How tomorrow moves

Improving Mass Balance Through Test Burns

Michael Bethge – CSX - Manager Hazardous Materials
Chris Machenberg – CSX – Director Hazardous Materials
S. Michael Austin – CSX – Director Hazardous Materials
Dr. Frederick Payne – Arcadis – Chief Scientist
Andrew McManus – Arcadis – IRR Manager
Jon Smith – Arcadis – Senior Geologist

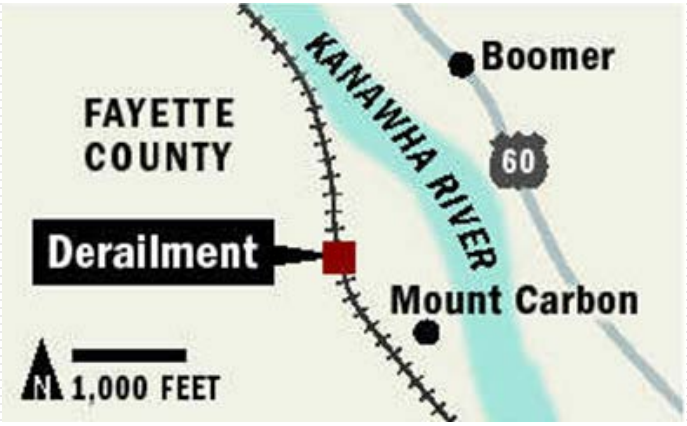
ARCADIS Design & Consultancy for natural and built assets

Outline

- Why balance mass?
- How to balance mass
- What do we not know?
- What do we do next?

Why Balance Mass?

- Environmental due diligence
  - Human, ecological and environmental risk assessment
  - Supports development of remediation strategy
  - Supports regulatory decision making and defines end points
- Regulatory requirements
  - USDOT PHMSA 5800 Reports
  - 33 U.S. Code Chapter 40 (i.e. OPA-90)
  - 33 U.S. Code 1251 (i.e. Clean Water Act)
  - Federal / State / Local regulatory agencies
- Core Values
  - Fact based
  - Right Results, Right Way



Outline

- Why balance mass?
- Balancing mass
- What do we not know?
- What do we do next?

Balancing Mass

"… a calculation of the estimated amount of crude oil released, consumed in the fire, the amounts recovered, and all assumptions used at arriving at such calculations."

