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A Joint AIChE and CCPS Meeting

April 12 – 16, 2026
Houston, TX

Where Chemical Engineering Meets Innovation

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Unrecognized Hazards in Ammonia Refrigeration Relief Systems

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Where Chemical Engineering Meets Innovation

About the Authors

Colin Armstrong is a Principal Engineer at AcuTech, and the Group Leader for Quantitative Risk Services. He brings years of experience in the areas of quantitative risk analysis and facility siting. Mr. Armstrong has served as a member of the API Facility Siting Committee for API RPs 752, 753, and 756. In his work, he has provided instruction and training in QRA and facility siting techniques to operating companies and university students. He has led hundreds of QRAs, facility siting studies, and PHA's for clients in the petroleum, chemical, agriculture, and alternative energy sectors, including over 100 ammonia refrigeration systems.

About the Authors

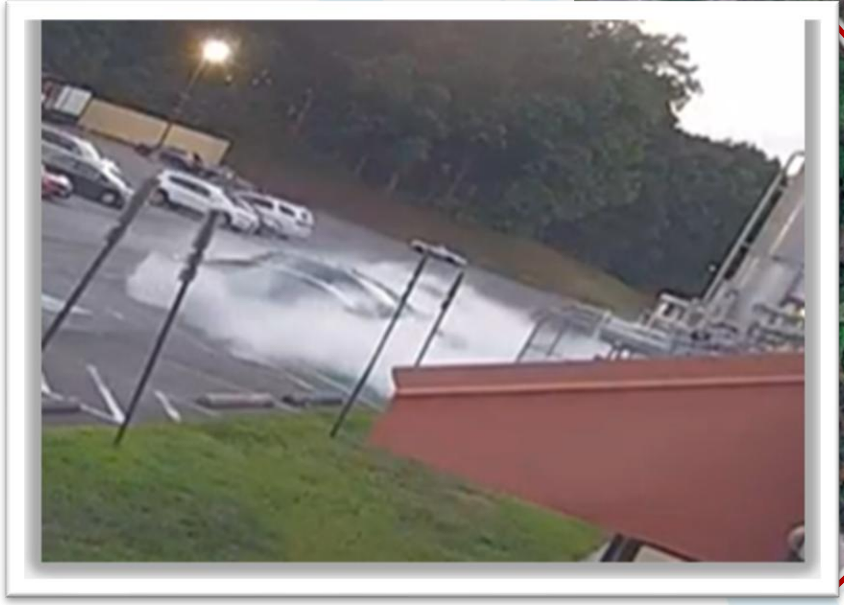
Melinda Hartz is currently a Chemical Incident Investigator for the CSB. She has previously worked in the chemical industry in various process engineering and plant operations roles for over 25 years, including in Teflon® and Kapton® production at DuPont, and styrenic block copolymer production at Kraton Corporation.

