Exceptional service in the national interest
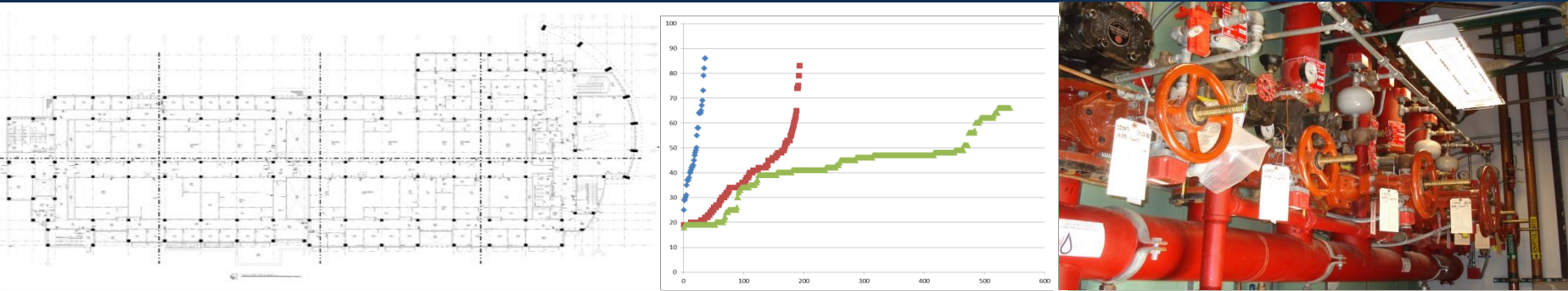
Sandia National Laboratories

Calculating Fire Risk at Sandia National Laboratories

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National Nuclear Security Administration

This briefing presents a methodology for evaluating risk on a building level.

Qualitative Fire Risk Index

- Benefits
  - Improve our Emergency Services Response Time criteria (documented in BNA)
  - Provide risk-based prioritization model for buildings across the site:
    - FPA schedule
    - Maintenance prioritization
    - Opportunities prioritization

Assumptions

Risk = Probability of a Fire * Consequence

- The Fire Consequence Index (FCI) is a relative risk ranking and is not a measure of absolute risk

- Categories will be selected and weighted based on their perceived contribution to severity and increased consequence of a fire, given a fire occurs

Fire Consequence Categories

- Replacement Value (RPV)
- Building Contents Value
- Square Footage of the Building
- Occupancy Type
- Building Population
- Fire Alarm
- Automatic Sprinkler Protection
- Response Time for Fire Department
- Special Consequences

Information from FIMS
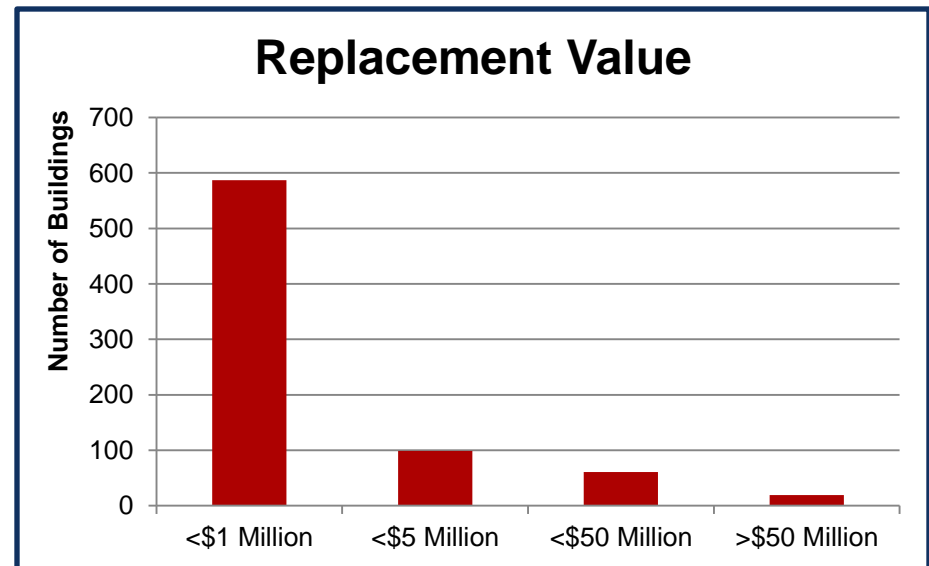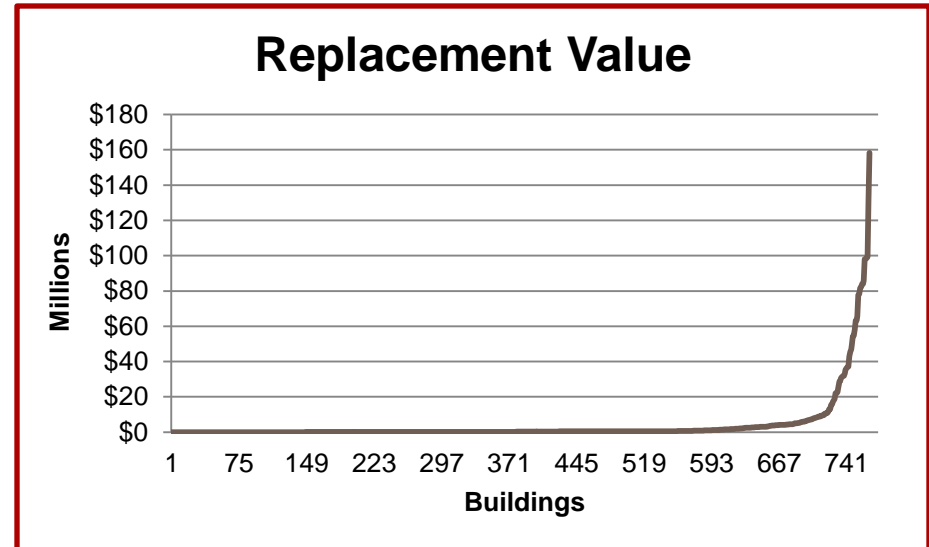## (FCI points given in parentheses)

