2019 PLS-CADD Advanced Training and User Group

# Vegetation Work Sites and Wildfire Risk Assessment

by

Tim Cashman, PE
Power Line Systems

# Introduction

- Vegetation management of overhead transmission and distribution line corridors has been a major topic in our industry from many years.
- Tree contact with transmission lines is a leading cause of electric power outages
- Vegetation management practices are under ever increasing regulatory scrutiny

# Introduction

- Texas experienced more then 4,000 power line caused wildfires in a 3 ½ year period around 2013[1]
- Estimated about 5% of wildfires caused by power lines in California between 2007 and 2016 accounting for about 11% of total acres burned[2]
- Power lines were found to cause 5 of the 11 major fires of the 2009 Black Saturday Fires in Victoria, Australia[3]

[1] Texas Wildfire Mitigation Project (www.wildfiremitigation.tees.tamus.edu)

[2] Kousky, Greig, Lingle & Kunreuther, “Wildfire Costs in California: The Role of Electric Utilities” August 2018

[3] Thompson, Christodoulou & Cronau, “Powerline failures scrutinized as potential cause of brushfire crisis” October 2013

# Presentation Outline

- Discuss vegetation clearances to overhead transmission and distribution lines
- Demonstrate vegetation clearance calculations in PLS-CADD
  - Grow-in clearances
  - Fall-in clearances
- Demonstrate creation of clearance Work Sites and graphical representations of clearance areas

# National Regulations

- Overhead transmission lines above 200kV or lower voltage lines designated by NERC or WECC fall under NERC FAC 003
- Most lines below 200kV fall under individual state regulatory policies and procedures
- RUS utilities fall under RUS regulations, including specific requirements of Bulletin 1724E-200

# NERC FAC 003 Highlights

- Prevent vegetation encroachments:
  - Into the Minimum Vegetation Clearance Distance (MVCD)
  - Due to fall-in from inside the ROW
  - Due to blowing together of applicable lines and vegetation located inside the ROW
- Prevent vegetation encroachments that account for:
  - Movement of conductors under their rating and all rated electrical operating conditions