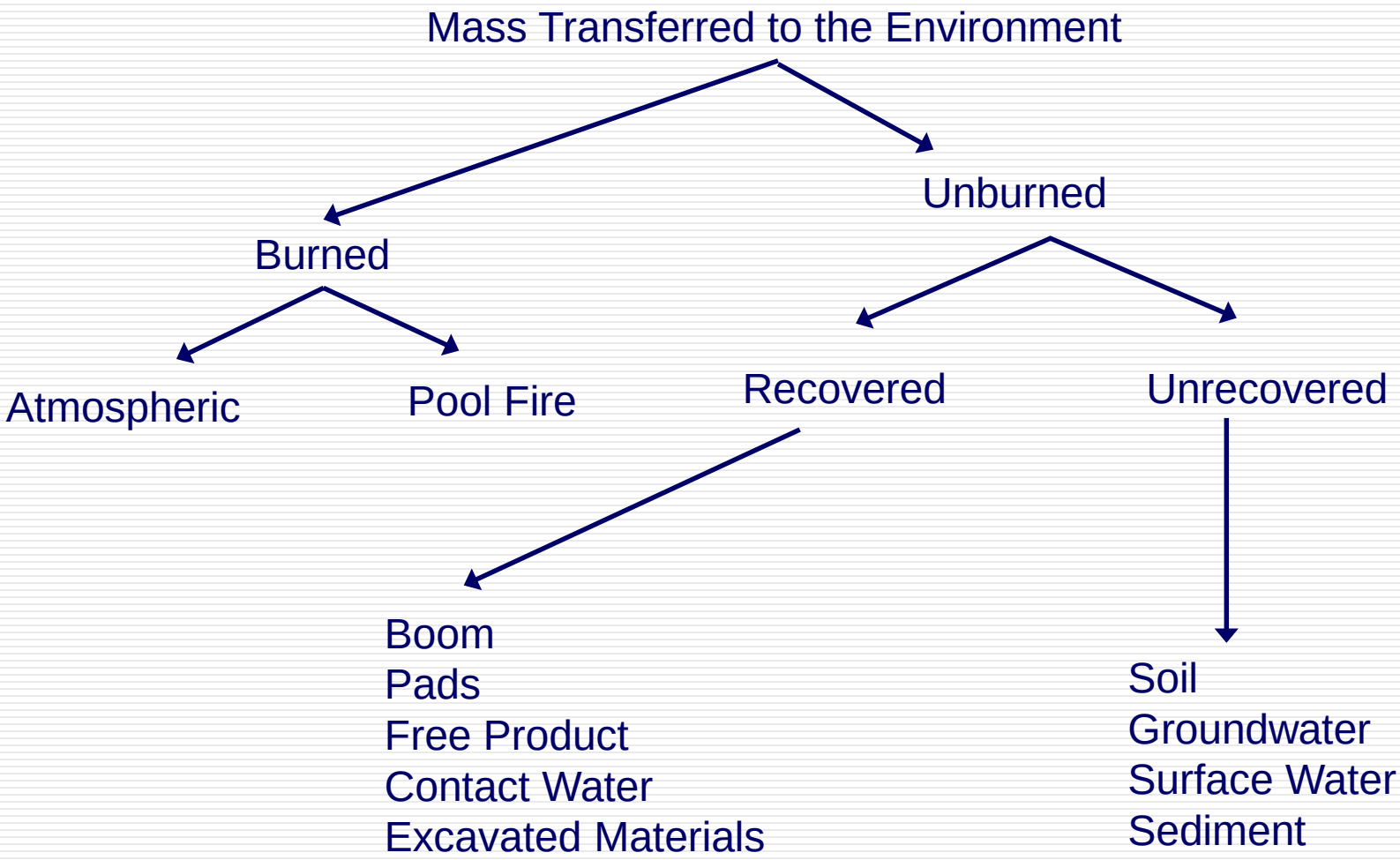
Initial volume in tank cars

- Consist
- Density of specific oil

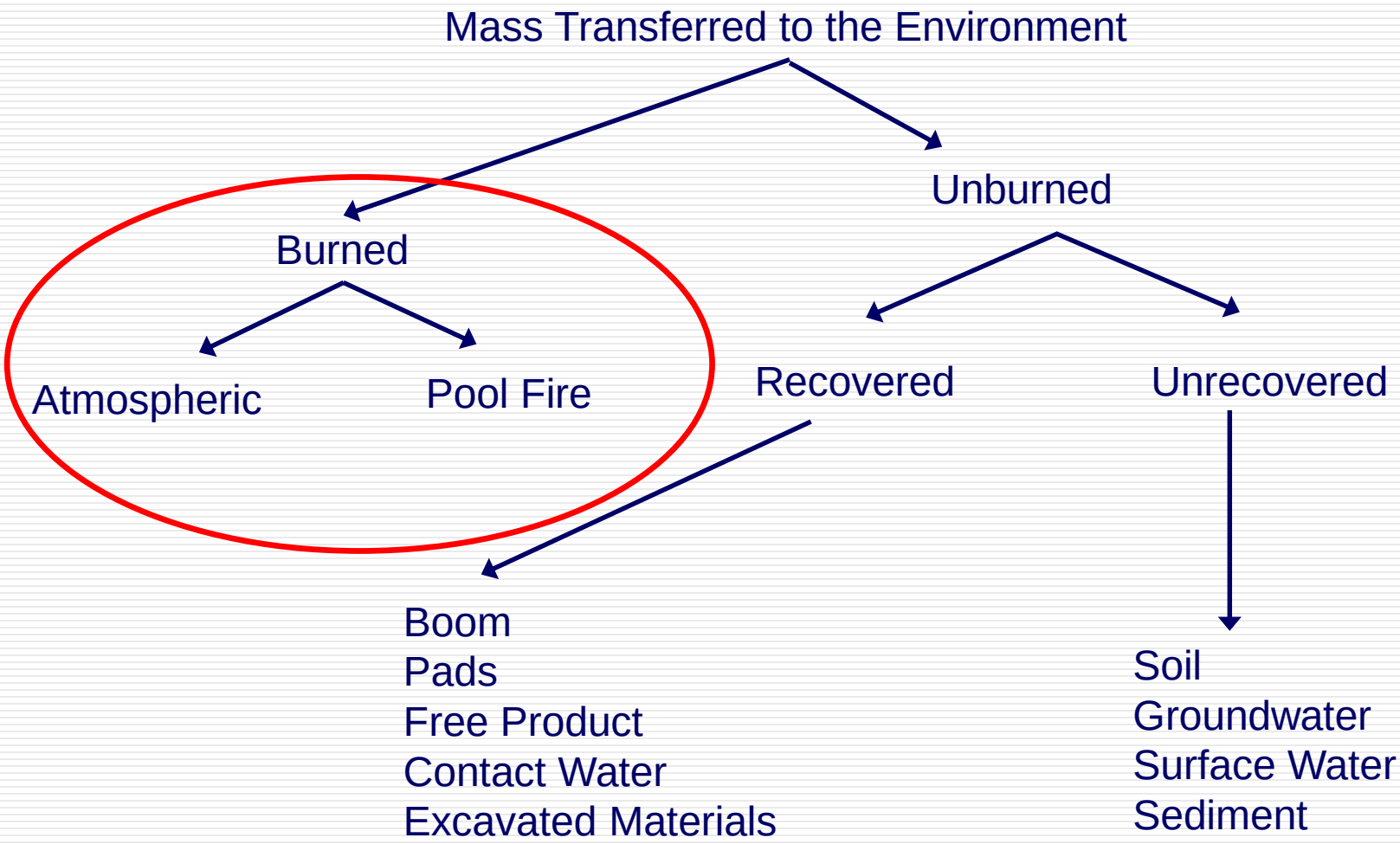
Volume recovered from tank cars

- Transfer volumes
- Heel volumes

Balancing Mass



Balancing Mass



Balancing Mass

Volume Burned

Area of fire X Duration of fire X Burn rate

Published Burn Rates

USCG – 3.5 to 4.5 mm/min

ASTM – 2.0 to 3.7 mm/min

U.S. Coast Guard

OIL SPILL RESPONSE OFFSHORE

IN-SITU BURN OPERATIONS MANUAL

Lynchburg – Starting point for crude oil mass balance process

- Simple case – one tank car, puncture, very small loss to rail bed
- River surface pool fire – a majority of the mass balance
- Coast Guard burn rate (3.5 to 4.5 mm/min) worked well to close the mass balance calculation

