



INTERNATIONAL ASSOCIATION OF FIRE FIGHTERS

# EVIDENCE-BASED FIRE GROUND OPERATIONS

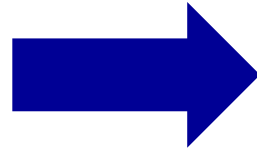
March 2026

**SUPPRESSION**

# WATER ON THE FIRE ASAP – FROM A POSITION OF ADVANTAGE



Reduces Heat Release Rate  
Reduces Temperatures  
Reduces Rate of Toxic Gas Production

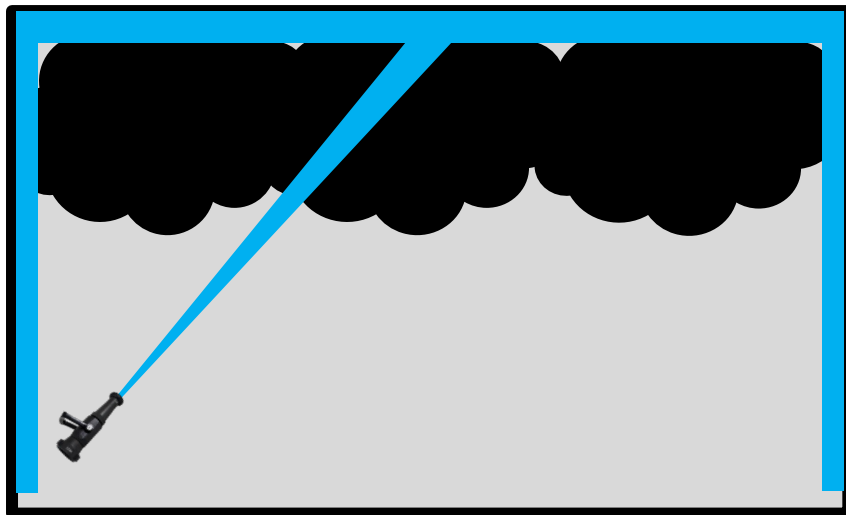


Improves Victim Survivability  
Minimizes FF Risk  
Helps Prevent Property Loss

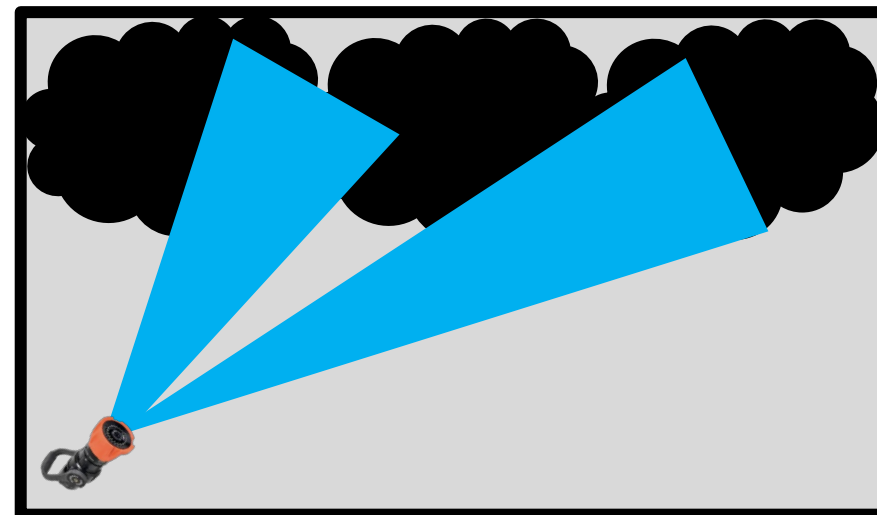
***Quickest Water on the Fire – Whether Interior or Exterior!***

# WHAT IS SURFACE COOLING?

- **Use of Straight or Solid Streams to Coat and Cool Surfaces**  
(Walls, Ceiling, Floors, Burning Combustibles/Furnishings)
- **Cool Surfaces in Order to Cool Gases**
- **150GPM or GREATER (Volume & Reach) – NFPA Requirement**



VS.



# WHY DO WE SURFACE COOL TODAY?

## What Do We Know?

- Water heated to a gas (steam) expands 1,700 times @ 212 deg F.

## Suppression Effects?

- Fire gases are being cooled from temperatures over 1,800 degrees F to below 200 degrees F rapidly, over the order of seconds or less.



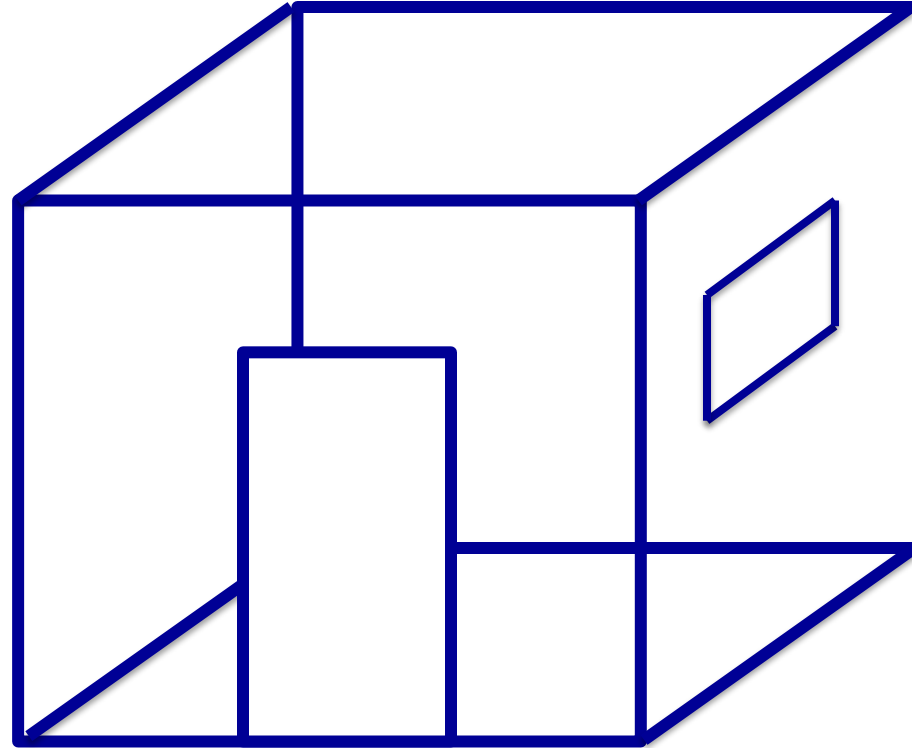
Net Effect =  
Gas Contraction



# SURFACE COOLING METHODOLOGY



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Treat Every Compartment As If It Were The Can  
(Can Walls = Room Walls/Ceiling/Floor)

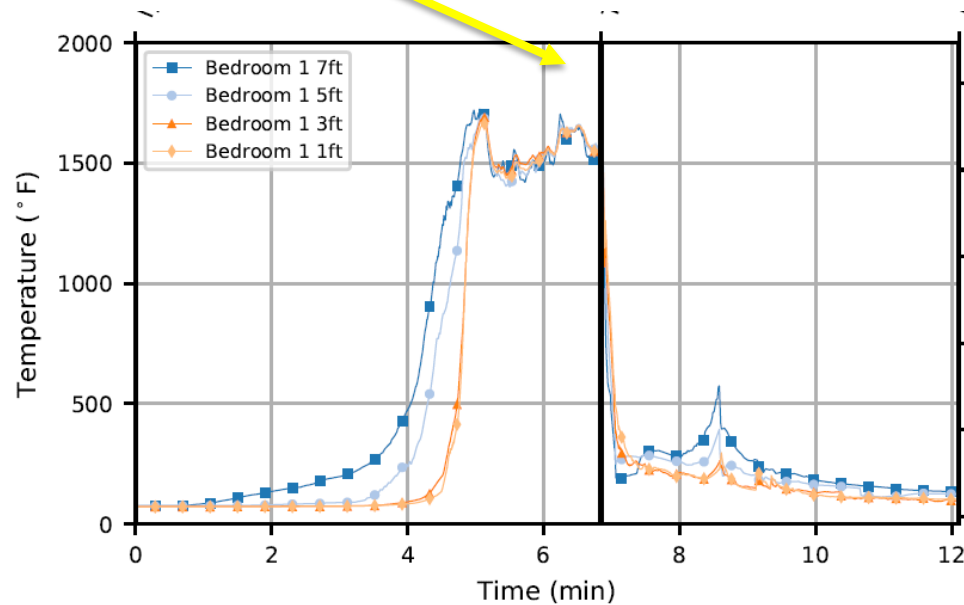
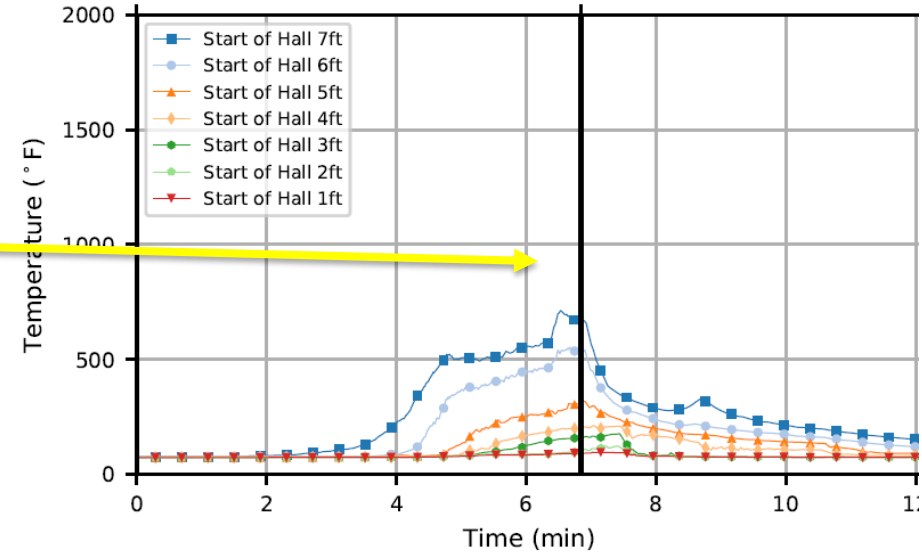
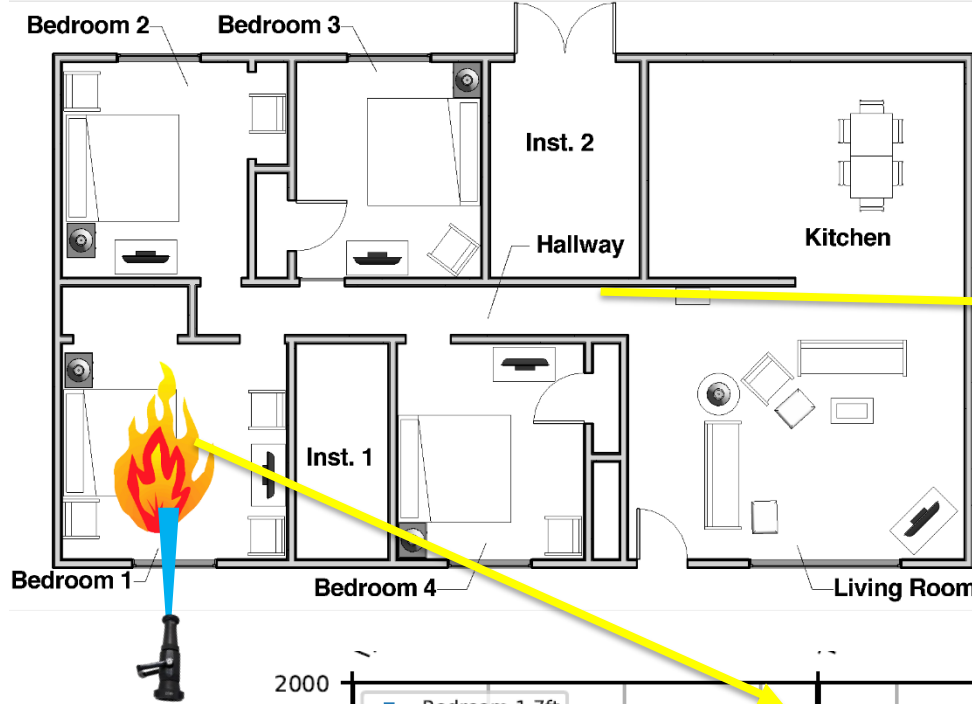
More Surfaces Cooled **Simultaneously** = More Gas Contraction

Improved Conditions Adjacent To & Remote From Water Application!