# NERC FAC 003-04 MVCD

FAC-003-4 Transmission Vegetation Management

**FAC-003 — TABLE 2 — Minimum Vegetation Clearance Distances (MVCD)[17]**
**For Alternating Current Voltages (feet)**

| ( AC ) Nominal System Voltage (KV)* | ( AC ) Maximum System Voltage (kV)[18] | MVCD (feet) Over sea level up to 500 ft | MVCD feet Over 500 ft up to 1000 ft | MVCD feet Over 1000 ft up to 2000 ft | MVCD feet Over 2000 ft up to 3000 ft | MVCD feet Over 3000 ft up to 4000 ft | MVCD feet Over 4000 ft up to 5000 ft | MVCD feet Over 5000 ft up to 6000 ft | MVCD feet Over 6000 ft up to 7000 ft | MVCD feet Over 7000 ft up to 8000 ft | MVCD feet Over 8000 ft up to 9000 ft | MVCD feet Over 9000 ft up to 10000 ft | MVCD feet Over 10000 ft up to 11000 ft | MVCD feet Over 11000 ft up to 12000 ft | MVCD feet Over 12000 ft up to 13000 ft | MVCD feet Over 13000 ft up to 14000 ft | MVCD feet Over 14000 ft up to 15000 ft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 765 | 800 | 11.6ft | 11.7ft | 11.9ft | 12.1ft | 12.2ft | 12.4ft | 12.6ft | 12.8ft | 13.0ft | 13.1ft | 13.3ft | 13.5ft | 13.7ft | 13.9ft | 14.1ft | 14.3ft |
| 500 | 550 | 7.0ft | 7.1ft | 7.2ft | 7.4ft | 7.5ft | 7.6ft | 7.8ft | 7.9ft | 8.1ft | 8.2ft | 8.3ft | 8.5ft | 8.6ft | 8.8ft | 8.9ft | 9.1ft |
| 345 | 362[19] | 4.3ft | 4.3ft | 4.4ft | 4.5ft | 4.6ft | 4.7ft | 4.8ft | 4.9ft | 5.0ft | 5.1ft | 5.2ft | 5.3ft | 5.4ft | 5.5ft | 5.6ft | 5.7ft |
| 287 | 302 | 5.2ft | 5.3ft | 5.4ft | 5.5ft | 5.6ft | 5.7ft | 5.8ft | 5.9ft | 6.1ft | 6.2ft | 6.3ft | 6.4ft | 6.5ft | 6.6ft | 6.8ft | 6.9ft |
| 230 | 242 | 4.0ft | 4.1ft | 4.2ft | 4.3ft | 4.3ft | 4.4ft | 4.5ft | 4.6ft | 4.7ft | 4.8ft | 4.9ft | 5.0ft | 5.1ft | 5.2ft | 5.3ft | 5.4ft |
| 161* | 169 | 2.7ft | 2.7ft | 2.8ft | 2.9ft | 2.9ft | 3.0ft | 3.0ft | 3.1ft | 3.2ft | 3.3ft | 3.3ft | 3.4ft | 3.5ft | 3.6ft | 3.7ft | 3.8ft |
| 138* | 145 | 2.3ft | 2.3ft | 2.4ft | 2.4ft | 2.5ft | 2.5ft | 2.6ft | 2.7ft | 2.7ft | 2.8ft | 2.8ft | 2.9ft | 3.0ft | 3.0ft | 3.1ft | 3.2ft |
| 115* | 121 | 1.9ft | 1.9ft | 1.9ft | 2.0ft | 2.0ft | 2.1ft | 2.1ft | 2.2ft | 2.2ft | 2.3ft | 2.3ft | 2.4ft | 2.5ft | 2.5ft | 2.6ft | 2.7ft |
| 88* | 100 | 1.5ft | 1.5ft | 1.6ft | 1.6ft | 1.7ft | 1.7ft | 1.8ft | 1.8ft | 1.8ft | 1.9ft | 1.9ft | 2.0ft | 2.0ft | 2.1ft | 2.2ft | 2.2ft |
| 69* | 72 | 1.1ft | 1.1ft | 1.1ft | 1.2ft | 1.2ft | 1.2ft | 1.2ft | 1.3ft | 1.3ft | 1.3ft | 1.4ft | 1.4ft | 1.4ft | 1.5ft | 1.6ft | 1.6ft |

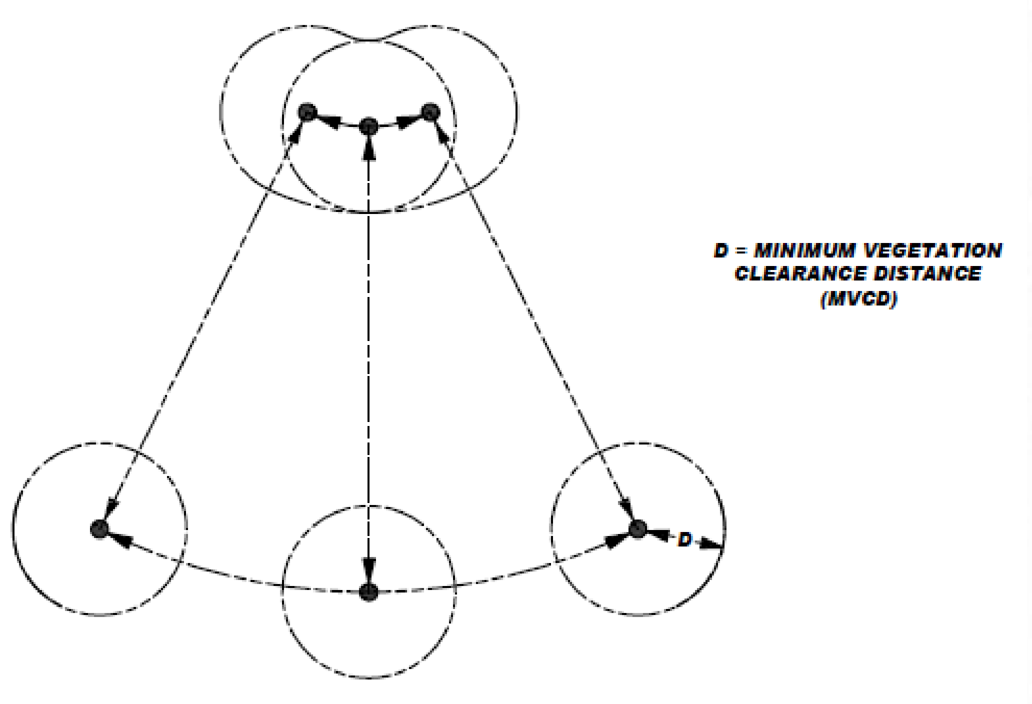
* Such lines are applicable to this standard only if PC has determined such per FAC-014 (refer to the Applicability Section above)

