Power Line Systems

IT'S ALL ABOUT YOUR POWER LINES

2019 PLS-CADD Advanced Training and User Group

Distribution Storm Hardening

by

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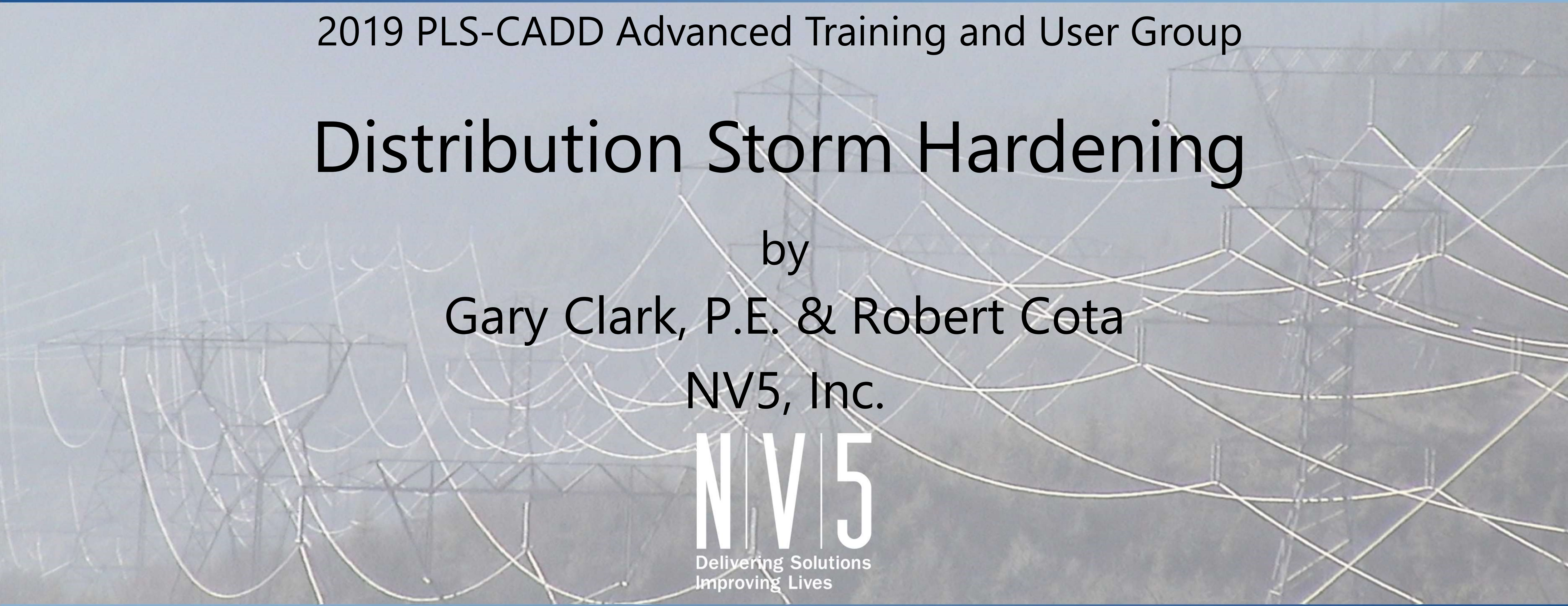
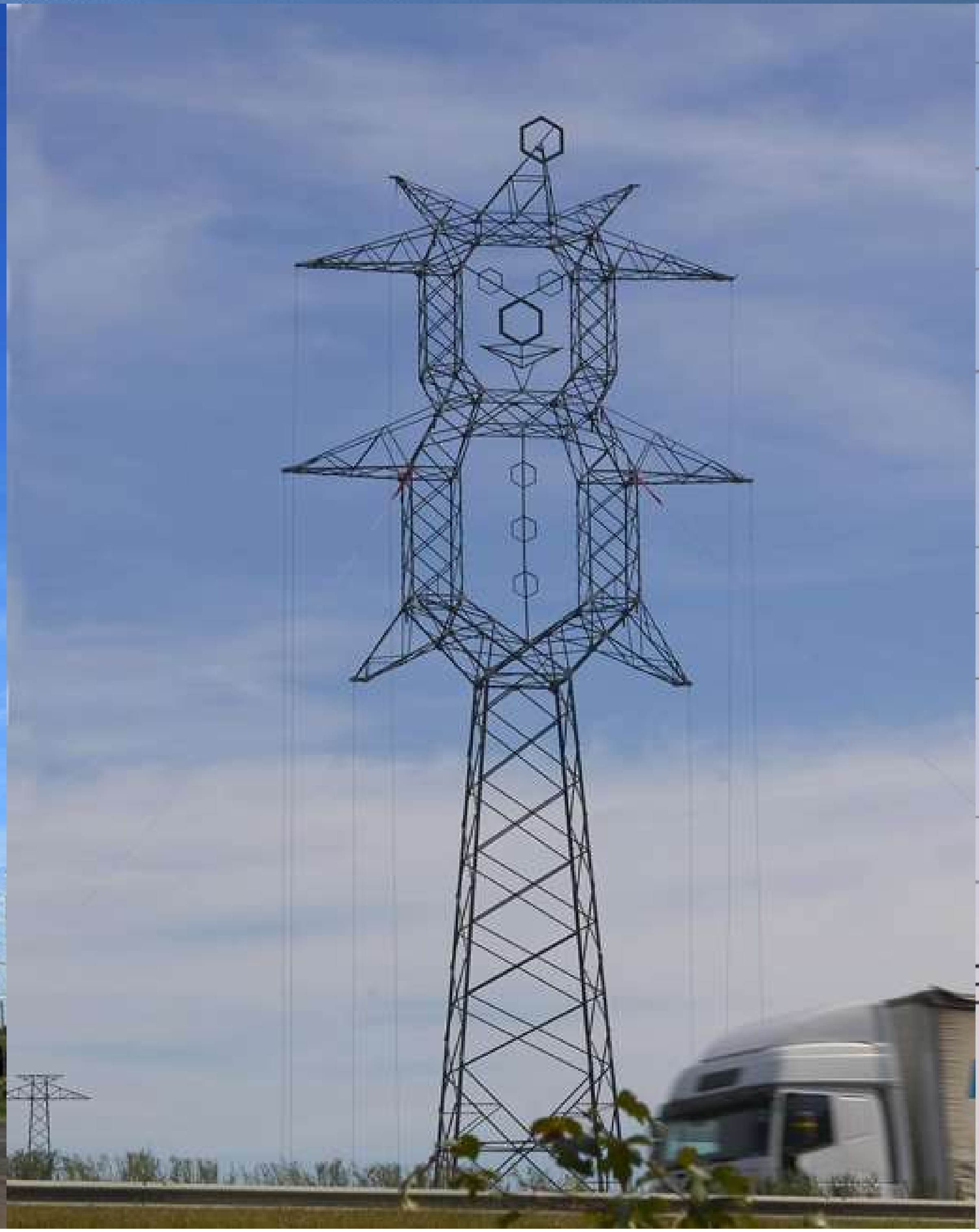
NV5, Inc.



POWER LINE SYSTEMS

IT'S THE SOLUTION

Power Line Design is Fun!



Power Line Design is Hard!