# CONTRACTION DUE TO COOLING



# CONTRACTION DUE TO COOLING



**Global Impact!**

# FLOW AND MOVE ADVANCEMENT

## Ahead of the Line:

- Reach & Surface Cooling
- Begin Knock-Back of Fire
- Keep FF & Victim Safety By Isolation With Water

'O' Pattern Acts As Doorway Moving Through Structure – Compartmentation

## Behind the Line:

- Fresh Air Entrained
- Improved Visibility
- Improved Victim Survivability  
(O<sub>2</sub> Increase)



# FLOW AND MOVE ADVANCEMENT



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# FLOW AND MOVE ADVANCEMENT



# HOW DID WE GET HERE?

## Hose Stream Mechanics

- Air Entrainment
- Water Mapping

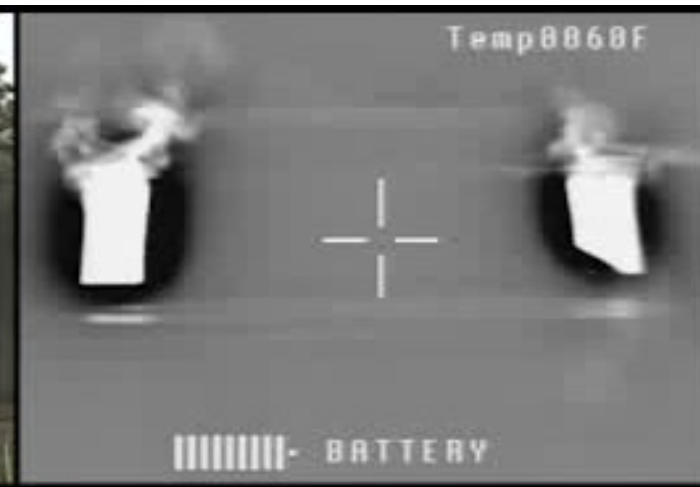
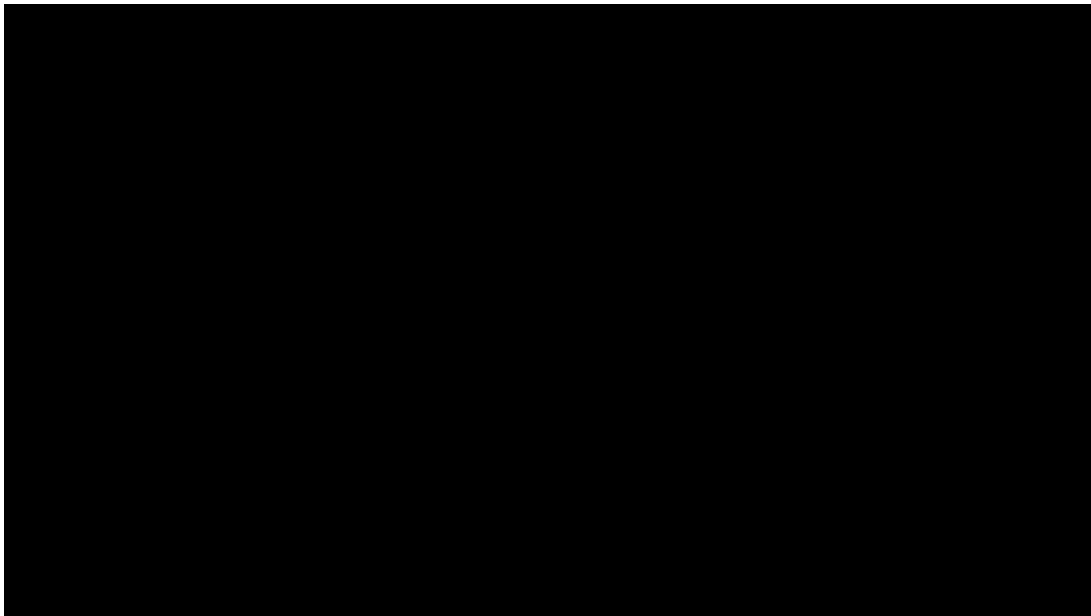
## Victim and Fire Fighter Hazards in Fire

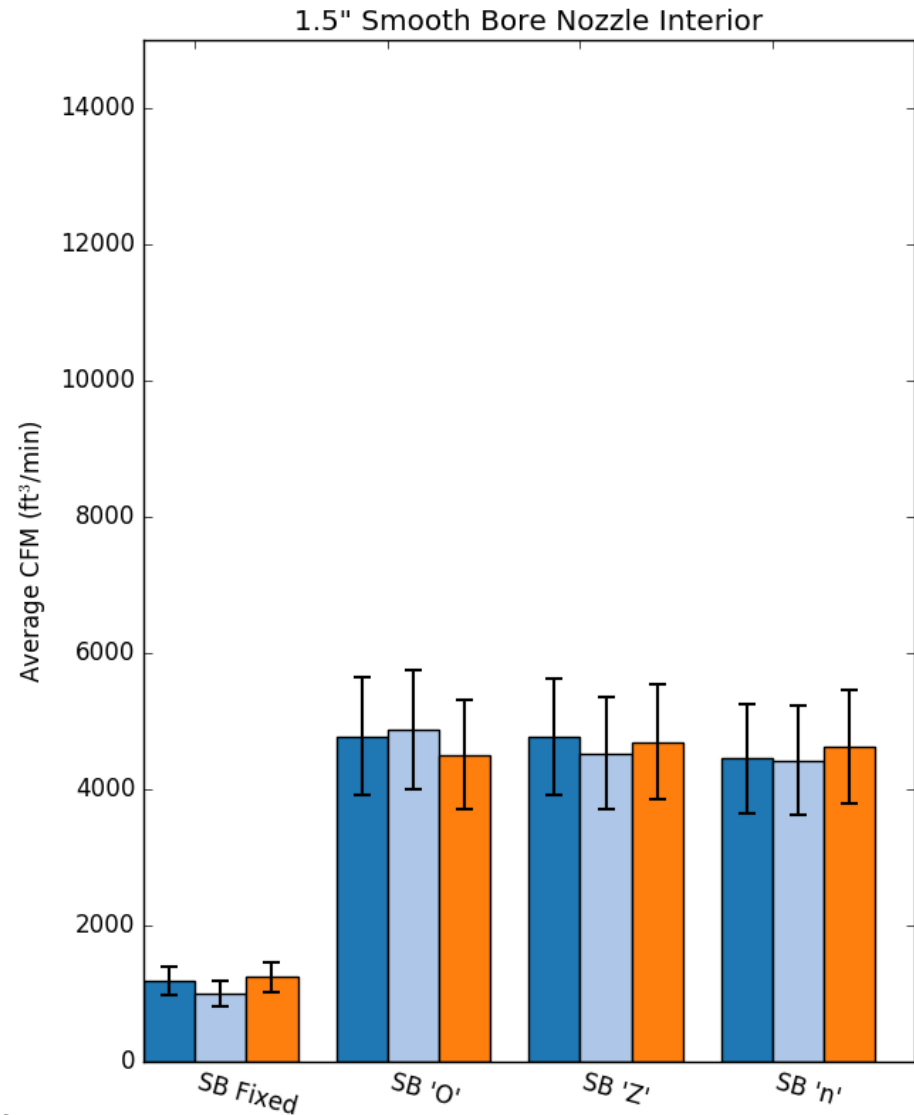
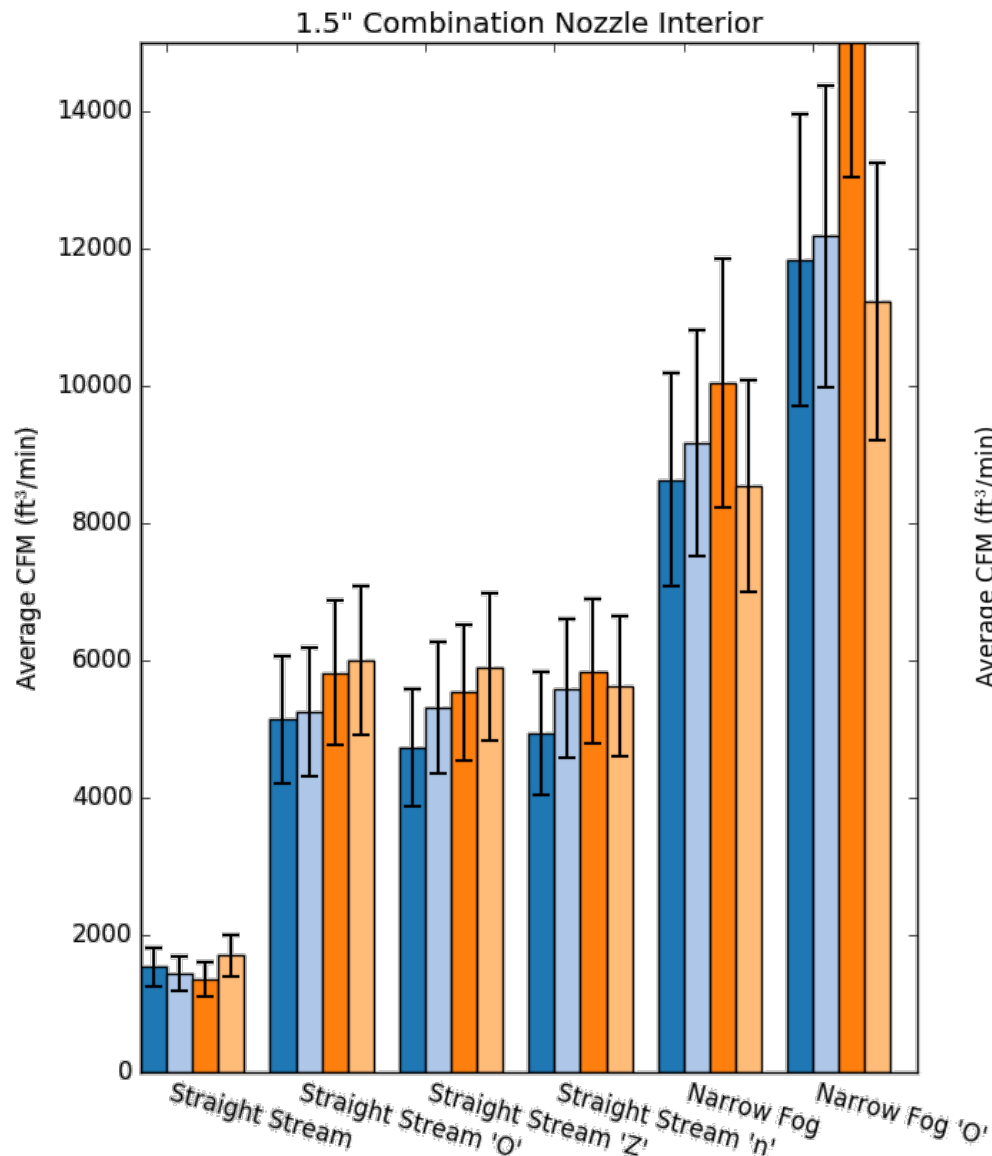


# AIR ENTRAINMENT

Line Size, Nozzle Flow/Pressure,  
Application Patterns, Stream Type,  
Stream Angle

