 cold left	1.164	1.452
SKD - student kitchen sink D	1.312	0.832
SKF - student kitchen sink F	1.580	0.529
FK - faculty kitchen - A108	0.831	0.120
ARRS - art room right sink - F105	0.424	0.638
WF3 - water fountain 3 - F112 (coral room)	1.773	1.360
WF4 - water fountain 4 - F115W	1.047	0.902
WF5 - water fountain 5 - B103B	0.945	0.374
ABS - auditorium back sink	1.141	1.314
B3LS - bathroom 3 left sink	0.898	0.866
B4 - bathroom 4 - C124G - next to sink 2	1.141	0.868
B5 - bathroom 5 - B103B	0.275	0.216
B6 - bathroom 6 - B124B	1.097	0.819
B7 - bathroom 7 - B112W - staff bathroom	0.649	0.617
B8 - bathroom 8 - C112W - staff bathroom	0.697	0.646
B9 - bathroom 9 - A108M - in office	0.142	0.105

Copper vs. Distance from Water meter

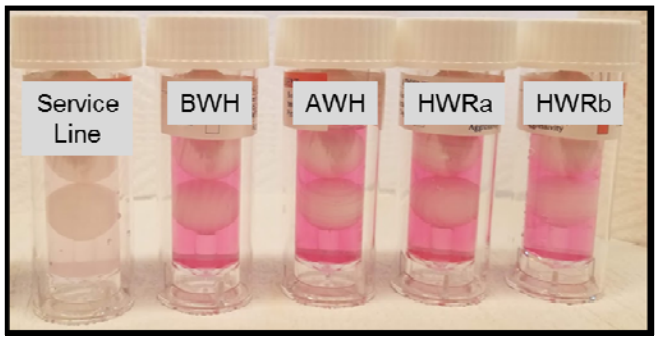


Microbiological Initial Results – Nitrifying bacteria

Nitrification



BRAC Analysis Rearrangement Test (BART)



Nitrification

Coloration	Red	Dark Pink	Light Pink	Clear
Approx. Population	100,000	10,000	1000	n/a

Date	SL	AS	BWH	HWRa	HWRb	AWH	SH2	B3C	B3H
6/22/2018							-	-	-
7/20/2018									
7/27/2018									
8/3/2018									
9/7/2018									
10/12/2018									

- Nitrifying bacteria was found
  - Hot water 29 of 29 samples
  - Cold water 17 of 22 samples
- Denitrifying bacteria was found less frequently 5 of 54 samples at different location each time

Other Observations

Chemical Results

- Pb exceeded AL only one time at the shower cold water (7-40 ppb)
- Zn and Ni comes from plumbing outside the utility room
- IDEM recommended fixture flushing did not consistently reduce Cu levels (30 seconds, 3 minutes, and 5 minutes)
- For first five visits, > 82% copper dissolved, and on the last visit all copper dissolved with exception of two locations (HWRa, WF2)