- RPV
  - >$50 Million (5)
  - ≤$50 Million (4)
  - <$5 Million (2)
  - <$1 Million (1)
- Building Contents Value
  - >$5 Million (5)
  - ≤$5 Million (4)
  - <$1 Million (3)
  - <$250 Thousand (1)
- Square Footage
  - >100,000 ft² (5)
  - ≤100,000 ft² (4)
  - <50,000 ft² (2)
  - <10,000 ft² (1)

Replacement Value

Replacement Value

From our files…

- Occupancy Type:
    - High Hazard (5)
    - Factory (3)
    - Utility (3)
    - Assembly (2)
    - Storage (2)
    - Business (Office & Lab) (1)
- Building Population
    - >300 (5)
    - $\leq$300 (4)
    - <100 (2)
    - <10 (1)
    - No occupants (0)

From our files…

- Working Fire Alarm transmitting to a constantly attended location? (0 if yes, 5 if no)

- Automatic sprinkler protection? (0 if yes, 5 if no)

- Travel Time- how long will it take the FD to reach the building?
  - Remote Sites (5)
  - Tech Area III (4)
  - Tech Area V (3)
  - Tech Area II, TAIV (2)
 - Tech Area I (1)

Special Consequences

- Special Consequences
  - Nuclear (5)
  - Exposure to the Public (5)
  - Accelerators (4)
  - Critical Infrastructure (4)
  - Clean Rooms (3)
  - Explosives (3)
  - Hazardous Material (3)
 - Critical Infrastructure Support (3)

$$FCI = \sum_{i=1}^{n} (Point\ Value_i\ *\ Weighting\ Factor_i)$$

Consequence Category	Value Range	Weighting Factor
Replacement Value (RPV)	1 - 5	4
Building Contents Value	1 - 5	3
Square Footage	1 - 5	1
Occupancy Type	1 - 5	1
Building Population	0 - 5	6
Fire Alarm	2 - 5	1
Automatic Sprinklers	0 - 5	3
Travel Time	1 - 5	2
Special Consequences	0 - 5	3

Fire Consequence Index-SNL/NM

Fire Consequence Index-SNL/NM

Highest consequence if a fire occurred
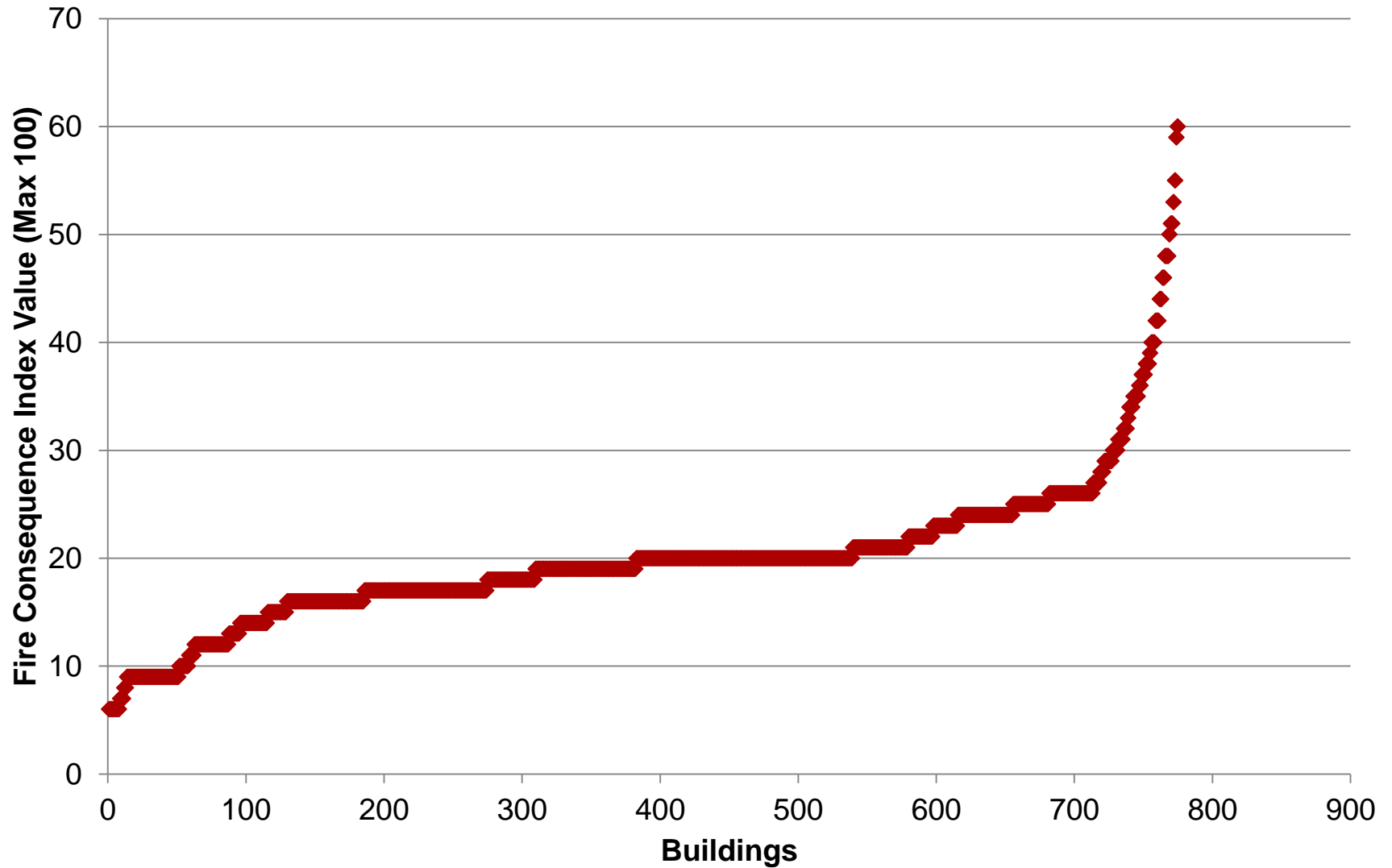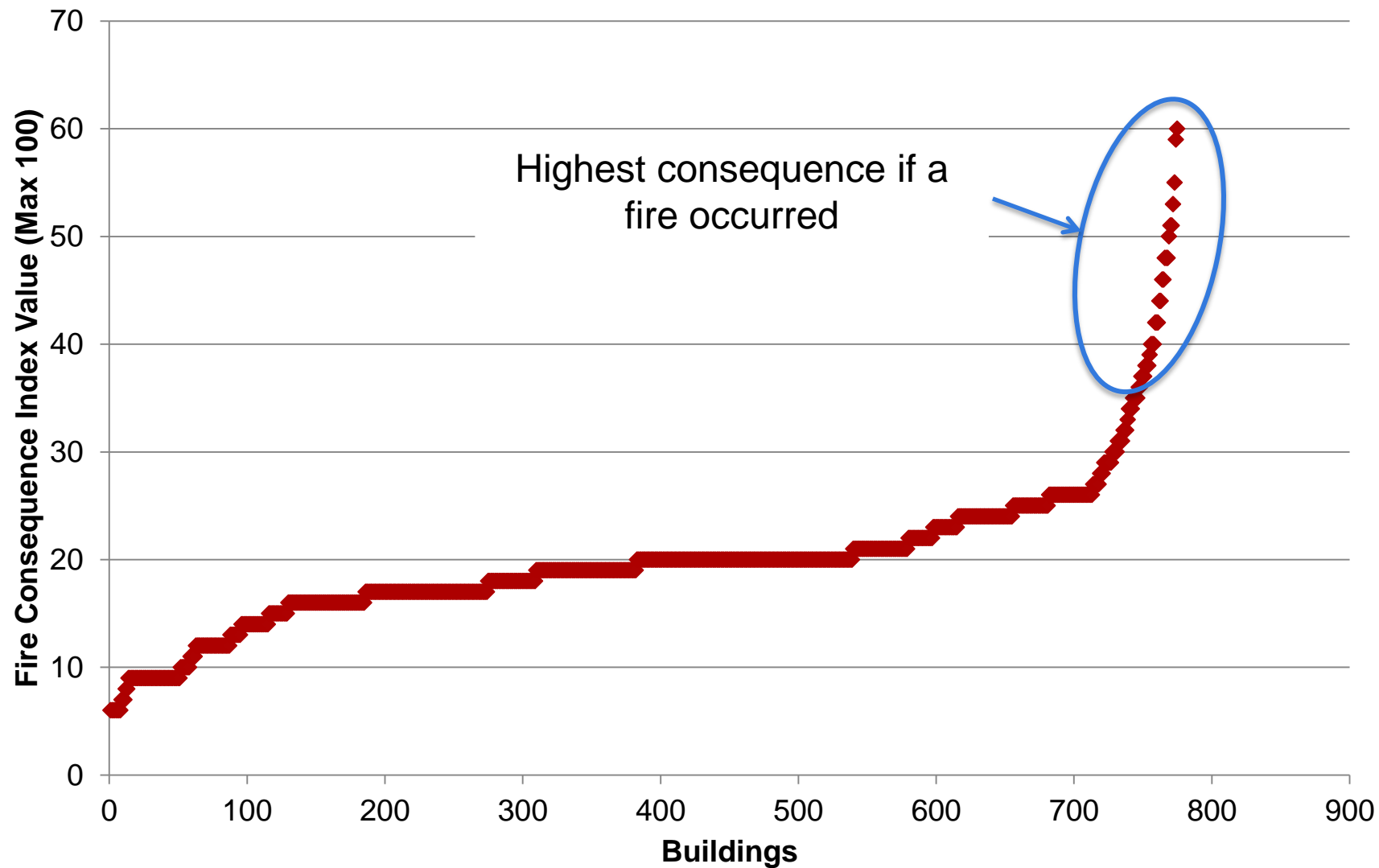
Buildings with Highest Fire Consequence