Advance vs. Fire Compartment

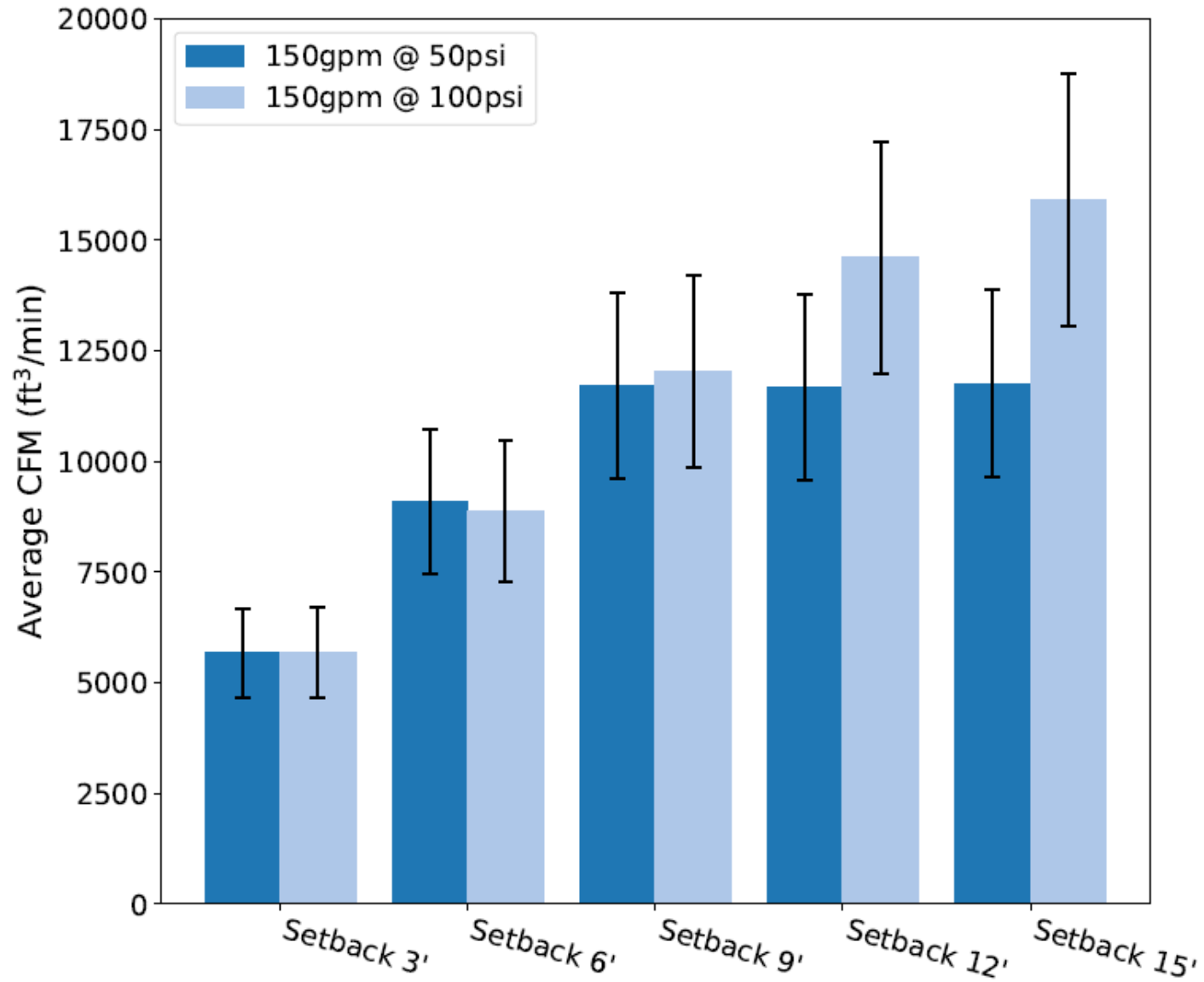




# Total Entrainment



# HYDRAULIC VENTILATION



# AIR ENTRAINMENT CONCLUSIONS

Entrainment **increases** with faster nozzle movement

Entrainment **increases** with more broken hose stream type

Solid Stream < Straight Stream < Narrow Fog < Wide Fog

Entrainment roughly the **same** regardless of the pattern at a set speed

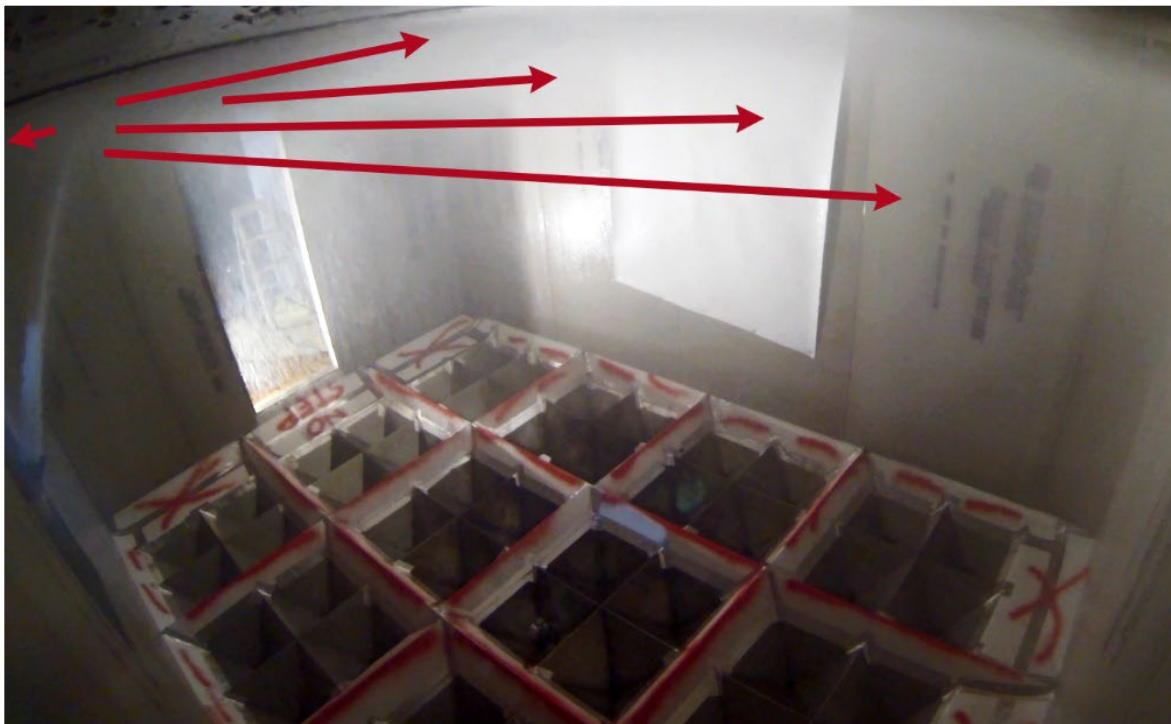
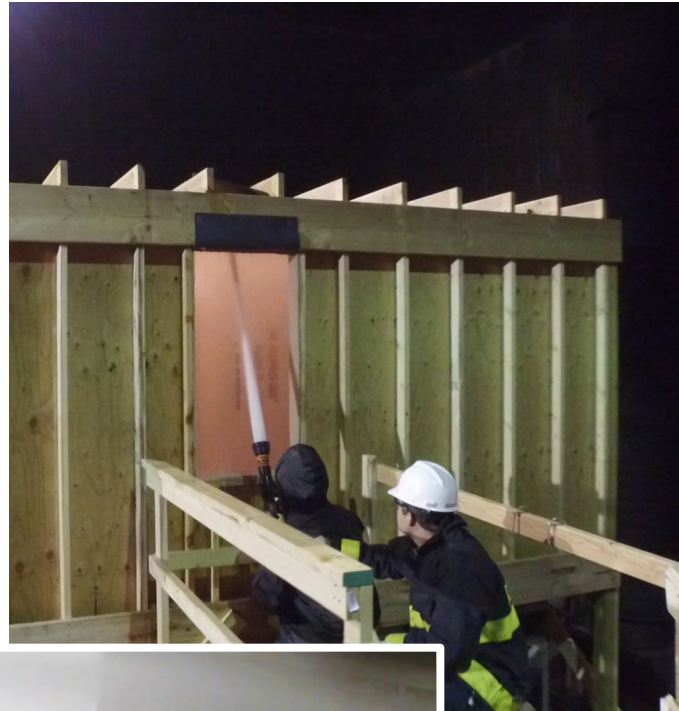
Hose streams capable of air entrainment => positive pressure fan



# WATER MAPPING

Line Size, Nozzle Flow/Pressure,  
Application Patterns, Stream Type,  
Stream Angle

Advance vs. Fire Compartment



# HOSE STREAM ANGLES



Perpendicular streams radiate water in 360 degrees

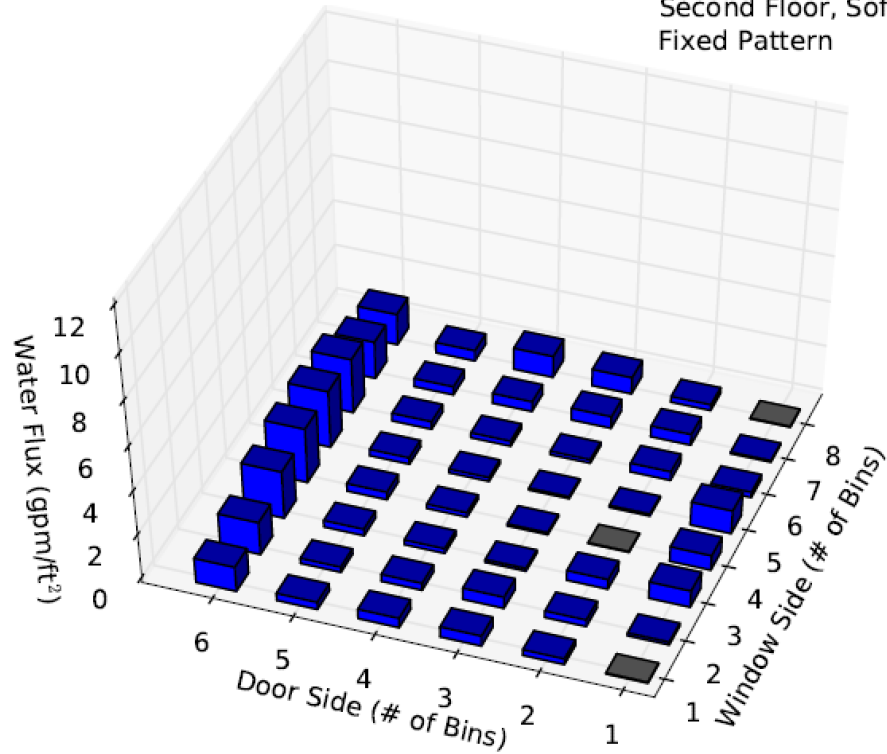
# HOSE STREAM ANGLES

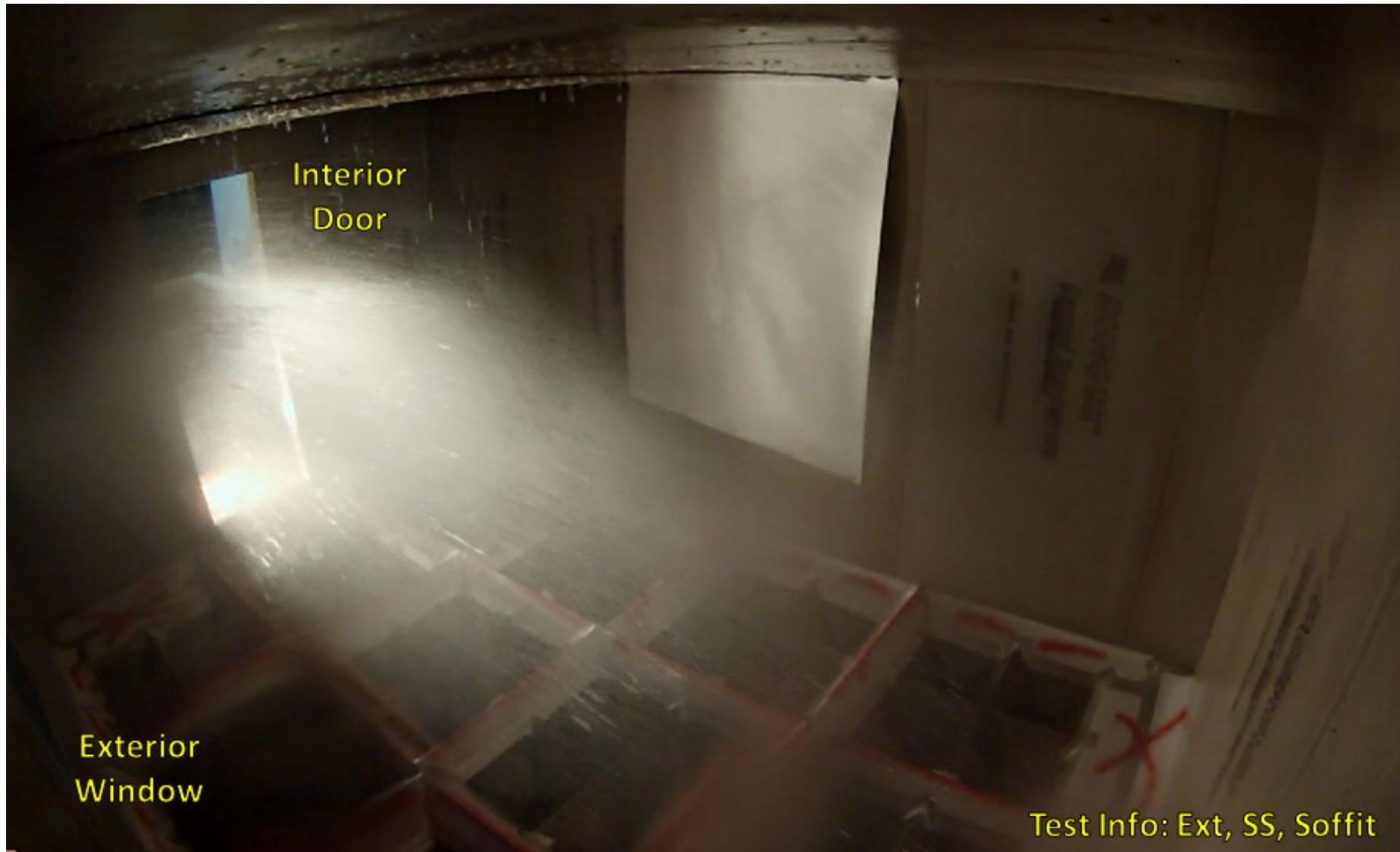


Steep angle provides greatest surface coverage in room

# CREATIVE METHODS

Straight Stream Window  
1 3/4" Hose, 150gpm @ 100psi  
Second Floor, Soffit  
Fixed Pattern





Interior  
Door

Exterior  
Window

Test Info: Ext, SS, Soffit

# ALTERNATIVE HITS



Door frame deflection allows water into compartment early



# WATER MAPPING CONCLUSIONS

Steeper angles provide greatest surface coverage in compartments

Following steep angle application, a follow-up application is needed.

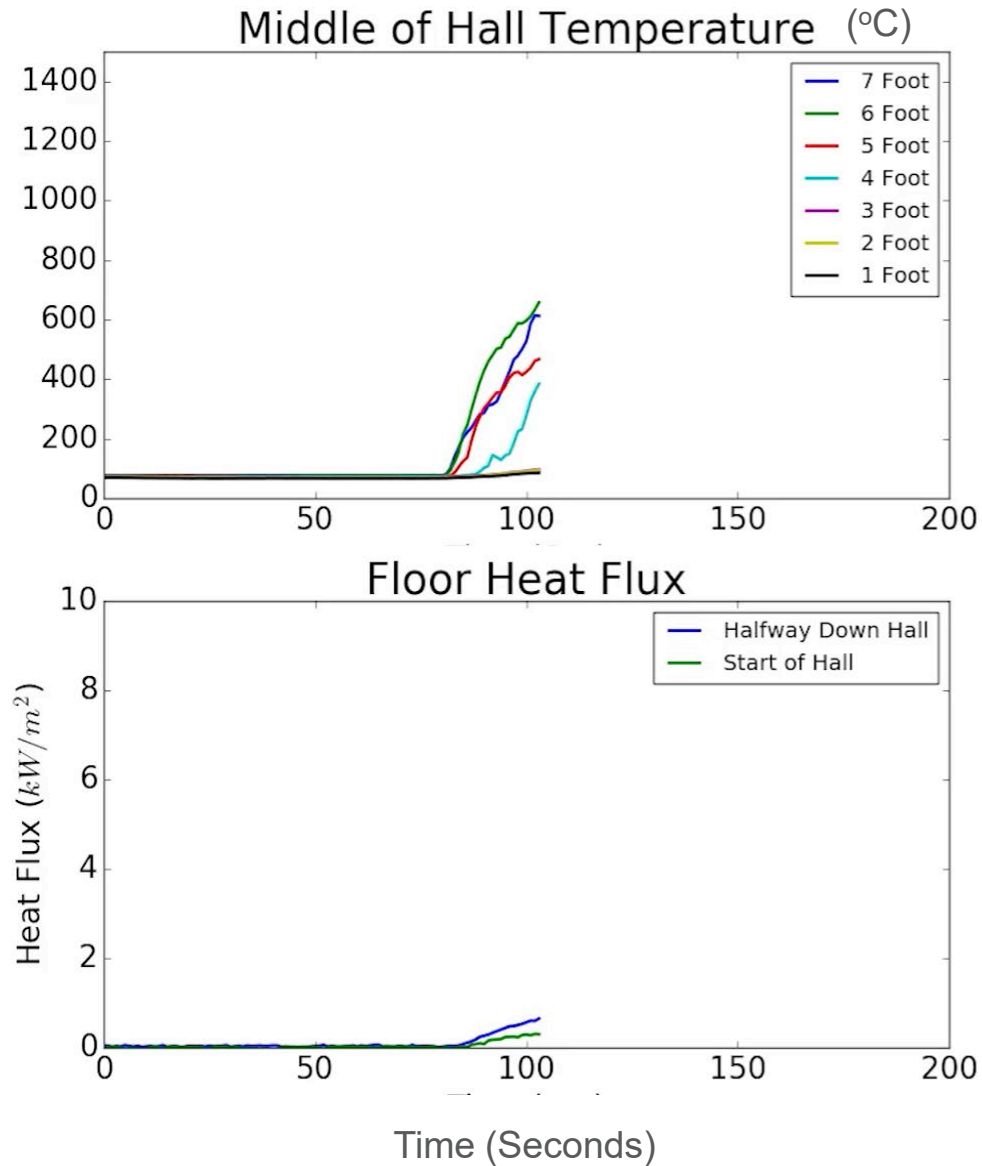
- On Plane = Nozzle in Window
- Off Plane = Window Header
- Interior = Stream on Base Fuels