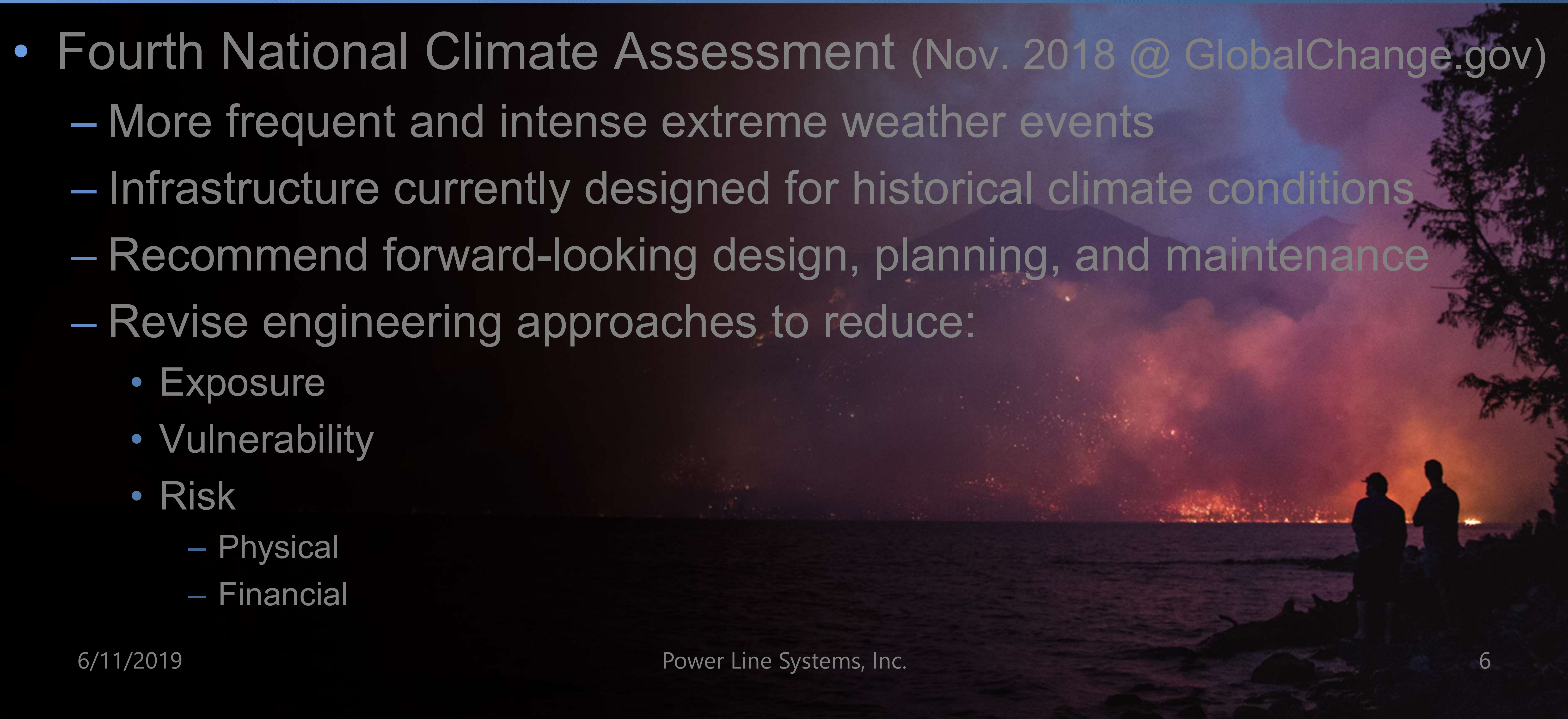
Power Line Design (Scope) is Evolving!

- DOE Hardening and Resiliency Report (August 2010)
  - Recognized increasing age of T&D assets
  - Concerns on increased coverage, i.e. risk, as population grows
- Pennsylvania PUC recognized storm hardening as a key to electric reliability in 2017 annual report
- Florida Public Service Commission (PSC) recognized the successful contributions of storm hardening in 2018
- California Public Utility Commission (CPUC) hosted inaugural Wildfire Technology Innovation Summit in 2019

Presentation Introduction

- We are all critical contributors
  - Safety
  - Quality
  - Efficiency
  - Sustainability
- An emerging threat requires a critical response to ensure:
  - Reliability
  - Resiliency

Storm Hardening Introduction

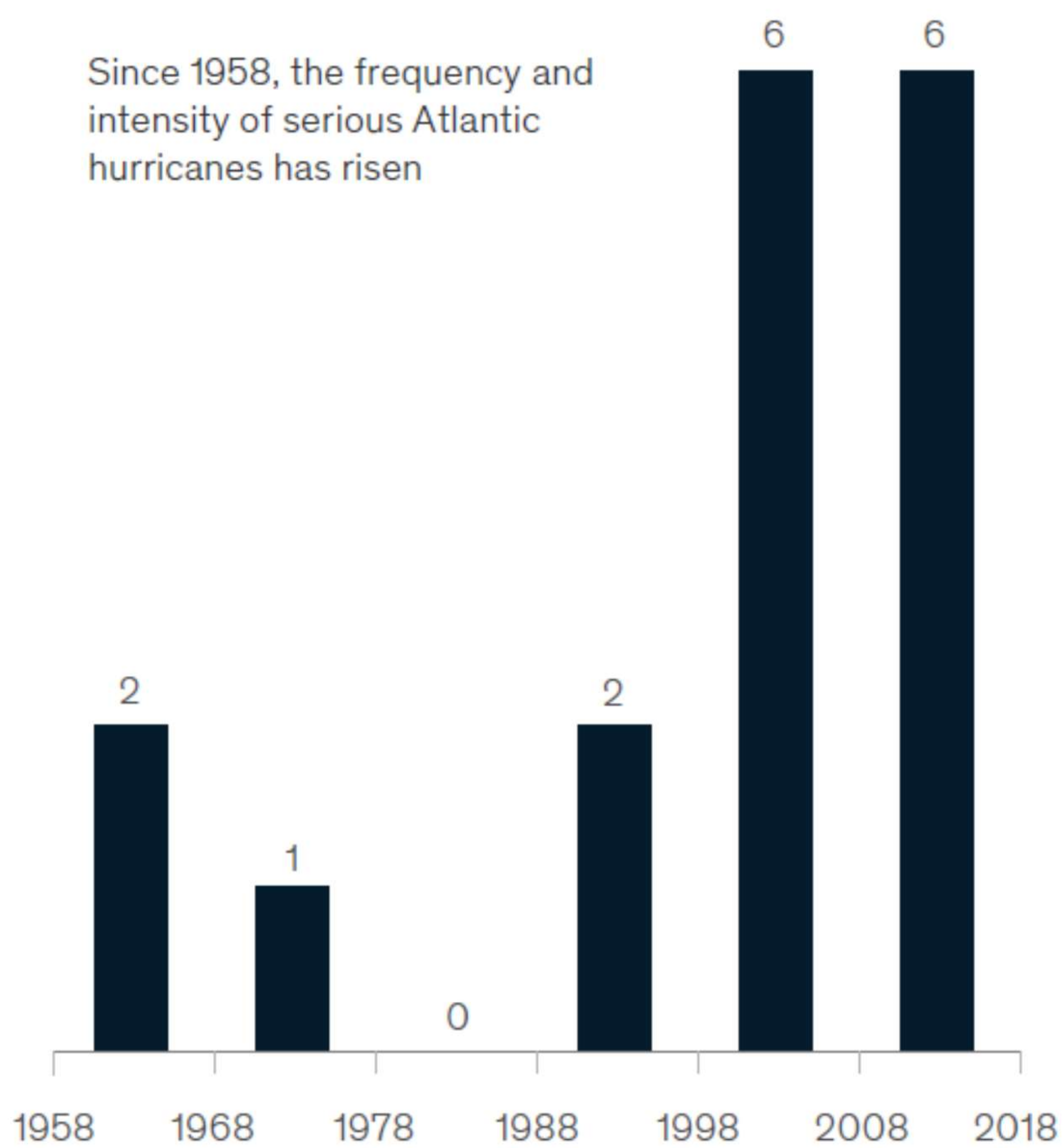


- Fourth National Climate Assessment (Nov. 2018 @ GlobalChange.gov)
  - More frequent and intense extreme weather events
  - Infrastructure currently designed for historical climate conditions
  - Recommend forward-looking design, planning, and maintenance
  - Revise engineering approaches to reduce:
    - Exposure
    - Vulnerability
    - Risk
      - Physical
      - Financial