- High RPV
- High Building Contents
- High Building Population
- Special Hazard
  - Hazardous Materials
  - Exposure to the Public

Semi-conductor facilities have the greatest fire consequence, based on this methodology.

Next Step

Fire Risk = **Probability of a Fire** * Consequence

- More difficult to quantify
    - Limited data points from Sandia fires
    - Building missions change over time

Probability Data

- **DOE Fire Loss Database**
  - Fires from all DOE sites reported
  - Data from 1991-2007
  - 2,541 Events during this time period
- **Events Categorized:**
  - Building Fire
  - Brush Fire (Wildland Fire)
  - Vehicle Fire
  - Other Fire (Fires occurring outside buildings excluding brush fires)

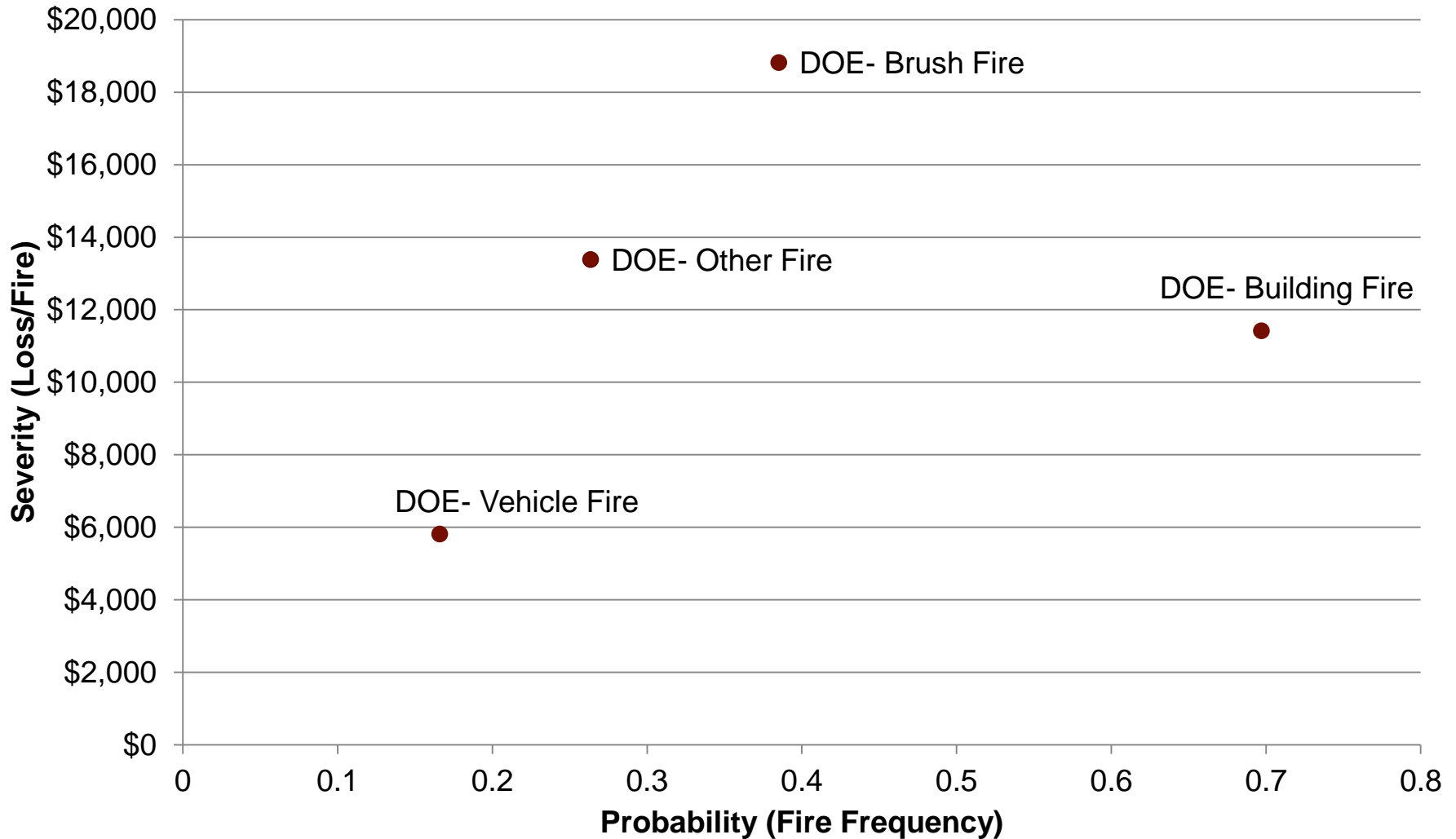# To Calculate Probability

- Poisson Distribution is most often used for rare events where:
    - Occurrences are independent
    - Average frequency of occurrence for the time period in question is known
    - Event can be counted in whole numbers

λ= Average Number of Days between Fires

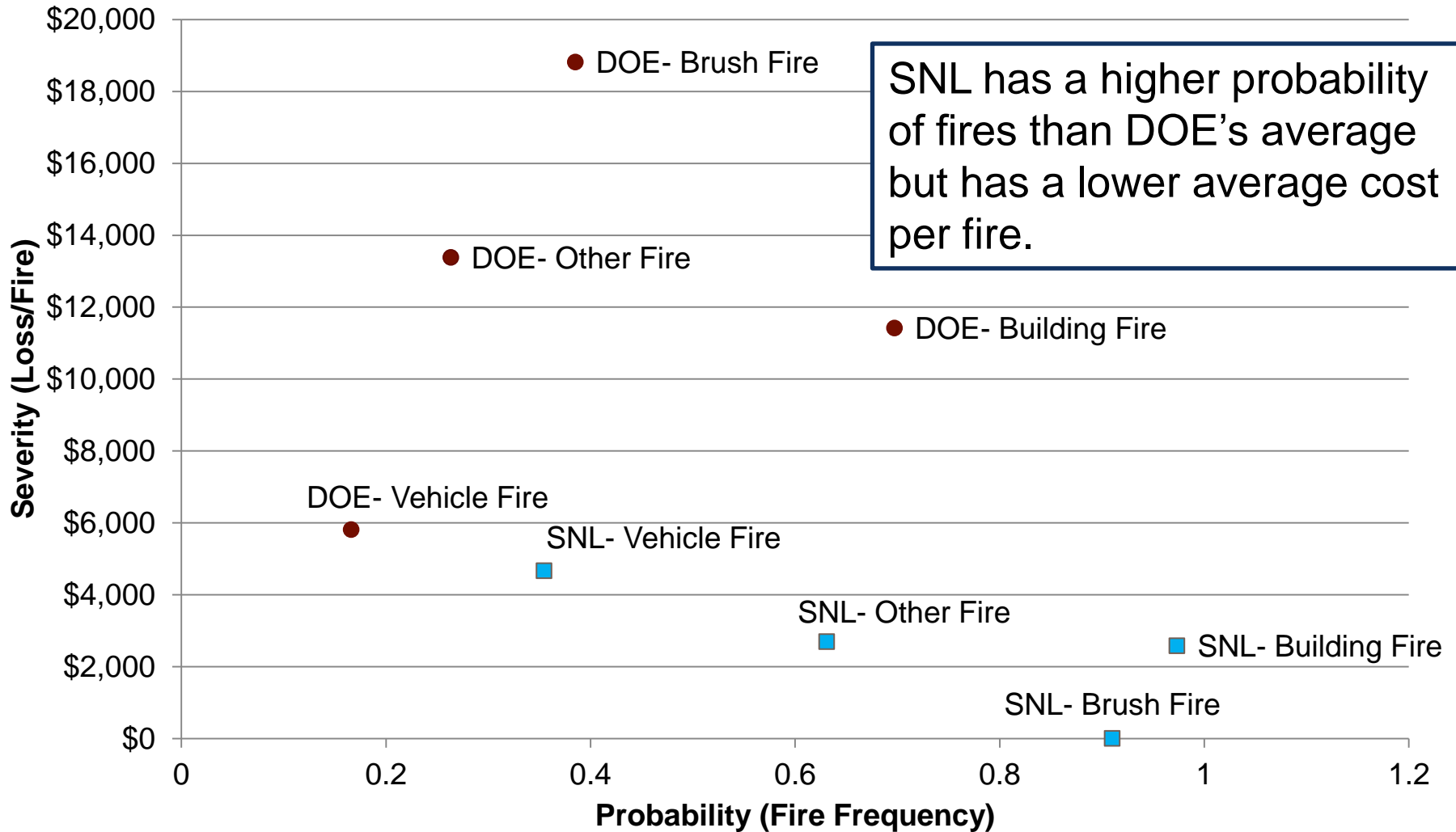Probability of a fire in a year $= 1 - e^{-\lambda * 365}$

Severity vs. Probability 1991-2007

Not included: Los Alamos Fire Cost, ~200 DOE fires that have no dates associated

Severity vs. Probability 1991-2007

SNL has a higher probability of fires than DOE's average but has a lower average cost per fire.

