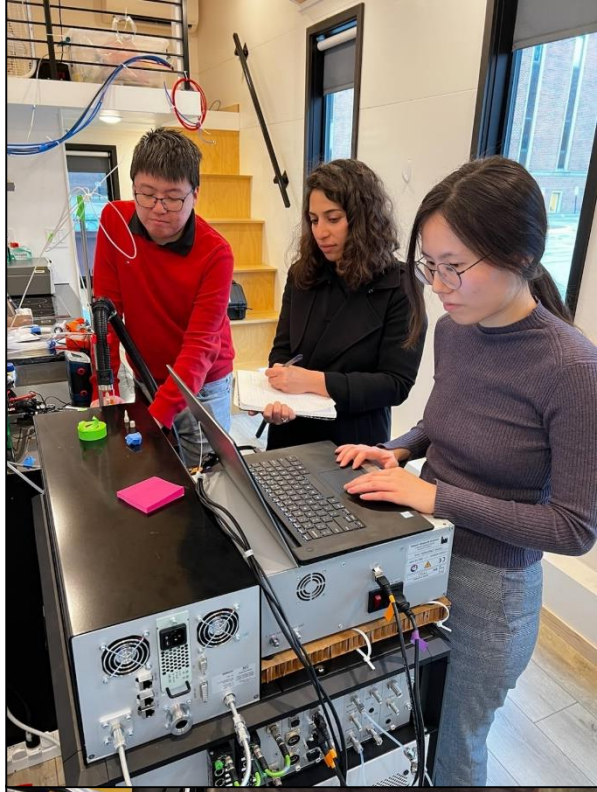
Community Update:

Rapid Response to the Norfolk Southern Chemical Spill and Chemical Fires in East Palestine, Ohio

Paula Coelho, Andrew Whelton, Ph.D.,

and many more

In collaboration with United for East Palestine



Rapid public health scientific support in response to disasters

2014 Chemical Spill (WV)
2017 Tubbs Fire (CA)
2018 Camp Fire (CA)
2020 Oregon Fires (OR)
2021 Chemical Spill (HI)
2021 Marshall Fire (CO)
2023 Chemical Spill/Fires (OH)
and others…

Key Questions:

1. What chemicals should been looked for?
2. Where did/do the chemicals go?
3. How do you return infrastructure/homes to safe use?
4. What were/are the chemical exposures?

PURDUE UNIVERSITY


January 10, 2014
Charleston, West Virginia


te
nge

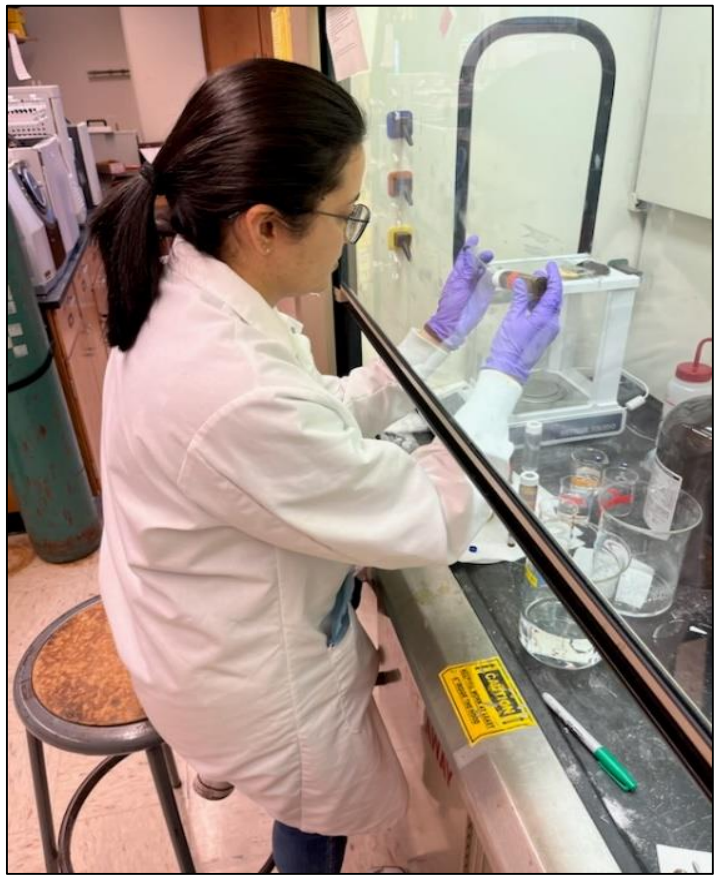

November 8, 2018
Butte Co, California


WELCOME
to the
ZOO
ZONE 5


cafe


December 30, 2021
Boulder Co, Colorado

About Paula



Hometown: Belem, Para, Brazil

Alma Mater: Federal University of Para (B.S. Sanitary and Environmental Engineering)

Program: Purdue University Ph.D. Student in Environmental and Ecological Engineering

Current Research/Research Projects

- Water quality (Microplastic in building faucets)
- East Palestine, Ohio, chemical spill

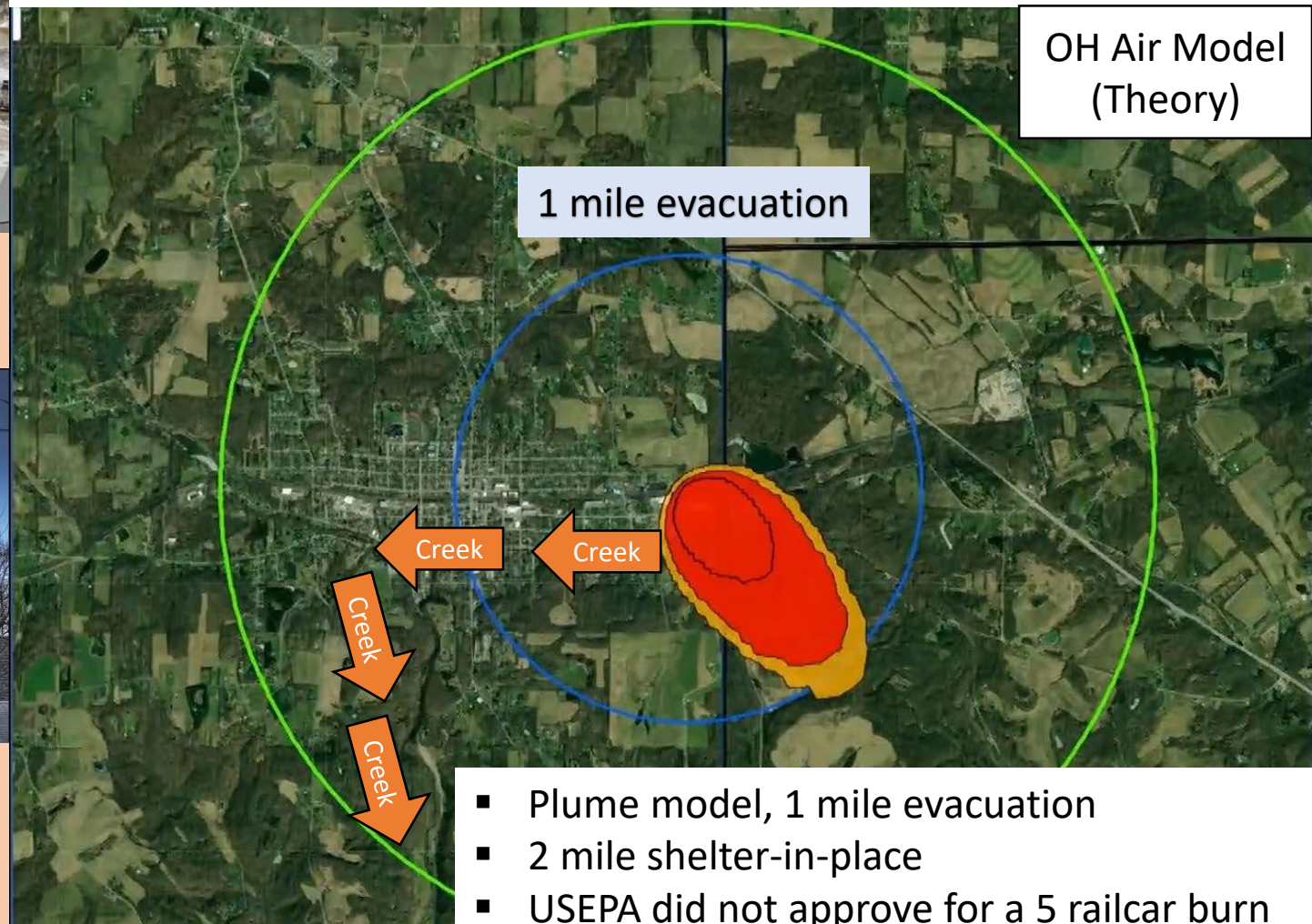
East Palestine, Ohio Chemical Spill and Chemical Fires

Feb 3. wreck

Feb 6 “controlled” burn

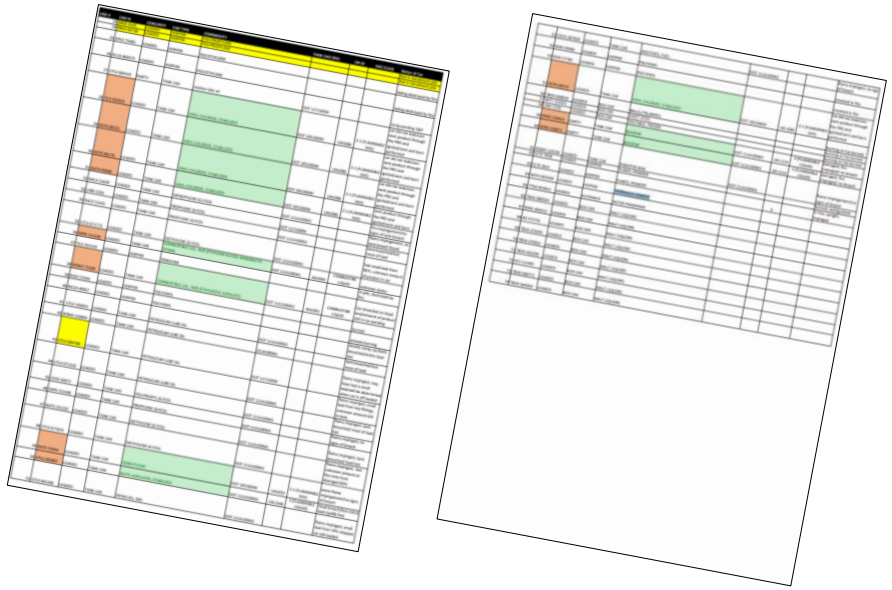
149 rail cars, 38 derailed

11 derailed were combustible liquids, flammable liquids, and flammable gas.