*+ Table 2 – Table of MVCD values at a 1.0 gap factor (in U.S. customary units), which is located in the EPRI report filed with FERC on August 12, 2015. (The 14000-15000 foot values were subsequently provided by EPRI in an updated Table 2 on December 1, 2015, filed with the FAC-003-4 Petition at FERC)*

[17] The distances in this Table are the minimums required to prevent Flash-over; however prudent vegetation maintenance practices dictate that substantially greater distances will be achieved at time of vegetation maintenance.

[18] Where applicable lines are operated at nominal voltages other than those listed, the applicable Transmission Owner or applicable Generator Owner should use the maximum system voltage to determine the appropriate clearance for that line.

[19] The change in transient overvoltage factors in the calculations are the driver in the decrease in MVCDs for voltages of 345 kV and above. Refer to pp.29-31 in the Supplemental Materials for additional information.



# RUS 1724E-200 Highlights

- Applies to all lines 200kV and above or lower voltage lines designated as critical per NERC FAC 003
- Radial clearances provided and based on IEEE 516 Standard (Different than FAC 003-04)
- Clearances to be applied at all rated operating conditions
- Displacement of conductor to include movement of suspension insulators <u>and deflection of flexible structures</u>

# RUS 1724E-200 Highlights

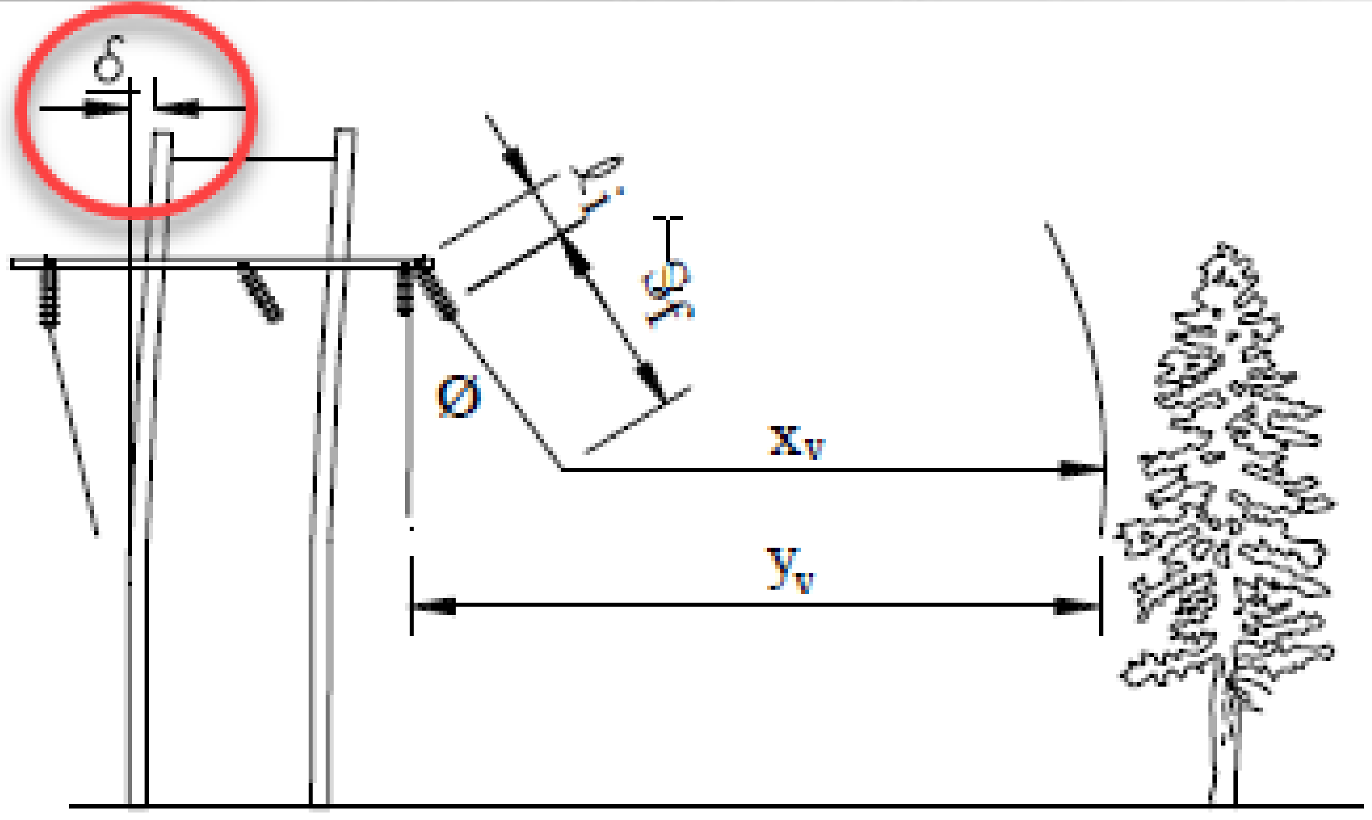



FIGURE 5-2: RADIAL CLEARANCE REQUIREMENT TO VEGETATION

where:

| | | |
|---|---|---|
| $\phi$ | = | 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) |
| $\ell_i$ | = | insulator string length ($\ell_i = 0$ for post insulators or restrained suspension insulators). |
| $y_v$ | = | horizontal clearance at the time of vegetation management work |
| $\delta$ | = | structure deflection at all rated operating conditions |

# RUS 1724E-200 Highlights

TABLE 5-2