Not included: Los Alamos Fire Cost, ~200 DOE fires that have no dates associated

Fire Probability- By Building

- Using Space Chargeback data, buildings are broken down into four types of space:
  - General Areas
    - Administrative, Conference, Hall, Kitchens, Equipment Rooms, and difference in square footage between space chargeback and FIMS
  - Office Areas
    - General Office, Management Office, Secretarial Office, Computer Rooms
  - Lab Areas
    - General Lab, High Bay Lab, Shop, Special Lab
  - Storage Areas

Fire Probability- By Building

- Using the DOE Fire Loss Database (1991-2007) and Sandia's recent DOE Fire Loss Reports (2008-2013), we can determine the probability of fires in these four types of spaces
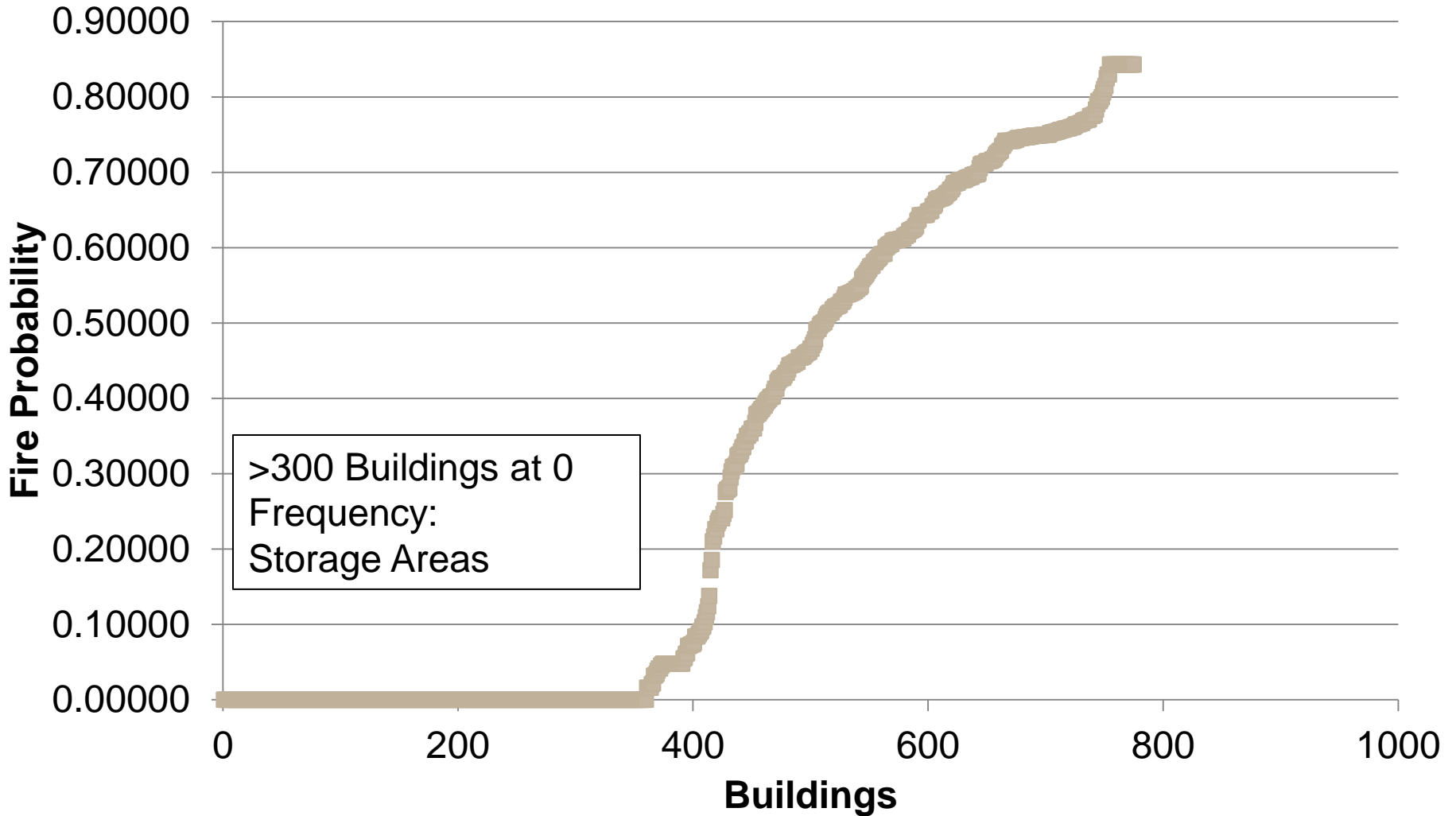
- Probability determined using the Poisson Distribution