- Plume model, 1 mile evacuation
- 2 mile shelter-in-place
- USEPA did not approve for a 5 railcar burn

What was on the train according to the Norfolk Southern document posted by the U.S. EPA …



Ethylhexyl acrylate
Vinyl chloride
Butyl acrylate
PVC resin
PE resin
Frozen vegetables
Powder flakes
Paraffin wax

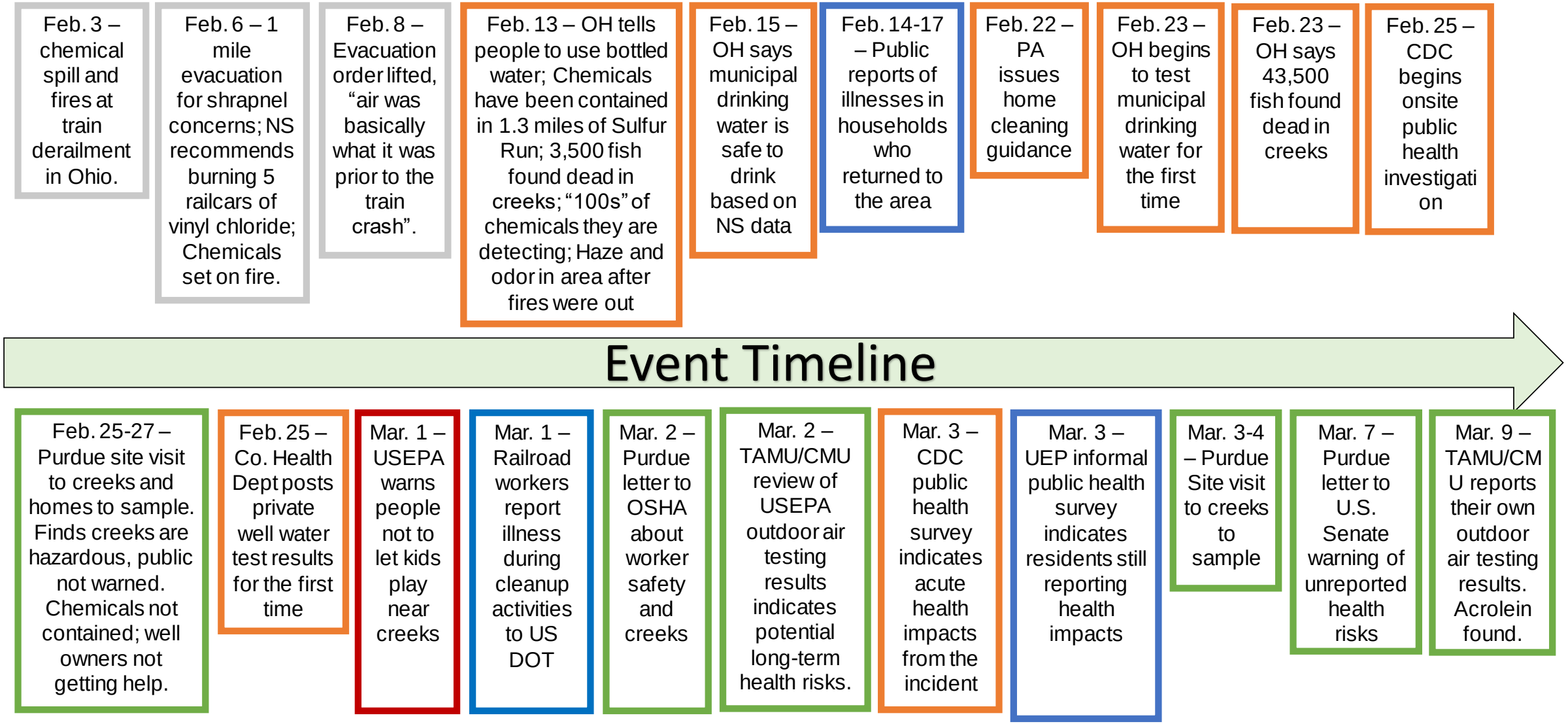
Propyl glycol
Diethylene glycol
Petro oil, NEC
Petroleum lube oil
Semolina
Balls
Fuel additives
Malt liquors

Benzene
Residue lube oil
Isobutylene
Sheet steel
Hydraulic cement
Passenger autos
Ethylene glycol methyl butyl ether [2-butoxyethanol]

Chemicals reported released or burned in early February 2023

Chemicals Reported	Physical and Chemical Properties					
	Molecular Weight, g/mole	Density, g/cm^3	Boiling Point at 760 mmHg, ^oF	Water Solubility, mg/L	Vapor Pressure, mmHg	Log K_{ow}
2-Butoxyethanol	118.17	0.902	335	100,000	0.6	0.83
Vinyl chloride	62.50	0.911	7	8,800	2,980	1.46
Butyl acrylate	128.17	0.890	295	1,000	5.45	2.36
Ethylhexyl acrylate	184.27	0.880	417	100	0.178	4.09
Propyl glycol	104.15	0.911	301	1,000,000	2.9	0.08
Diethylene glycol	106.12	1.118	473	100,000	0.0057	-1.47
Petro oil, NEC	Contains thousands of individual chemicals. When burned creates and releases numerous.					
Petroleum lube oil	Contains thousands of individual chemicals. When burned creates and releases numerous.					
Polyethylene	Not a chemical. This is a plastic. When burned creates and releases numerous.					
Semolina	Not a chemical. This is wheat. When burned creates and releases numerous.					
Polyvinylchloride	Not a chemical. This is a plastic. When burned creates and releases numerous.					
Balls	Not a chemical. Composition unclear.					
Frozen vegetables	Not a chemical. When burned creates and releases numerous.					
Powder flakes	Not a chemical. Composition unclear.					

Obtained from the NLM PubChem database. Temperatures where density water solubility, vapor pressure, and Henry's Law Constant's were were determined were either 20, 23, or 25 degrees Celsius


Feb. 3 – chemical spill and fires at train derailment in Ohio.
Feb. 6 – 1 mile evacuation for shrapnel concerns; NS recommends burning 5 railcars of vinyl chloride; Chemicals set on fire.
Feb. 8 – Evacuation order lifted, "air was basically what it was prior to the train crash".
Feb. 13 – OH tells people to use bottled water; Chemicals have been contained in 1.3 miles of Sulfur Run; 3,500 fish found dead in creeks; "100s" of chemicals they are detecting; Haze and odor in area after fires were out
Feb. 15 – OH says municipal drinking water is safe to drink based on NS data
Feb. 14-17 – Public reports of illnesses in households who returned to the area
Feb. 22 – PA issues home cleaning guidance
Feb. 23 – OH begins to test municipal drinking water for the first time
Feb. 23 – OH says 43,500 fish found dead in creeks
Feb. 25 – CDC begins onsite public health investigation
Event Timeline
Feb. 25-27 – Purdue site visit to creeks and homes to sample. Finds creeks are hazardous, public not warned. Chemicals not contained; well owners not getting help.
Feb. 25 – Co. Health Dept posts private well water test results for the first time
Mar. 1 – USEPA warns people not to let kids play near creeks
Mar. 1 – Railroad workers report illness during cleanup activities to US DOT
Mar. 2 – Purdue letter to OSHA about worker safety and creeks
Mar. 2 – TAMU/CMU review of USEPA outdoor air testing results indicates potential long-term health risks.
Mar. 3 – CDC public health survey indicates acute health impacts from the incident
Mar. 3 – UEP informal public health survey indicates residents still reporting health impacts
Mar. 3-4 – Purdue Site visit to creeks to sample
Mar. 7 – Purdue letter to U.S. Senate warning of unreported health risks
Mar. 9 – TAMU/CMU reports their own outdoor air testing results. Acrolein found.

Analysis by TAMU/CMU of USEPA's Outdoor Air Testing Results (Feb 24)

	EPA Reported Concentrations		Calculated Hazard Quotient (HQ) for East Palestine (OH)		HQ due to "Normal" Levels in Counties Across USA, Counties in Ohio, and in Columbiana County (OH)				
Chemicals (CAS#)	**Median (mg/m3) in East Palestine (OH) Feb 2023**	**Highest (mg/m3) in East Palestine (OH) Feb 2023**	**HQ for median in East Palestine (OH) Feb 2023**	**HQ for highest in East Palestine (OH) Feb 2023**	**HQ for median county in USA (EPA NATA 2014)**	**HQ for highest county in USA (EPA NATA 2014)**	**HQ for median county in Ohio (EPA NATA 2014)**	**HQ for highest county in Ohio (EPA NATA 2014)**	**HQ for Columbiana County, Ohio (EPA NATA 2014)**
1,1,2-Trichloroethane (79-00-5)	0.00007	0.00145	0.35	0.73	0.00	0.02	0.00	0.00	0.00
1,3-Butadiene (106-99-0)	0.000084	0.00053	0.04	0.27	0.01	0.08	0.01	0.02	0.01
Acrolein (107-02-8)	0.00014	0.0008	7.0	40	0.89	6.1	0.88	1.56	0.83
Benzene (71-43-2)	0.00084	0.012	0.03	0.40	0.01	0.03	0.01	0.02	0.01
m,p-Xylenes (179601-23-1)	0.00078	0.0098	0.01	0.10	0.00	0.01	0.00	0.01	0.00
Naphthalene (91-20-3)	0.00007	0.0014	0.02	0.47	0.01	0.04	0.01	0.02	0.01
o-Xylene (95-47-6)	0.00029	0.021	0.00	0.21	0.00	0.01	0.00	0.01	0.00
Trichloroethylene (79-01-6)	0.000018	0.00053	0.01	0.27	0.00	0.17	0.01	0.03	0.01
Vinyl Chloride (75-01-4)	0.00026	0.016	0.00	0.20	0.00	0.00	0.00	0.00	0.00