RADIAL OPERATING CLEARANCES (in feet) FROM IEEE 516 FOR USE IN DETERMINING CLEARANCES TO VEGETATION FROM CONDUCTORS
(NERC Standard FAC-003.1 Transmission Vegetation Management Program, IEEE 516, Guideline For Maintenance Methods Of Energized Power Lines)

**Conditions under which clearances apply:**

**Displaced by Wind:** Radial operating clearances are to be applied at all rated operating conditions.The designer should determine applicable conductor temperature and wind conditions for all rated operating conditions. The displacement of the conductor is to include deflection of suspension insulators and deflection of flexible structures.

The operating clearances shown are for the displaced conductors and do not provide for the horizontal distance required to account for blowout of the conductor and the insulator string. This distance is to be added to the required clearance. See Equation 5-1.

| **Clearances are based on the Maximum Operating Voltage.** | | | | | | |
|---|---|---|---|---|---|---|
| **Nominal voltage, Phase to Phase, $kV_{L-L}$** | **34.5 & 46[1]** | **69[1]** | **115[1]** | **138[1]** | **161[1]** | **230[1,2]** |
| Max. Operating Voltage, Phase to Phase, $kV_{L-L}$ | ---- | 72.5 | 120.8 | 144.9 | 169.1 | 241.5 |
| Max. Operating Voltage, Phase to Ground, $kV_{L-G}$ | ---- | 41.8 | 69.7 | 83.7 | 97.6 | 139.4 |
| **Radial Table 5 IEEE Standard 516 Operating Clearances** | Clearances in feet | | | | | |
| **Operating clearance at all rated operating conditions** | 1.8 | 1.8 | 1.9 | 2.3 | 2.5 | 2.7 |
| **Design adder for survey and installation tolerance** | 1.5 feet for all voltages | | | | | |
| **Design adder for vegetation** | Determined by designer (see Note 3 below) | | | | | |
| **ALTITUDE CORRECTION TO BE ADDED TO VALUES ABOVE** | | | | | | |
| Additional feet of clearance per 1000 feet of altitude above 3300 feet | .02 | .02 | .05 | .07 | .08 | .12 |