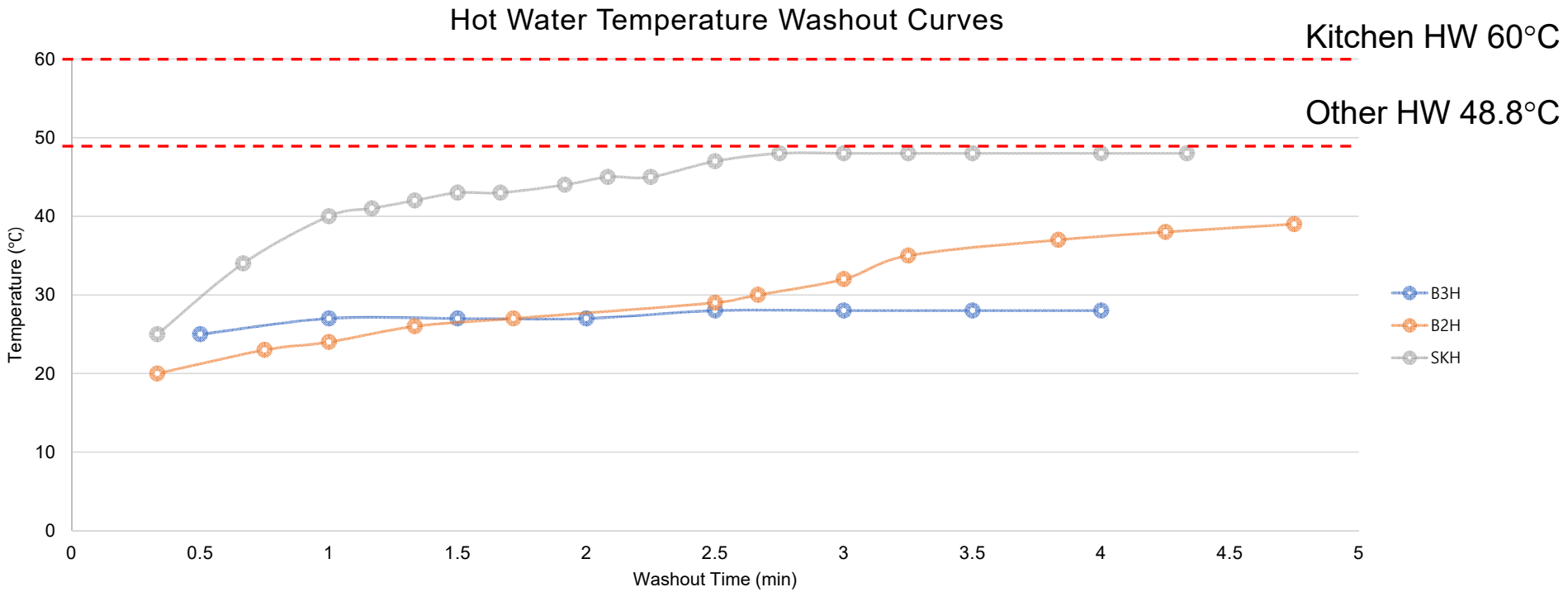
Microbiological Results

- *Legionella spp.* was detected in Summer hot water and not in Fall hot water

	After meter	Cold Water Lines	Hot Water Lines	MCL[1] SDWR[2]
HPC (CFU/100mL)	11 –(56.6)– 400	0.67 –(3.83)– 214,000	0 –(98.3)– 19,430,000*	N/A
TCC (cell/mL)	1.24E+05 –(7.47E+05)– 1 .23E+06	1.47E+05 –(1.17E+06)– 1.91E+06	3.36E+05 –(6.15E+05)– 1.15E+06	N/A

*Highest found in BWH on last visit, but the maximum would be 15,033 with exception of that data

Other Observations

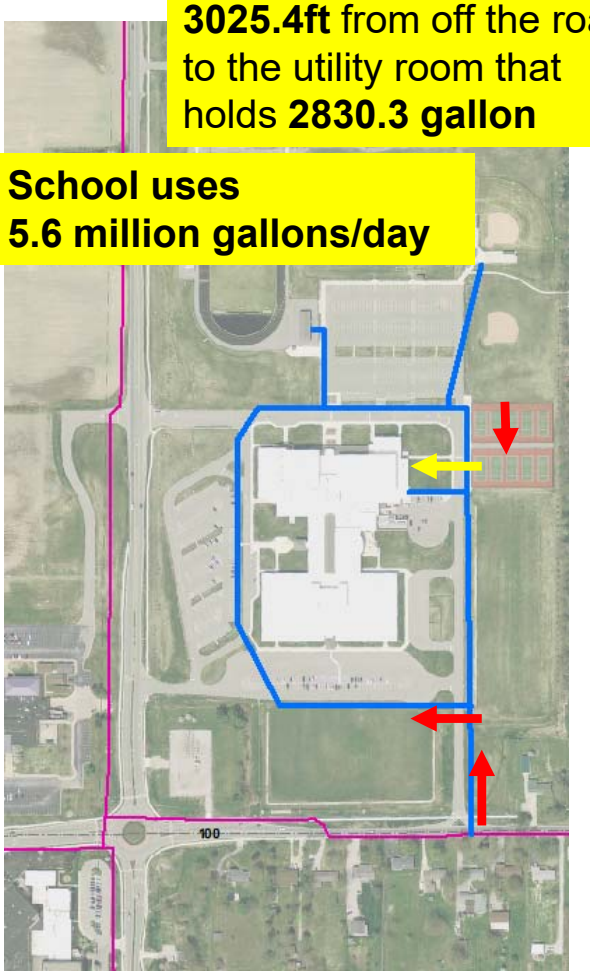


	Delivery length		Return length
AM to B3H	509.97 ft	B3H to HWRC	496.75 ft
AM to B2H	252.002 ft	B2H to HWRC	215.49 ft
AM to SKH	267.75 ft	SKH to HWRC	282.3 ft