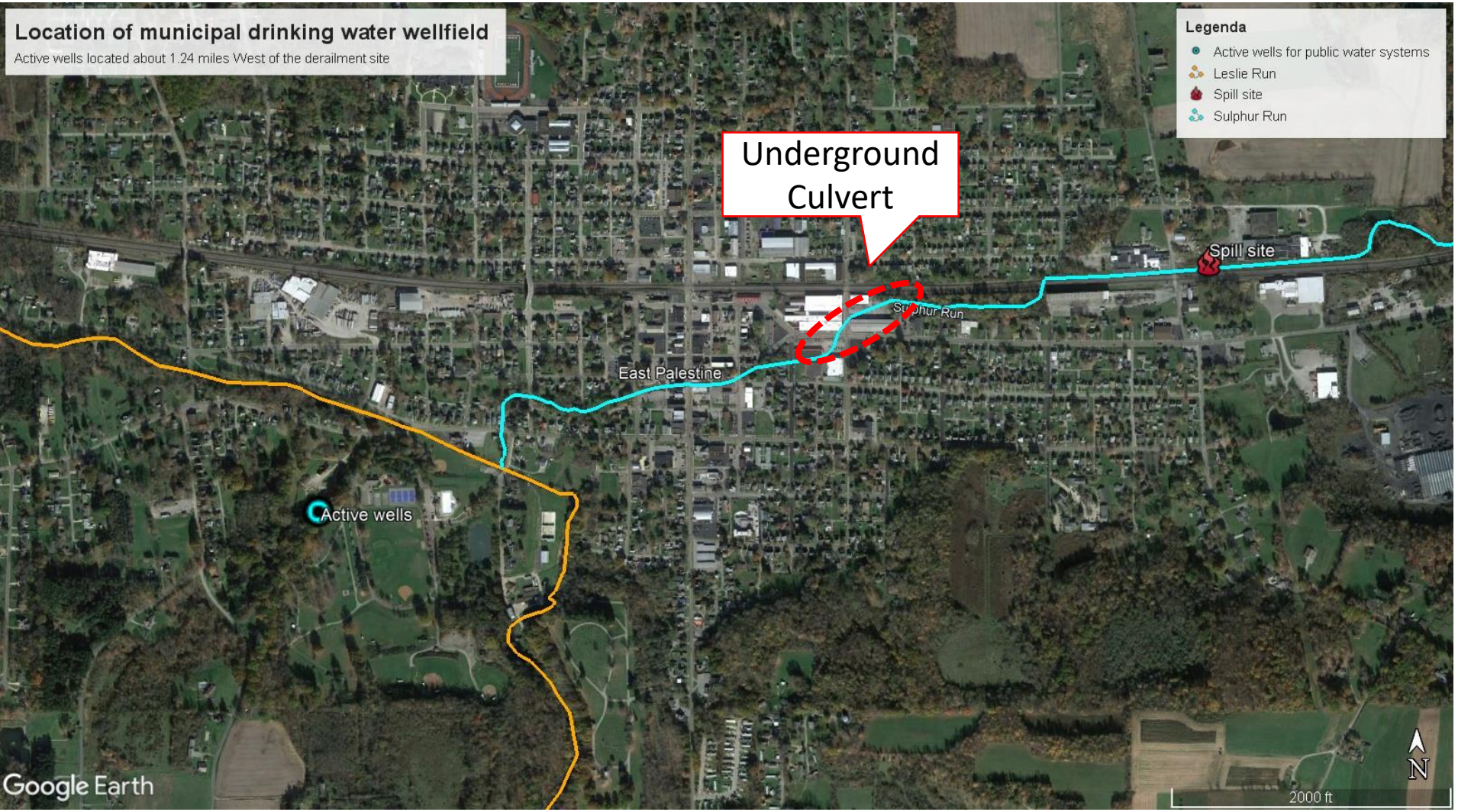
Background Information:

- Hazard Quotient (HQ) = Concentration ÷ RfC
- HQ < 1: little concern for single chemical
- HQ < 0.1: little concern for multiple chemicals
- RfC = level likely to be without appreciable risk over a lifetime

Interpretation:

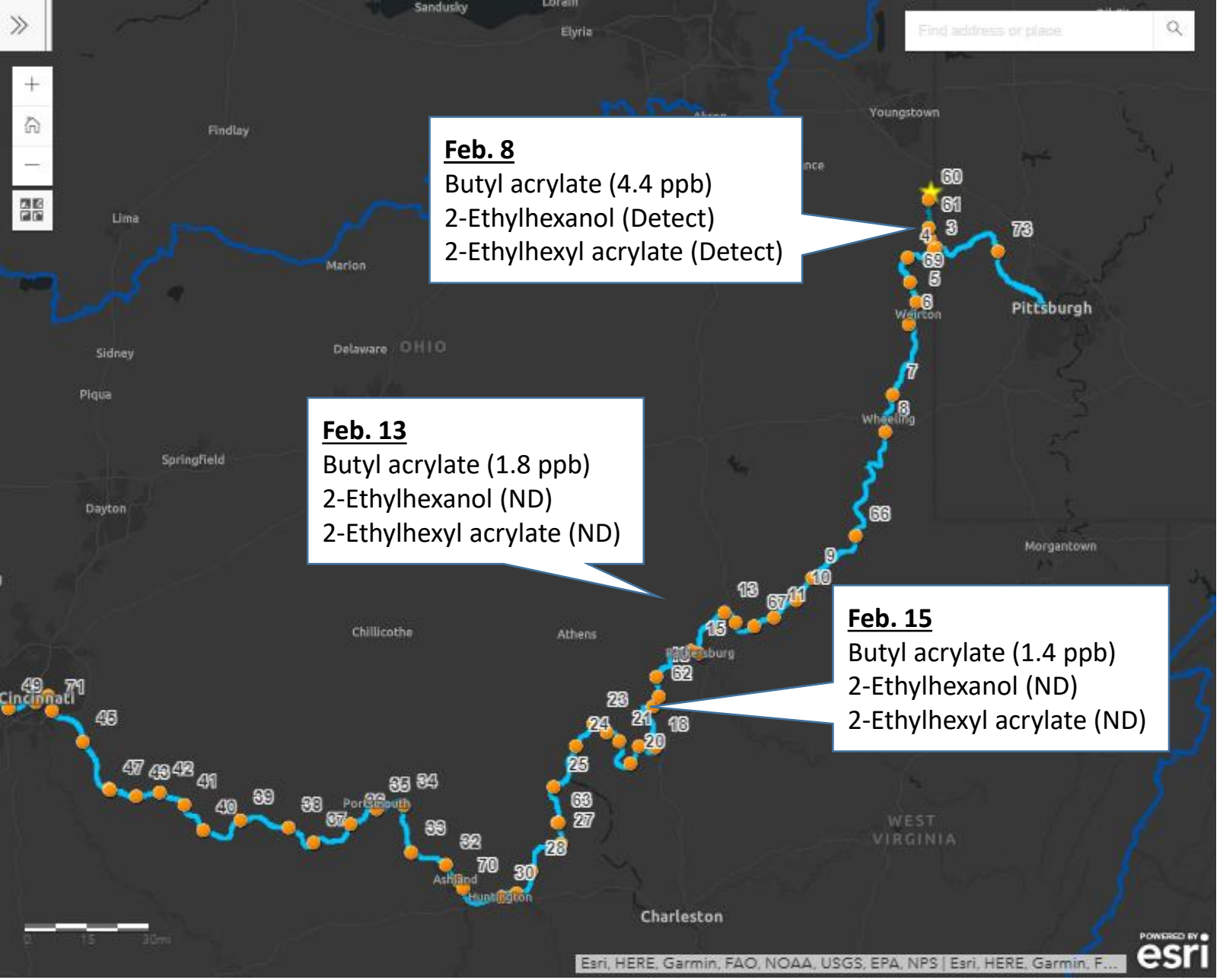
- ***Concentrations for nine of the ~50 chemicals EPA reported are higher than "normal" average levels***
- ***If they continue at these levels, they may be of health concern (especially acrolein)***

Some of the creeks impacted were considered “high quality streams” because of the water quality, fish, and bugs



The East Palestine municipal drinking water wellfield 1.24 miles West of the derailment.

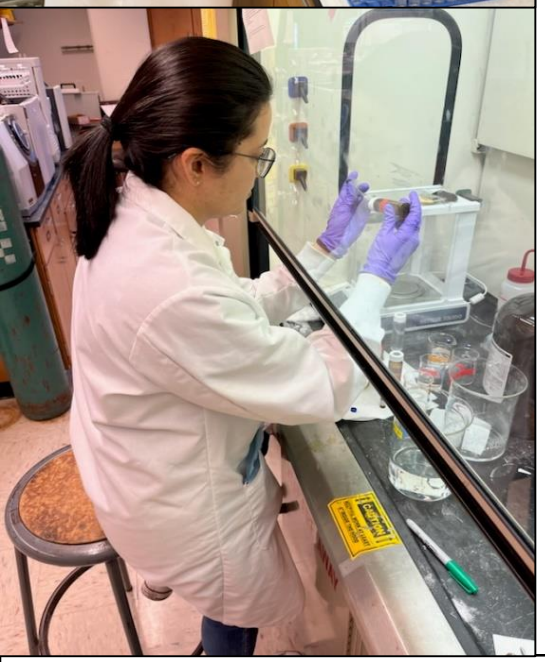
Groundwater has “high susceptibility to contamination partly due to the lack of a protective layer of clay.”



Feb. 3 – Derailment and spill
Feb. 6 – Fires

Compound	ATSDR Screening Level, ppb
Butyl acrylate	560
2-Ethylhexanol	200
2-Ethylhexylacrylate	500
2-Butoxyethanol	None issued

ATSDR hasn't responded about what screening levels represent. Contacted 2x by the recommendation by USEPA (Incident Commander)



Key Questions:

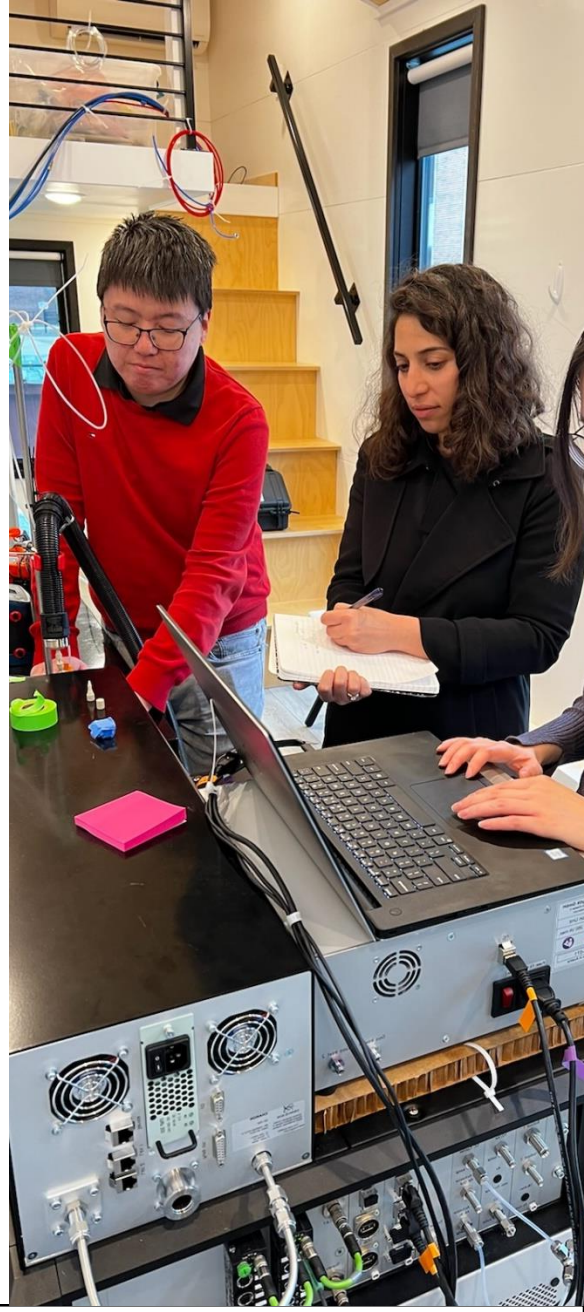
1. What chemicals should been looked for?
2. Where did/do the chemicals go?
3. How do you return infrastructure/homes to safe use?
4. What were/are the chemical exposures?