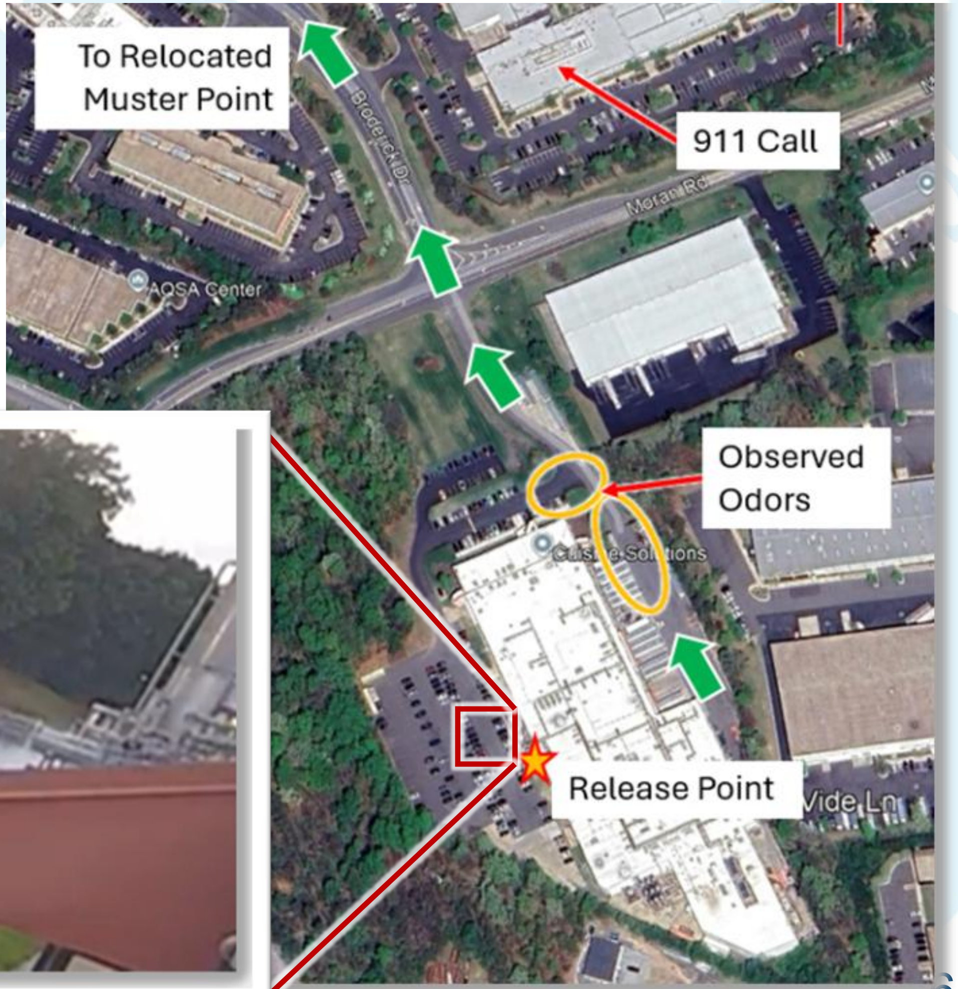
Overview

- The Cuisine Solutions investigation by CSB
- The incident as case study
- Factors influencing relief discharge safety
- Building wake effects
- Impact on emergency response

