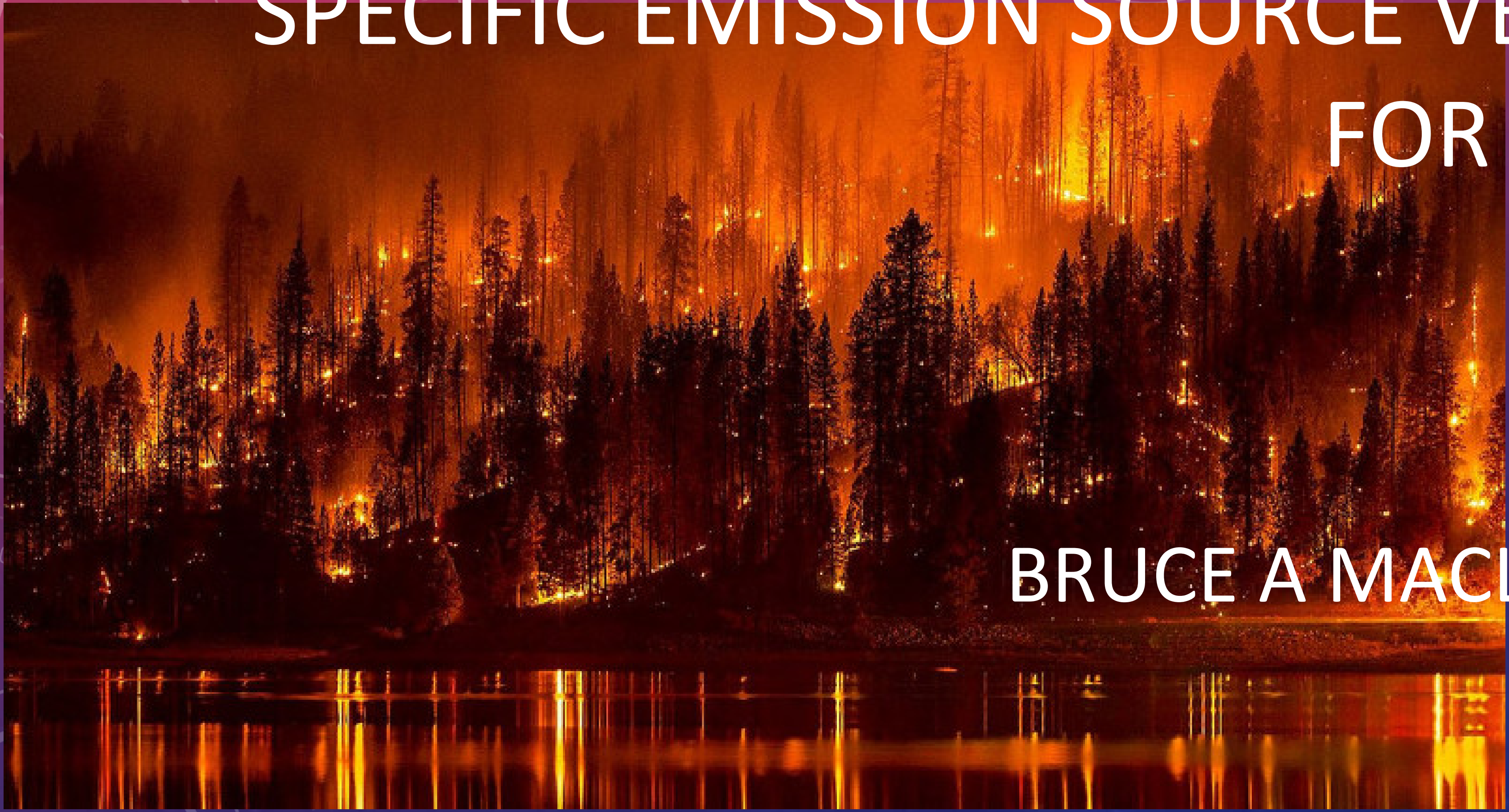
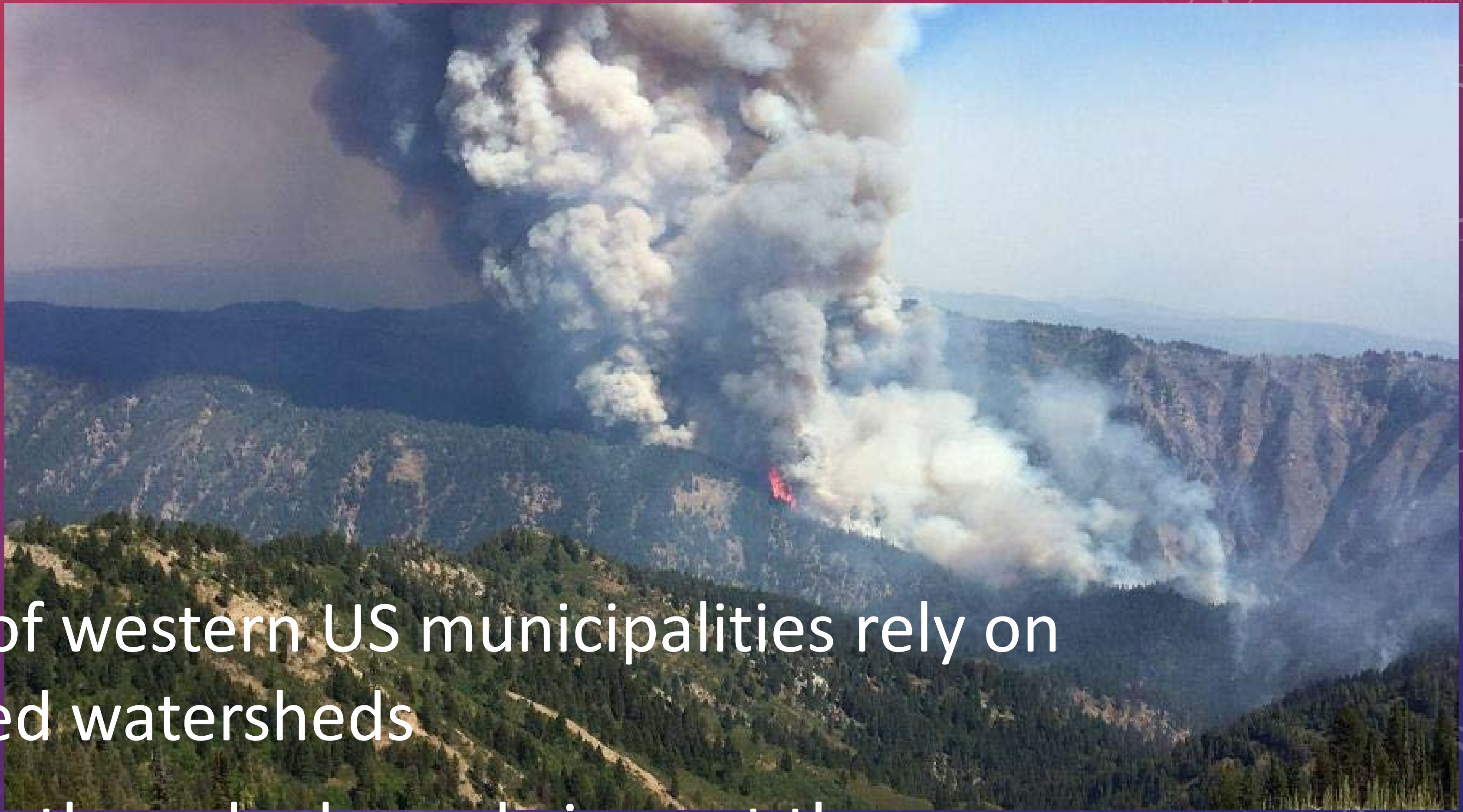
SOIL AND COMBUSTION DEBRIS AS SPECIFIC EMISSION SOURCE VECTORS FOR WATER