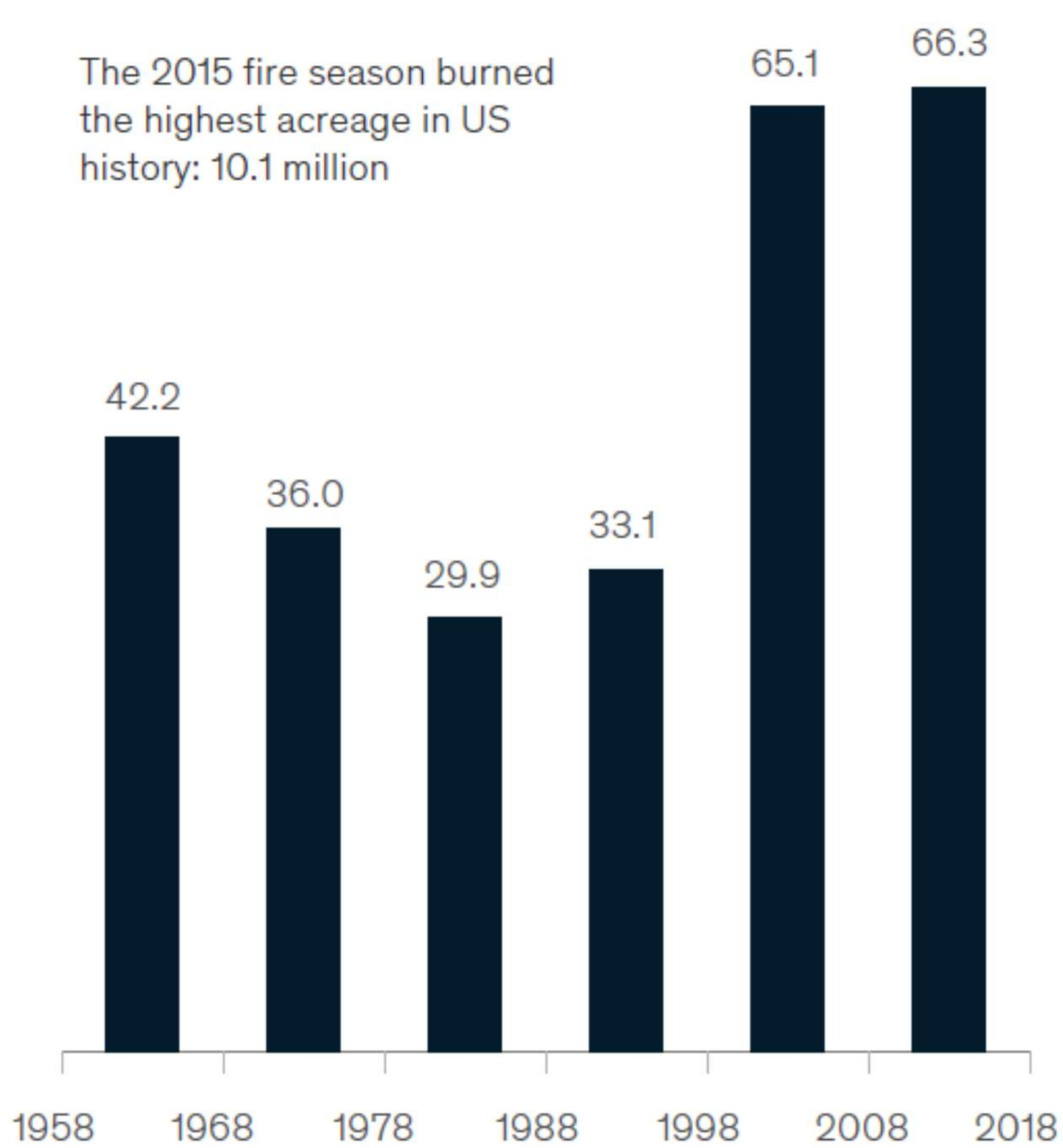
Storm Hardening Statistics

Hurricanes and wildfires are getting worse.

Above-average-strength Atlantic hurricane seasons,[1] number per decade

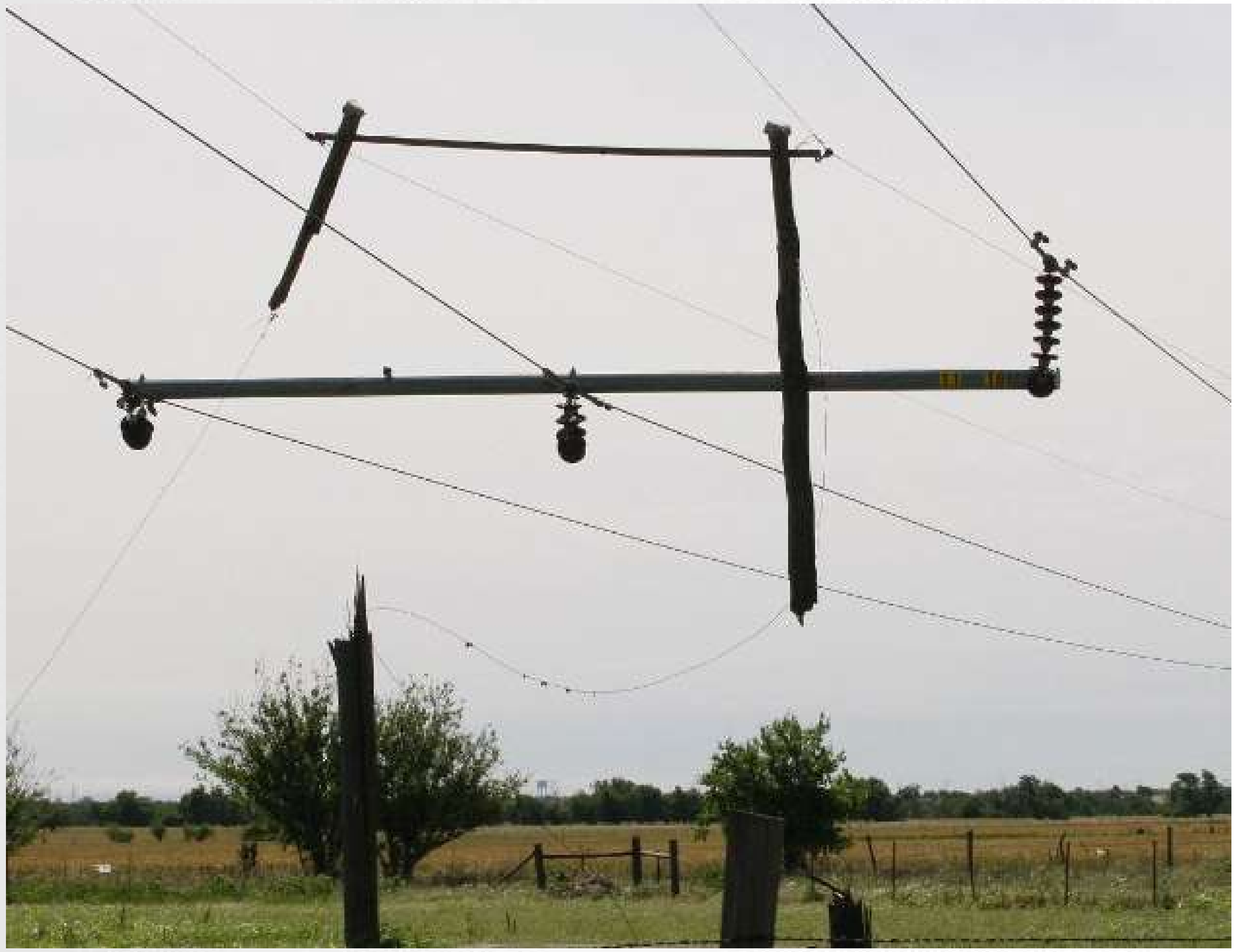


Area burned by wildfires in the US, millions of acres per decade



What is Storm Hardening?