Sweep with your body, not the nozzle (minimal entrainment, better coverage)

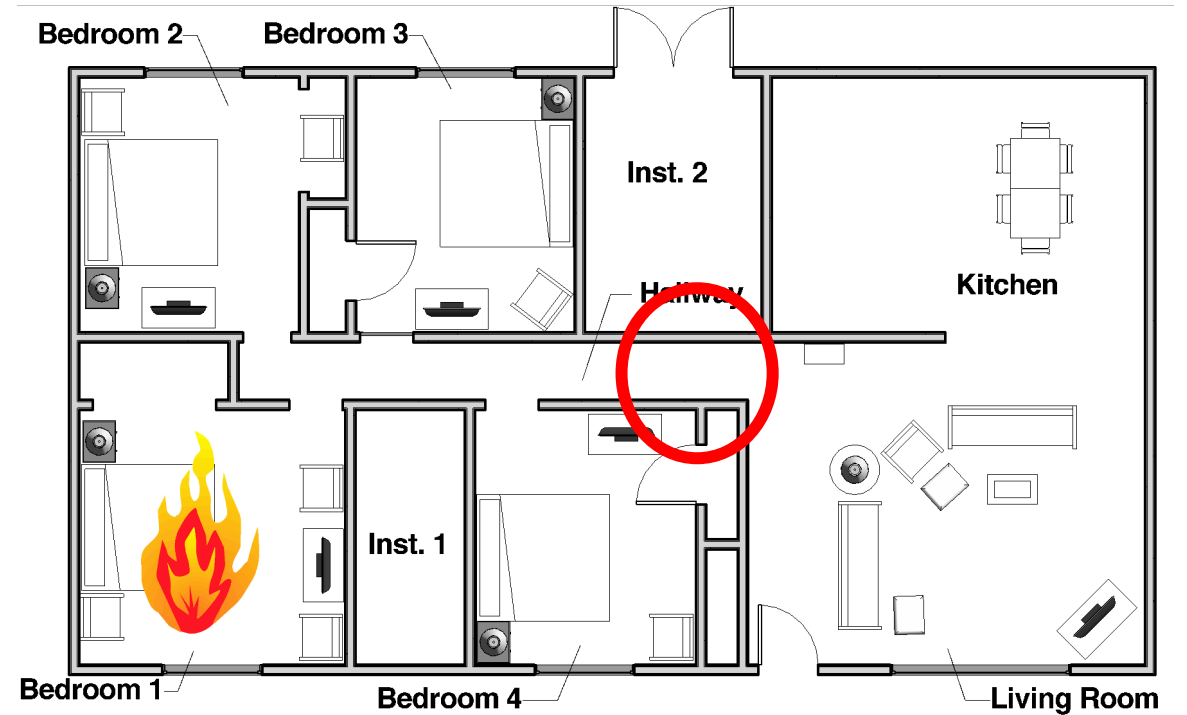
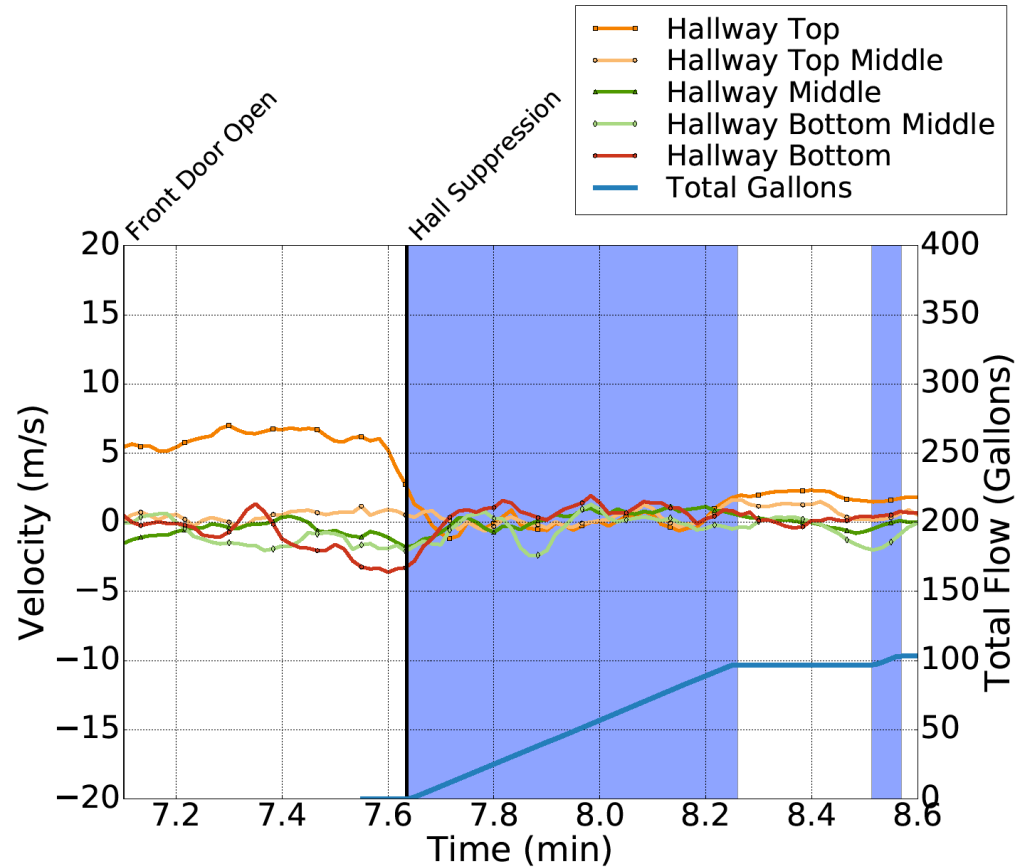
Proper mapping allows for long distance relationship and early extinguishment.



# FIRE FIGHTER HAZARDS – COOL AS YOU GO

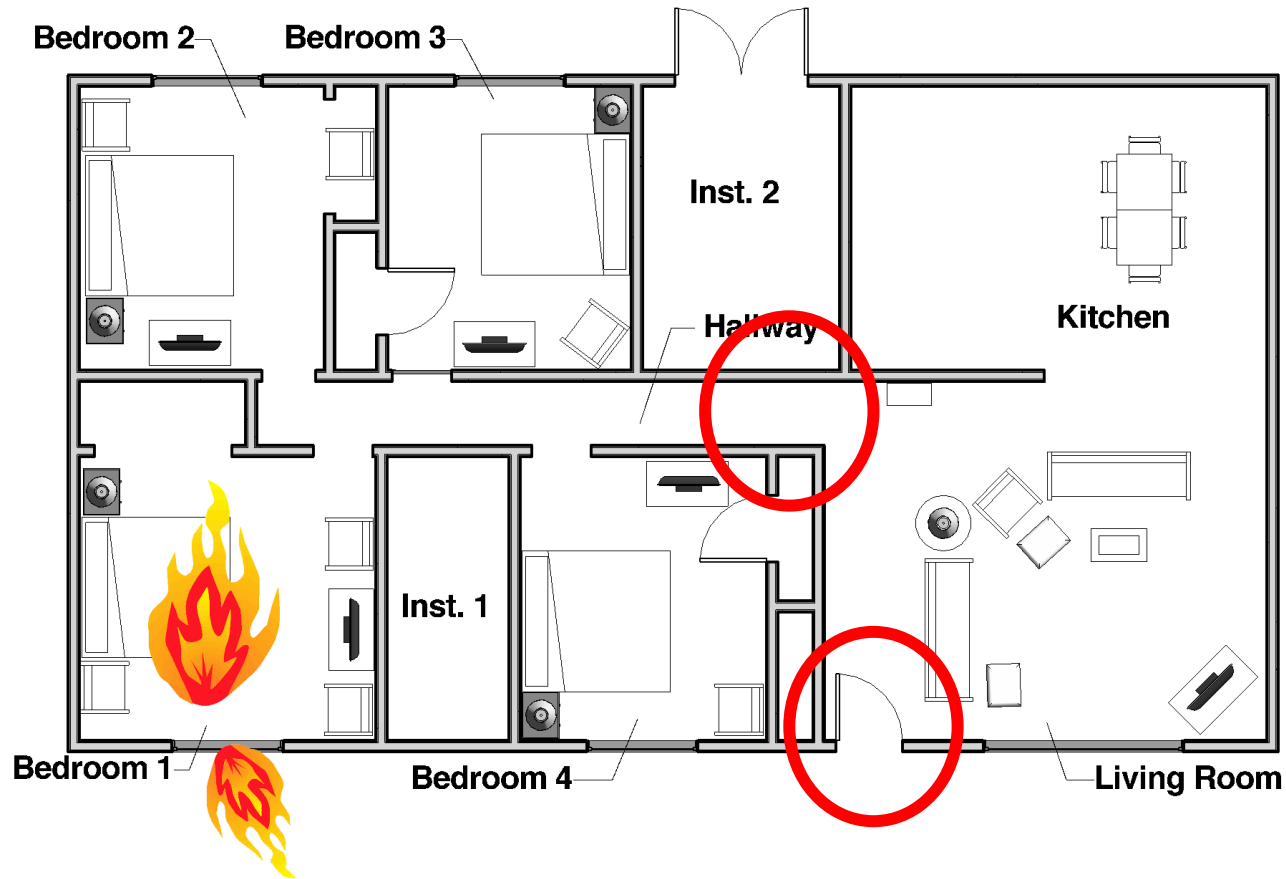


# WATER CAN IMPACT THE FLOW PATH: EVEN ON A "DEAD END"

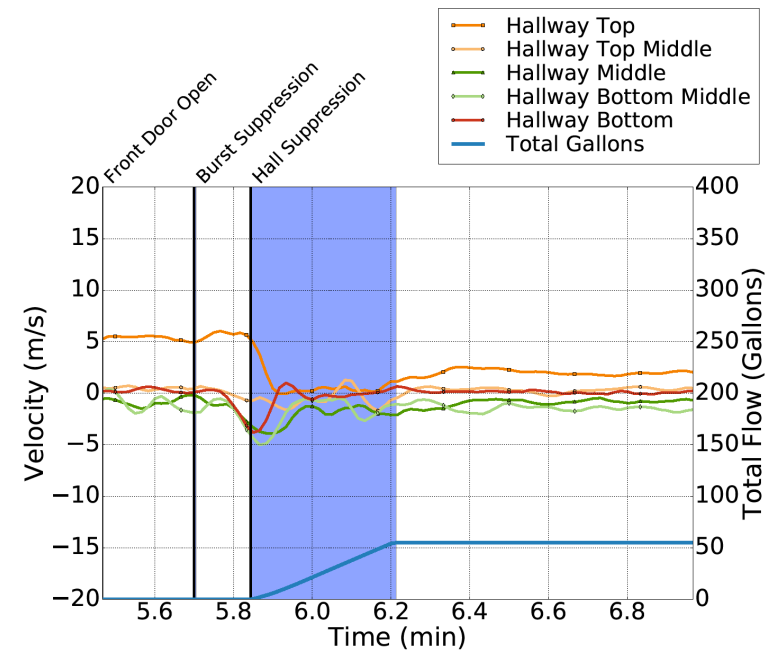
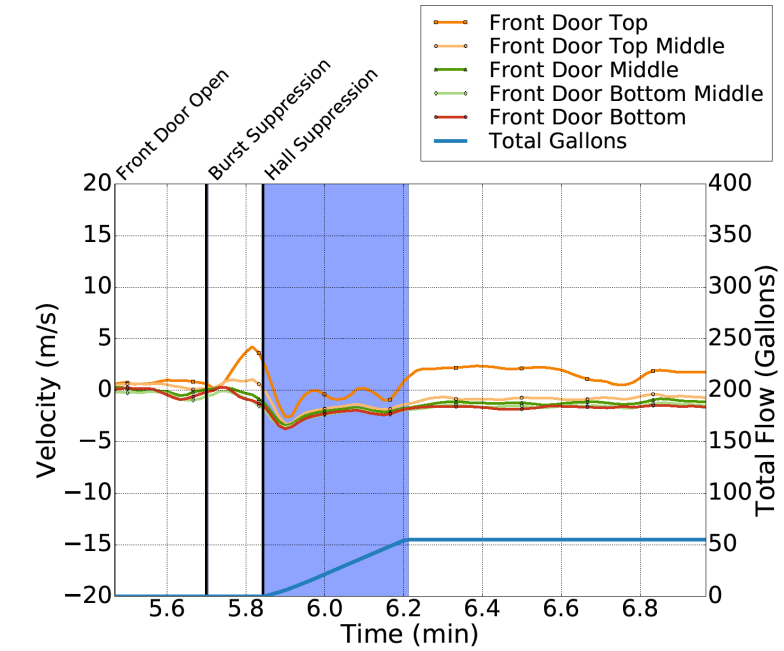


Single Room of Fire, No Vent

# WATER CAN IMPACT THE FLOW PATH



Single Room of Fire,  
With Vent



# SEALING OFF THE FLOW PATH



Solid Stream, Wall – Ceiling – Wall, Flow & Move

# SEALING OFF THE FLOW PATH



Solid Stream, Wall – Ceiling – Wall, Flow & Move

# SEALING OFF THE FLOW PATH

Small droplets =  
Inadequate  
Surface Cooling

Low Mass =  
Steam Post  
Initial Cooling



Narrow Fog Stream, O Pattern, Flow & Move

# EXTERIOR WATER APPLICATION



Maximum Water  
Minimal Air

Don't Block the Vent!