*Notes:*

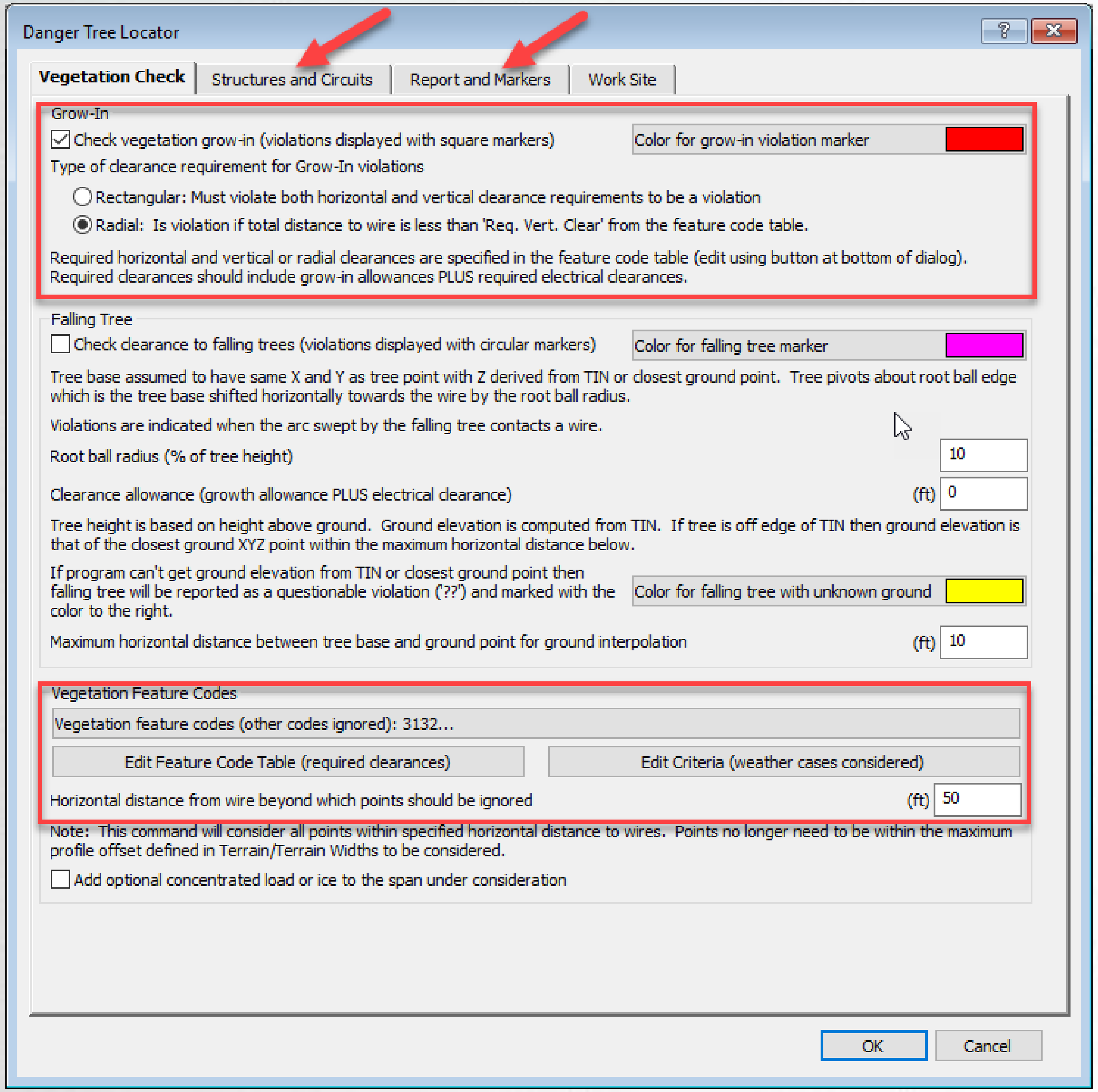
1. These clearances apply to all transmission lines operated at 200 kV phase-to-phase and above and to any lower voltage lines designated as critical (refer to NERC FAC 003).
2. The 230 kV clearance is based on 3.0 Per Unit switching surge.
3. The design adder for vegetation, applied to conductors displaced by wind, should account for reasonably anticipated tree movement, species types and growth rates, species failure characteristics, and local climate and rainfall patterns. The design adder for vegetation, applied to conductors at rest, should account for worker approach distances in addition to the aforementioned factors.