BRUCE A MACLER, PHD

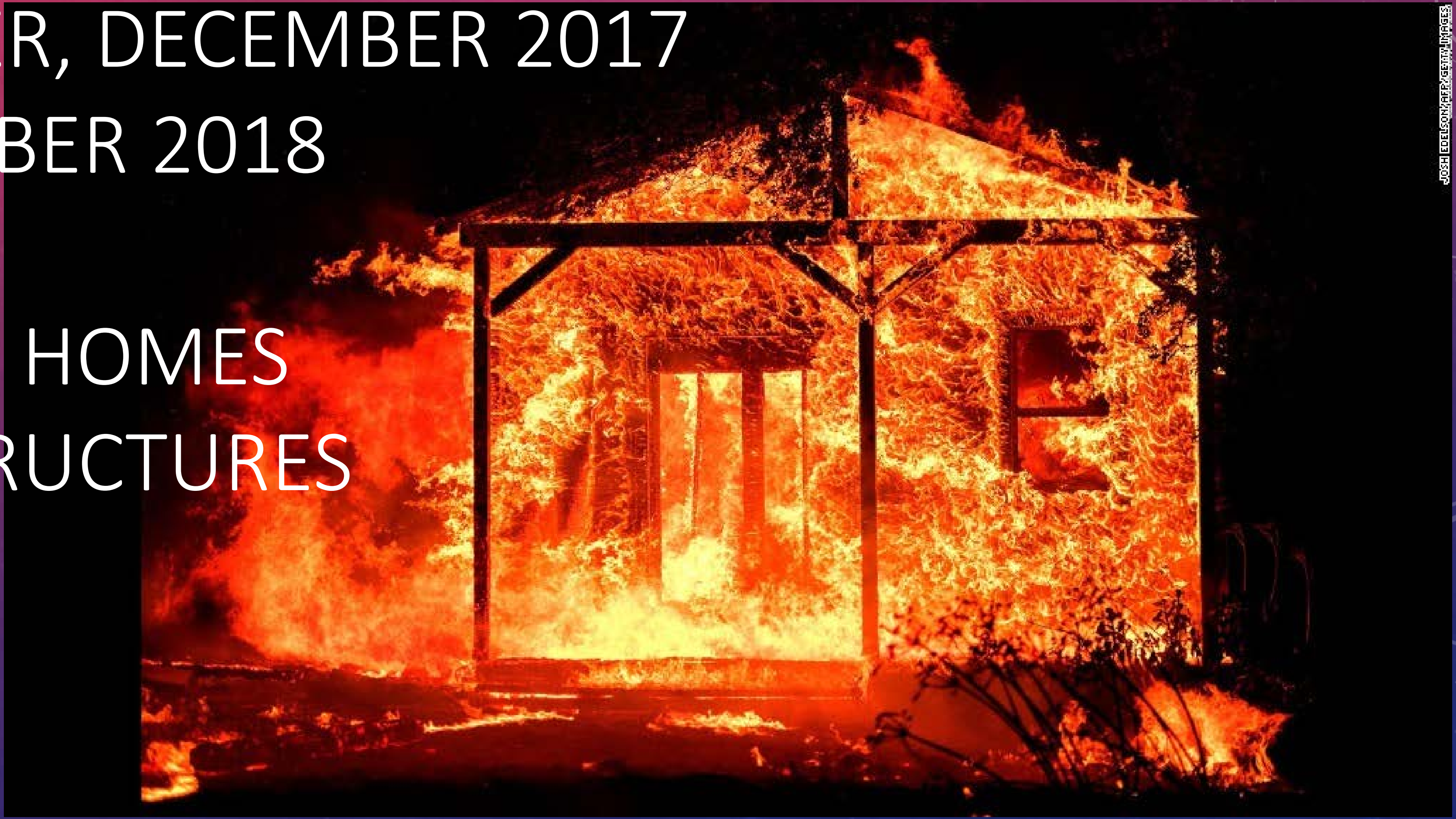
WILDFIRES AND WATER

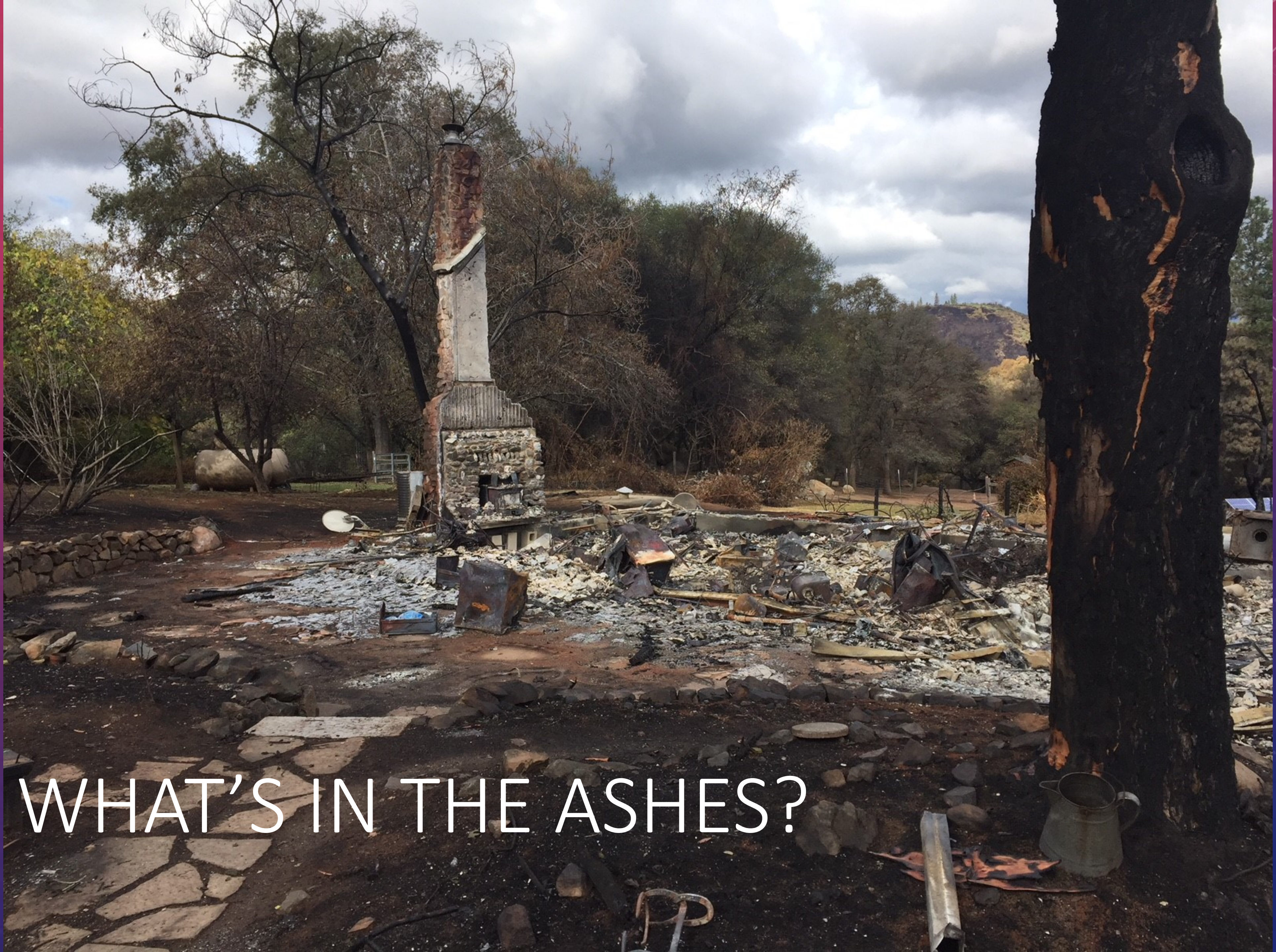


- About two-thirds of western US municipalities rely on water from forested watersheds
- Wildfires can abruptly and adversely impact these watersheds
- These effects of wildfires are complex and long-lasting