- Infrastructure engineering improvements to withstand:
  - Extreme Wind
  - Extreme Flooding
  - Unplanned Attachments
  - Unknown Obstructions (vegetation)
- Extreme events include:
  - Hurricanes
  - Tornados
  - Wildfires



What is Typical Storm Hardening?

- Hardening measurements include
  - Smarter technology
  - More resilient materials
  - Improved engineering approaches
  - Improved maintenance approaches
- No one-size-fits-all approach
  - Strategic undergrounding
  - Critical microgrids
  - Equipment-only upgrades

Can we “harden” traditional engineering approaches?

- The bare minimum isn’t good enough
  - Model for realistic operating temperatures
  - Model for known local winds, not code-required minimums
- To assume or not to assume…
  - What is the likelihood of a future comm. underbuild?
  - Should this corner pole be considered a terminal deadend?
  - Should I look deeper into this long vs. short span configuration?
  - Is it worth the effort to add an interset pole?
  - Is 10%+2’ embedment still a valid “rule”?

PLS-CADD Analysis of Wildfire or Storm Risk

- Data inputs required:
  - Recently collected survey data
  - Surveyed conditions (weather & wind)
- User inputs required:
  - Code and/or utility required clearances
  - Weather case(s)
- PLS-CADD outputs:
  - Vegetation reports: grow-in & falling tree violations
  - Plan & Profile (P&P) with highlighted risk areas
  - KMZ with work sites

PLS-CADD Real-World Analysis Capabilities

- Rural Utilities Service (RUS) 1724E-200: Figure 5-2

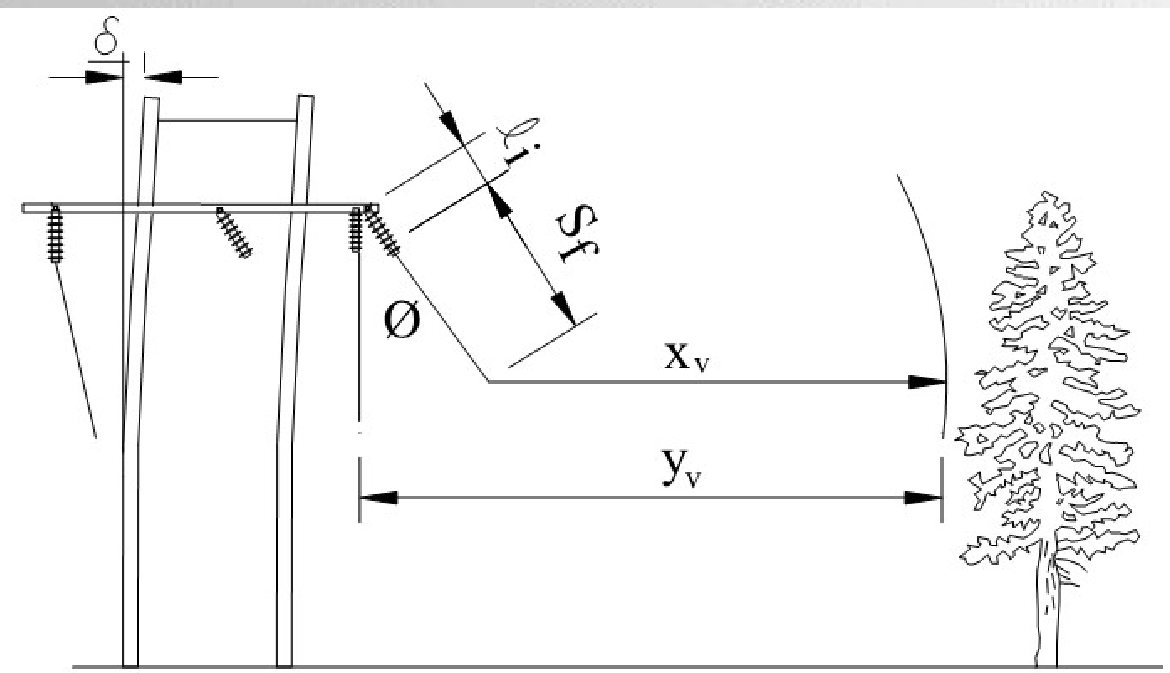
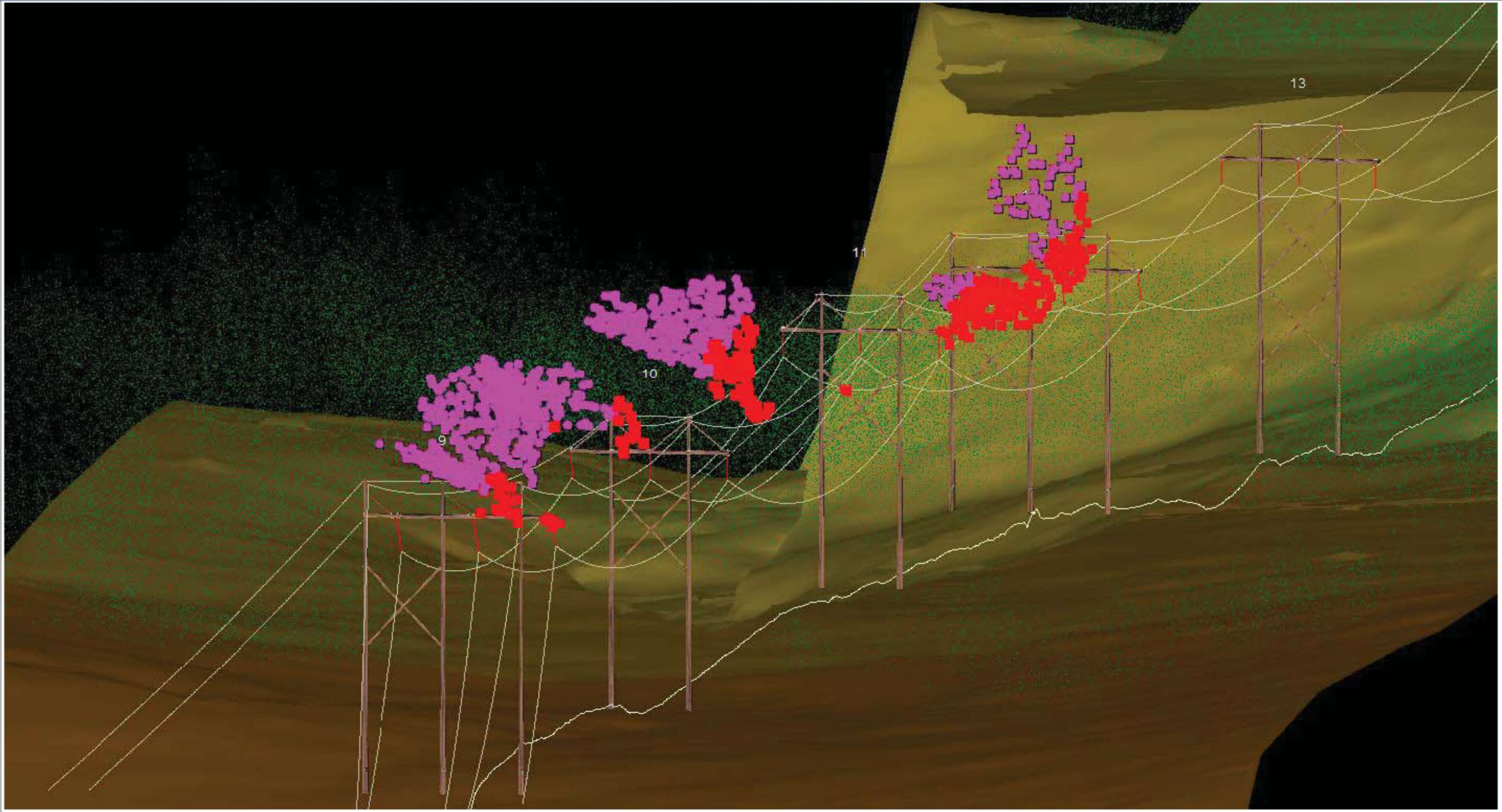