Mt. Carbon Mass Balance

- Significant increase in complexity
  - Large number of tank cars involved
  - Pool fires on ground surface
  - Sheet flow fires
  - Multiple heat induced tears

- Lynchburg water surface pool fire burn rates over-estimated oil consumed in rail bed pool fires
- Indicated the need for estimates of rail bed pool fire burn rates

Outline

- Why balance mass?
- Balancing Mass
- What do we not know?
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What do we not know?

Crude oil burn rates in a railroad setting

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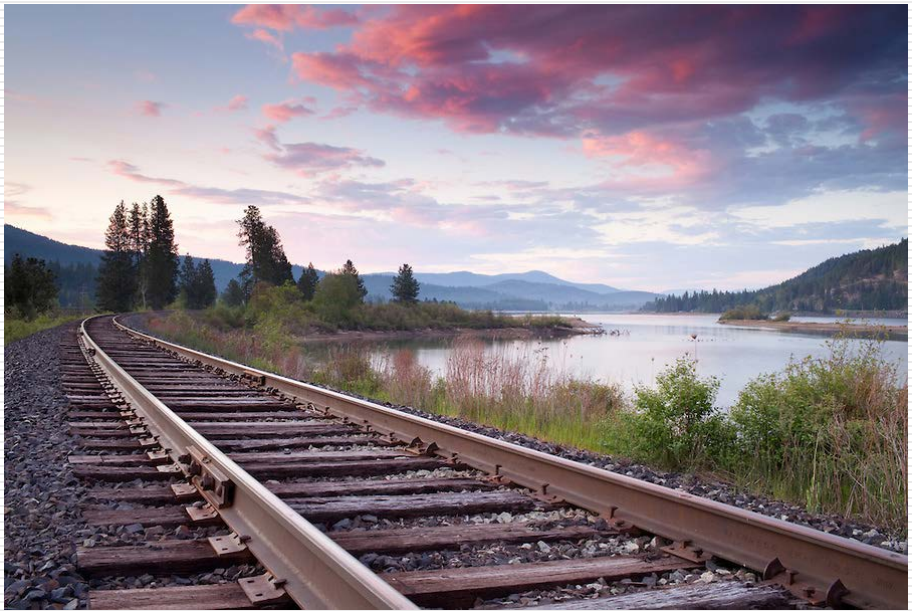

Outline

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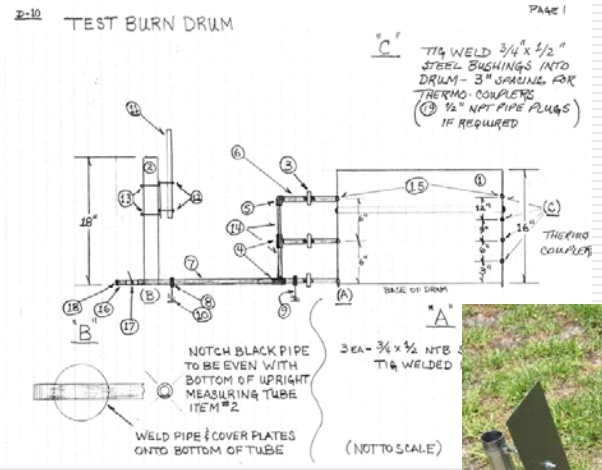
Two Series of Test Burns – May and November 2015