The Cuisine Solutions Incident

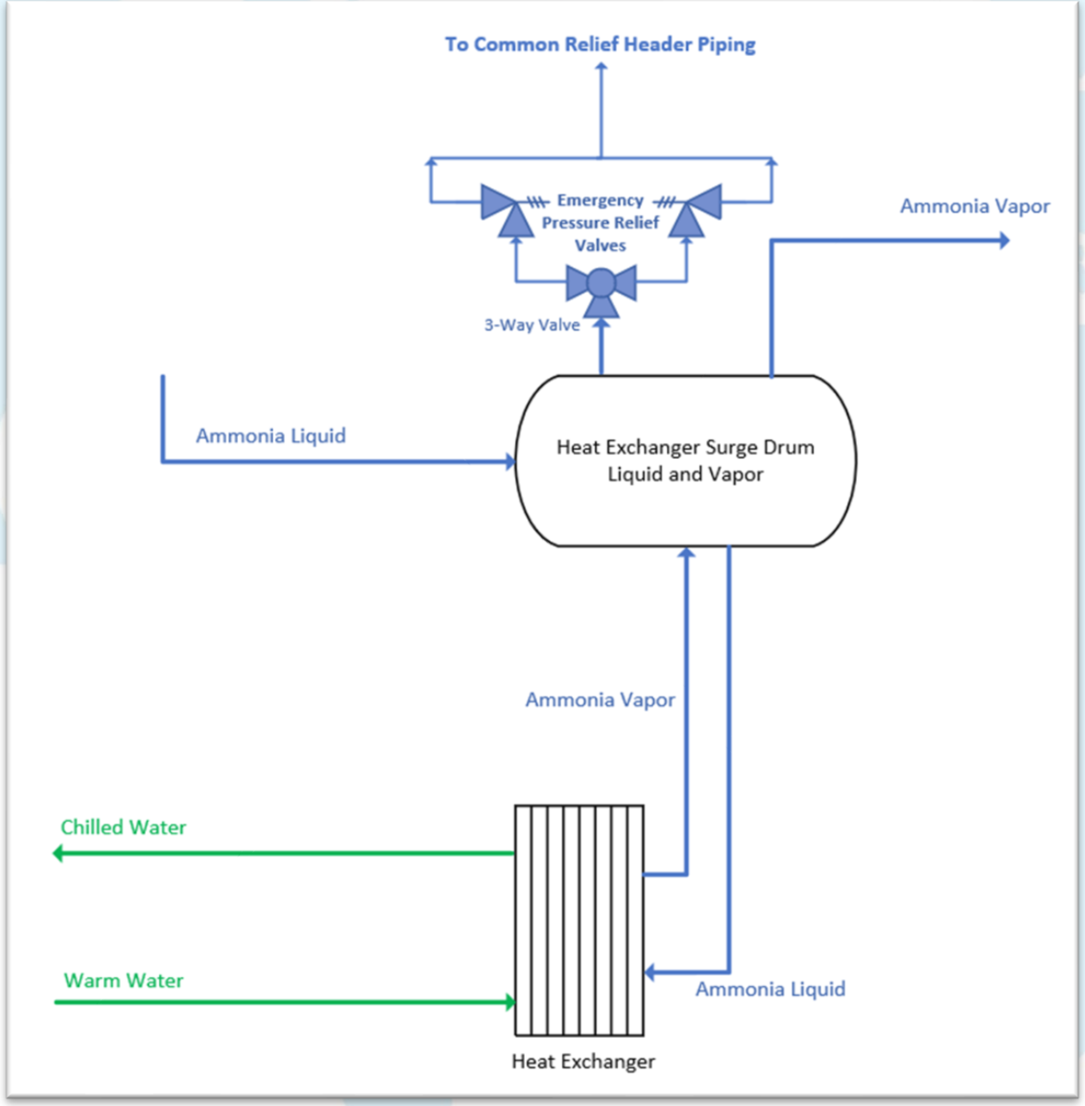
- July 31, 2024 ~8:20 pm
- Ammonia refrigeration surge drum relief device
- Slumped visible cloud west side
- Exposures on the east side (building wake)
- Limited evacuation routes





Case Study

- CSB concluded the ammonia release contained liquid aerosol
- Presence of liquid was key to the ammonia release slumping to ground level and impacting evacuees
- Relatively small ammonia release, but because of slumping and building wake effects, relief discharged to an unsafe location



Relief Discharge Factors

Phase

- Liquid droplets form cold, dense mists and/or rainout, slumping to ground level
- Knock out liquids or ensure complete flashing to vapor

Velocity/Relief Pressure

- Higher relief pressure and discharge velocity = increased air entrainment and dilution, momentum in a safe direction
- Maximize discharge velocity, while satisfying backpressure requirements

Relief Discharge Factors

Orientation

- Upward discharge maximizes plume height
- Orient away from people and other elevated structures

Elevation

- Higher discharge elevation allows safer dispersion
- Consider potential for wake entrainment and adjacent structure influences

Relief Discharge Factors

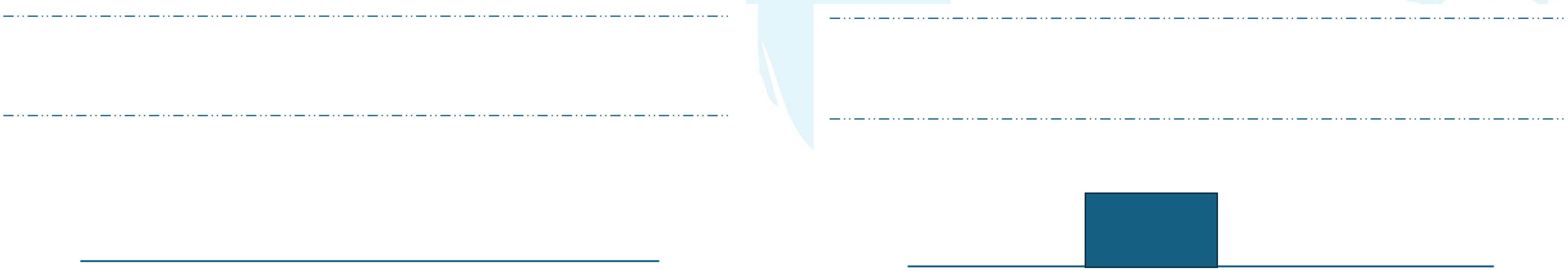
Location

- Maximize distance and discharge away from people or elevated structures
- Consider horizontal and vertical distances, including wake effects