$$\text{Probability of a fire in a year} = 1 - e^{-\lambda * 365}$$

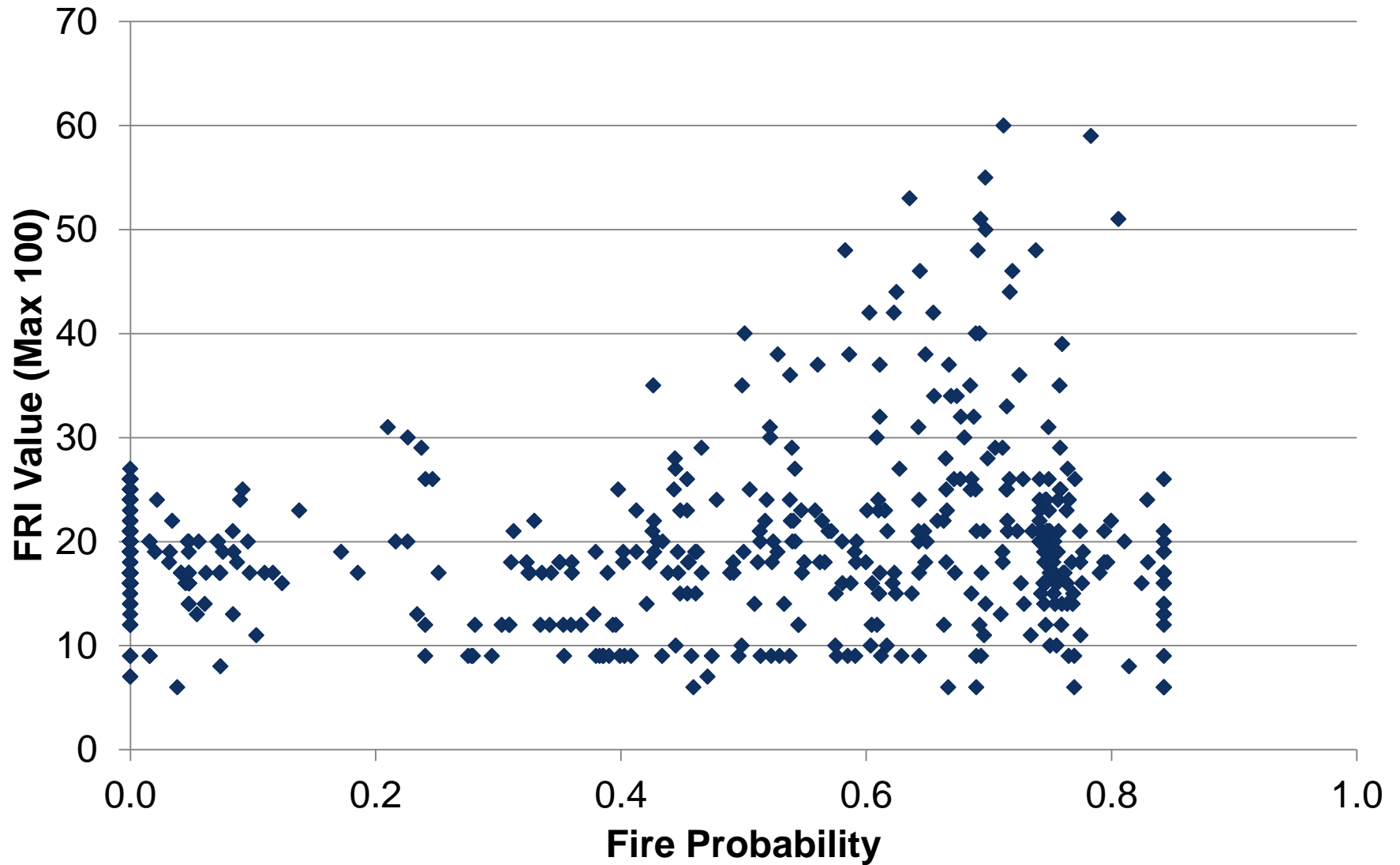| Space	Frequency (λ)	Probability
General	0.005069	0.84279
Lab	0.003707	0.74155
Office*	0.000124	0.04425
Storage	0	0