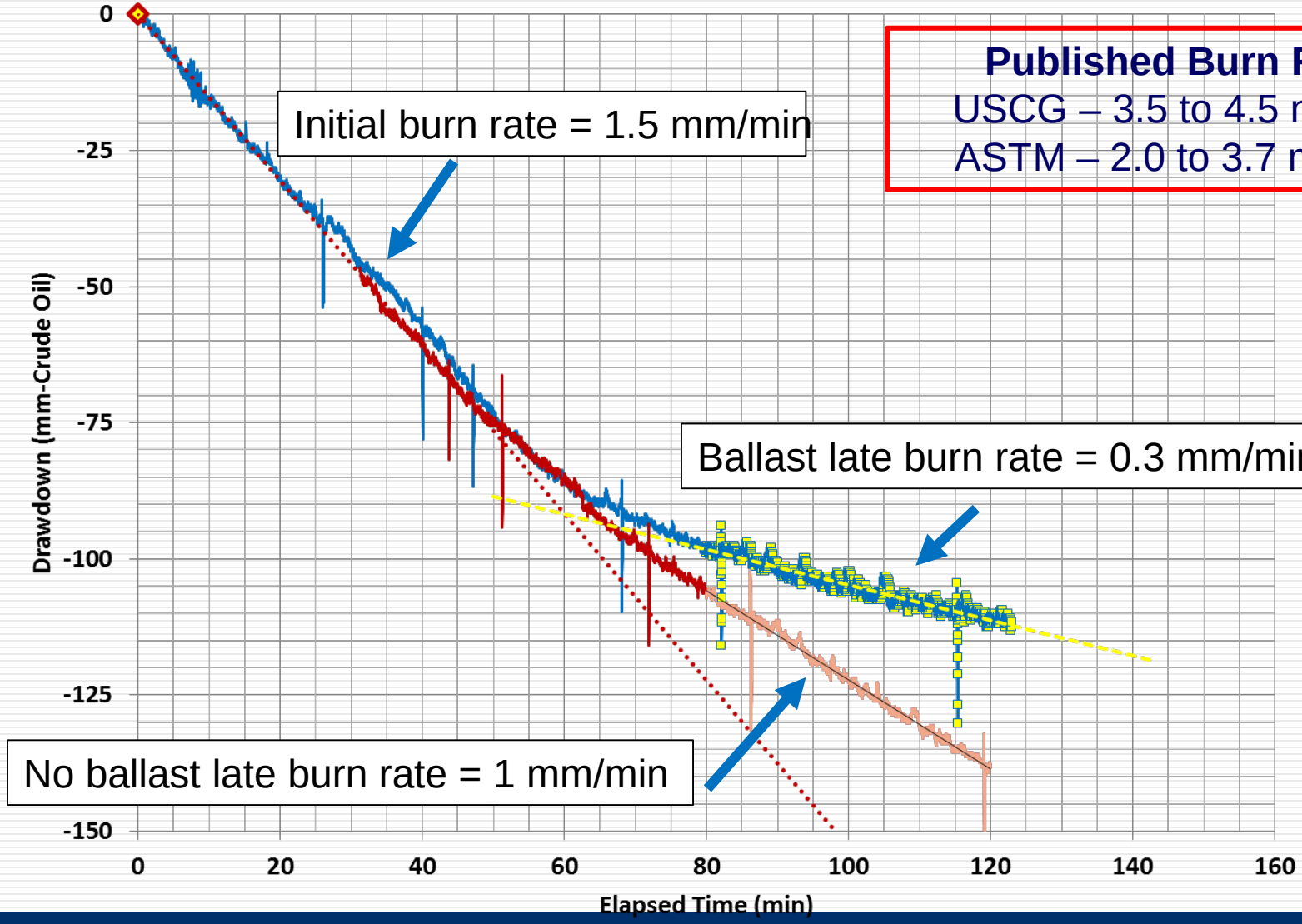
- Fire Academy of the South (Jacksonville, FL)
- Multiple commodities tested
  - Kerosene
  - Fresh crude oil
  - Aged crude oil
  - Ethanol