Site visits so far

February 25-27
March 3-4
March 17-19
March 23-25
May 4-5

Creek water sampling (17 locations)
Creek soil sampling
Well water sampling (15 wells)
Outdoor home wipe sampling
Interviews with homeowners

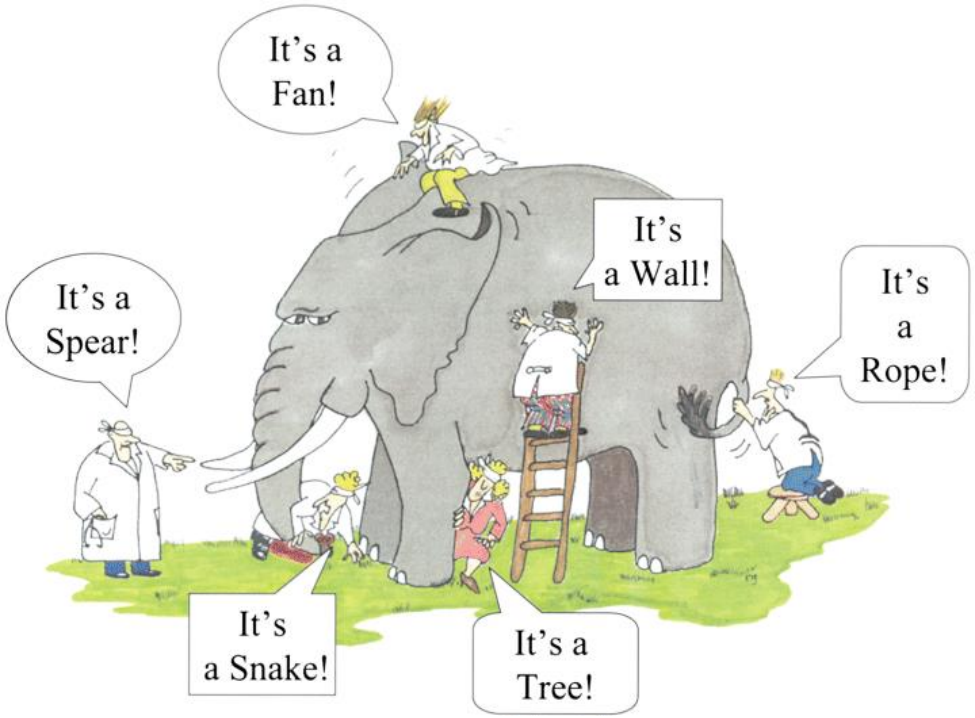
Study is approved by the Purdue University Human Research Protection Program, Internal Review Board (IRB)-2023-422



PURDUE UNIVERSITY

Our Approach: 3 weeks after the incident, barely any data was publicly available data despite “safety” claims

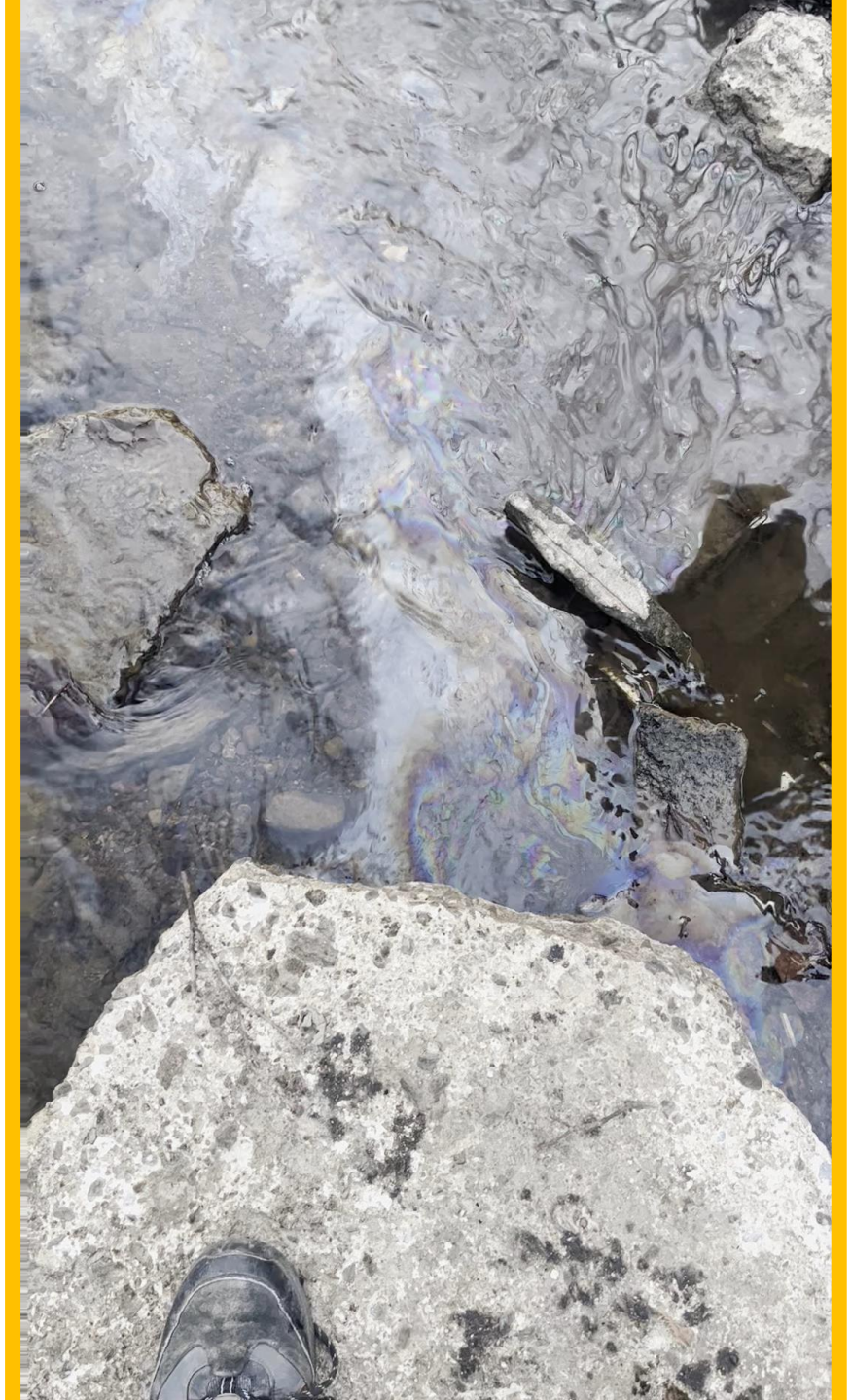
Critical *scientific decisions right after a chemical spill are*
1. What do you test for?
2. Where and how do you test?



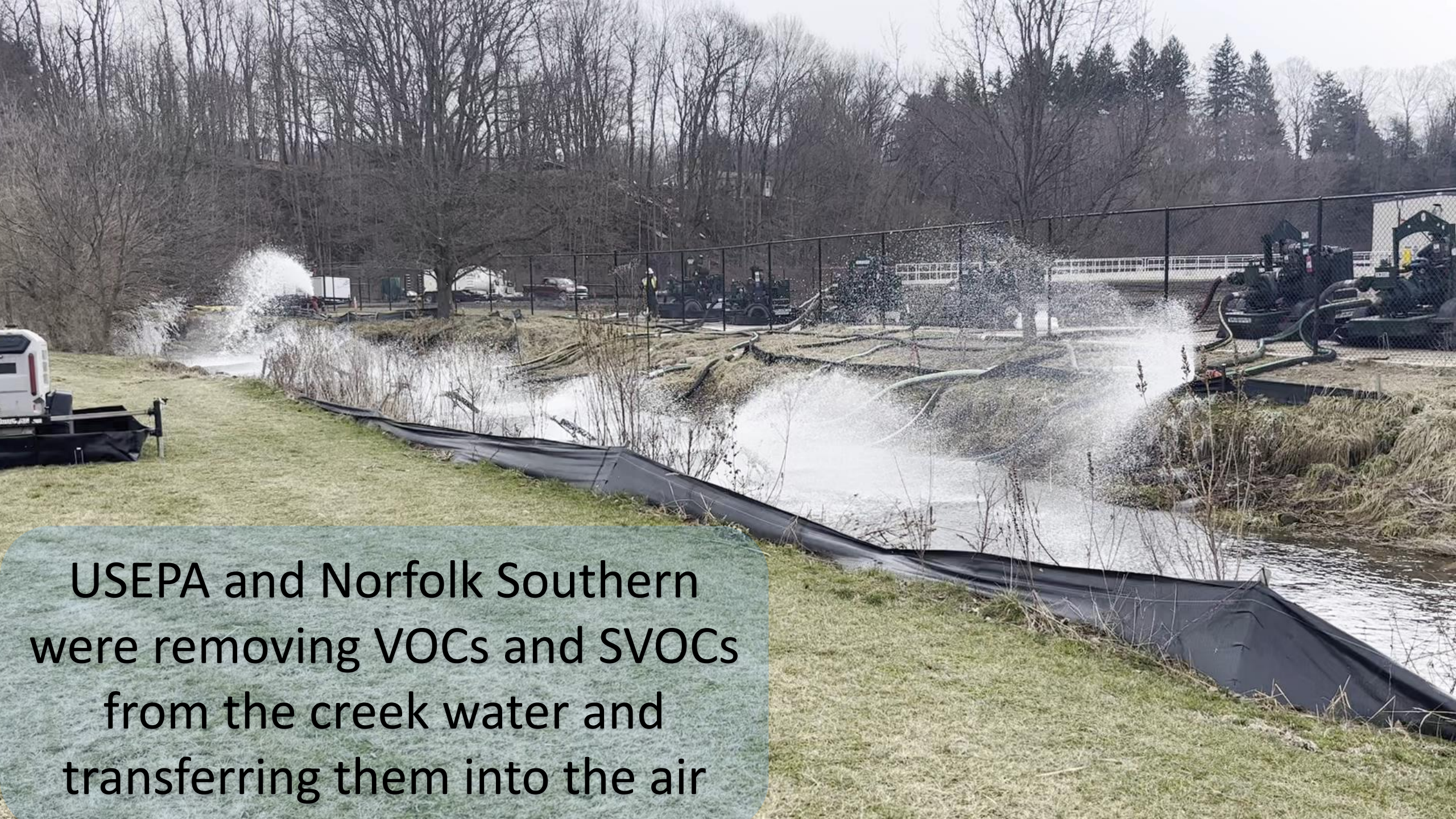
Review public agency data
Household interview
Home and private well investigation
Creeks investigation

What are we screening for?