# EXTERIOR WATER APPLICATION



# SPEED OF TRANSITION = ENEMY OF REGROWTH



# SPEED OF TRANSITION = ENEMY OF REGROWTH



Half Bale Whip



Window Frame



# POOR TECHNIQUE

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# GOOD TECHNIQUE



# RESETTING THE CLOCK



# FIRE GROUND CONFIRMED



# SIMULTANEOUS OPERATIONS



# TAKE ADVANTAGE OF THE SITUATION



# EXTERIOR WATER APPLICATION - HIGHLIGHTS

## STEEP ANGLE



- A hose stream at a steep angle deflected off the ceiling ensures the ceiling, wall, and floor are coated simultaneously.
- Improves conditions within the fire compartment quickly

## COOL SURFACES



- A smooth bore nozzle in the half-bale position or combination nozzle in a narrow fog rotated in a large circle cools the most surfaces in the compartment after the initial application.

## HIGHER ELEVATION



- The hose stream can be deflected off the lintel to achieve additional distribution, followed by entry into the structure for final extinguishment.

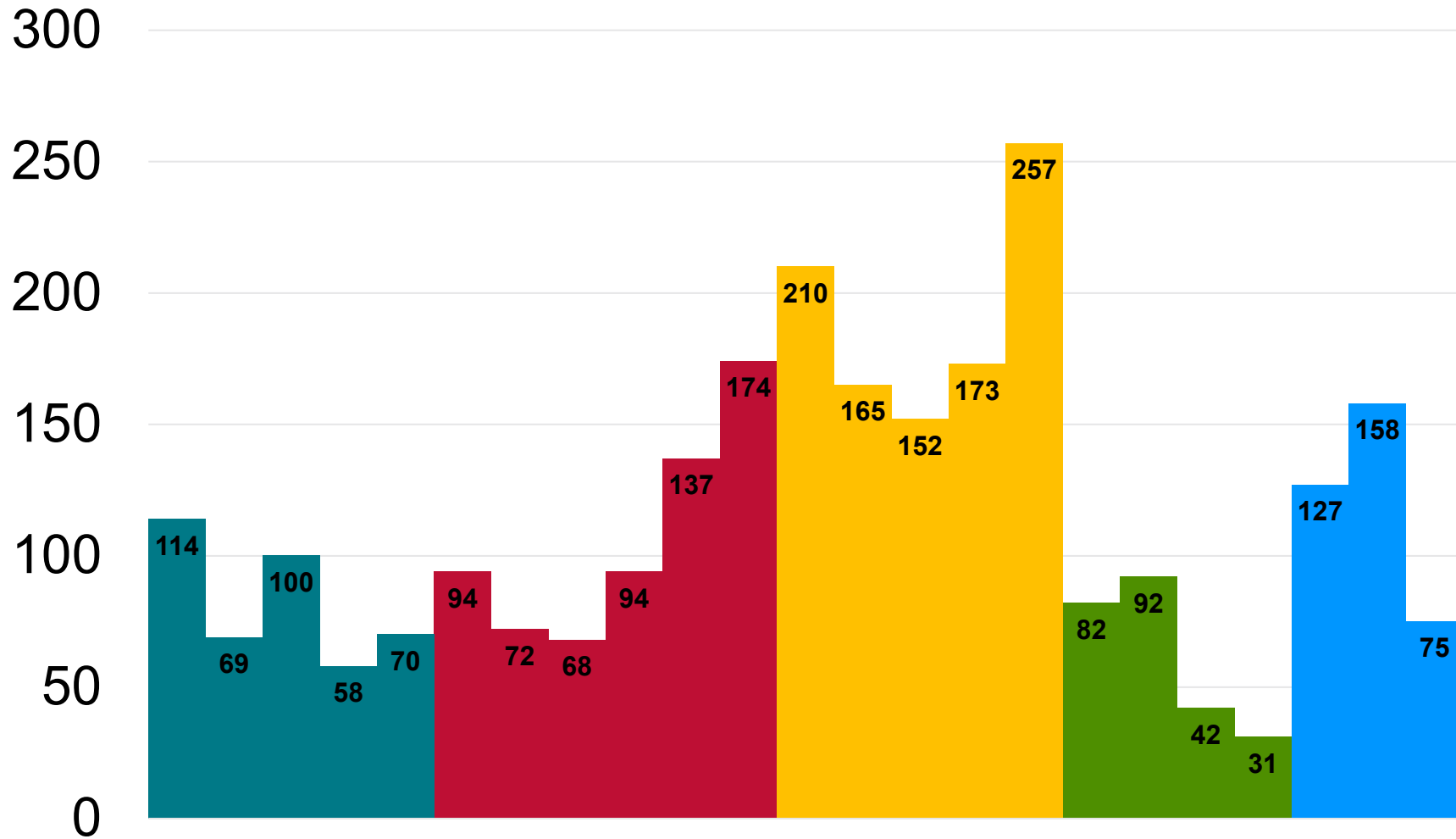
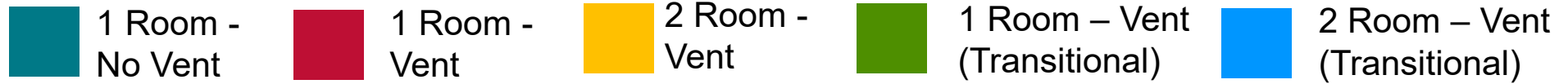


# WHAT'S THE MOST AMOUNT OF WATER USED?

150 - 165 GPM  
flowrate for all  
experiments



# WATER USAGE (GALLONS)



# WATER USAGE (GALLONS) – COORDINATED ATTACK IN ACQUIRED STRUCTURES SINGLE FAMILY HOMES (1 and 2 STORIES)

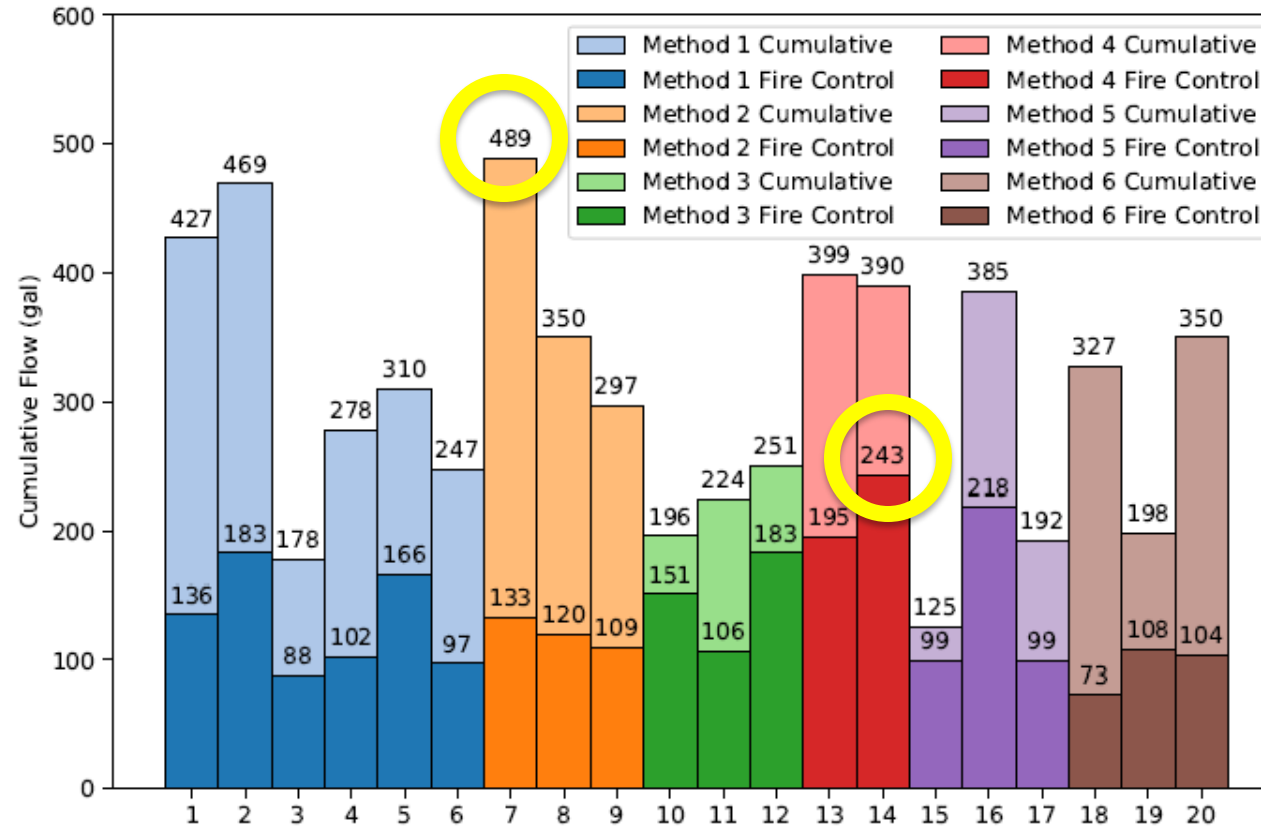


Figure 5.1: Water usage per experiment, colored by coordination method. Dark shaded bars represent water usage prior to fire control and light shaded bars represent total water usage for the experiment, including overhaul.

# WATER USAGE IN MULTI-FAMILY DWELLINGS

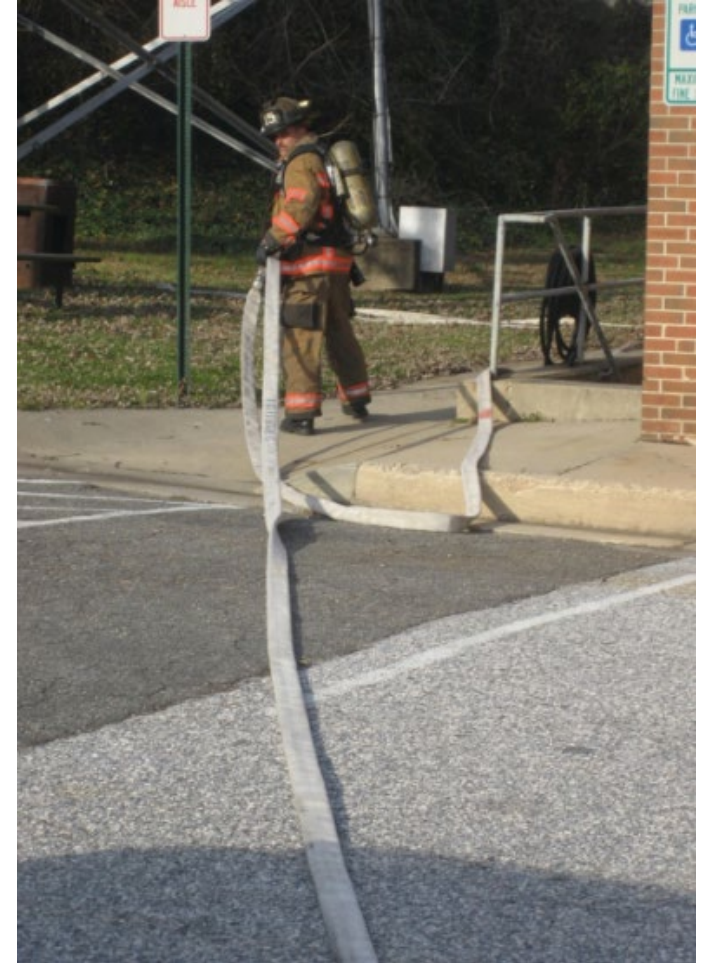


Proper Surface Cooling Wins (Single 1 ¾" Handline): 185 Gal

# THIS DOESN'T CHANGE OUR THINKING



**Still need to  
establish a water  
supply and  
deploy  
backup lines**



# SUPPRESSION SUMMARY: INTERIOR APPLICATION

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- Flowing and moving on the interior improves victim survivability behind the operating handline.
- Flowing and moving takes advantage of air entrainment to bring fresh air in with the line.
- ‘O’ Pattern or Wall-Ceiling-Wall advance maximizes surface cooling.
- High initial application into fire compartment followed by lowering stream onto base fuels. Coat surfaces 1<sup>st</sup> = vent-limited to fuel limited.



# RECAP: THE GRAND FINALE

- Proper mapping wins, exterior AND interior
- Contraction outweighs expansion with solid and straight streams
- Total water needed for two rooms post-flashover is minimal (<200 gal)

**Knock-Back.....Off plane.....INTERIOR/EXTERIOR**

**Knock-Down.....On plane.....INTERIOR/EXTERIOR**

**Base Fire Extinguishment.....Nozzle Must Be In The Room**



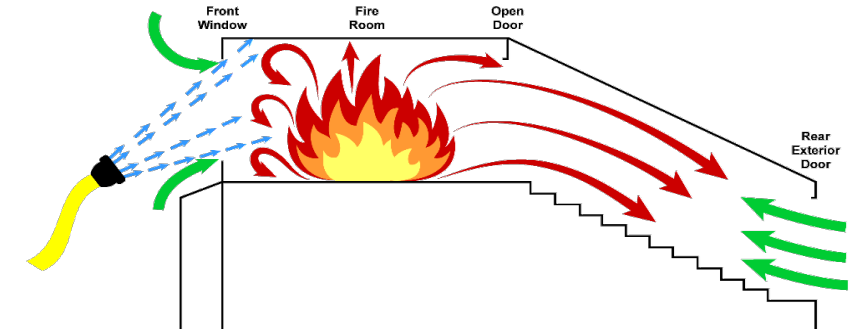
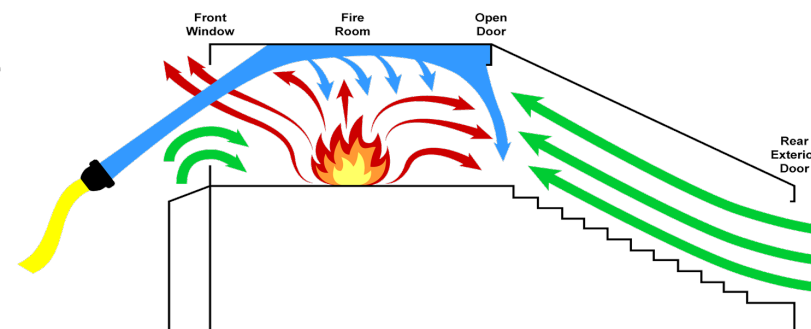
# SUPPRESSION SUMMARY: EXTERIOR APPLICATION