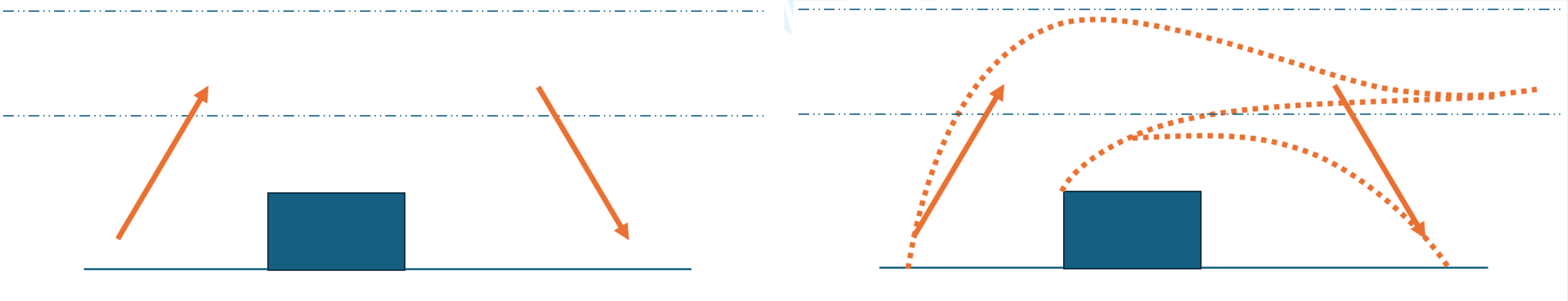
Temperature

- Colder relief temperatures create colder, denser plumes that can slump to ground level
- Consider relief temperatures for all scenarios, and do not assume ammonia will always rise