- Small surface area pools
- With and without rail ballast

May 2015 – Small Surface Area Burns with/without Ballast

Small Diameter Test Burn Results



November 2015 – Variable Surface Area Burns with/without Ballast

November 2015 Plan View

Large pans

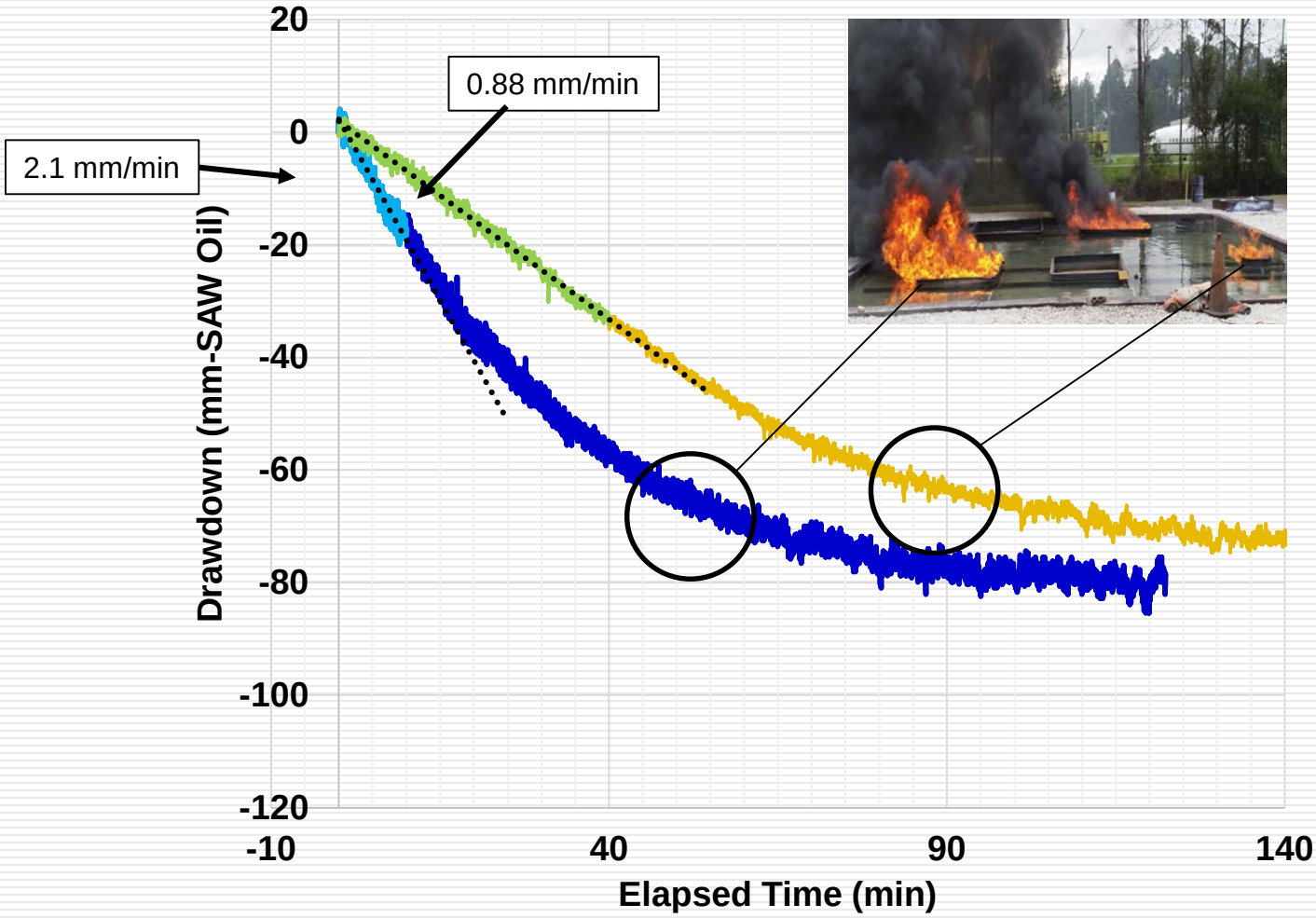
Heat shield/sink