Steep angle provides maximum surface cooling

Follow-up application limits regrowth

The Big 3

1. Maximum Water
2. Minimal Air
3. Don't Occlude



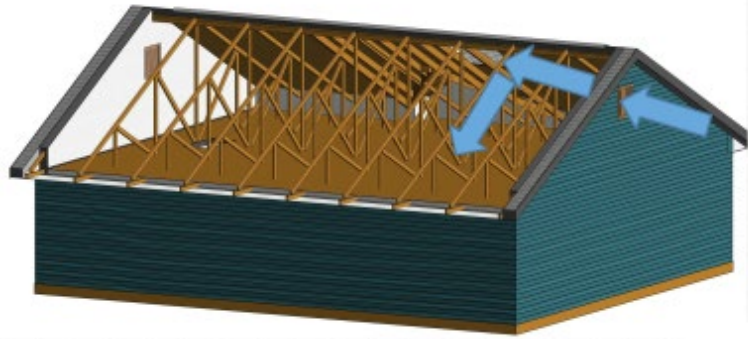
# ATTIC FIRES



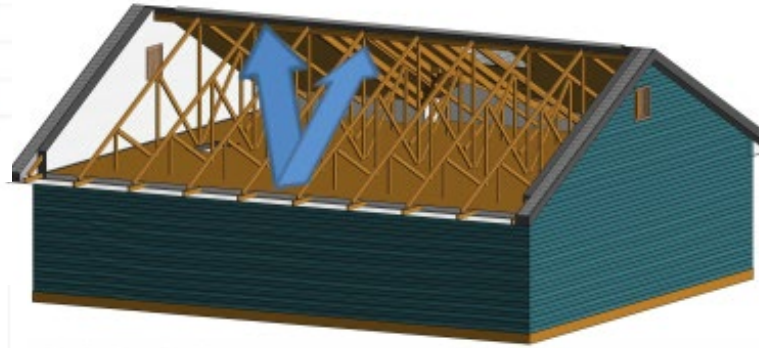
- Limited Access
- Vent Controlled



# ATTIC CONSTRUCTION AFFECTS HOSE STREAM PENETRATION



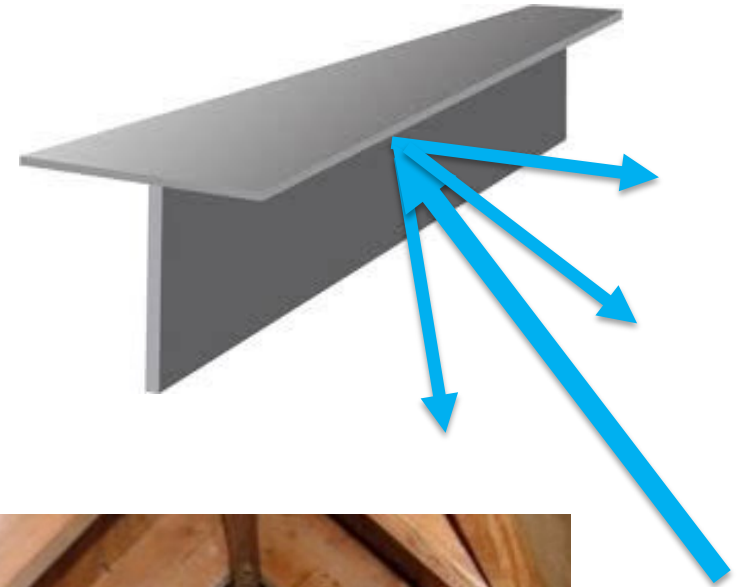
**GABLE**



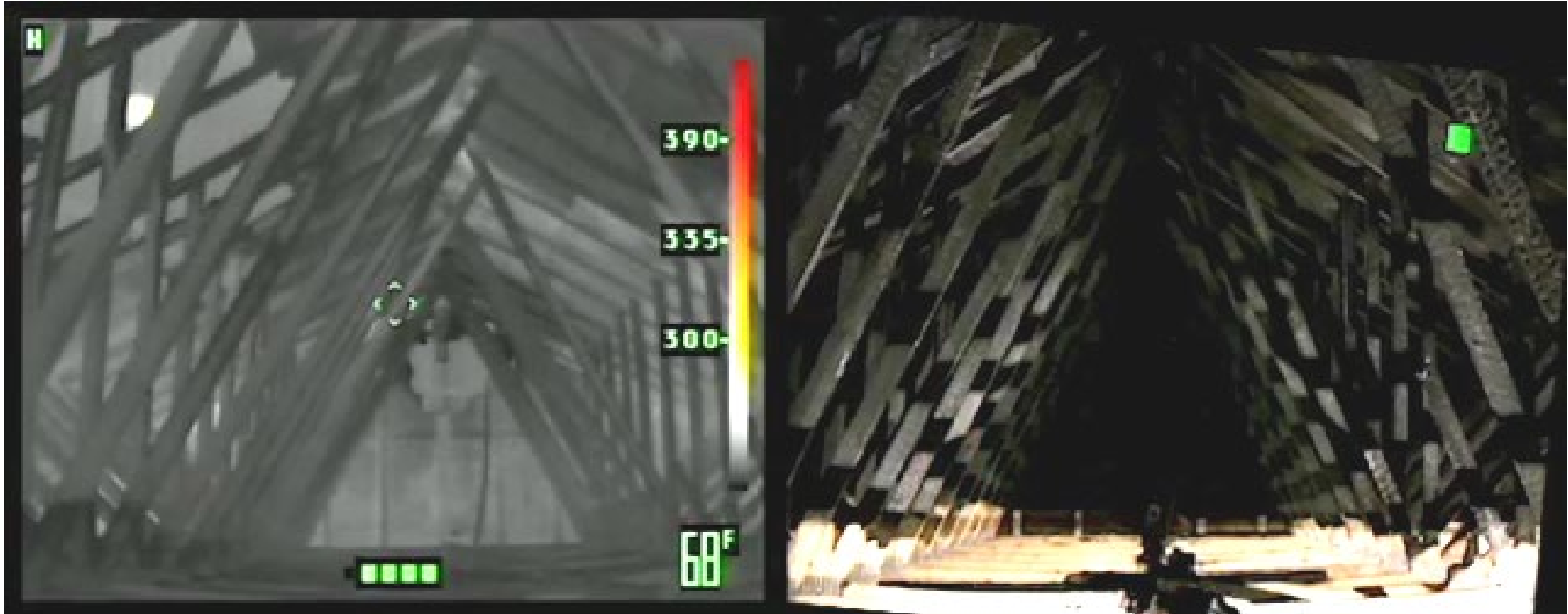
**BELOW**



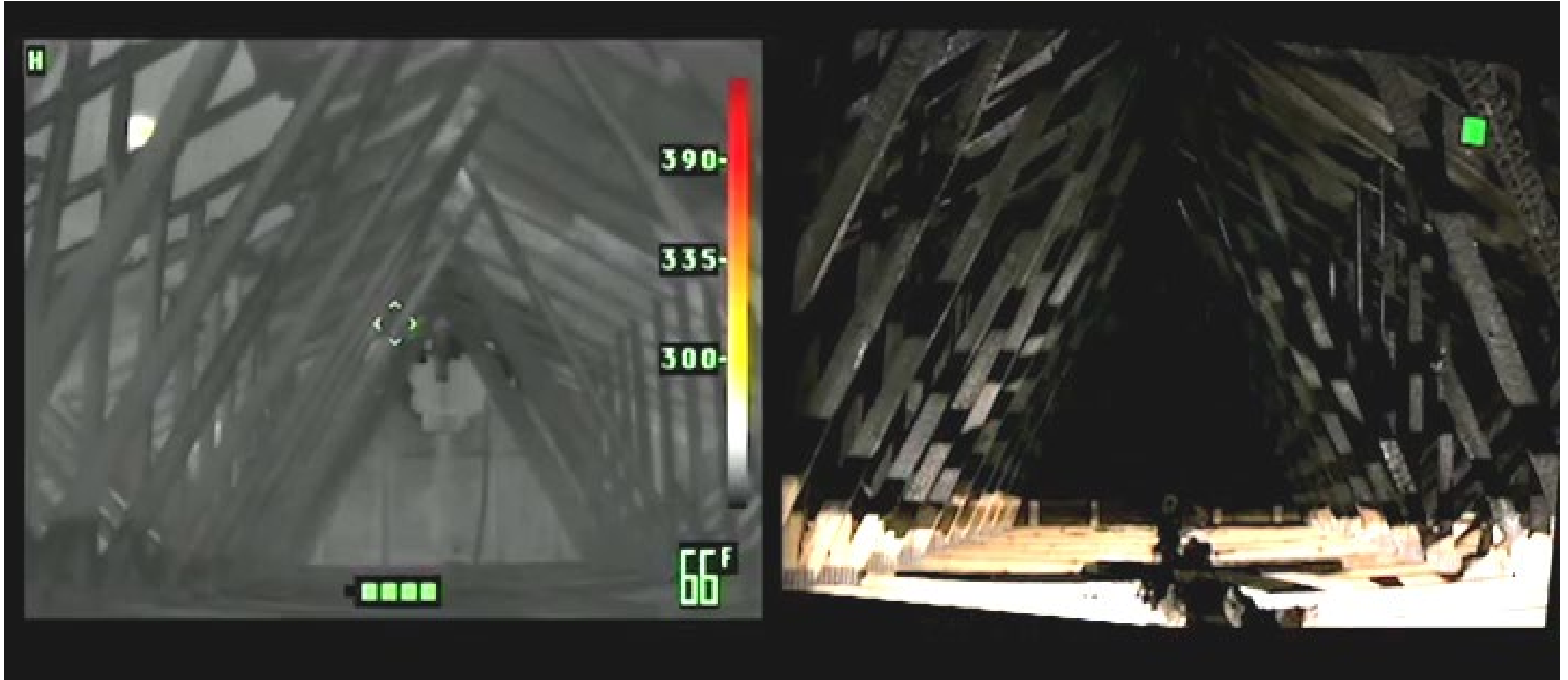
**EAVES**



# WETTING SHEATHING WITH AN EAVE ATTACK SLOWS ATTIC FIRE GROWTH

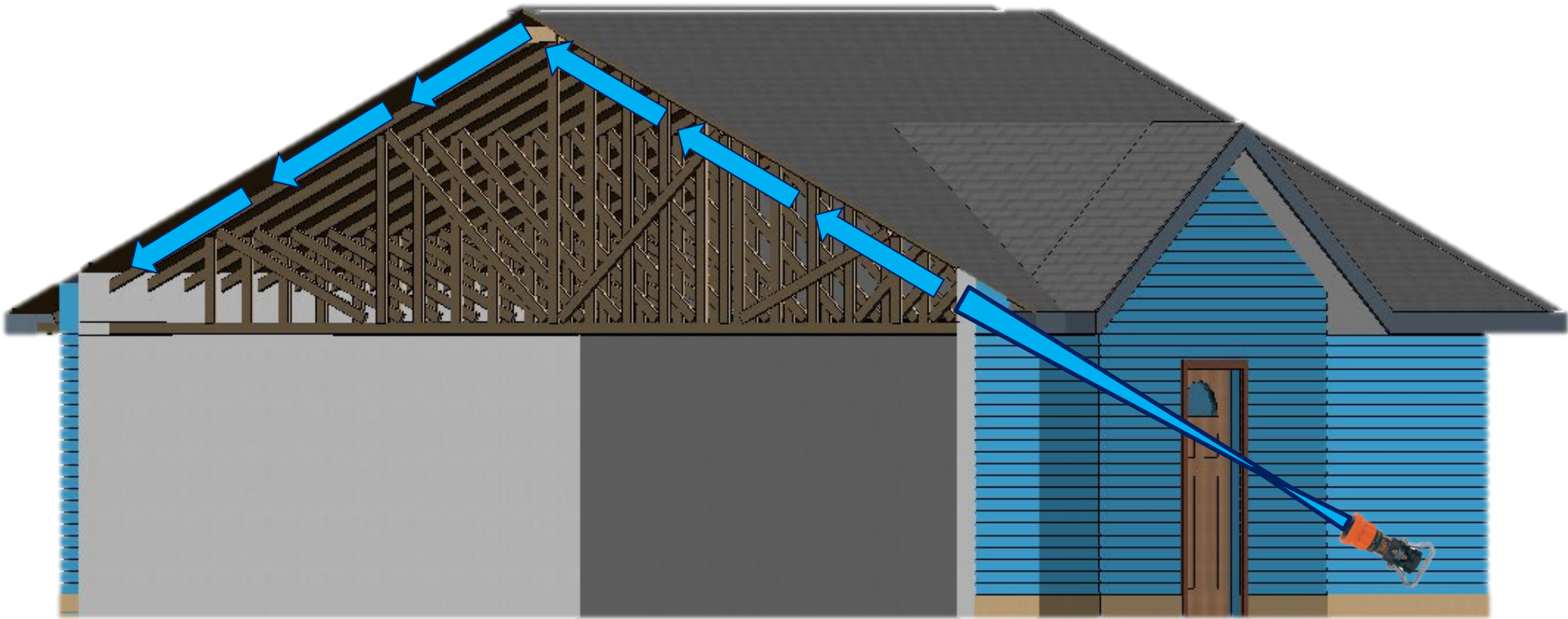


# ATTIC CONSTRUCTION AFFECTS HOSE STREAM PENETRATION



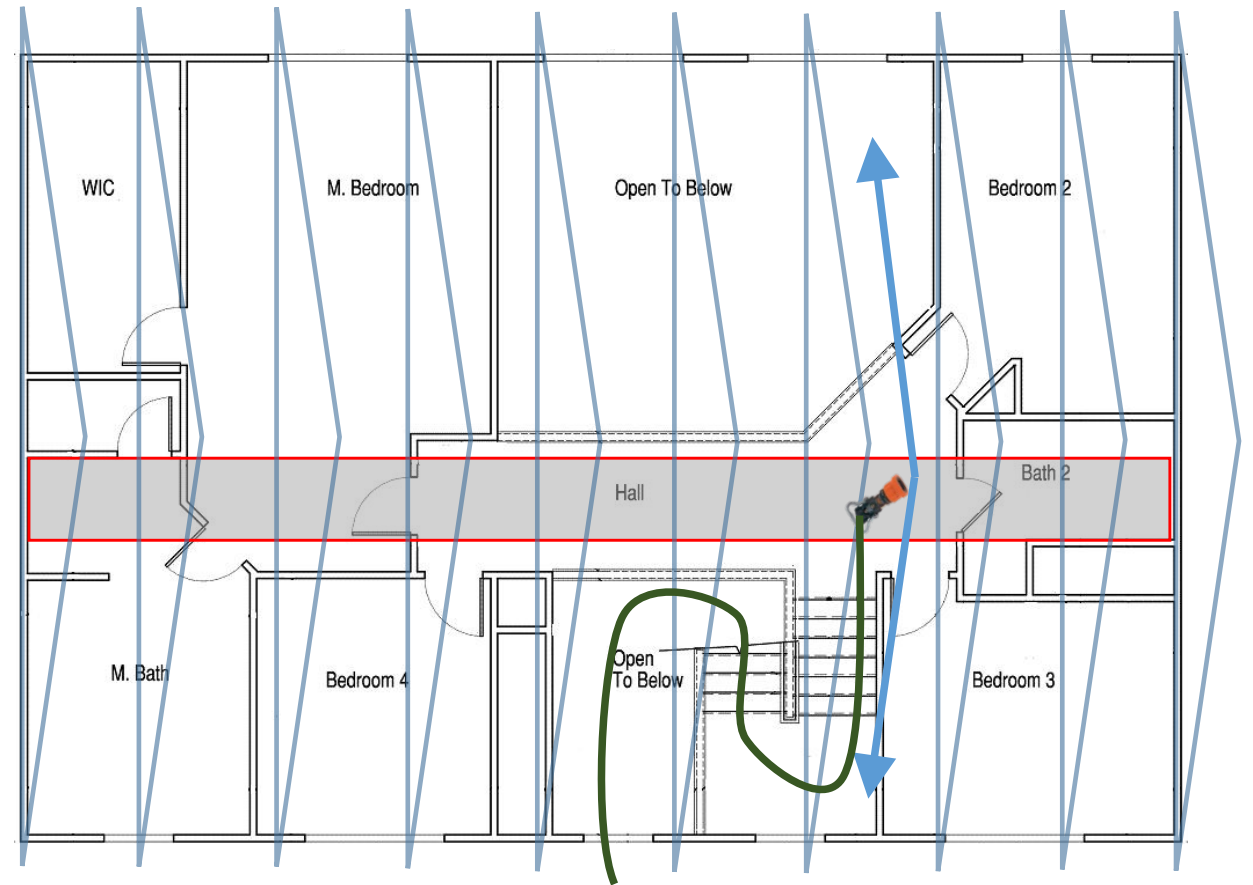
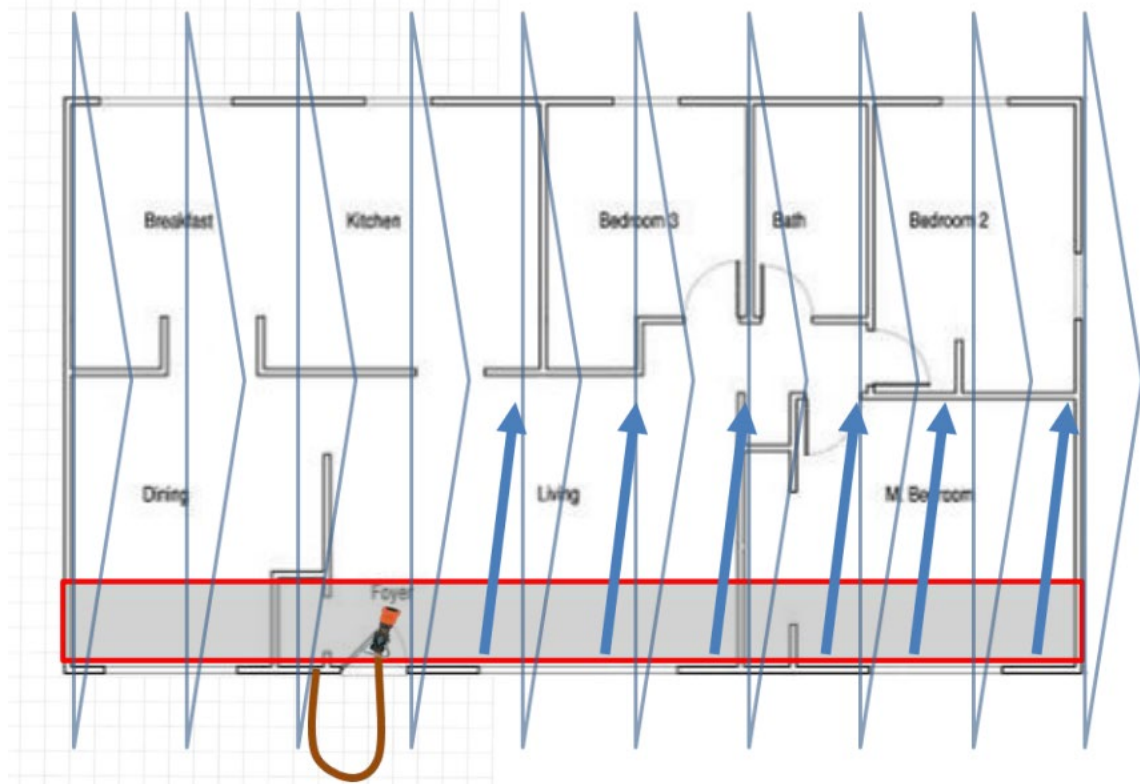
# WATER APPLICATION INTO THE EAVES

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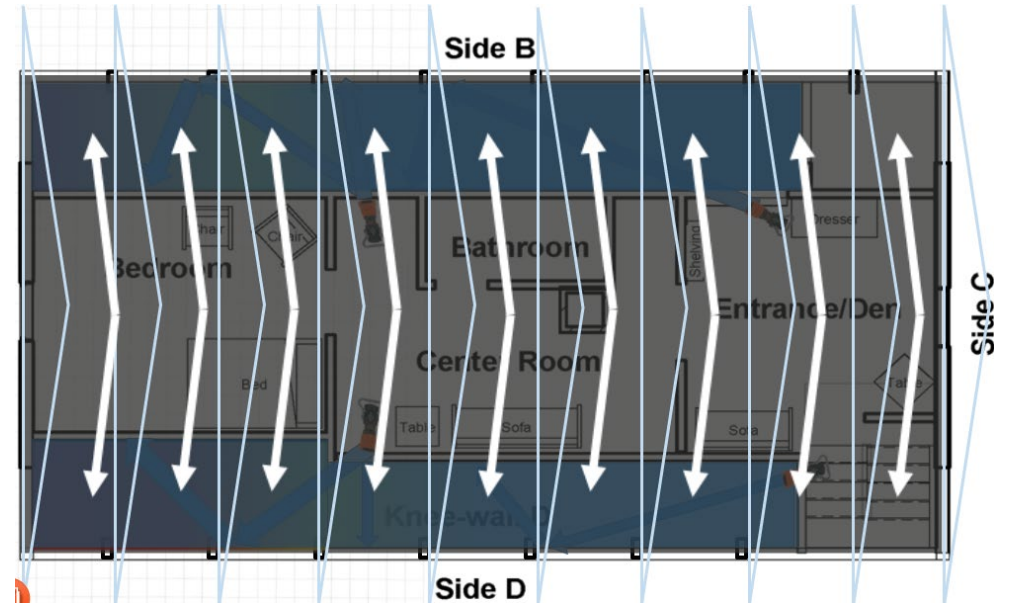
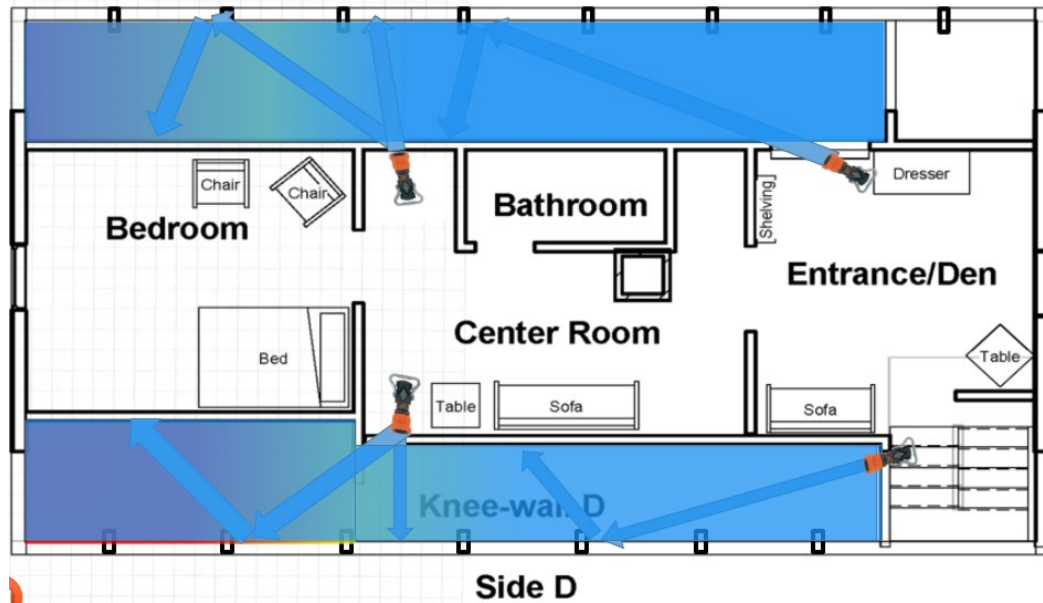
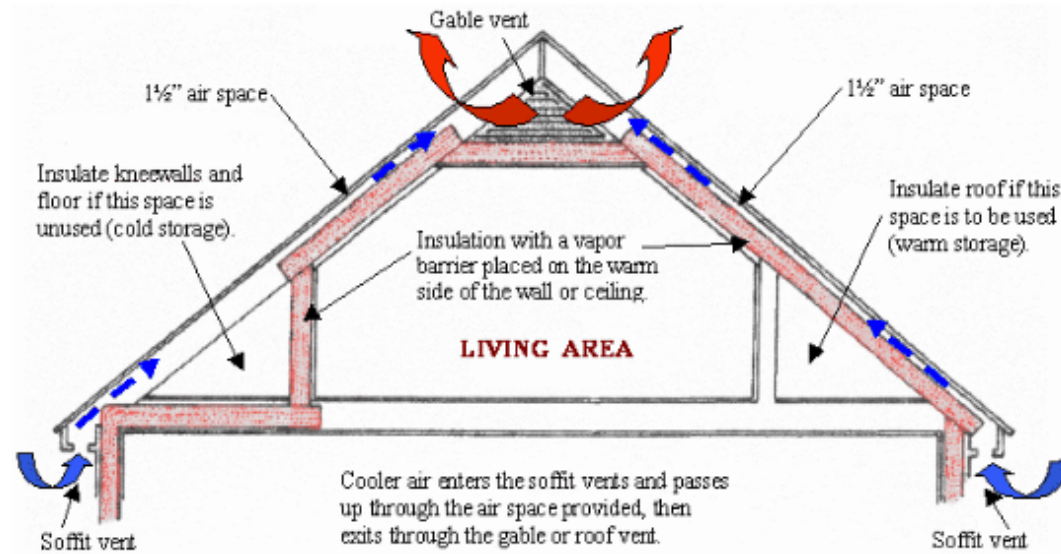