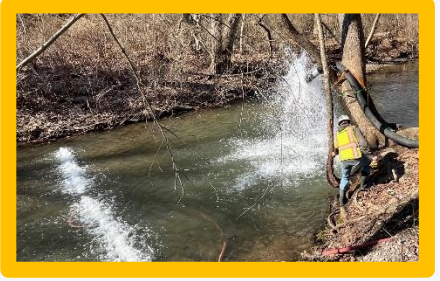
- Water pH, temperature
- Volatile organic compounds (VOC)
- Semi-volatile organic compounds (SVOC)
- Per- and polyfluoroalkyl substances (PFAS)
- Total petroleum hydrocarbons (TPH)
- Heavy metals (Iron, lead, zinc, etc.)
- Ions (Sulphur, phosphorous, etc.)



Free floating chemicals 3 weeks after the spill

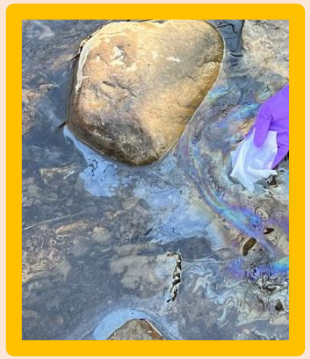

USEPA and Norfolk Southern were removing VOCs and SVOCs from the creek water and transferring them into the air

February Field Observations



Aeration

Sorbent
Pad/Boom



Creek

Groundwater

Well

Home

PURDUE
UNIVERSITY

What have we found? Inconsistent testing by government agencies for chemicals of concern

USEPA Outdoor Air	OH Surface Water	OH Municipal Water	OH Private Well Water
Acrolein	**Not tested**	**Not tested**	**Not tested**
Not tested	Butyl acrylate	Butyl acrylate	Butyl acrylate (not confirmed)
Not tested	2-Ethylhexanol	**Not tested**	**Not tested**
Not tested	2-Ethylhexyl acrylate	2-Ethylhexyl acrylate	2-Ethylhexyl acrylate (not confirmed)
Not tested	2-Butoxyethanol	**Not tested**	**Not tested**
Vinyl chloride	Vinyl chloride	Vinyl chloride	Vinyl chloride
Benzene	Benzene	Benzene	Benzene
Xylenes	Xylenes	Xylenes	Xylenes
Naphthalene	Naphthalene	Naphthalene	Naphthalene
1,3-Butadiene	**Not tested**	1,3-Butadiene	1,3-Butadiene
1,1,2-Trichloroethane	1,1,2-Trichloroethane	1,1,2-Trichloroethane	1,1,2-Trichloroethane
Trichloroethylene	**Not tested**	Trichloroethylene	**Not tested**
Phosgene	**Not tested**	**Not tested**	**Not tested**
Ethylene glycol (Not tested)	**Not tested**	**Not tested**	**Not tested**

PA DATA NOT SHOWN

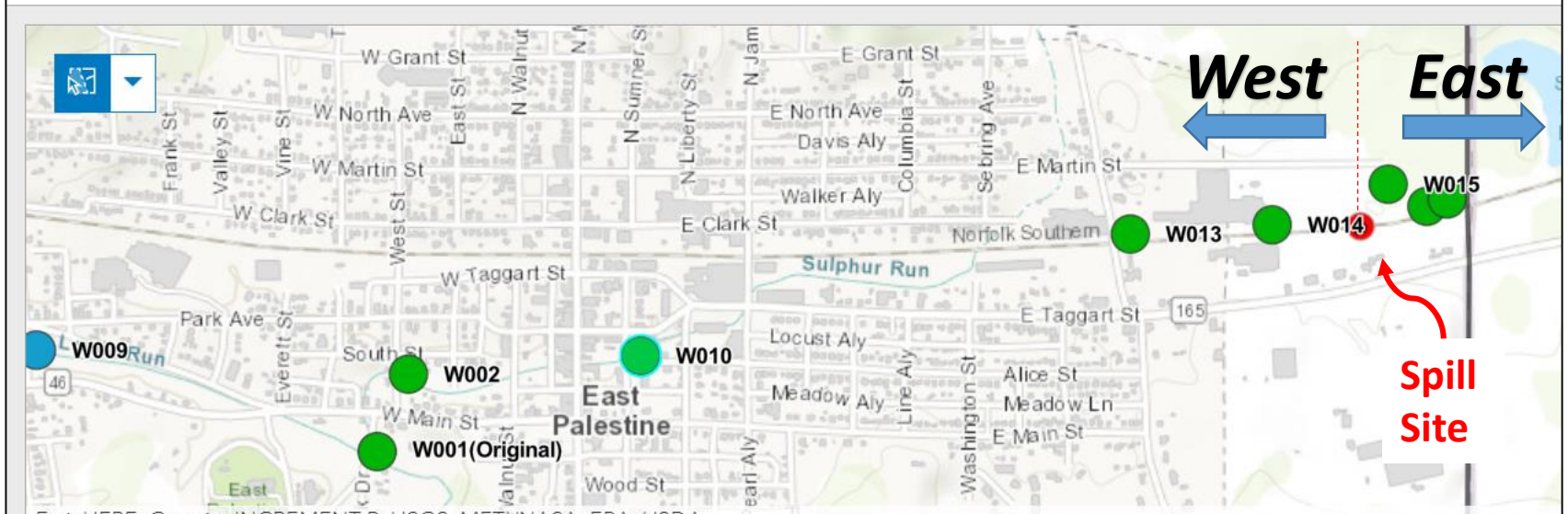
NS DATA NOT SHOWN

Purdue Surface Water Detections (Mar 7 Letter to US Senate): **Acrolein**, *n*-Butyl ether, Butyl acrylate, 2-Butoxyethanol, 1,3-Butadiene, 2-Ethylhexyl acrylate, **Ethylene glycol**


Creek water sampling
(18 locations)
Legend
Spill site
Creek sampling locations
Background sampling locations
C14
C13
C12
C15
C4
C2
C16
Spill site
C5
C6
C11
Darlington
C9
C10
Negley
C8
C7
Ohio River
N
6 mi
Google Earth

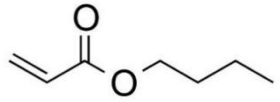
The Ohio EPA required Norfolk Southern to collect and analyze creek water samples, but not all chemicals were tested for at the same time

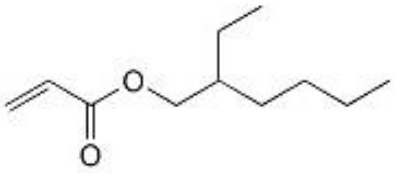
Chemical	Method Detection Limit, ppb	Date of 1st Sample	Max West of Site, ppb	Max East of Site, ppb	Max Norfolk Southern Background, ppb (1st sample)
Vinyl chloride	0.29	Feb 9	7,700	0.58	< 0.29 (Feb 5)
Butyl acrylate	1.0	Feb 9	180,000	22	< 1 (Feb 5)
2-Ethylhexyl acrylate	1.0	Feb 9	122,000	68.1	491 (Feb 5)
Benzene	0.34	Feb 9	39.3	3.6	< 0.34 (Feb 4)
2-Butoxyethanol	Unclear	Feb 9	657,000	848,000	556 (Feb 4)
Methyl acrylate	1.0	Feb 9	3.3	ND	< 1 (Feb 5)
Polypropylene glycol	619	Feb 28	111,000	33,000	1,030 (Feb 28)
Diproplylene glycol	5,000	Feb 28	106,000	29,600	< 5,000 (Feb 28)
Diethylene glycol	5,000	Feb 28	19,700	89,100	< 5,000 (Feb 28)

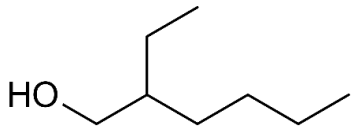


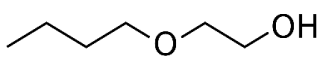
Some of their "background" samples were within the plume fallout area

We developed an analytical method to target four primary contaminants (as well as others) and collected background creek water samples