For the entire site

*There has only been one office fire at Sandia in this time frame, so there is not enough data to determine an accurate frequency.
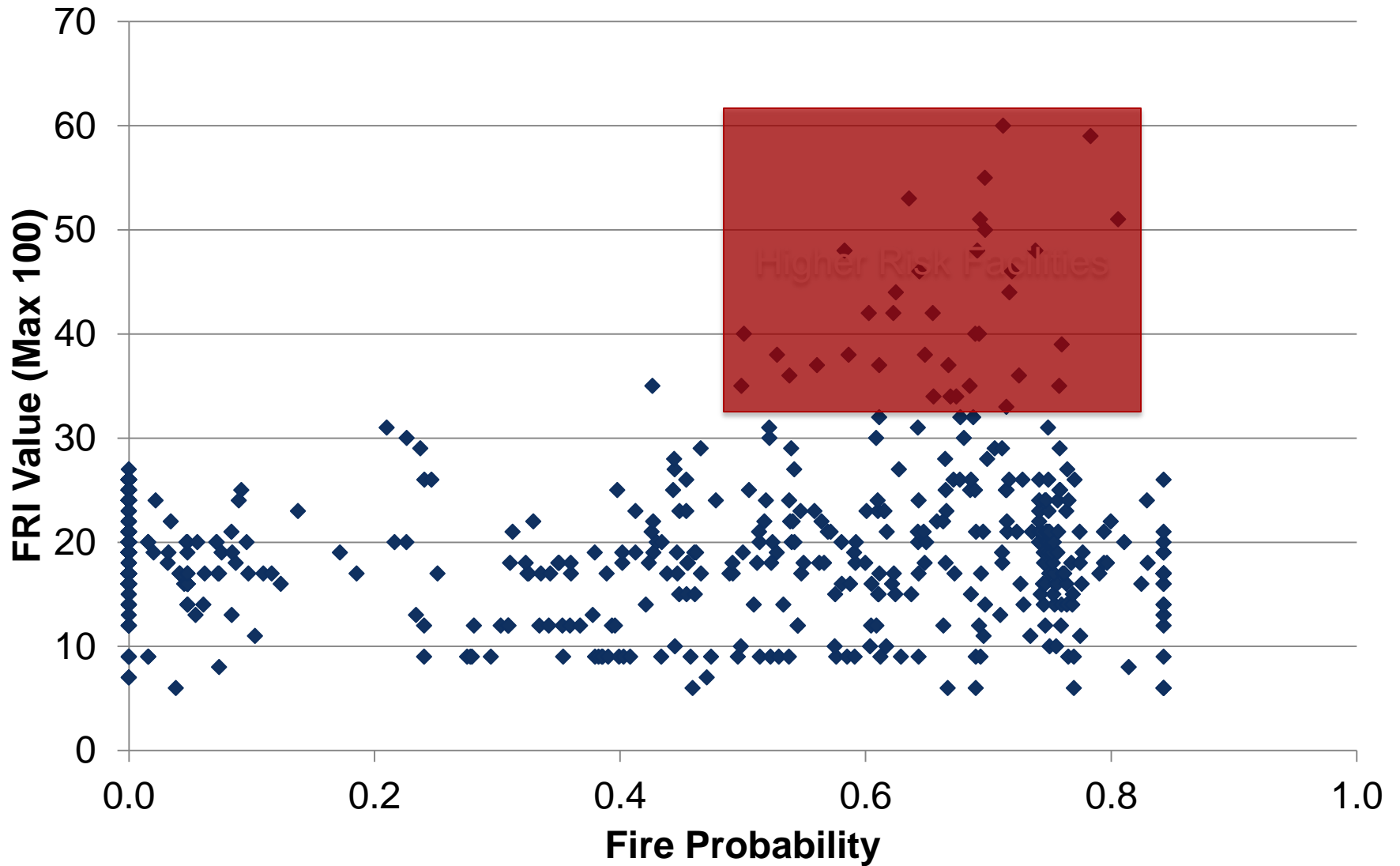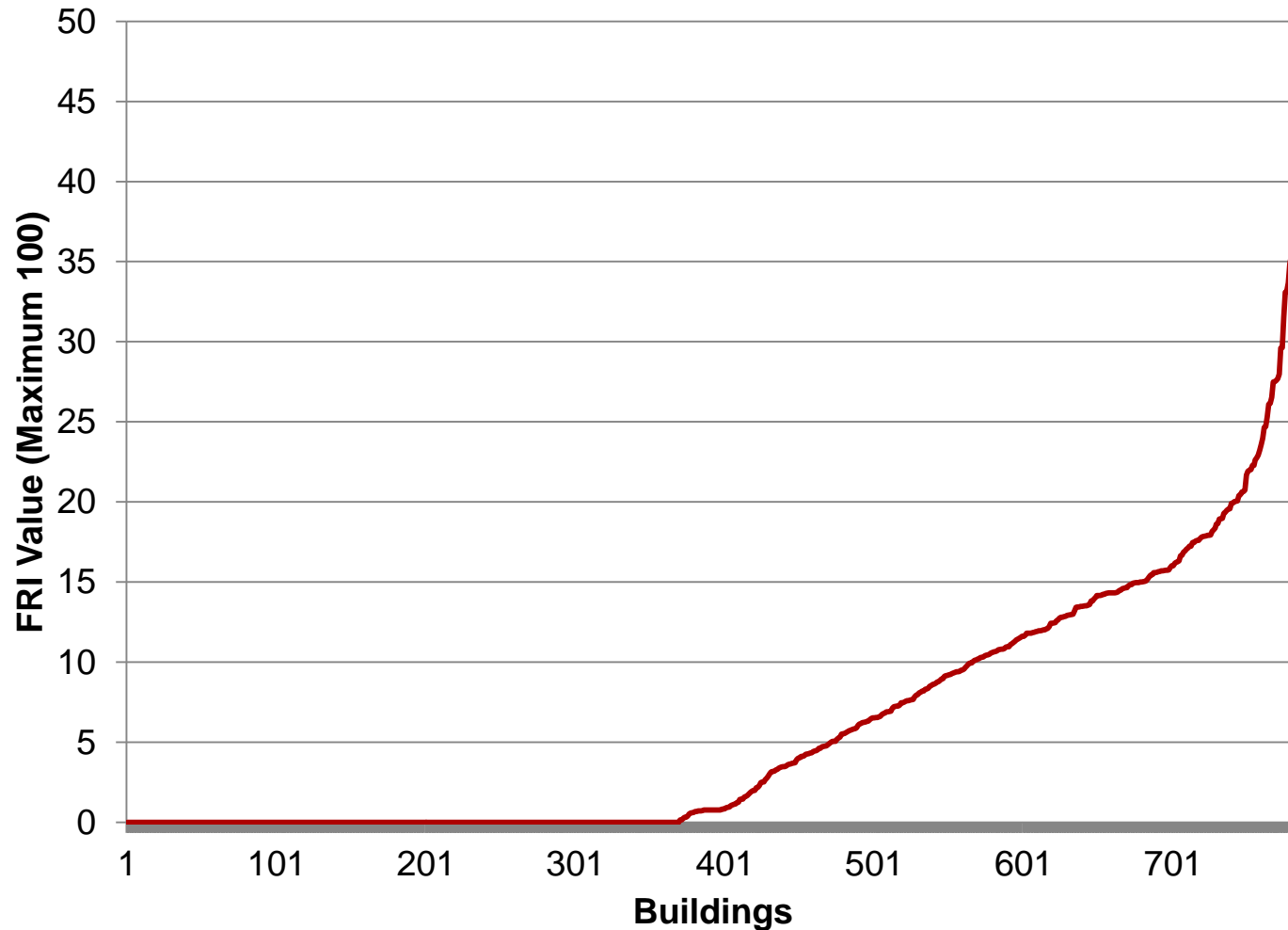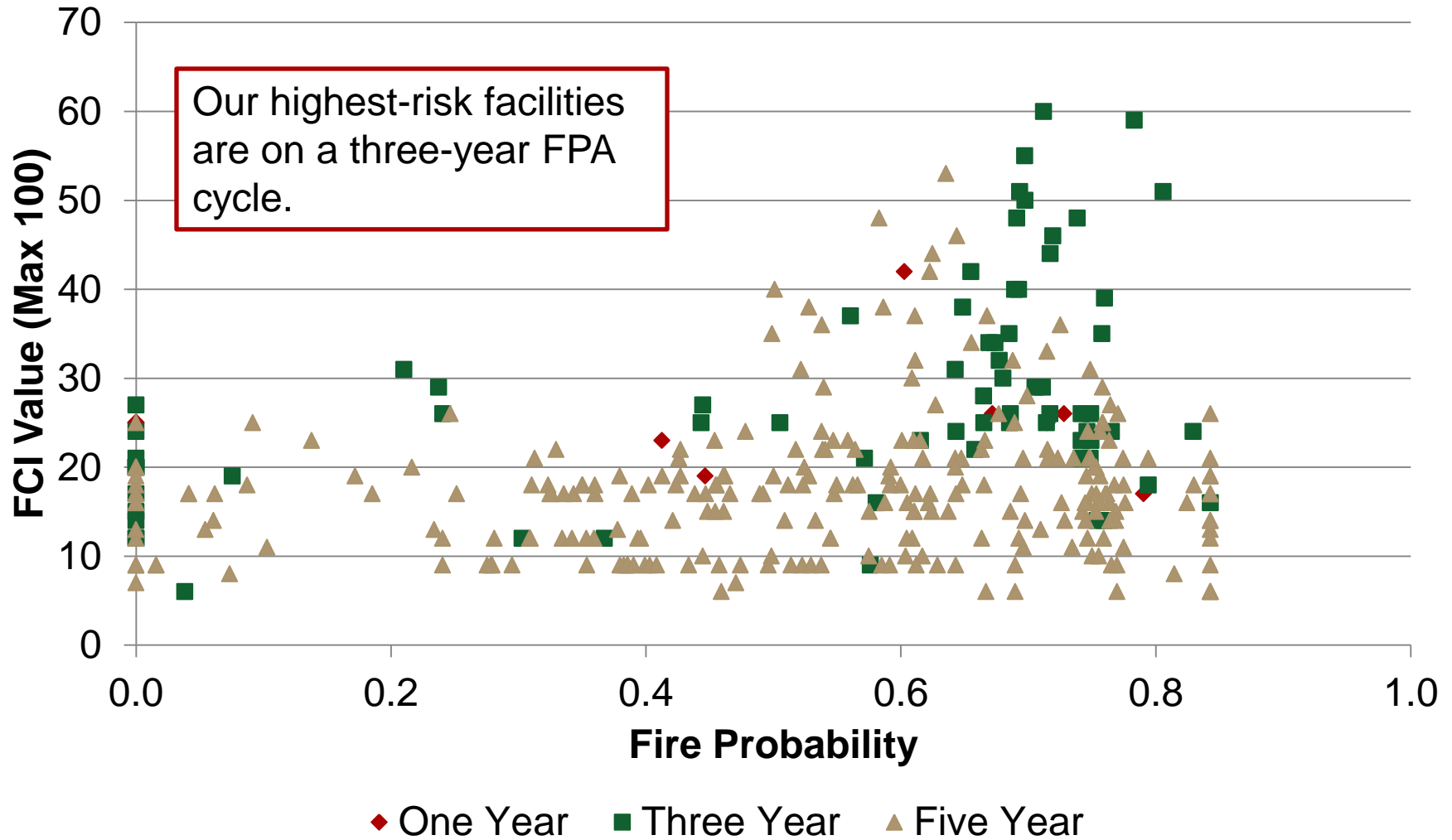
Fire Probabilities