FIGURE 5-2: RADIAL CLEARANCE REQUIREMENT TO VEGETATION

where:

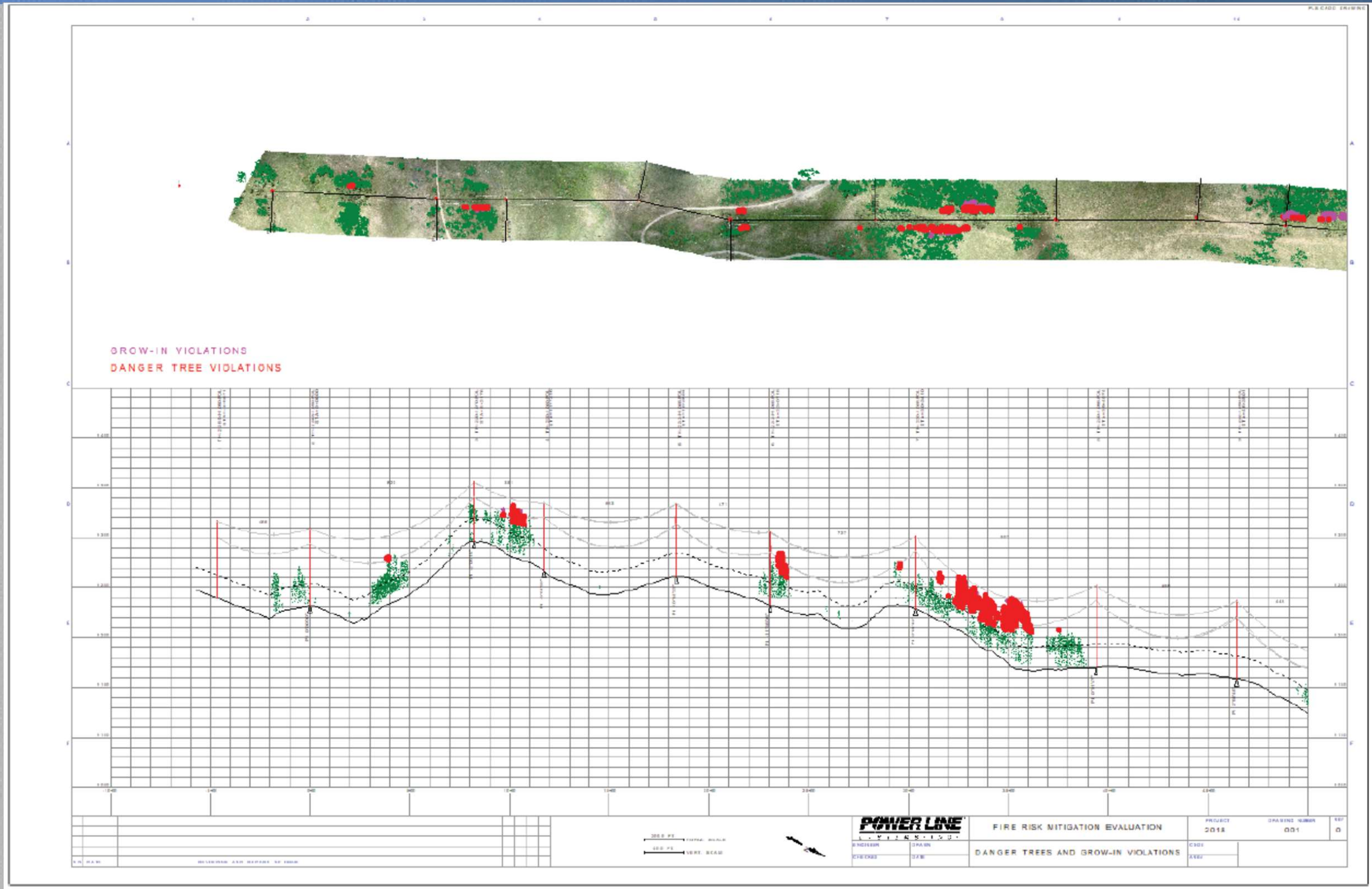
ϕ	=	conductor swing out angle in degrees under all rated operating conditions
S_f	=	conductor final sag at all rated operating conditions
x_v	=	radial clearance (include altitude correction if necessary)
ℓ_i	=	insulator string length ($\ell_i = 0$ for post insulators or restrained suspension insulators).
y_v	=	horizontal clearance at the time of vegetation management work
δ	=	structure deflection at all rated operating conditions

PLS-CADD Risk Analysis Example – 3D Model



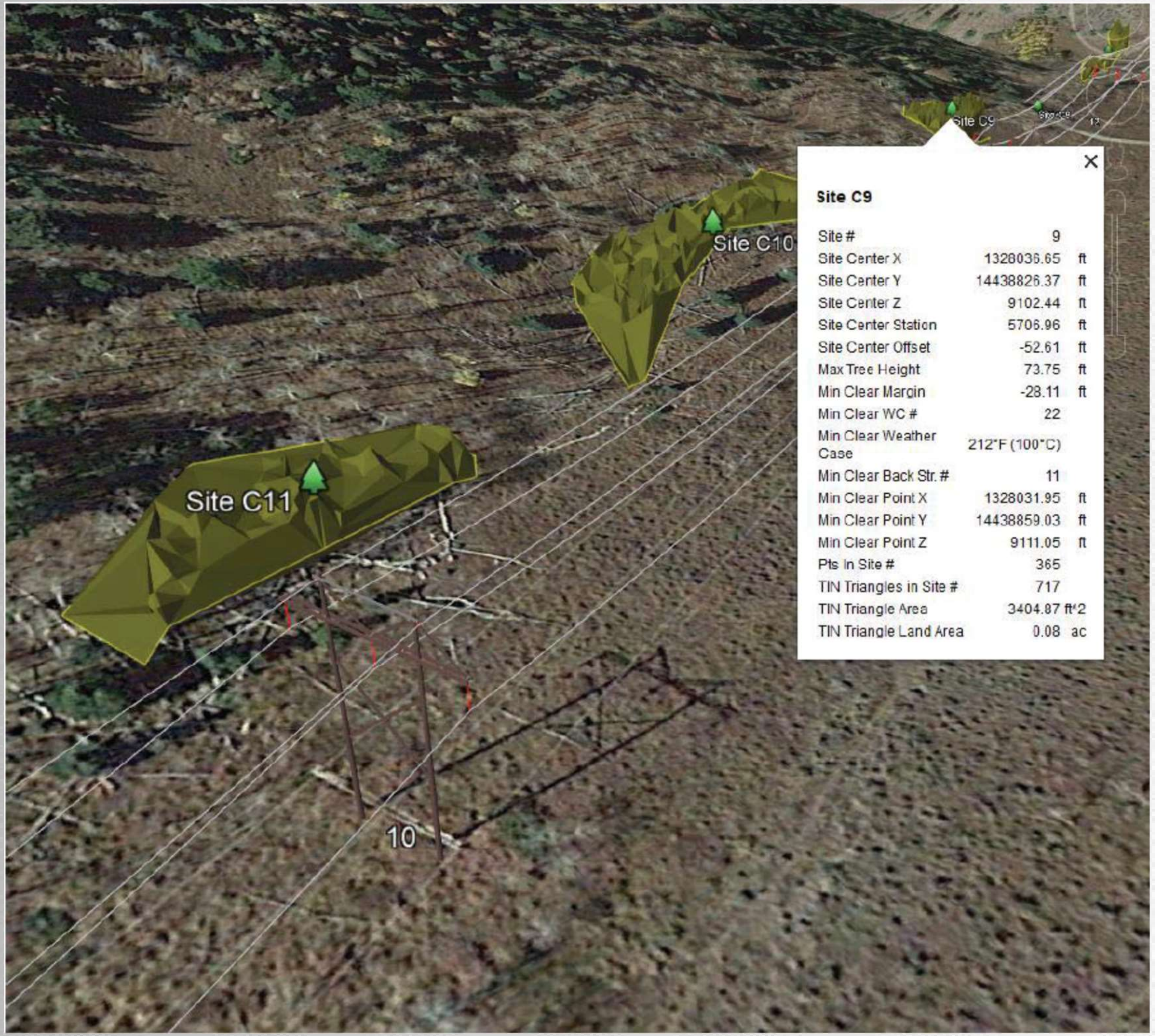
[PLS-CADD model showing grow-in violations in red and falling tree violations in pink]