Butyl acrylate 

2-Ethylhexyl acrylate 

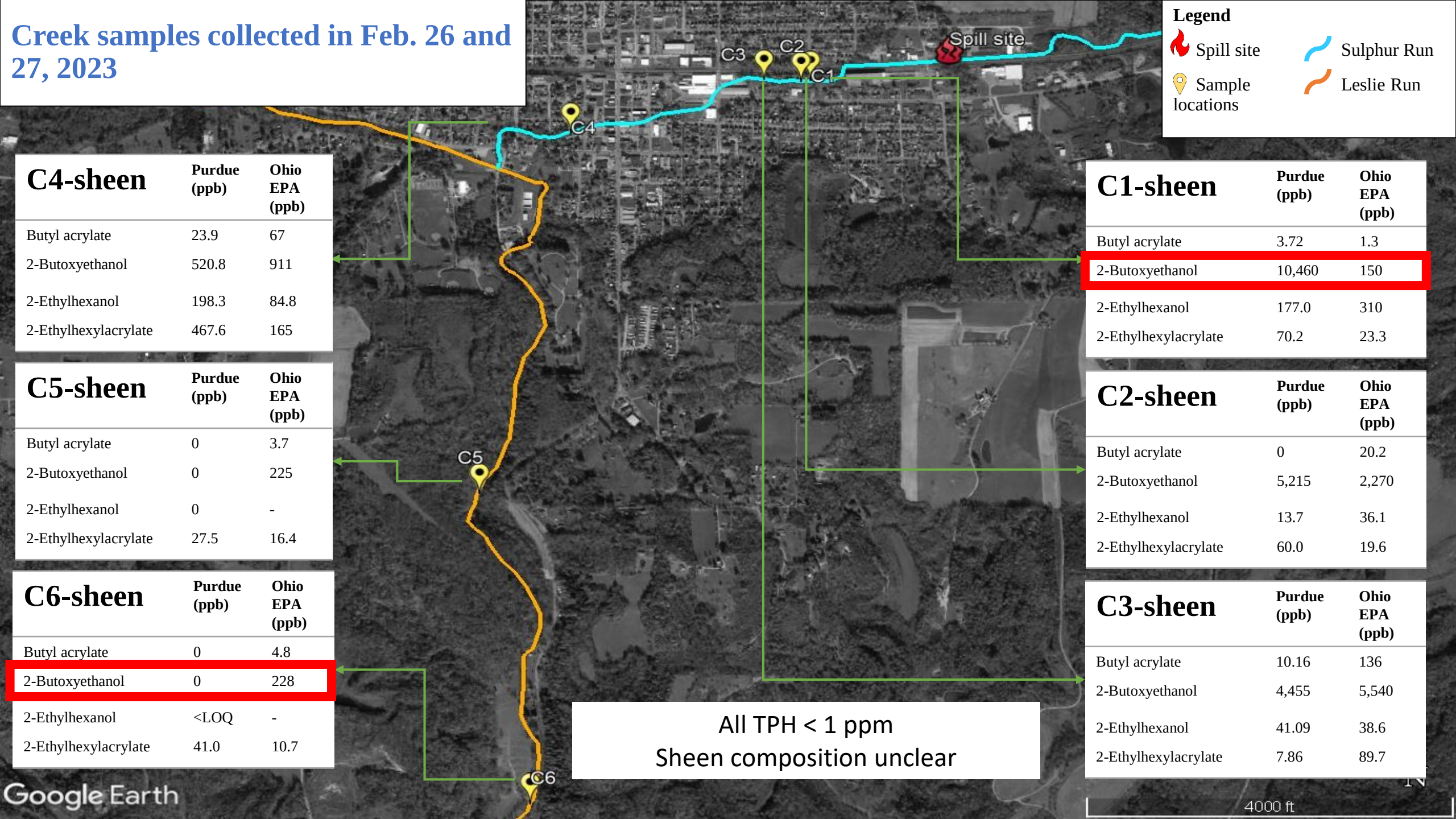
2-Ethylhexanol 

2-Butoxyethanol 

Compound	Method			Our Background Locations			
	% Recovery with LLE	MRL - Minimum Reporting Limit (ppb)	MDL - Method Detection Limit (ppb)	C9	C11	C12	C14
Butyl acrylate	64.4	2.6	0.6	ND	ND	ND	ND
2-Butoxyethanol	49.5	5.3	1.03	ND	ND	ND	ND
2-Ethylhexanol	103.5	2.6	0.6	ND	ND	ND	2.8
2-Ethylhexyl acrylate	70.4	1.3	0.5	ND	ND	ND	ND

<LOQ = Less than limit of quantitation
ND = Non-detected

Creek samples collected in Feb. 26 and 27, 2023



C4-sheen	Purdue (ppb)	Ohio EPA (ppb)
Butyl acrylate	23.9	67
2-Butoxyethanol	520.8	911
2-Ethylhexanol	198.3	84.8
2-Ethylhexylacrylate	467.6	165

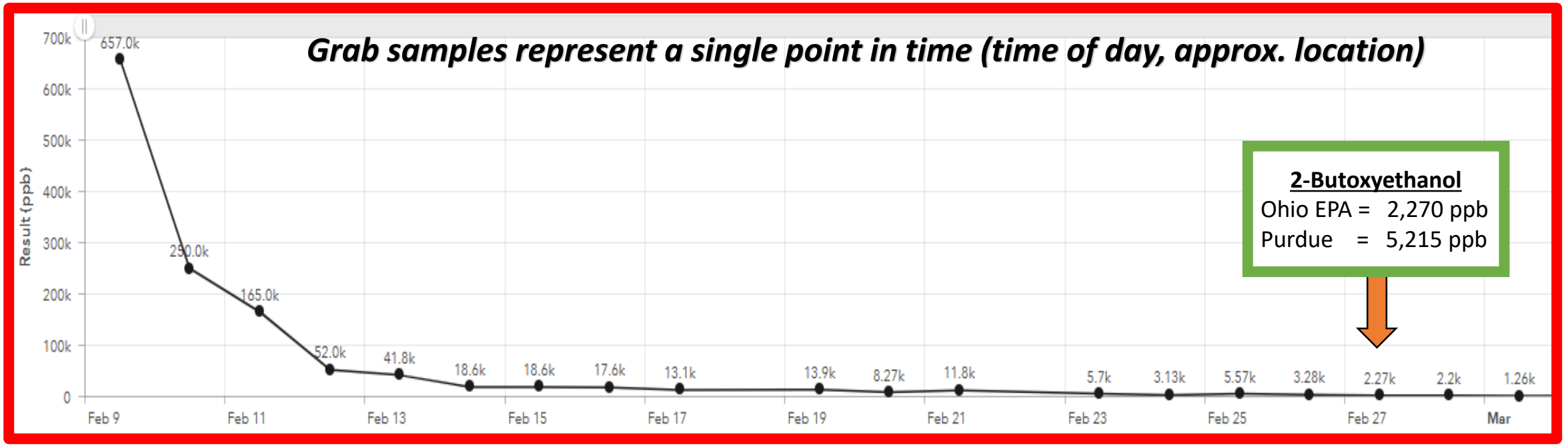
C5-sheen	Purdue (ppb)	Ohio EPA (ppb)
Butyl acrylate	0	3.7
2-Butoxyethanol	0	225
2-Ethylhexanol	0	-
2-Ethylhexylacrylate	27.5	16.4

C6-sheen	Purdue (ppb)	Ohio EPA (ppb)
Butyl acrylate	0	4.8
2-Butoxyethanol	0	228
2-Ethylhexanol	<LOQ	-
2-Ethylhexylacrylate	41.0	10.7

C1-sheen	Purdue (ppb)	Ohio EPA (ppb)
Butyl acrylate	3.72	1.3
2-Butoxyethanol	10,460	150
2-Ethylhexanol	177.0	310
2-Ethylhexylacrylate	70.2	23.3

C2-sheen	Purdue (ppb)	Ohio EPA (ppb)
Butyl acrylate	0	20.2
2-Butoxyethanol	5,215	2,270
2-Ethylhexanol	13.7	36.1
2-Ethylhexylacrylate	60.0	19.6

C3-sheen	Purdue (ppb)	Ohio EPA (ppb)
Butyl acrylate	10.16	136
2-Butoxyethanol	4,455	5,540
2-Ethylhexanol	41.09	38.6
2-Ethylhexylacrylate	7.86	89.7



- Data posted by Ohio EPA represent single point(s) in time and GC/MS analysis.
- Approach for Norfolk Southern creek sampling not well described online.
- By Ohio EPA direction, Purdue asked Norfolk Southern for their sampling plan twice, with no response.
- Time of day, sampling location, rainfall, creek turbulence may influence results.

Many more results coming from us in the coming days to weeks

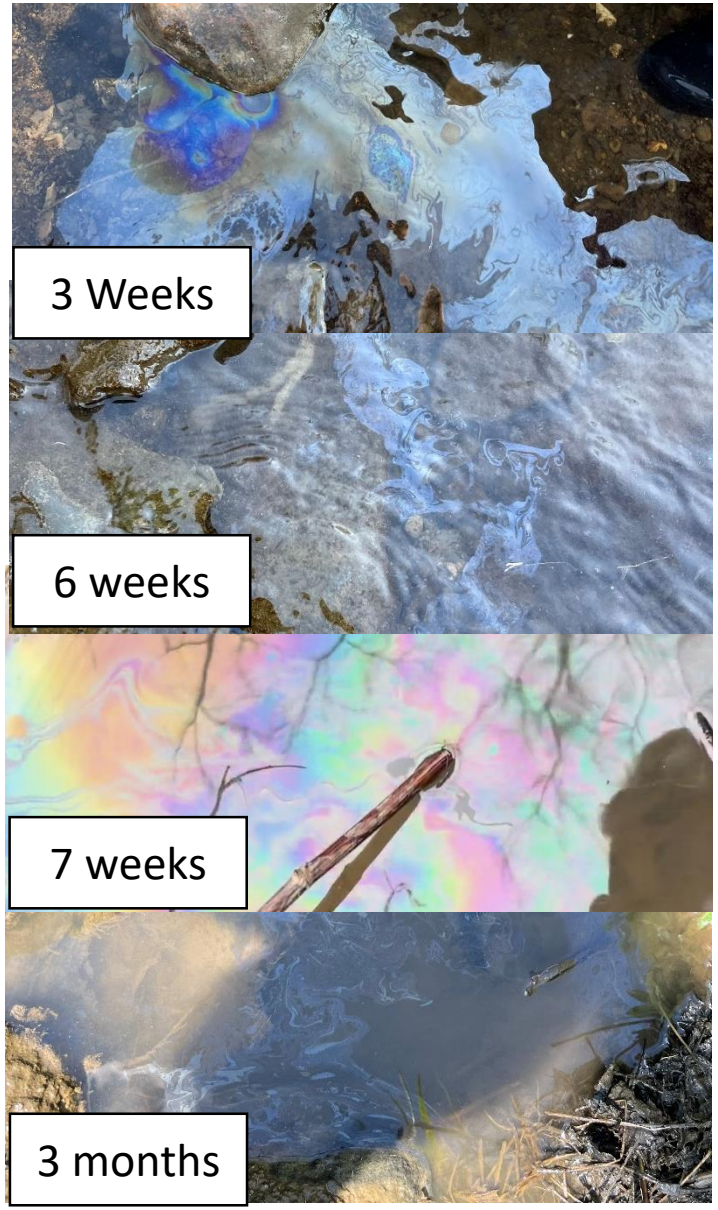
As expected, contaminant levels decreased over time, but sheen and odor were still present 7 weeks after the spill

Compound	Sulphur Run Location			Leslie Run Location			
	3 wk	6 wk	7 wk	3 wk	6 wk	7 wk	3 mt
Butyl acrylate	23.9	ND	ND	ND	ND	ND	ND
2-Butoxyethanol	520.8	ND	ND	ND	ND	ND	ND
2-Ethylhexanol	198.3	ND	ND	ND	ND	<LOQ	ND
2-Ethylhexyl acrylate	467.6	ND	ND	41.0	ND	ND	ND