Fire Risk Index

Fire Risk Index

Higher Risk Facilities

FRI Value (Max 100) (y-axis: 0, 10, 20, 30, 40, 50, 60, 70)

Fire Probability (x-axis: 0.0, 0.2, 0.4, 0.6, 0.8, 1.0)

Fire Risk = Probability of a Fire * Consequence

Fire Risk Index

SNL Current Fire Protection Assessment (FPA) Process

Our highest-risk facilities are on a three-year FPA cycle.

SNL Proposed FPA Process
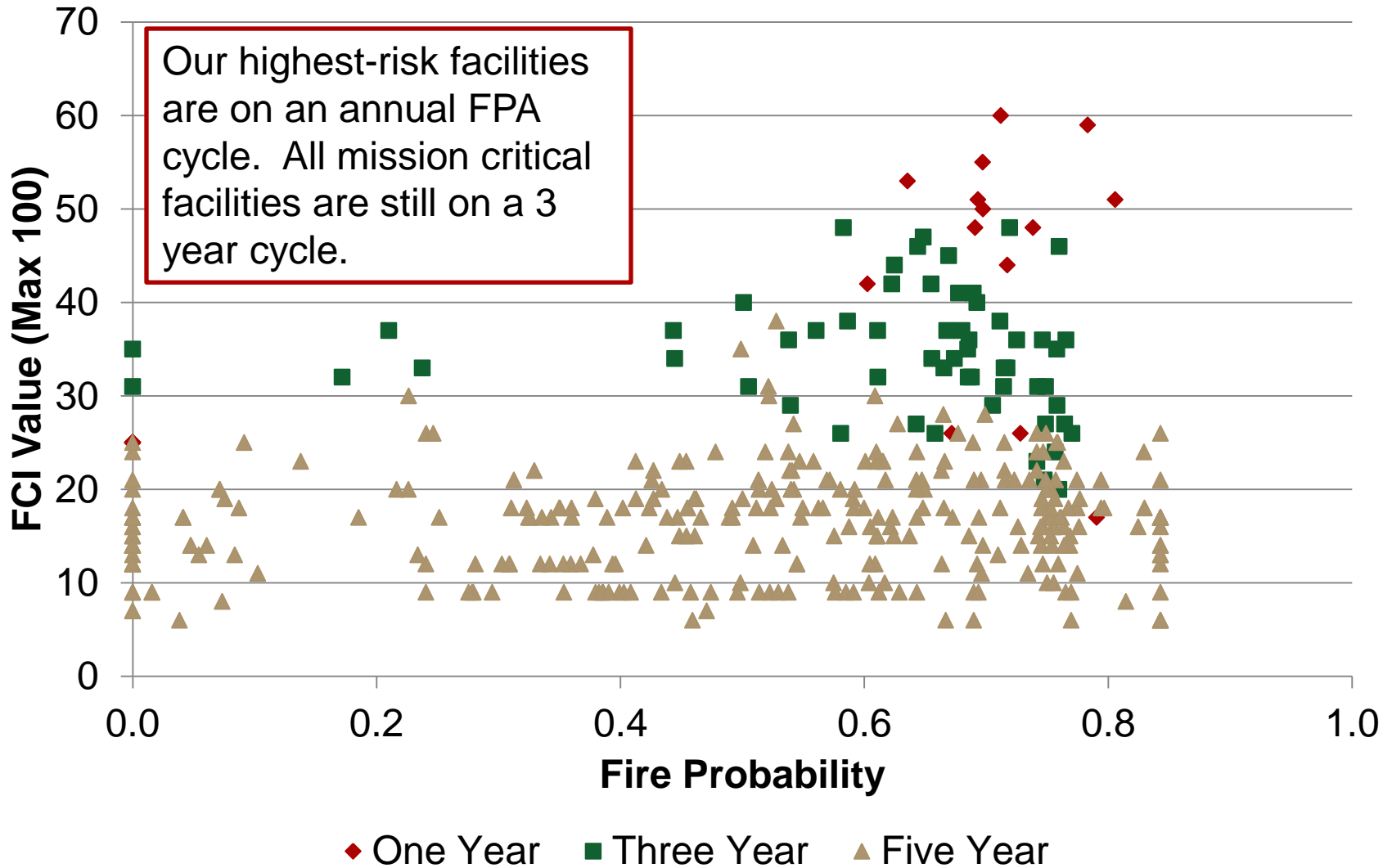
What's Next?

- Difficult to quantify controls

- More Data = Better Results

- Implementation of FRI

Thank You!