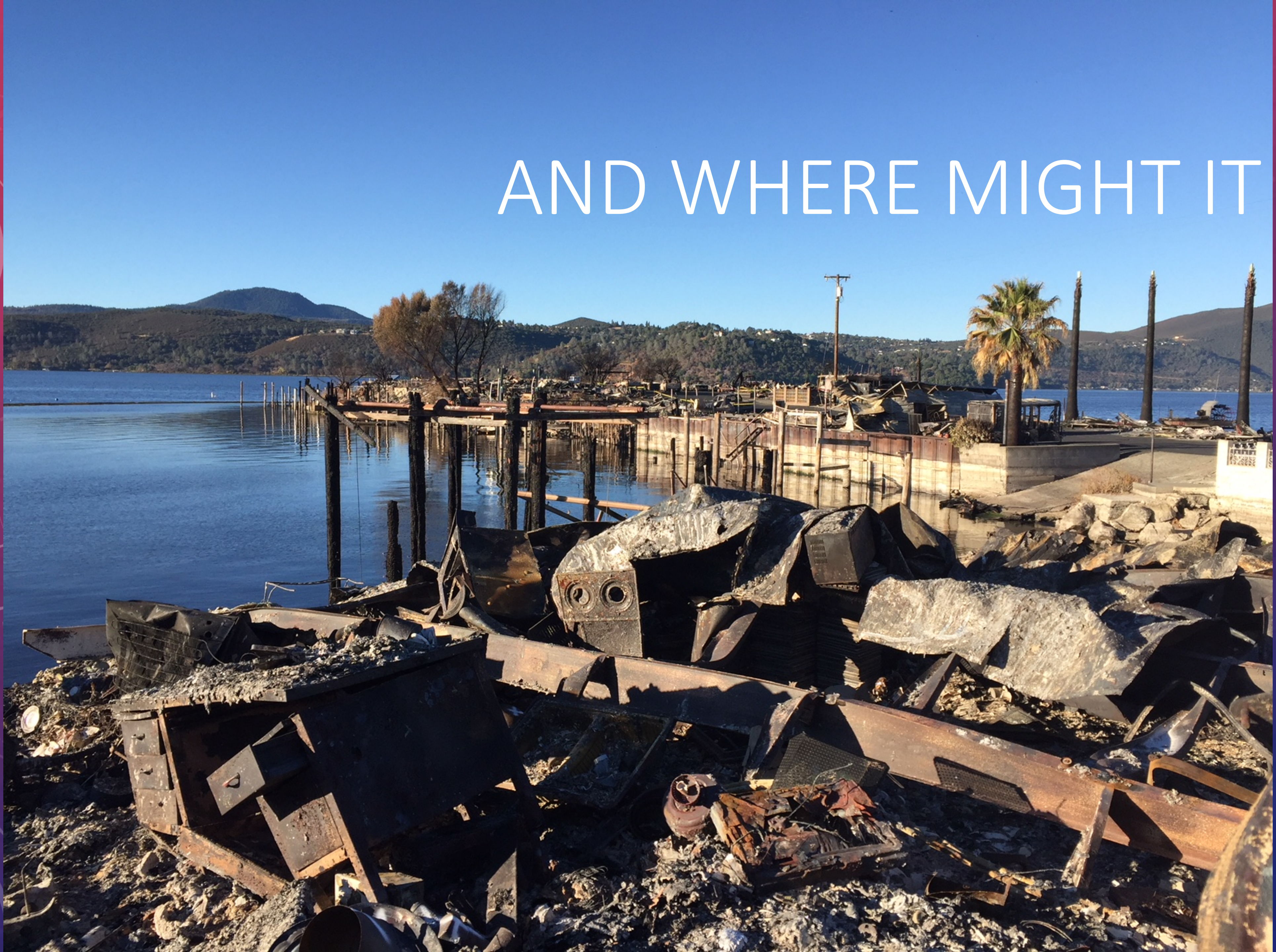
CALIFORNIA URBAN INTERFACE WILDFIRES
OCTOBER, DECEMBER 2017
NOVEMBER 2018

~35,000 HOMES
AND STRUCTURES