<LOQ = Less than limit of quantitation
ND = Non-detected

Sheen was present, but exact chemical composition unclear

- Responders used TPH analysis early on and found max. TPH-DRO (20 ppm) TPH-GRO (14 ppm) in Leslie and Sulphur Runs. Levels decreased with time.
- 3 weeks after the incident we found
  - TPH-DRO < 1 ppm
  - TPH-GRO < 1 ppm
  - GC/MS analysis did not reveal the contaminants present
- 3 months later sheen was still eluting from creek banks, but not openly flowing like we saw initially
- RESP aerated creeks, pressure washed creeks and rocks in some locations
- Numerous rain events occurred



Contaminated properties were found, but private drinking water wells sampled were not contaminated

- X wells sampled
- Some wells <100 feet from heavily contaminated creeks
- Mines were present in the area
- Groundwater geology

In May, residents were told by a home water treatment company that a well contained vinyl chloride above the safe drinking water limit…

WATER SAMPLE TESTED FOR VINYL CHLORIDE	AMOUNT OF VINYL CHLORIDE FOUND IN SAMPLE	MAXIMUM ACCEPTABLE CONTAMINANT LEVEL	PERCENTAGE OF ACCEPTABLE CONTAMINANT LEVEL REACHED
Sample 1 - Untreated	4.04 µg/L	5.0 µg/L	80.8%
Sample 2 - Untreated	5.28 µg/L	5.0 µg/L	106%
Sample 3 - Untreated	5.22 µg/L	5.0 µg/L	104%
Sample 4 – Treated with Sentry Wellness System	Not Detected	5.0 µg/L	0%

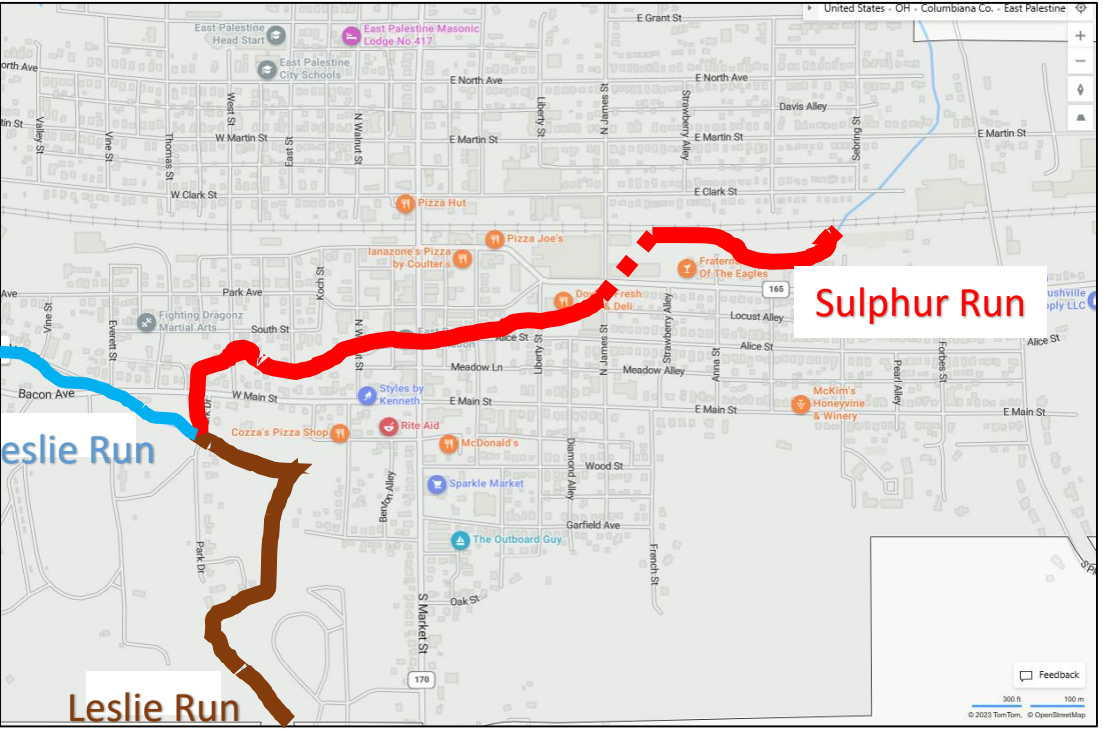
But it turns out the lab report was misread. There was no VC contamination.

We found that indoor air was contaminated with organic chemicals for some buildings for 1.5 to 3 months (at least)

3 weeks after: Ohio Governor stated that "air testing had been conducted in 578 homes and no contaminants associated with the derailment were detected." East Palestine Update - 2/26/23 | Governor Mike DeWine (ohio.gov).

5-7 weeks after: Ohio Governor disclosed that indoor air chemical contamination was still being caused in homes and businesses near **Sulphur Run** (East Palestine Update - 3/15/23 | Governor Mike DeWine (ohio.gov); East Palestine Update - 3/14/23 | Governor Mike DeWine (ohio.gov); East Palestine Update - 3/9/23 | Governor Mike DeWine (ohio.gov)).

To address these chemical exposures the culverts were subjected to high-pressure washing to remove any contaminated sediment in those culverts



3 months after: We visited a building along Sulphur Run that had the acrid odor.

- Building had been aired out multiple times with fans
- Occupant complained of chemical exposure symptoms
- Occupant asked USEPA for help, but they never came, but Norfolk Southern did….

11 days after the incident, NS indoor air testing with a PID "<0.1 ppm"

- "Strong, super glue, pool, fruity, unpleasant, overwhelming odors prompted the air monitoring team to leave the building."

18 days after the incident, occupant commissioned indoor air testing

- Butyl acrylate (26 ppb) ➔ **EXCEEDED USEPA SCREENING LEVEL OF 20 ppb**
- 2-Ethylhexyl acrylate (3 ppb)
- Benzene (0.6 ppb)
- Soot also found. Insurance company declared the materials a total loss

Closer Review: PIDs were inappropriately used to declare air safe. Devices were unable to detect health risks of significance

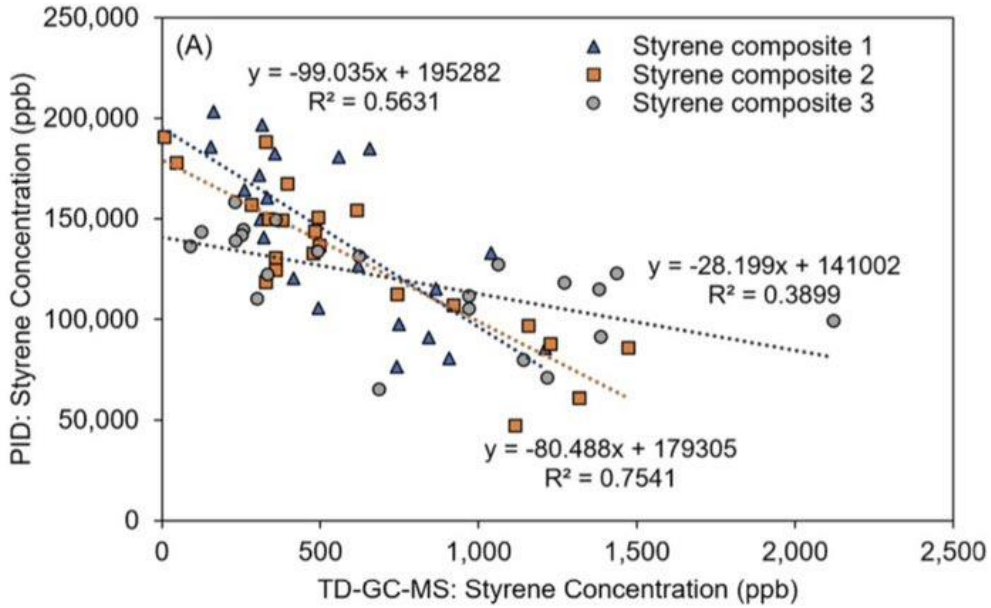
Issues with PIDs known for >10 years

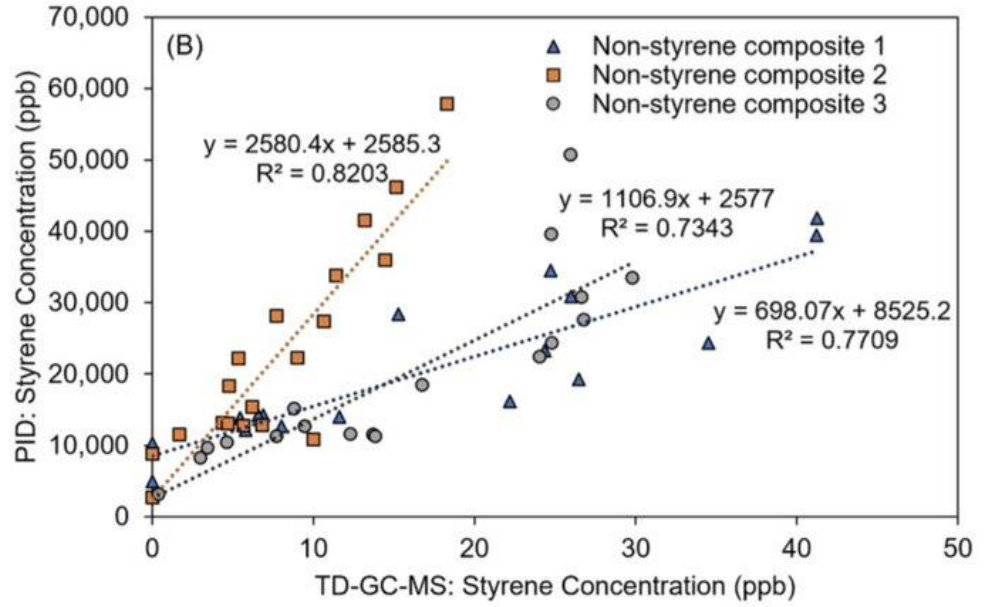
[2023, Regulatory Significance of Plastic Manufacturing Air Pollution Discharged into Terrestrial Environments and Real-Time Sensing Challenges | Environmental Science & Technology Letters (acs.org)]

[2014, Effect of interferents on the performance of direct-reading organic vapor monitors (tandfonline.com)]

[2013, Effect of calibration environment on the performance of direct-reading organic vapor monitors (tandfonline.com)]

