Wind Persistence Studies Performed for Exelon Emergency Preparedness

RETS-REMP
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Presented By: Ian Lake

ChemStaff

Exelon®

A Special Thanks To…

- Paul Holland, Exelon EP
- Dennis Oltmans, ChemStaff
- Bob Claes, ChemStaff
- Mark Carroll, Murray and Trettel, Inc

Study Objectives

- Perform wind persistence evaluation using site meteorological tower data and site specific evacuation time estimates (ETEs)
- Compare study results with current protective action strategies
- Present results to help EP staff evaluate if expanded initial protective actions are appropriate or desirable

Background

Bases

- NUREG-0654 Supplement 3, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants
  - Section 2.5 Wind Persistence Issues
    - Suggests licensees perform wind persistence analysis to determine appropriate modification to protective action strategies
  - Section 2.7 Strategy for Rapidly Progressing Scenarios and Note 7
    - Provides basis for using 90-percent ETE values and 2 mile keyhole downwind to 5 miles

Purpose

Using the bases established…

- Methodology was developed based on maximum wind shifts over ETE time frames
- Results were provided as a function of the standard deviation of the wind movement over the site selected ETE
- Results will decrease the likelihood that once a PAR is issued, there will not be a need to correct the existing PAR due to changes in wind direction

Methodology

Justification

- ChemStaff was provided with official ETE times provided by Exelon EP
- Hourly meteorological data was provided by the program vendor (Murray and Trettle) for all available tower elevations
  - 10 years of data were provided for the 10 Exelon sites, where available
  - 2.75 years of data were provided for the 3 former CENG sites

Example ETE Evaluation

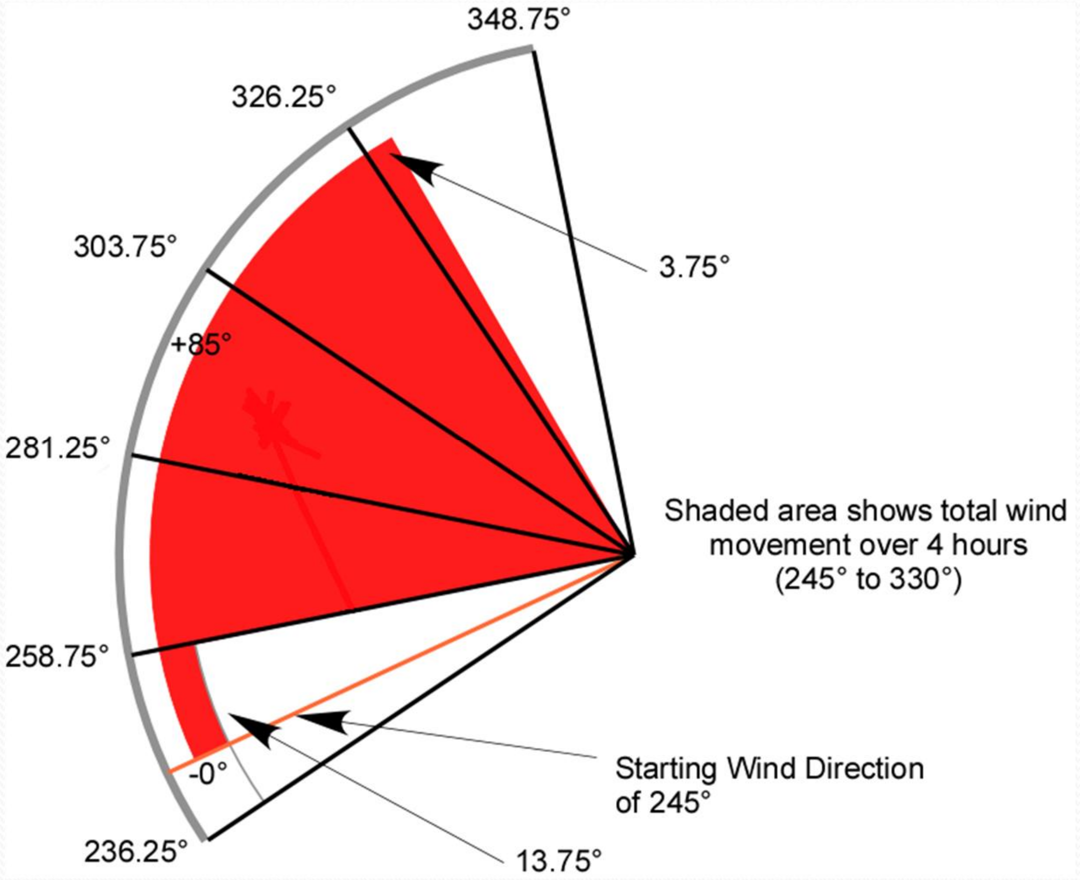
Table 7-1. Time to Clear the Indicated Area of *__90__* Percent of the Affected Population