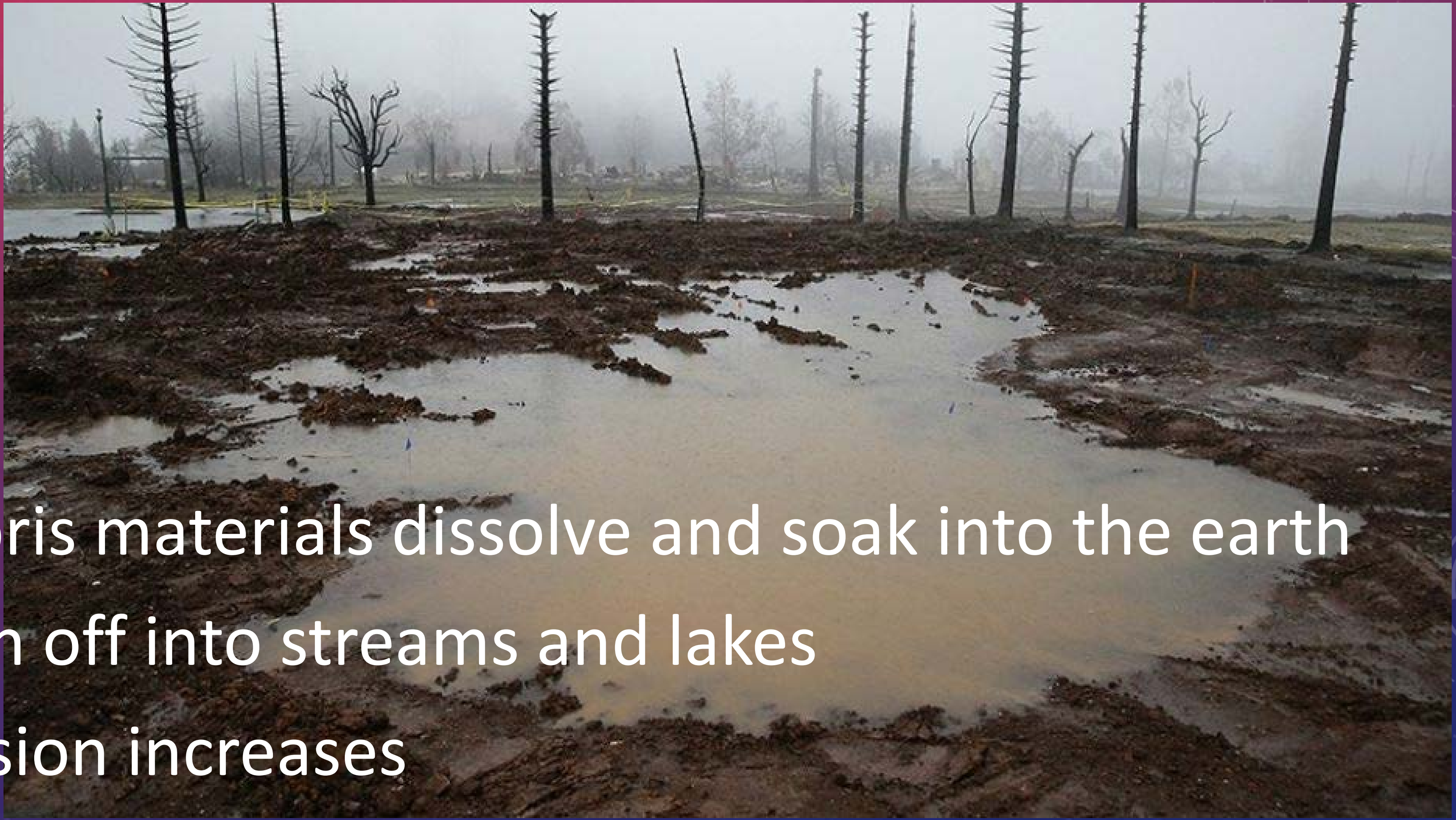



WHAT'S IN THE ASHES?

AND WHERE MIGHT IT GO?



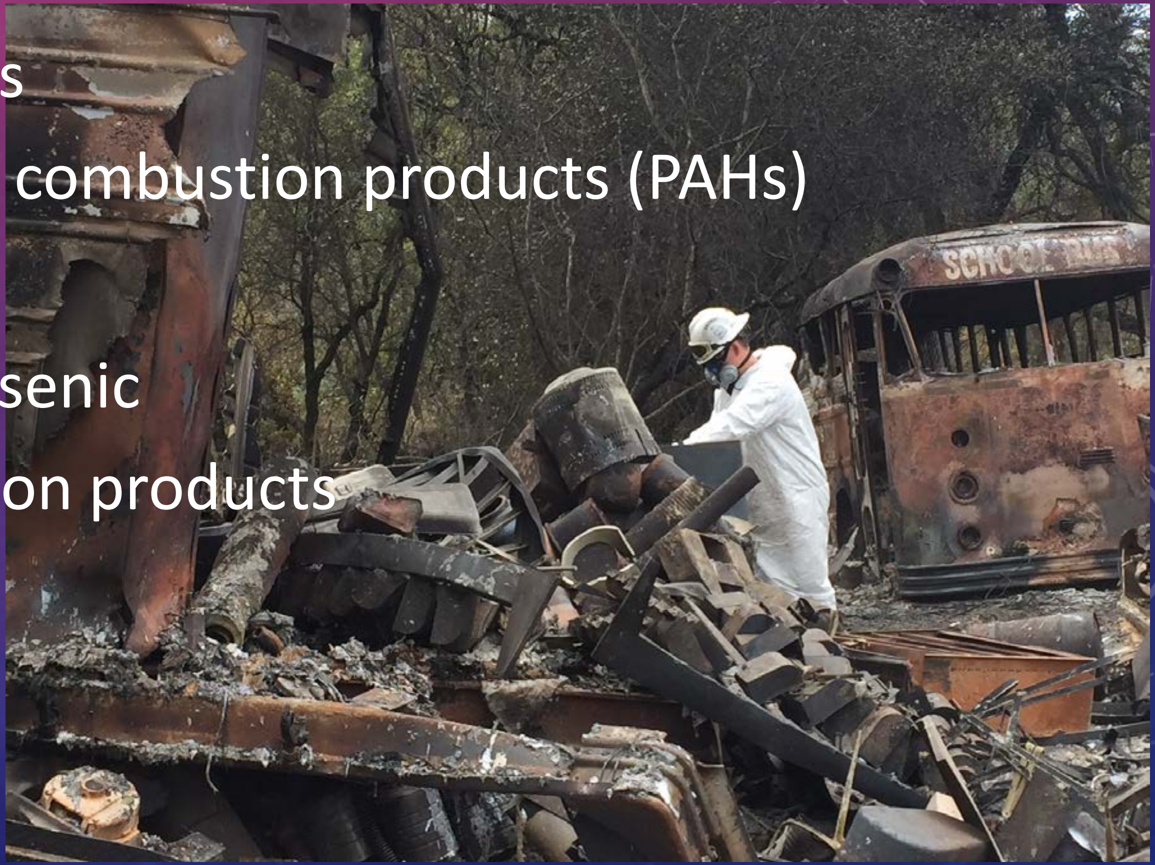
AND THEN THE RAINS COME….