[2012, Effect of Calibration and Environmental Condition on the Performance of Direct-Reading Organic Vapor Monitors (tandfonline.com)]



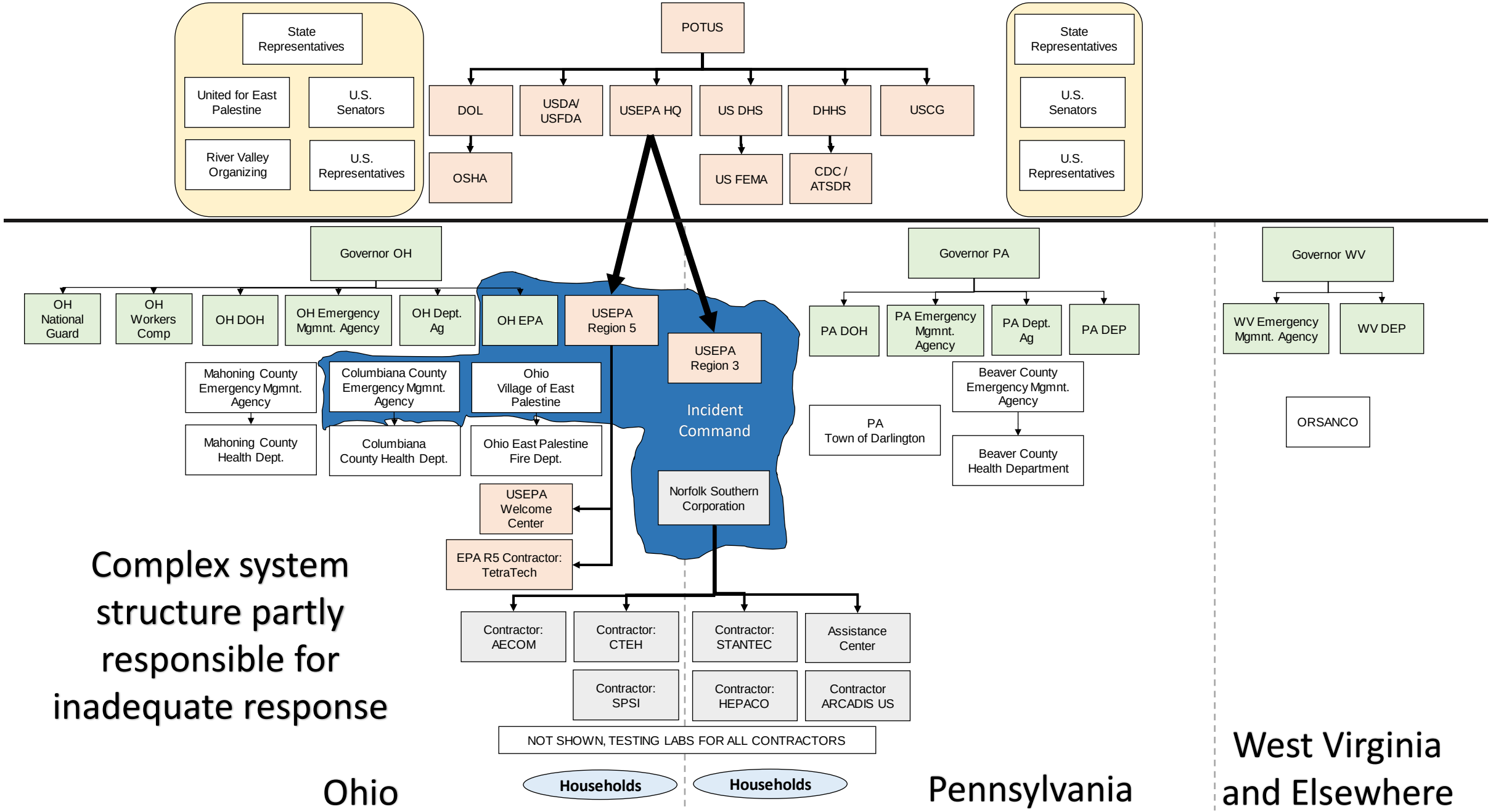


Noh et al. 2023. *ACS Env. Sci. Technol. Letters.* [https://doi.org/10.1021/acs.estlett.2c00710]

Coming Results from Us

Honey characterization from apiaries within a 5 mile radius

Chemical fate assessment in and near creeks

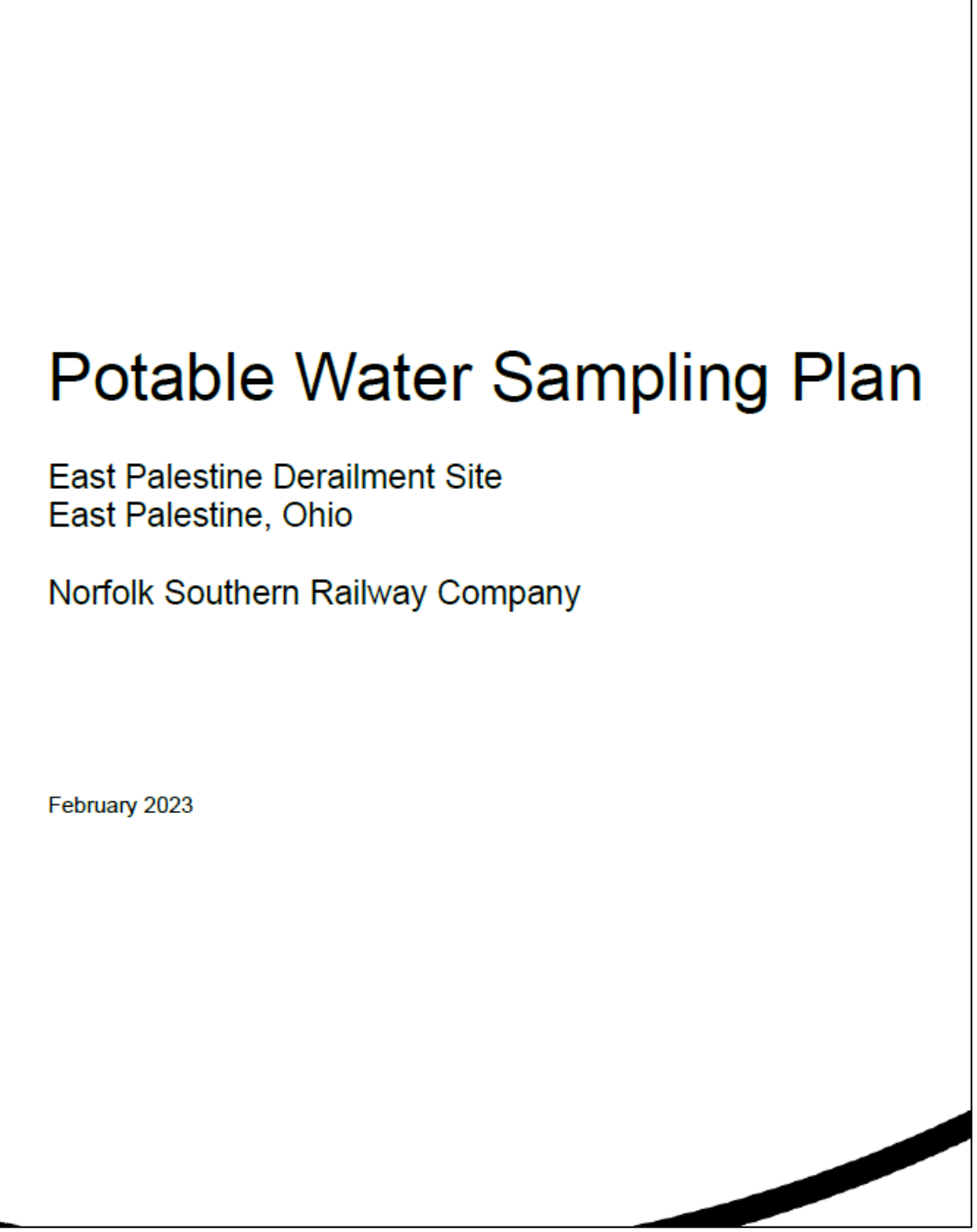


Complex system structure partly responsible for inadequate response

Ohio

Pennsylvania

West Virginia and Elsewhere



A Flawed Foundational Document:

Water sampling plan developed by AECOM for Norfolk Southern which was embraced by Incident Command

- ❑ Did not screen for ethylene glycol methyl butyl ether [2-butoxyethano] a chemical known to be spilled when this document was created.
- ❑ Other chemicals not included.
- ❑ Ohio EPA and County Health Depts sampled drinking water following this plan.
- ❑ No testing data was shared publicly until 3.5 weeks after the disaster.
- ❑ Plan was never publicly posted.

Other topics you may have heard about…

1. Governors and Mayors prevented waste from entering their communities for treatment and disposal. In Ohio, a truck hauling soil waste spilled.
2. Multiple universities stepped in to provide scientific support.
3. Evidence indicates that chemicals reached Negley and elsewhere in air, not in the plume model shown publicly by the Ohio Governor.
4. USEPA did not disclose the modelled footprint of the chemical plume.
5. CDC survey team conduced chemical exposures took place.
6. Chemical illnesses DID occur in February and March at least (CDC employees, contractors, residents, visitors), but results not shared yet to explain.

A LOT of people are volunteering their time and resources to provide scientific support to the community

PURDUE UNIVERSITY

Andrew Whelton, Ph.D., Civil Env. Eng
Nusrat Jung, Ph.D., Civil Eng.
Brandon Boor, Ph.D., Civil Eng.
Caitlin Proctor, Ag. Env. Eng.
Linda Lee, Ph.D., Agronomy
Jeff Youngblood, Ph.D., Materials Eng.
Marty Frisbee, Ph.D., Earth Sci.
Brock Harpur, Ph.D., Entomology
Youn Jeong Choi, Ph.D., Agronomy
Gouri Prabhakar, Ph.D., Atmospheric Sci.
Bobbie Vance, CE
Brad Caffery, CE
Stephanie Surdyka, ChE

Paula Coelho, EEE
Rasul Diop, EEE
Stephanie Heffner, EEE
Kristofer Isaacson, EEE
Gracie Fitzgerald, EEE
Aliya Ehde, EEE
Akshat Verma, MSE
Katherine Del Real, EEE
Laura Gustafson, CE
Ana Maria Torres, CE
Jinglin Jiang, CE
Xiaosu Ding, CE
Sam Spears, EEE

Paula Coelho
Andrew Whelton, Ph.D.
awhelton@purdue.edu

Kyle Doudrick, Ph.D
Civil & Env. Engineering

Files and results available at
www.PlumbingSafety.org