Other Observations

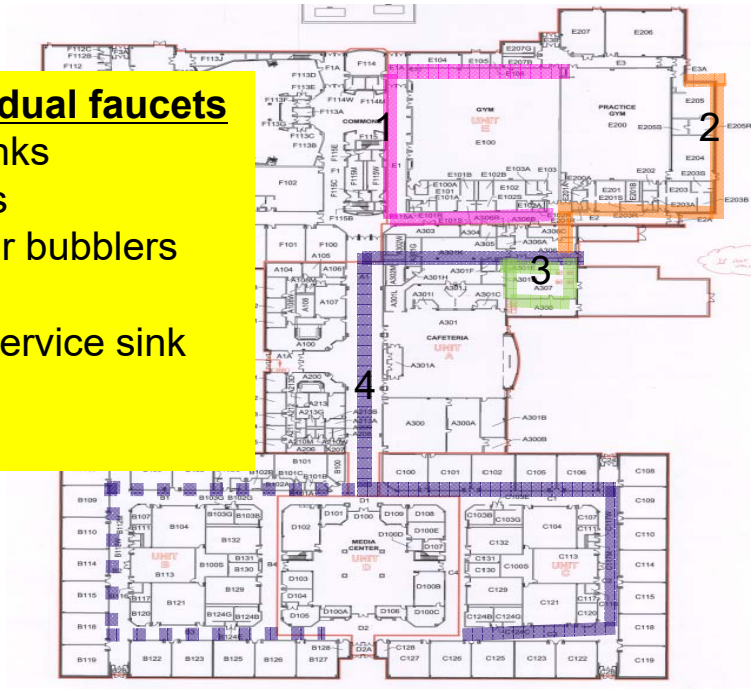
3025.4ft from off the road to the utility room that holds **2830.3 gallon**

School uses
5.6 million gallons/day



When water comes from public utility

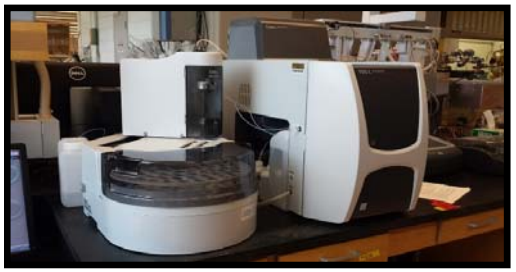
Total 219 individual faucets
65 classroom sinks
82 lavatory sinks
23 drinking water bubblers
15 cabinet sinks
3 mop sinks, 1 service sink
35 showers

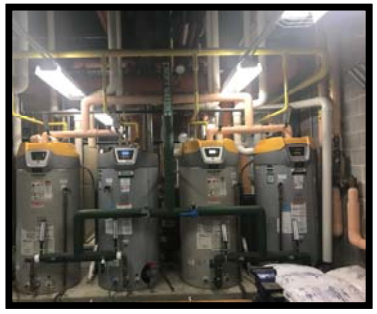


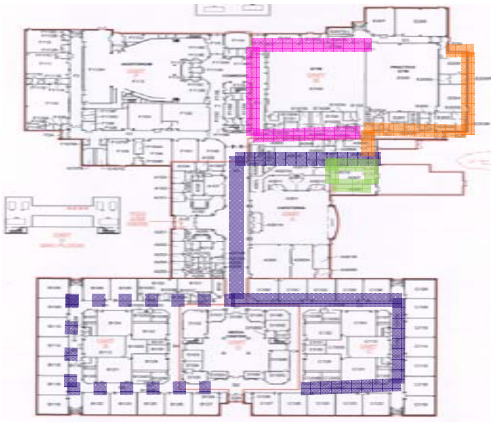
1: 410.52 ft, 9.42 gal
2: 337.25 ft, 7.74 gal
3: 259.75 ft, 5.96 gal
4: 874 ft, 136.2 gal

More Analysis to come

3000+ individual water quality measurements have been sampled







Chemical
Chlorine residual, pH, temperature
Monochloramine, Free ammonia
Dissolved oxygen (DO)
Total Dissolved Solids (TDS)
Alkalinity
Total and dissolved organic carbon (TOC, DOC)
Total and dissolved metals
Ions
Total trihalomethanes (TTHM)

Microbial
Nitrifying/Denitrifying bacteria Bart test
Culture-based heterotrophic Plate Count (HPC)
Total Cell Counts (TCC)
Quantitative Polymerase Chain Reaction (qPCR)

Conclusions/Recommendations

- School drinking water on last visit did not meet the drinking water standard for copper
- Spot flushing may not work as copper levels may rebound quickly
- The copper problem is systemic in the building, not at select locations
- Periods of stagnation (holidays, weekends, breaks, etc) may result in greater copper levels when the building is reopened

- To address the copper problem, point of use treatment devices are likely necessary and/or in-building water treatment
- Follow-up testing needed to determine if devices are working and how long they last before failure
- Plumbing system should be considered to design sampling plan

Next Step

- Complete compiling all data
- Create and select best graphs and tables
- Enhance microbiology discussion
- Make recommendations
  - Sampling procedure and method
  - Representative of samples
  - What factors should we look for
  - What do we do if we find problems

Acknowledgement

This work was funded by the USEPA.
Special thanks to collaborators at the School as well as Michigan State Univ., Univ. Memphis (Dr. Maryam Salehi), Purdue Univ. (Dr. Caitlin Proctor, Erica Wang, John Maiyo), and CEG.
www.PlumbingSafety.org