# WATER IN THE EAVES – FROM THE INSIDE



# KNEE WALL FIRES



# MASTER STREAMS – POSITION WITH A PURPOSE



# SEARCH AND RESCUE

# SURVIVABLE SPACES IN STRUCTURES

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- Fire conditions on size-up do NOT translate to victim survivability
- Proximity and elevation are KEY!
- Variability based on FD intervention and structure geometry.
- No clear cut answer.

Must assume **survivable spaces** exist –  
So Where Can We Search?



*Suppression Stops Things From Getting Worse, Ventilation Needed to Make Things Better*



# VICTIM SURVIVABILITY

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Survivability Profile Decreases  
as  
Time of Exposure Increases

**Finding them is the first step to removing them!**



# DATA BASED DECISION MAKING

## #1 Bedroom

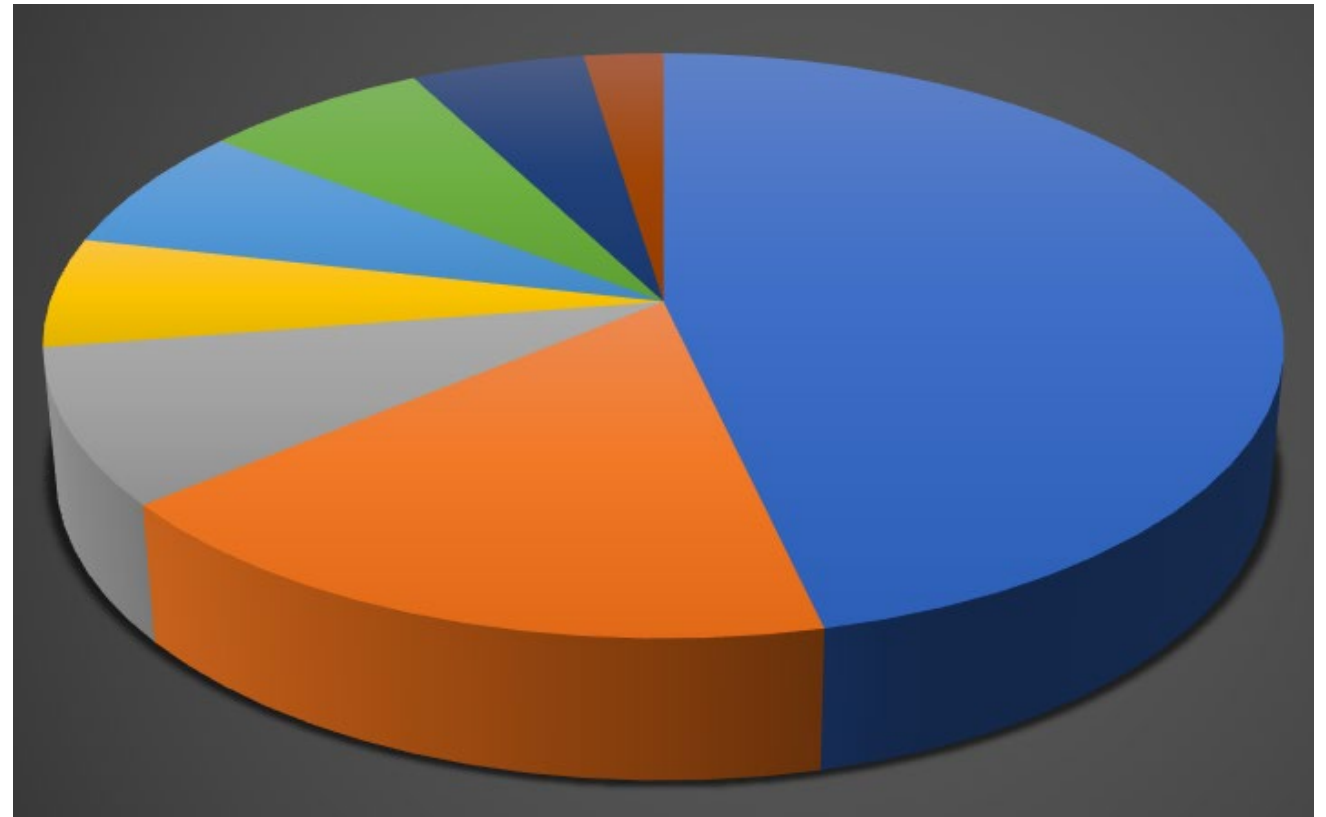
- Likely Sleeping or Utilizing Place of Refuge
- Closed Doors!