PLS-CADD Risk Analysis Example – P&P



[PLS-CADD plan & profile drawing showing grow-in and falling tree violations]

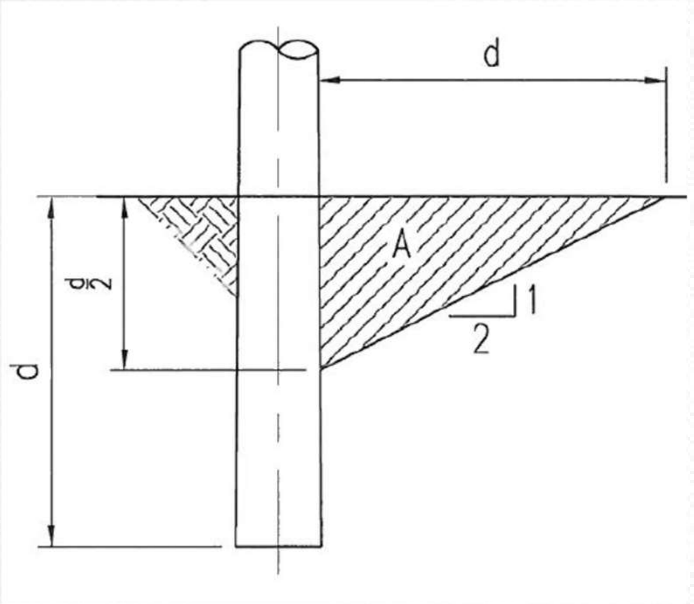
PLS-CADD Risk Analysis Example – KMZ

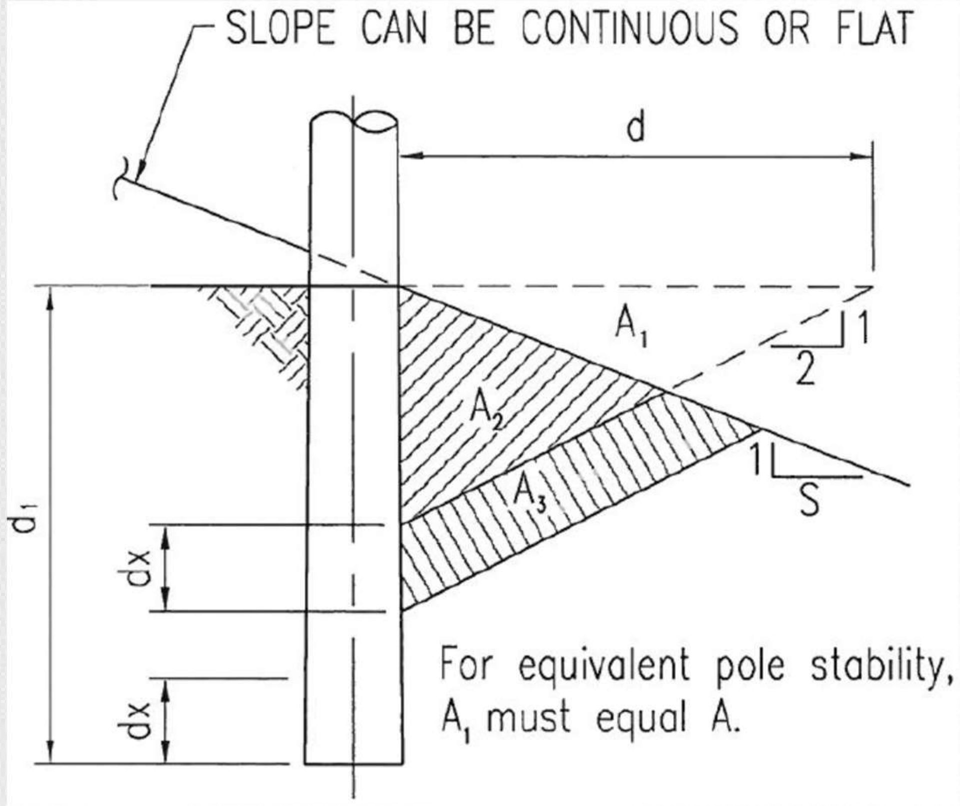


See PLS white paper @ https://www.powline.com/technotes/Wildfire_Risk_Assessment_Using_PLS-CADD.pdf

PLS-CADD Analysis of Slope Stability & Embedments

- What is considered a slope?
  - Ratio greater than ~3:1 (horizontal to vertical)
  - Ditch that exceeds critical discount depth
- What are slope installation risks?
  - Poor soil compaction
  - Continued soil erosion
- How can we mitigate slope installs?
  - Pick a different spot!
  - Additional embedment (soil discount)