Medium pans

Small Diameter Drum

Small Diameter Drum

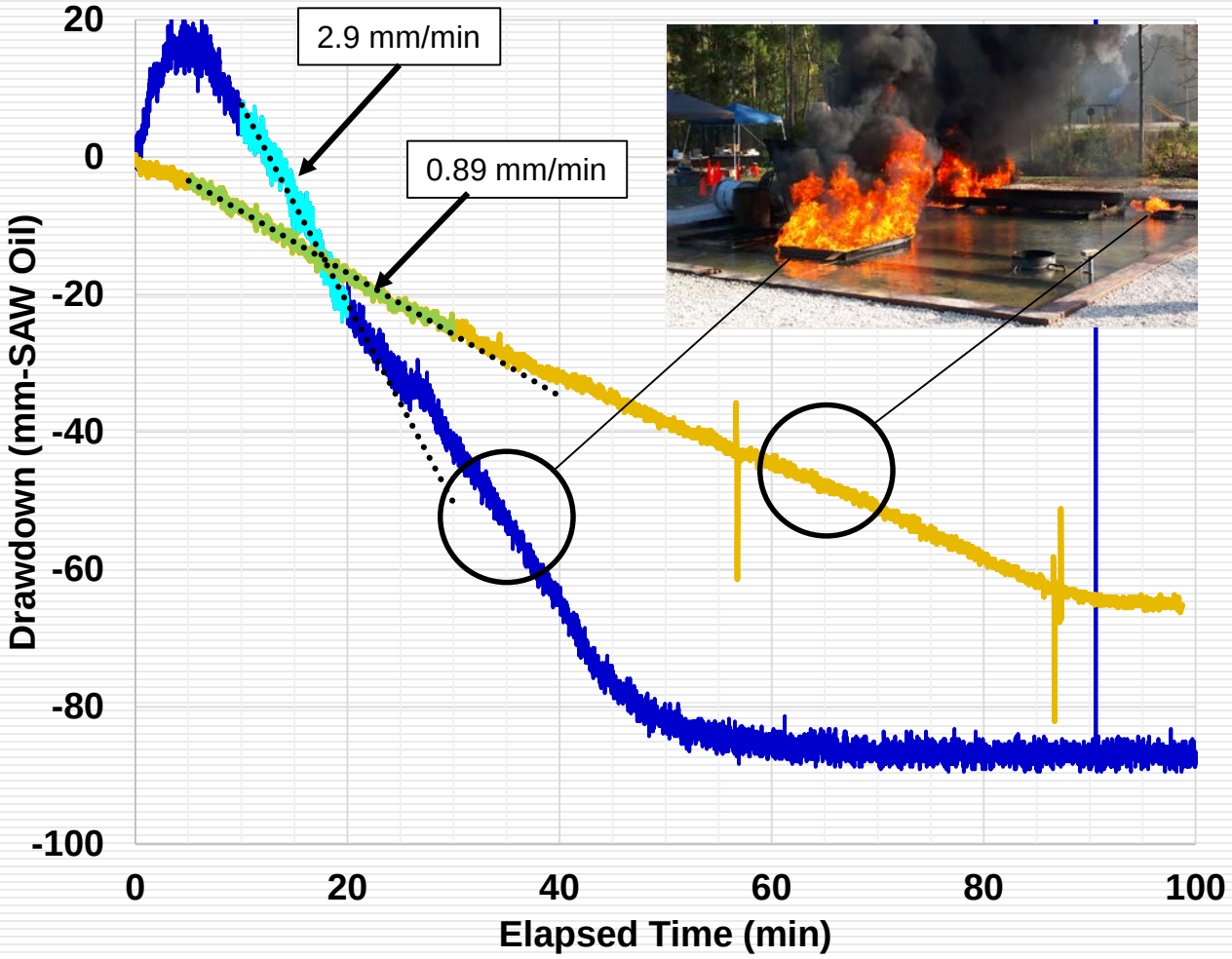
November 2015 Test Results



Weathered Crude Test With Ballast

- Burn rates higher in larger pan, before oil surface retreated into the ballast
- Burn rates declined when the oil surface retreated into the ballast