- Fire debris materials dissolve and soak into the earth
- They run off into streams and lakes
- Soil erosion increases

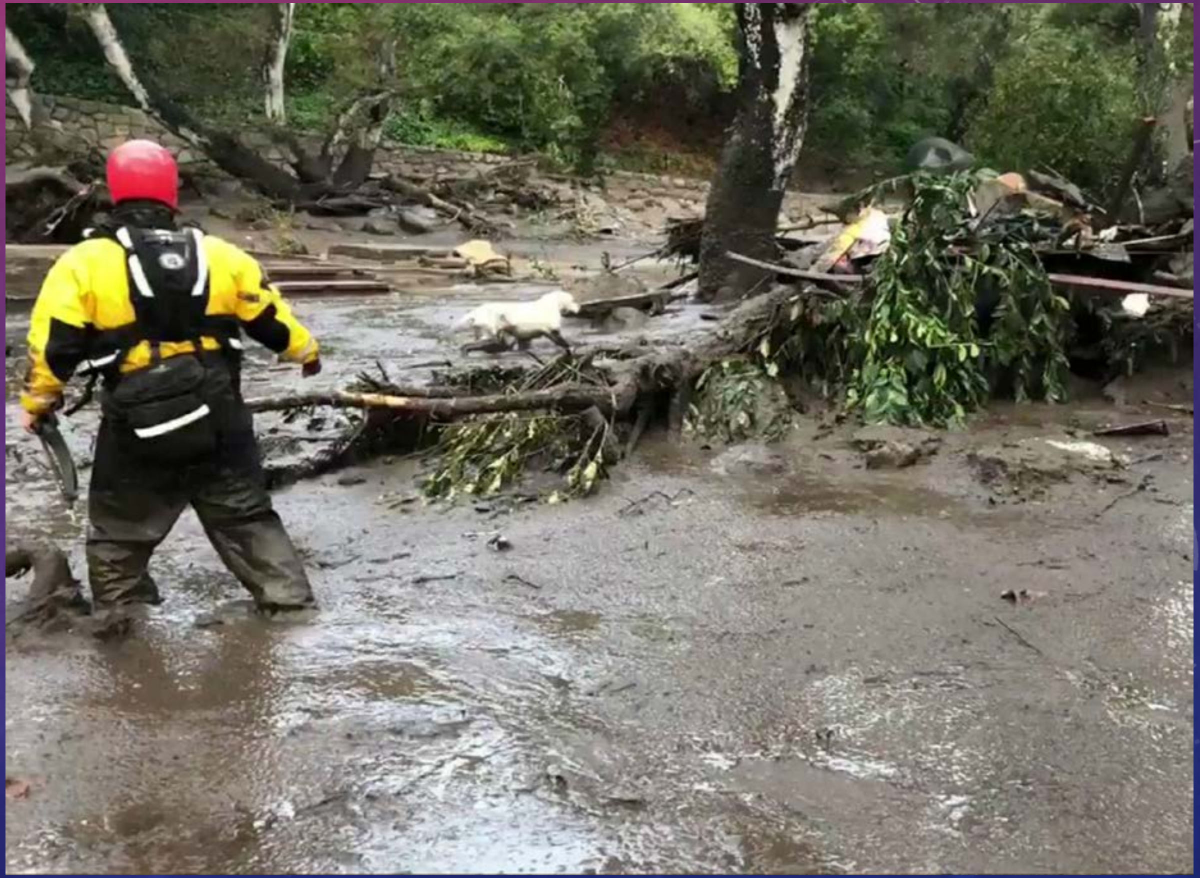
BURNED MATERIALS + WATER = WHAT?

- From burned wildlands vegetation
  - Nutrients: nitrogen and phosphorous
  - Dissolved organic carbon and carbon combustion products (PAHs)
- From burned structures
  - Metals: lead, aluminum, mercury, arsenic
  - Organic carbon and carbon combustion products
- From ash
  - pH changes
  - Sediment and turbidity



IMPACTS ON WATERSHEDS

- Loss of aquatic habitat from sedimentation and scouring
  - Debris and mud flows may be catastrophic
- Eutrophication, dissolved oxygen effects from algal blooms
- Possible toxicity from algal blooms
- Possible changes in species or ecosystems



POSSIBLE IMPACTS FOR DRINKING WATER

- Increased solids and turbidity from sediment (soil and ash)
- Increased organic carbon (TOC)
- Algal growth and species changes from nutrients
- Treatment challenges from algal blooms
- Toxic metals and organics
- pH changes