## #2 Family Room

- Likely Nearby Entrance

## #3 Hallway

- Likely Trying To Exit



■ Bedroom (45%)

■ Family (17%)

■ Hallway (8%)

■ Other (9%)

■ Kitchen (7%)

■ Bathroom (7%)

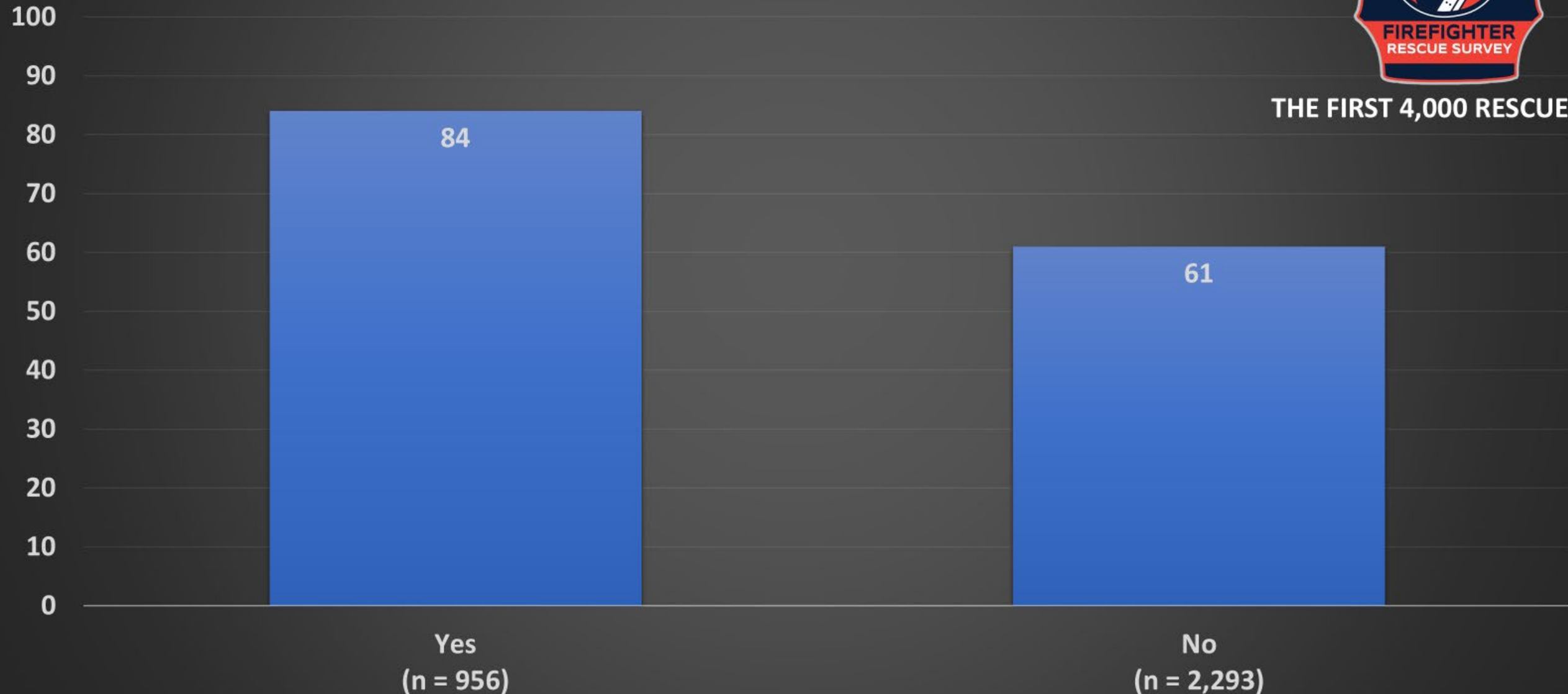
■ Balcony/Porch/Deck (5%)

■ Foyer (2%)

# Was the Victim Behind a Closed Door v Survival Percentage



THE FIRST 4,000 RESCUES



# TOXIC VS. THERMAL INSULT

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Intimate With The Fire = Thermal Exposure

Remote From The Fire = Toxic Exposure

So Where Are The Ones Most Threatened?



# SOLVING THE PARADOX

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- Where is the fire?
- Type of structure
- Time of day
- Signs of life
- Any report?



# SEARCH TACTICS

Window  
Vs.  
Door  
Initiated



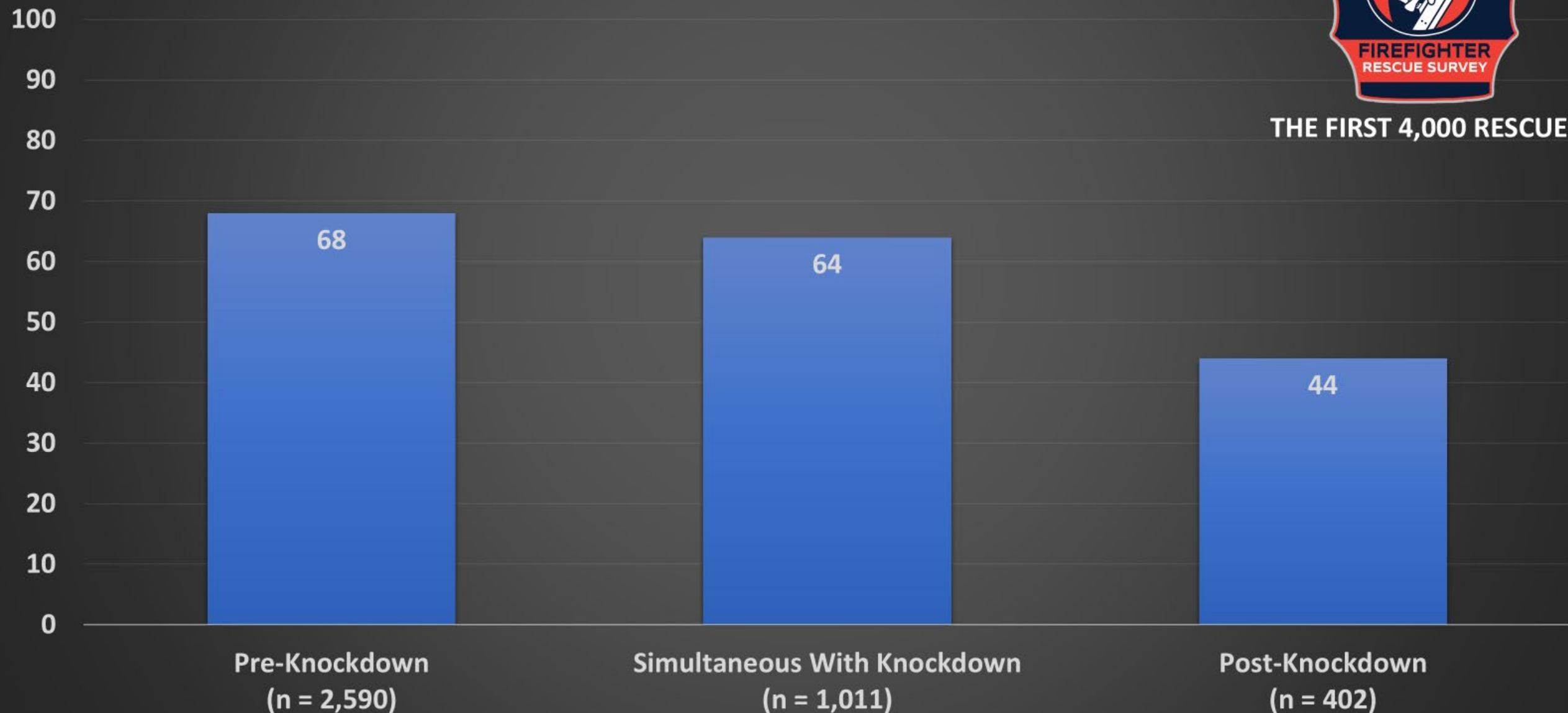
“Primary”  
and  
“Secondary”



# When Was Search Initiated (Fire Conditions) v Survival Percentage



THE FIRST 4,000 RESCUES



# LOOKING FOR LUMPY







# SEARCH SUMMARY

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## **Search Ahead of Suppression:**

- Isolation to the fire compartment was effective at reducing flame spread and toxic/thermal exposure
- Isolation of searchable spaces was effective at reducing toxic/thermal exposure
- Ventilation of isolated spaces was effective at improving conditions

## **Search During or Post Suppression:**

- De-isolation and ventilation was effective at reducing toxic exposure (Get all doors and windows in IDLH open – FAST)



# RESCUE TACTICS

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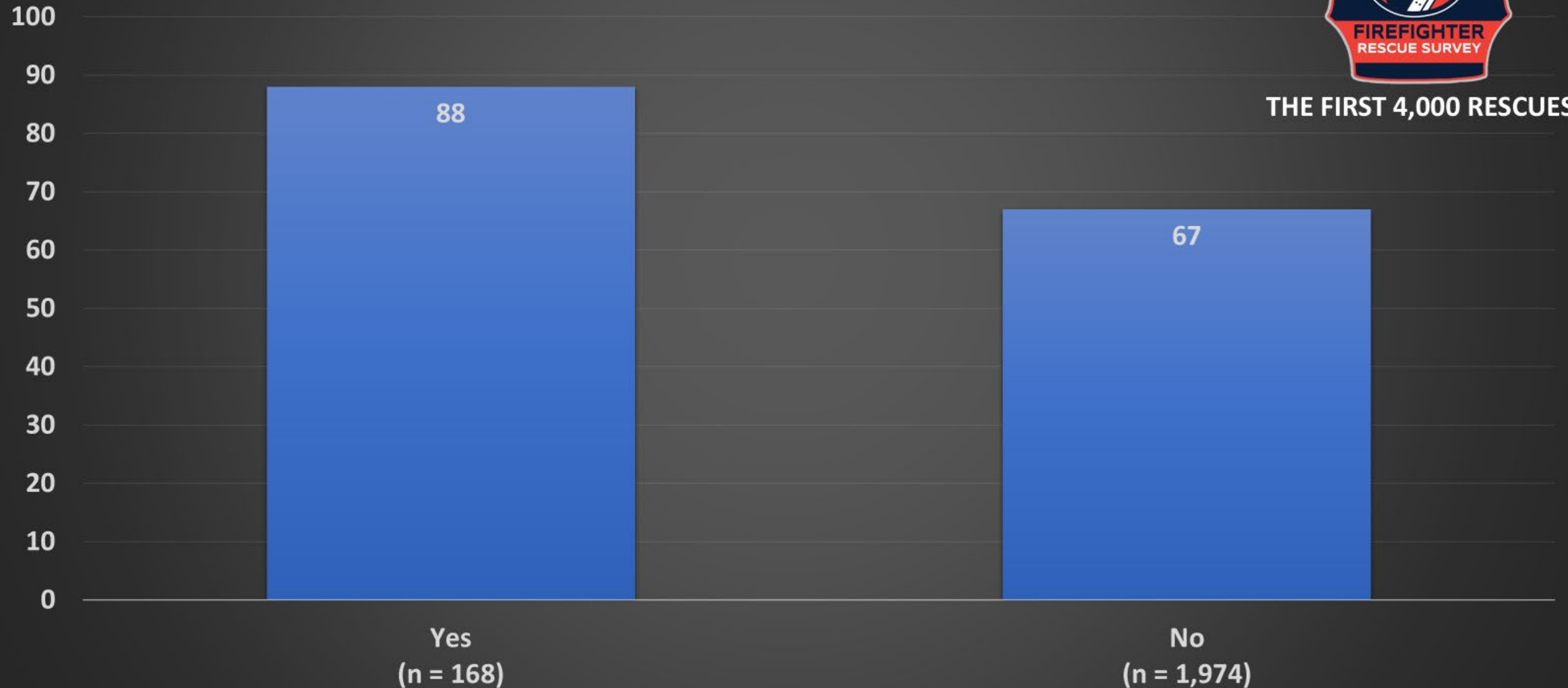
- Back the way we came
- Isolate and find new egress
- Isolate and shelter in place



# Was Victim Sheltered in Place (>2 Mins) v Survival Percentage



THE FIRST 4,000 RESCUES





# RESCUE SUMMARY

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## Victim Removal:

- Lower elevations shown to result in a lower accumulated exposure compared to higher elevations (1 ft vs 3 ft above the floor)
- Prior to suppression, delayed removal or alternate pathways (avoid passing fire compartment) reduces exposure





**QUESTIONS?**