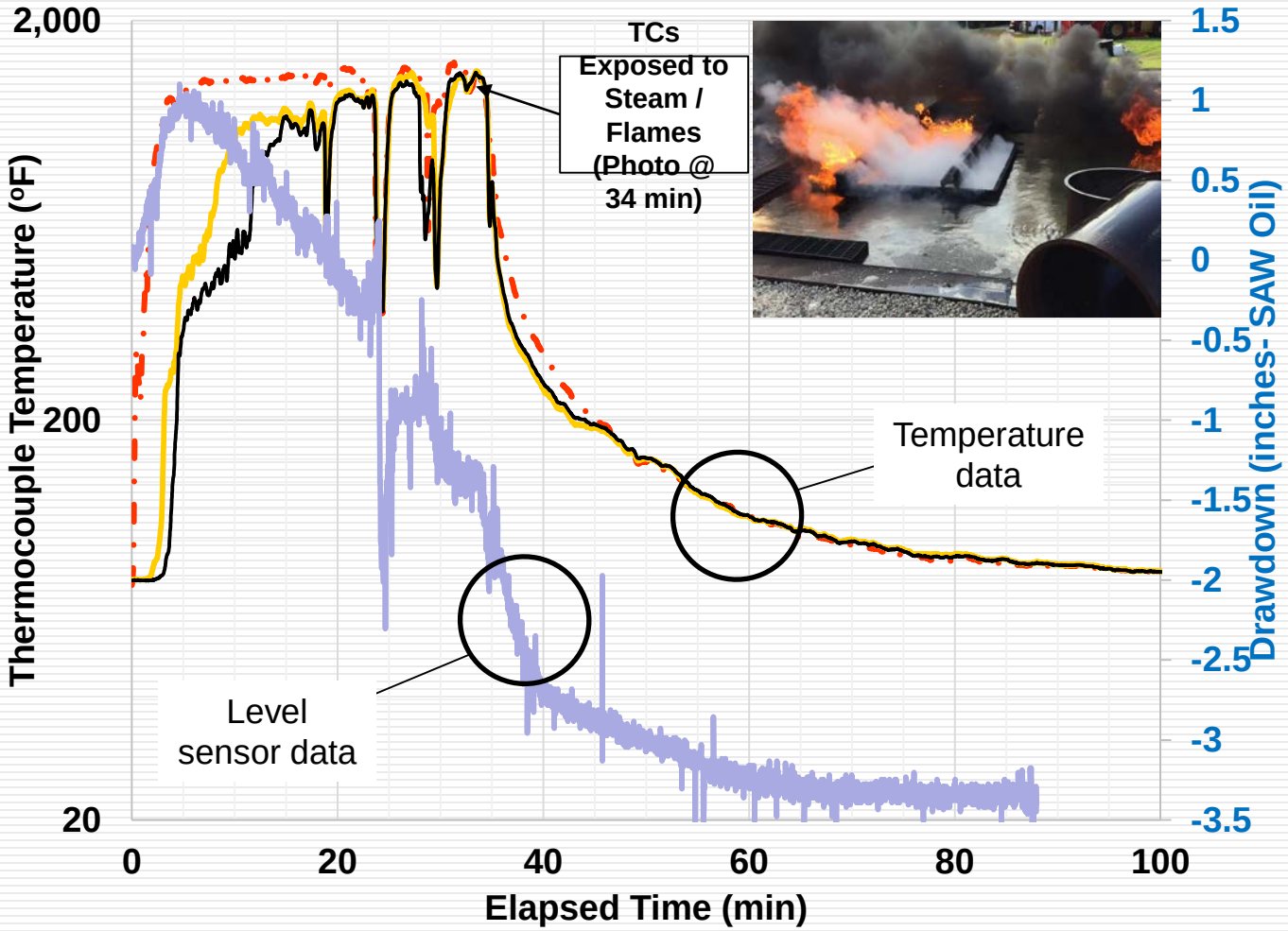
November 2015 Test Results



Weathered Crude Test No Ballast

- Burn rates higher in larger pan, as expected
- Initial fluid level rise attributed to sensor deflection
- Smaller pan matches data from early time data from small pan with ballast

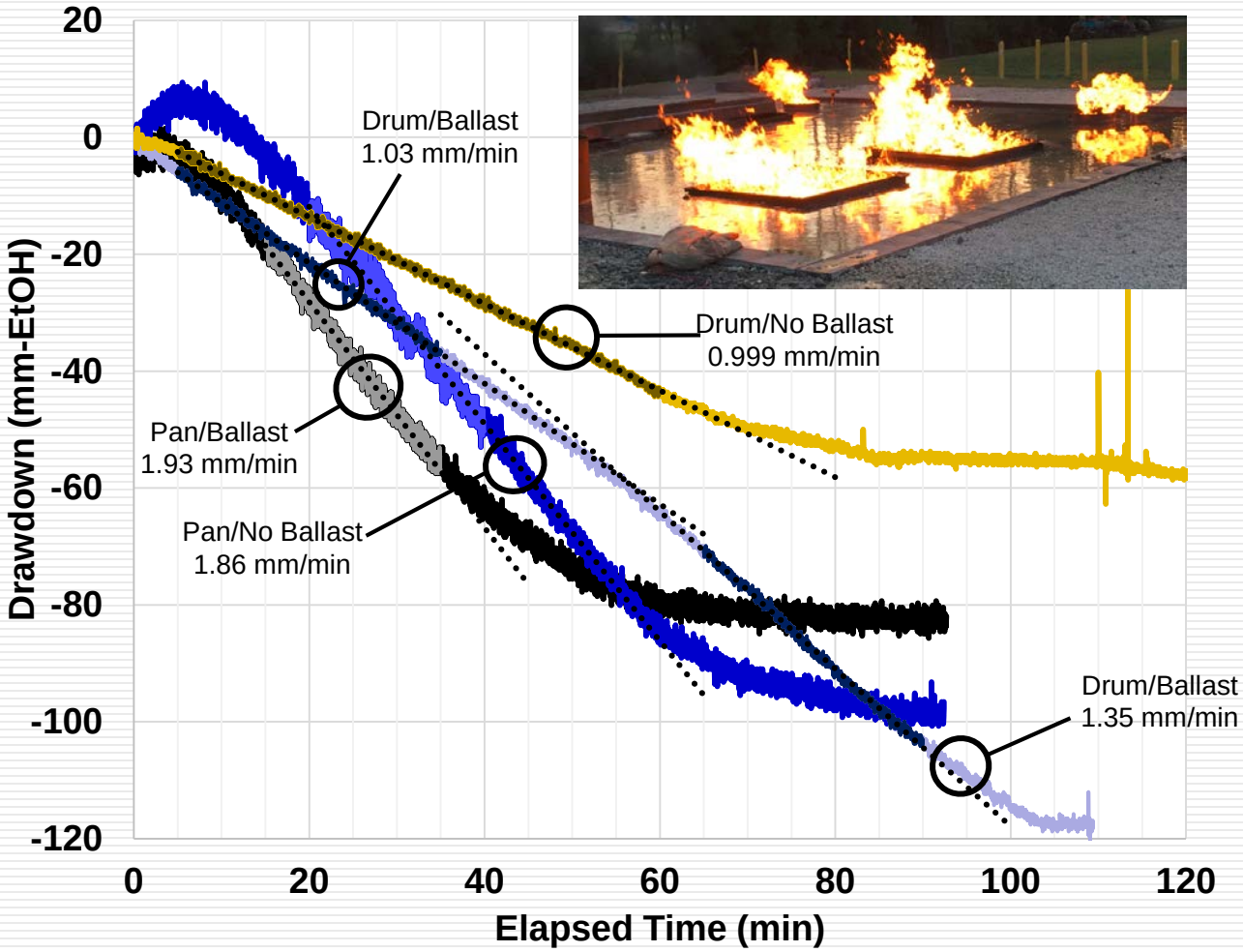
November 2015 Test Results



Boil-over Event

- Weathered crude oil
- Water was present in the oil recovered from the field
- Boil-over and steam formation began at approximately 18 min
- Temperature probe data shows periodic drops during steam eruptions
- Initial increase in fluid level likely due to pan deformation