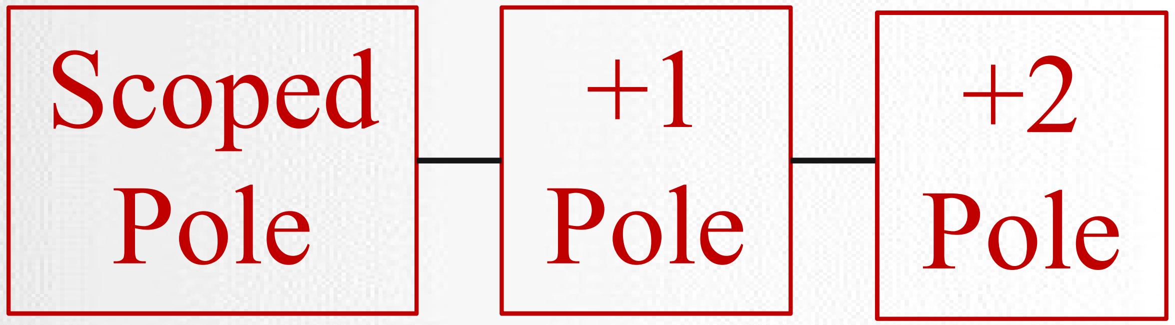


PLS-CADD Automation Example – Slope Embedment

Structure Number	Max Z Delta at 5'	Additional Embedment Required	Structure Height or Pole Length (ft)	Actual Embedded Depth (ft)	Modeled Embedded Depth (ft)	Calculated Embedded Depth (ft)	Min. Bury Depth before Add'l Butt Coating Req. (ft)	Standard Butt Coating (ft)	Additional Coating Required (ft)	Special Embedment Text	Special Foundation Text
P1	1.488	1.5	55	9	9	9	9	10		EMBED POLE 9' PER OHS 303	
P2	0.791		55	7.5	7.5	7.5	9	10			
P3	0.67		50	7	7	7	9	10			
P4	0.251		55	7.5	7.5	7.5	9	10			
P5	1.254	1.5	45	8	8	8	9	10		EMBED POLE 8' PER OHS 303	
P6	1.771	2	60	10	10	10	9.5	10.5	0.5	EMBED POLE 10' PER OHS 303	6" OF ADDITIONAL POLE BUTT COATING REQUIRED
P7	2.789	3	50	10	10	10	9	10	1	EMBED POLE 10' PER OHS 303	1' OF ADDITIONAL POLE BUTT COATING REQUIRED
P8	2.825	3	50	10	10	10	9	10	1	EMBED POLE 10' PER OHS 303	1' OF ADDITIONAL POLE BUTT COATING REQUIRED
P9	2.422	2.5	55	10	10	10	9	10	1	EMBED POLE 10' PER OHS 303	1' OF ADDITIONAL POLE BUTT COATING REQUIRED
P10	2.512	3	60	11	11	11	9.5	10.5	1.5	EMBED POLE 11' PER OHS 303	1'-6" OF ADDITIONAL POLE BUTT COATING REQUIRED
P11	1.264	1.5	55	9	9	9	9	10		EMBED POLE 9' PER OHS 303	
P12	2.063	2.5	50	9.5	9.5	9.5	9	10	0.5	EMBED POLE 9'-6" PER OHS 303	6" OF ADDITIONAL POLE BUTT COATING REQUIRED
P13	2.645	3	60	11	11	11	9.5	10.5	1.5	EMBED POLE 11' PER OHS 303	1'-6" OF ADDITIONAL POLE BUTT COATING REQUIRED
P14	2.659	3	55	10.5	10.5	10.5	9	10	1.5	EMBED POLE 10'-6" PER OHS 303	1'-6" OF ADDITIONAL POLE BUTT COATING REQUIRED
P15	1.797	2	50	9	9	9	9	10		EMBED POLE 9' PER OHS 303	
P16	2.533	3	50	10	10	10	9	10	1	EMBED POLE 10' PER OHS 303	1' OF ADDITIONAL POLE BUTT COATING REQUIRED
P17	1.129	1.5	60	9.5	9.5	9.5	9.5	10.5		EMBED POLE 9'-6" PER OHS 303	
P20	1.516	2	60	10	10	10	9.5	10.5	0.5	EMBED POLE 10' PER OHS 303	6" OF ADDITIONAL POLE BUTT COATING REQUIRED
P21	2.332	2.5	55	10	10	10	9	10	1	EMBED POLE 10' PER OHS 303	1' OF ADDITIONAL POLE BUTT COATING REQUIRED

PLS-CADD Analysis of Replacement Impacts

- System hardening is an everyday occurrence
  - Single pole replacements
  - Single span reconductors
- Can't assume it's okay to simply:
  - Match existing adjacent span tensions
  - Match corresponding existing guying
- BEST PRACTICE
  - Model adjacent "+1" poles as M4 structure, along with "+2" spans
  - G.O. 95 Rule 44.2: analyze "+1" impact with updated intrusive data



PLS-CADD Analysis of Span Imbalances

- Be wary and try to mitigate extreme span imbalances
  - Long spans (over 500’)
  - 2:1 span ratios e.g. 300’ vs. 150’ spans at the same pole
- Issues created
  - Cascading deflection & failures
  - Soil ratcheting
- Mitigation measures
  - Interset poles
  - Add guying for long span
  - Double tangent crossarms and/or greater embedment

PLS-CADD Analysis of Critical Crossings

- Typical critical crossings
  - Highways
  - Environmentally sensitive areas
  - Always-on customers
- Hardening approach: terminal deadend (see GO95 Rule 47.3)
  - Increases resiliency & reduces maintenance risks or delays
  - Consider increasing conductor size for difficult spans at a minimum
- Main benefits
  - Limits cascading failure potential
  - Simpler replacement, as terminal DE is designed for stringing

PLS-CADD Analysis of Stringing Tensions

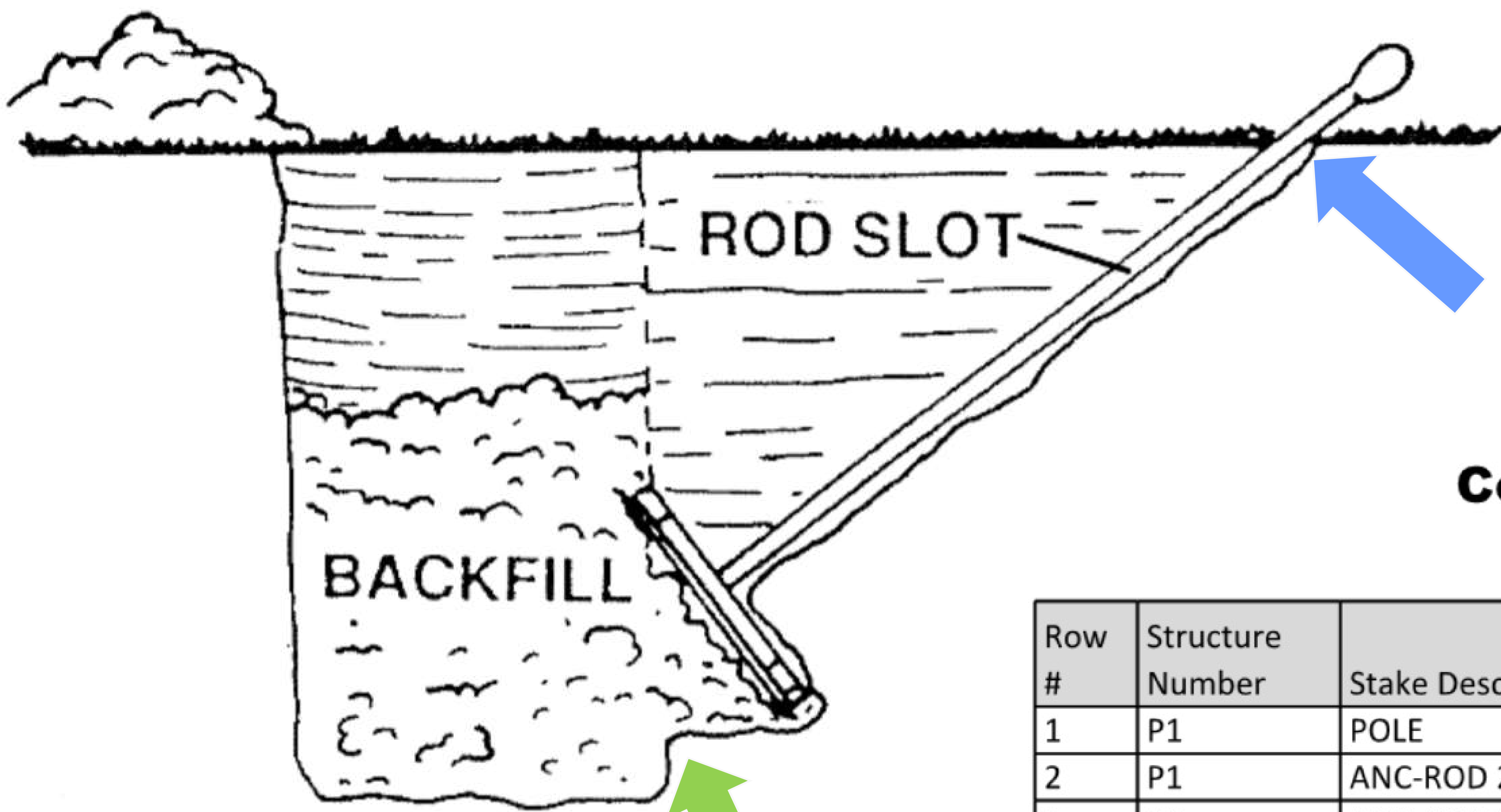
- Typical code-compliant stringing approach based on
  - Safety factors
  - Percentages at load condition
- Consider evaluating beyond percentages
  - Particularly with lighter but stronger conductors
  - CIGRE Technical Brochure #273
    - Consider catenary constants to reduce aeolian vibrations

- Sanity check → are stringing tensions realistic? Ask the crew!