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
Region	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	1:45	1:50	1:35	1:40	1:35	1:40	1:45	2:25	1:30	1:40	2:10	1:35	1:35	1:50
R02	3:10	3:30	2:55	3:15	2:50	3:10	3:25	3:30	2:50	3:00	3:05	2:45	2:50	3:25
R03	5:10	5:30	4:45	5:05	4:35	5:05	5:30	5:35	4:35	4:50	4:50	4:35	4:40	5:30
2-Mile Region and Keyhole to 5 Miles														
R04	2:15	2:25	2:10	2:35	2:25	2:25	2:35	3:00	2:30	2:35	2:35	2:25	2:25	2:30
R05	2:25	2:25	2:05	2:15	2:25	2:20	2:45	3:00	2:20	2:25	2:35	2:25	2:25	2:25
R06	2:30	2:40	2:10	2:10	2:05	2:45	2:45	3:00	2:10	2:15	2:30	2:00	2:05	3:00
R07	2:40	2:40	2:10	2:25	2:10	2:35	2:40	3:00	2:10	2:15	2:30	2:00	2:05	3:00
R08	2:55	3:00	2:20	2:35	2:20	2:50	3:15	3:20	2:20	2:30	2:30	2:15	2:20	3:20
R09	1:45	1:50	1:35	1:40	1:35	1:40	1:50	2:25	1:35	1:40	2:15	1:35	1:40	1:50
R10	1:45	1:50	1:35	1:40	1:35	1:45	1:45	2:25	1:30	1:40	2:10	1:35	1:35	1:50
R11	1:50	2:00	1:45	1:55	1:40	1:45	2:00	2:30	1:40	1:50	2:20	1:40	1:40	1:55
R12	1:50	2:00	1:45	1:55	1:40	1:50	2:00	2:30	1:45	2:00	2:20	1:45	1:45	1:55
R13	2:20	2:40	2:15	2:40	2:10	2:20	2:35	2:40	2:10	2:30	2:40	2:15	2:15	2:25
R14	2:50	3:10	2:40	2:55	2:35	2:45	3:10	3:15	2:40	2:45	2:50	2:35	2:35	2:55
R15	2:25	2:45	2:15	2:35	2:20	2:30	2:40	2:55	2:25	2:25	2:40	2:15	2:15	2:25
R16	2:55	3:10	2:55	3:10	2:45	3:00	3:10	3:15	3:05	3:05	3:05	2:50	2:55	2:55
5-Mile Region and Keyhole to EPZ Boundary														
R17	4:20	4:35	4:10	4:25	4:05	4:20	4:40	4:40	4:10	4:15	4:20	4:05	4:05	4:25
R18	3:40	3:50	3:30	3:35	3:30	3:35	3:50	3:50	3:25	3:35	3:35	3:25	3:25	3:50
R19	3:30	3:40	3:05	3:30	3:05	3:25	3:40	3:45	3:10	3:15	3:15	3:05	3:05	3:45
R20	3:30	3:45	3:15	3:25	3:05	3:30	3:45	3:50	3:10	3:20	3:20	3:05	3:10	3:50
R21	4:30	4:50	3:55	4:10	3:45	4:35	4:50	5:05	3:50	4:10	4:20	3:45	3:45	5:15
R22	4:25	4:45	4:00	4:15	4:00	4:35	4:50	5:00	4:00	4:15	4:20	3:50	4:00	5:10
R23	4:25	4:45	4:00	4:20	3:55	4:25	4:45	4:55	4:00	4:10	4:10	3:50	4:00	5:10
R24	4:15	4:35	3:55	4:10	3:50	4:20	4:30	4:45	3:50	4:00	4:00	3:50	3:55	4:50
R25	3:30	3:50	3:15	3:40	3:10	3:30	3:50	3:50	3:10	3:15	3:15	3:10	3:15	3:45

Areas of Investigation

- A mathematical computer model was developed to investigate:
  - Wind direction stability
    - The max change in wind direction over the site specific ETE.
      - This change was reported both in terms of sectors, as well as degrees.
        - A sector was considered a 22.5^{o} change and was always rounded up to the nearest whole sector.
  - All available MET tower elevations
  - Seasonal and day/night variability
    - In addition to overall results Summer (June 21-September 20), Fall (September 21 - December 20),Winter (December 21-March 20), Spring (March 21 - June 20), Day (0600-1700), and Night (1800-0500) were evaluated

Example



348.75°
326.25°
303.75°
+85°
281.25°
258.75°
-0°
236.25°
3.75°
Shaded area shows total wind movement over 4 hours (245° to 330°)
Starting Wind Direction of 245°
13.75°