CONSEQUENCES FOR DRINKING WATER TREATMENT

- Increased turbidity: increased filtration, shorter run times
- Increased algae: increased filtration, pH adjustment, taste & odor, disinfection byproducts (DBPs) and possible cyanotoxins
- Increased organic carbon: increased coagulation, membrane fouling, DBPs, biological activity, chlorine demand
- Increased toxic materials: possible Maximum Contaminant Level violations

SURFACE WATER TREATMENT ISSUES

- Requires water quality data from source monitoring
- May need to adjust coagulant addition, pH, pre-chlorination to address increased turbidity and TOC
- Nutrient-driven algal blooms require additional attention to diurnal pH changes, taste and odor problems
- Filter runs may be shorter
- Membrane fouling likely to increase
- Disinfectant demand may increase

SURFACE WATER QUALITY MONITORING

- Monitoring may be useful for surface water sources of drinking water
- There is a general consensus on what should be monitored:
  - Turbidity/ total suspended solids
  - Total organic carbon
  - Total nitrogen (nitrate, ammonia)
  - Phosphorous
  - pH

WORTH MONITORING, IF INDICATED

- Metals (especially, lead and mercury)
- Arsenic
- Bromide (DBP precursor)
- Total trihalomethane (TTHM) formation potential
- Alkalinity
- Any constituents required for permits (zinc, chromium, copper, etc)

SAMPLING STRATEGIES

- Post-fire water quality can change over months or years, depending on rainfall and recovery BMPs
- If this could be an issue, useful to have a baseline sample before first significant runoff
- Sample “first flush” (first storm-related increase in flows)
- Sample subsequent flushes from later storms
- If in snow country, sample during spring melt

GROUNDWATER IMPACTS

- For most unconsolidated soils, little or no impacts expected for groundwater
- Natural filtration controls sediment/turbidity
- Nitrate, phosphate could slowly increase
- Some metals and organic contaminants from structures may migrate downward around immediate area
  - Lead, arsenic

FIRE-RELATED WATER DISTRIBUTION SYSTEM CONTAMINATION DISCOVERED

- The 2017 Tubbs Fire burned into Santa Rosa, California
- In the Fountaingrove area, the water distribution system depressurized during the fire
  - Water usage
  - Broken service connections
- During initial recovery, citizens reported solvent smell in DW
- Testing showed many VOCs, especially benzene
- Benzene generally elevated all over, up to 900 ug/L at some sites

HOW DID BENZENE GET THERE?

- No evidence of on-site or historical sources
- System depressurized as buildings burned
- Hot anoxic gases, smoke pulled into system through open service lines
- Some service lines were PVC and HDPE
- Smoke and materials from damaged pipes thought to have condensed and dissolved into remaining water

MONITORING DATA

- Limited data on distribution system contamination immediately after fire
- Burned buildings
  - Benzene and other VOCs sometimes found in service lines
- Standing buildings
  - Some with contamination in service lines
  - Usually associated with nearby burned buildings or fire-damaged water lines
- Distribution systems
  - In compliance
  - Some detections, usually at low points or dead ends

RECOVERY ISSUES

- Contamination was highly localized and not easily predictable
- Bulk benzene was successfully flushed out
  - Levels lowered to ~1ug/L, the CA MCL
- But benzene absorbed into plastic pipe and pipe gaskets
  - Only slowly leached out
- Extensive monitoring, flushing and replacement
- How clean is "clean"?

HEALTH CONSIDERATIONS

- Benzene toxicity
  - Long term exposures can lead to bone marrow problems and anemia
  - Long term exposures can also lead to leukemia (blood cancer)
- Toxicity of other VOCs
  - Most others affect liver, at much higher exposures
- Risk assessment
  - Few, if any, actually drank any contaminated water at all, for a short time
  - Risk is <1 cancer/ 1,000,000 people from drinking water at 1 ug/L benzene for 70 years

GUIDANCE NEEDED AND WANTED

- A useful guidance to help utilities address issues, were they to unexpectedly come up
- Self-assessment protocol for situation and risk
- If at risk, advice on areas with elevated concern
- Possible and practical mitigation and remediation strategies
- Off-the-shelf rapid screening and sampling advice and plans
- Best response and recovery operations practices

PRIMARY RESEARCH NEEDS

- What would be in the smoke and fumes drawn into a drinking water distribution system?
  - Would these pose health concerns if ingested in water?
- Could plastic service lines and distribution system components be damaged by the materials or heat?
  - If so, what contaminants might be there?