November 2015 Test Results

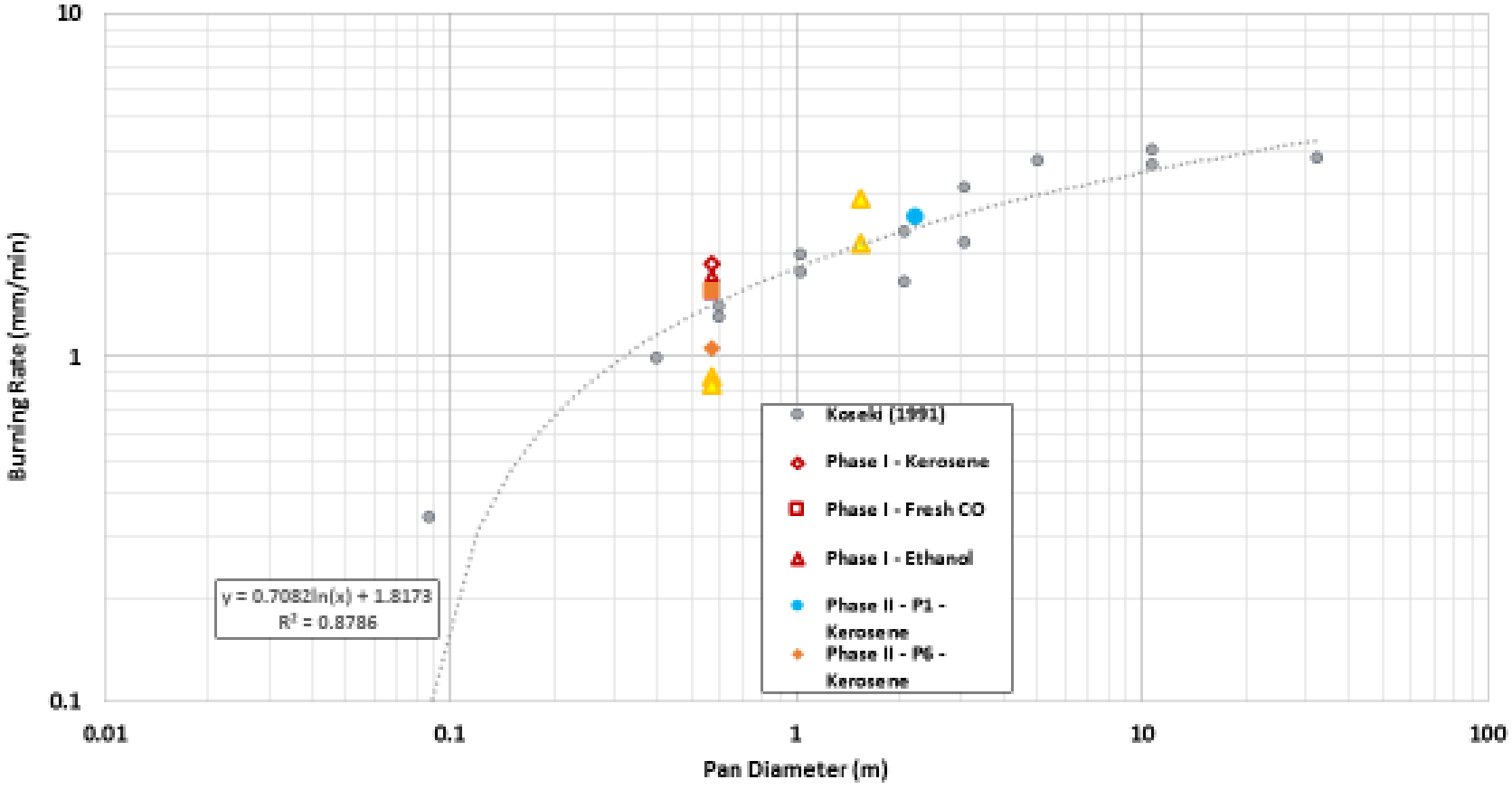


Ethanol Tests

- Burn rates higher in larger pan, as expected
- Burn rate slowed as fluid level entered ballast in pan

November 2015 Test Results

Comparison to Previous Literature



Conclusions

- Why balance mass?
  - Regulatory requirements
  - Due diligence
  - Values
- Balancing mass
  - Accurate starting quantities
  - Thorough and documented damage assessment
  - Account for every drop in every media
  - Consider the setting, environment, and commodity
- What do we now know?
  - Water may be present in product from shipper
  - Variable burn rates for non “pure” products
  - Burn rate ranges for terrestrial vs. aquatic fires
  - Variable burn rates due to subsurface interactions

Questions?

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