Notes

- Data was not 100% recoverable. Only data values between 0 and 360 degrees were considered valid
  - No attempt was made to estimate the wind movement over missing time periods/invalid data.
- Sector wind shift was calculated as the maximum CW or CCW shift in degrees over an ETE time period
- Maximum sector shift was calculated as

$$\frac{\|\max wind\ shift^{o}\|}{22.5^{o}}$$

Statistical Analysis – Calculating Standard Deviation

- With the maximum sector shift calculated…
  - The mean of all valid maximum sector shifts was calculated

$$mean = \frac{\sum P_i}{count}$$

  - The square of the difference from the mean for each valid data point was calculated

$$P_i^2 = (P_i - mean)^2$$

  - The Variance of the data population was calculated

$$Variance = \frac{\sum P_i^2}{count}$$

  - The Standard Deviation was calculated

$$\sigma = \sqrt{Variance}$$

Results

Interpreting the results

- Results were provided in the form of a summary table

	2 mile region and Keyhole to 5 Miles Evacuation time (hours)	Sensor Elevation (feet)	1 Standard Dev.		Sensor Elevation (feet)	1 Standard Dev.		Sensor Elevation (feet)	1 Standard Dev.	
			Sectors	Degrees		Sectors	Degrees		Sectors	Degrees
All	4	30	2.274	50.8	175	2.102	47.0	270	1.981	44.1
Winter	4	30	2.024	45.0	175	1.844	41.0	270	1.691	37.5
Spring	4	30	2.266	50.6	175	2.145	48.0	270	2.009	44.8
Summer	4	30	2.469	55.3	175	2.329	52.3	270	2.264	50.5
Fall	4	30	2.253	50.4	175	1.997	44.5	270	1.885	42.0
Average			2.253	50.3		2.079	46.5		1.962	43.7
Day	4	30	2.335	52.1	175	2.158	48.3	270	2.007	44.8
Night	4	30	2.212	49.5	175	2.046	45.7	270	1.954	43.5
Average			2.274	50.8		45.7	47.0		1.981	44.1

Interpreting the results

- Determination of the PAR
  - The "1 Standard Deviation Sectors column" was used
    - Sectors were rounded up (i.e. σ=2.111 rounds to σ=3)
  - The data as evaluated includes points associated with the downwind sector, as such that sector must be included in the sector count.
    - $\sigma\ Evacuation\ Sectors = 2\sigma - 1$
  - Depending on the level of confidence desired by management extending to 2σ or 3σ is also easily achievable
    - $2\sigma\ Evacuation\ Sectors = 2(2\sigma) - 1$
    - $3\sigma\ Evacuation\ Sectors = 2(3\sigma) - 1$

Interpreting the results

- Example:
  - Use the “All” 175’ as an example

Sensor Elevation (feet)	1 Standard Dev.	
	Sectors	Degrees
175	2.102	47.0

- σ *Evacuation Sectors* = 5 sectors
- 2σ *Evacuation Sectors* = 11 *sectors*
- 3σ *Evacuation Sectors* = All sectors

Conclusions

- Data tables were provided to Exelon EP staff for their evaluation – no definitive PAR recommendations have been given at this time
- There was not a significant difference between the “All” and seasonal or day/night comparisons.
  - In determining PAR, management should keep simple and use the “All” dataset
- All possible tower elevations were included for comparison
  - In determining PAR, management should use the elevation height closest to the elevation of the plant vent stack

Summary of Results

Site	5 Mile Evacuation time (hours)	Sensor Elevation (feet)	1 Standard Dev.		Sensor Elevation (feet)	1 Standard Dev.		Sensor Elevation (feet)	1 Standard Dev.	
			Sectors	Degrees		Sectors	Degrees		Sectors	Degrees
Byron	4	250	1.699	37.5	30	1.863	41.5			
Braidwood	3	203	1.595	34.9	34	1.597	35.1			
LaSalle	2	375	1.214	25.8	33	1.317	28.3	200	1.259	26.8
Dresden	3	300	1.645	36.1	35	1.805	39.8	150	1.711	37.6
Quad Cities	3	296	1.562	34.2	33	1.674	37.0	196	1.610	35.3
TMI	5	95	3.016	67.8	145[1]	2.940	66.0			
Peach Bottom	3	320	1.690	37.3	33	2.199	49.2	75	2.102	46.8
Limerick[2]	4	175	2.102	47.0	30	2.274	50.8	270	1.981	44.1
Oyster Creek[3,4]	6	380	2.150	48.0	33	2.304	51.8	150	2.256	50.4
Clinton[5]	2	197	1.243	26.5	33	1.315	28.2			
Calvert Cliffs[6]	9	197	3.090	69.6	33	3.278	73.6			
Nine Mile Point[6]	3	200	1.758	38.6	30	1.861	41.0	100	1.822	40.1
Ginna[6]	3	250	1.637	35.8	33	1.895	42.0	150	1.707	37.5

[1] 5 year data, 150’ Met Tower data started reporting January 1, 2007
[2] 8 year data, M&T started collecting January 1, 2005
[3] 8 year data, M&T started collecting in January 1, 2005
[4] Staged evacuation time used
[5] 9 year data, M&T started collecting December 10, 2004
[6] 2.5 year data, M&T collected from January 1, 2011 through September 30,2013