PLS-CADD XML Automation

- XML provides obvious benefits
  - Simple material counts
  - Tabulate analyses results
- Consider XML automated calculation tools to support
  - Internal QA/QC (embedments, materials, etc.)
  - Unique construction requests, such as anchor plate slot trench
  - Confirm a unique and multi-tiered engineering standard, such as crossarm and pin loading requirements
  - Create automated and customized pole loading reports

PLS-CADD Automation Example – Guying Construction



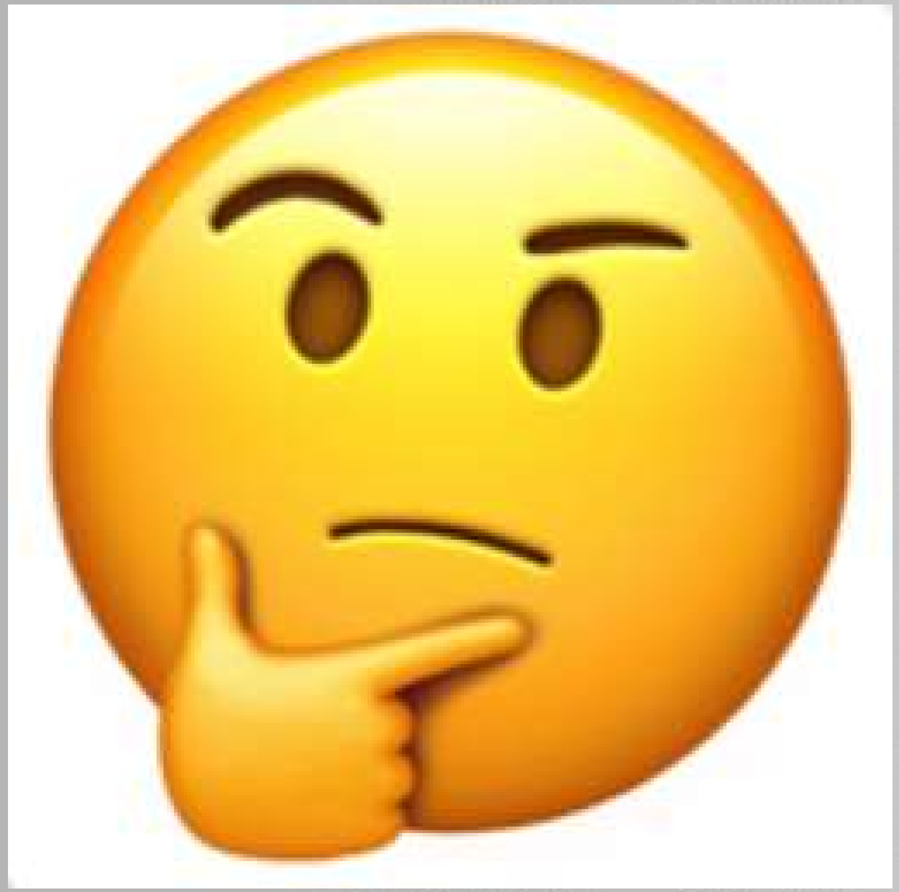
Construction Staking Table

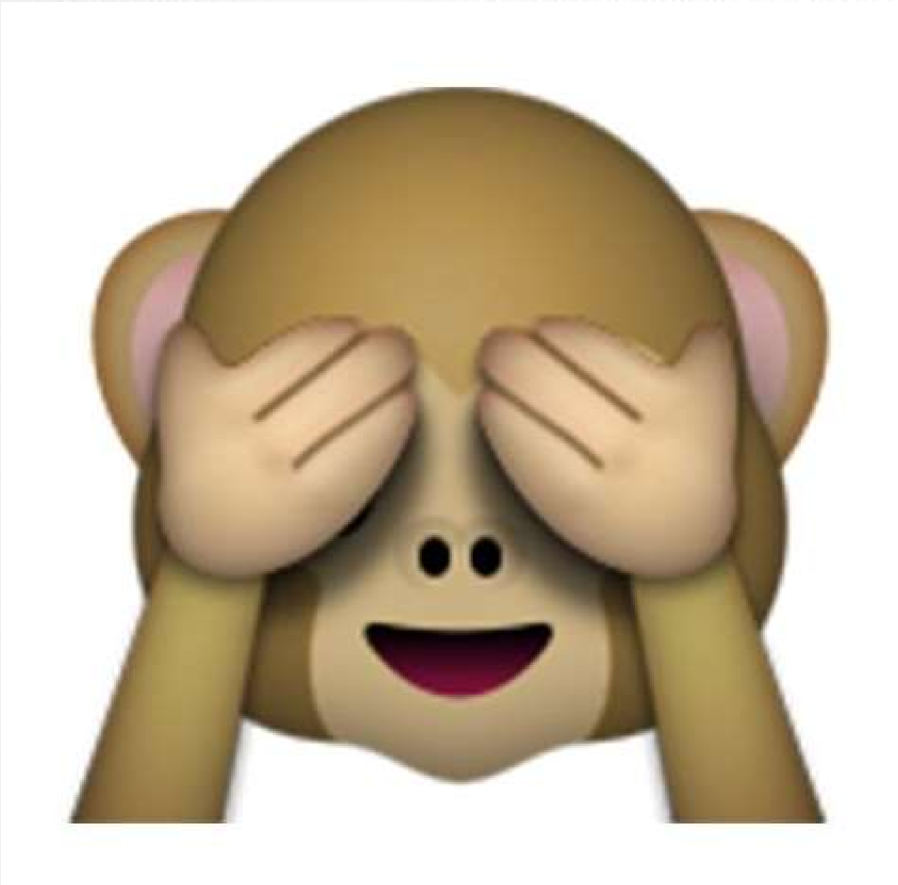
Row #	Structure Number	Stake Description	X Easting (ft)	Y Northing (ft)	Z Elev (ft)	Line Angle (deg)	Pole Property Label
1	P1	POLE	[illegible]	1.000	101.00	111.01	Distribution 50-1, WEATHERING
2	P1	ANC-ROD 20'	20.000	2.000	102.00		
3	P1	ANC-HOLE 25'	25.000	3.000	103.00		
4	P1	ANC-ROD 16'	16.000	4.000	104.00		
5	P1	ANC-HOLE 21'	21.000	5.000	105.00		
6	P2	POLE	150.000	6.000	106.00	-0.24	Distribution 50-1, WEATHERING
7	P3	POLE	300.000	7.000	107.00	-8.25	Distribution 50-1, WEATHERING
8	P4	POLE	450.000	8.000	108.00	-8.25	Distribution 35-1, WEATHERING
9	P4	ANC-ROD 10'	460.000	9.000	109.00		
10	P4	ANC-HOLE 14'	474.000	10.000	110.00		

Hardening from Start to Finish

- A hardened design needs a hardened as-built
- Take advantage of a well-engineered design by simply:
  - Importing as-built LiDAR into IFC PLS-CADD model
  - Update structure groups if allowed, i.e. “new” vs. “existing”
  - Determine if additional construction tolerances are allowed
    - GO95 example: Table 6 min. pole embedments
    - Consider XML pole loading summary reviews
  - We are the last line of defense!
    - Final chance to protect your company, client, license, etc.

Live Demo Time!





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FAC 008/009

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Thanks for your time! Any questions?

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