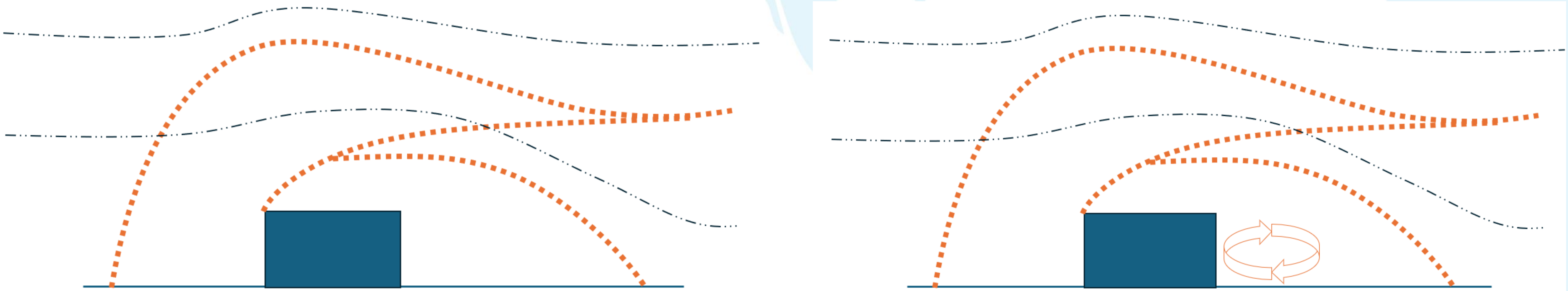
Building Wake Effects



Building Wake Effects



Building Wake Effects



Building Wake Effects

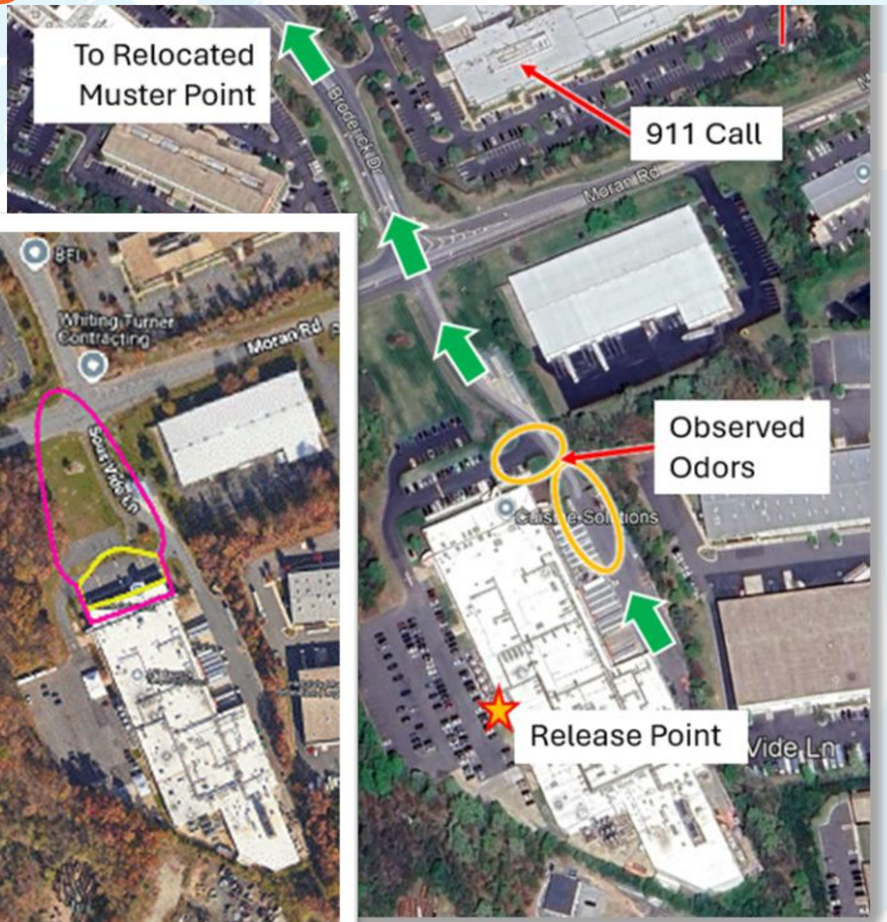
$$\lambda = (H^{*} - h_{b})/\delta$$

- H^* = Height of cloud prior to building effects
- h_b = Building height
- δ = Minimum(h_b,b_b)
- b_b = Building width

λ	**Effect of Building Wake**
λ>1.5	No effect
0.2<λ<1.5	Plume lowered, but not taken into lee zone
0< λ<0.2	Partial takeup into lee zone
λ <0	Complete takeup into lee zone

Cuisine Solutions: Building Wake Effects

- No visible cloud along evacuation route
- Some evacuees observed odors, hesitated, turned back, or had difficulty breathing
- Dispersion analysis indicated ammonia entrainment in building wake



Impact on Emergency Response

- Plan egress routes considering potential of slumping release and building wake effects, or prevent releases reaching ground level
- Train personnel to evacuate based on situational awareness such as wind direction
- Consider shelter-in-place or other alternative strategies, such as use of escape PPE, if needed
- Different release scenarios may require separate, distinct emergency response plans
- Key is planning ahead of time

Conclusions

- Most effective way to assess atmospheric discharges is quantitative dispersion modeling
- Consider
  - Installing equipment to knock out entrained liquids (saturated streams are common in refrigeration)
  - Elevating relief stacks higher than the minimum requirements from IIAR 2
  - Maximizing distance from structures/people
  - Minimizing the diameter and number of discharge points to maximize velocity in a safe direction
  - Relieving as close to vertically as possible
- Wake effects can cause unrecognized hazards and needs to be evaluated for effective emergency planning
- Different release scenarios may require different response strategies