# Vegetation Clearances in PLS-CADD

- Separate checks for Grow-in and Fall-in
- Simultaneously check up to 200 weather cases, including wind conditions (i.e. blowout)
- Wire positions <u>including structure deflections</u> can be calculated
- Group violations into Work Sites to easily identify clearing areas
- Create vegetation TIN and Work Site DXF/SHP files

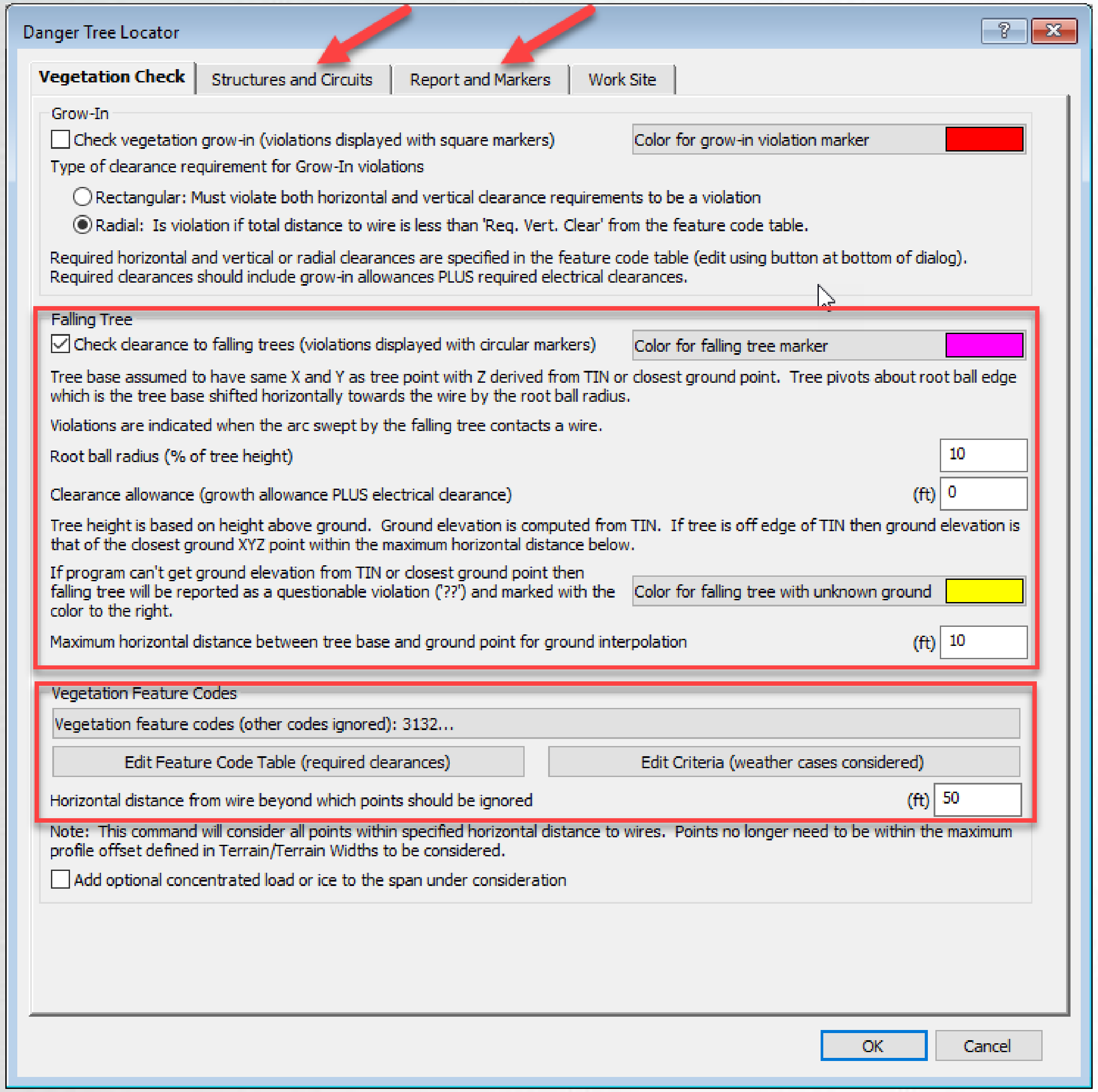
# Example Reports and Settings – Grow-In

- Select Grow-In analysis
- Select vegetation point feature code(s)
- Confirm clearances
- Confirm weather condition(s) for analysis
- Options available for range of structures, report info and graphical markers



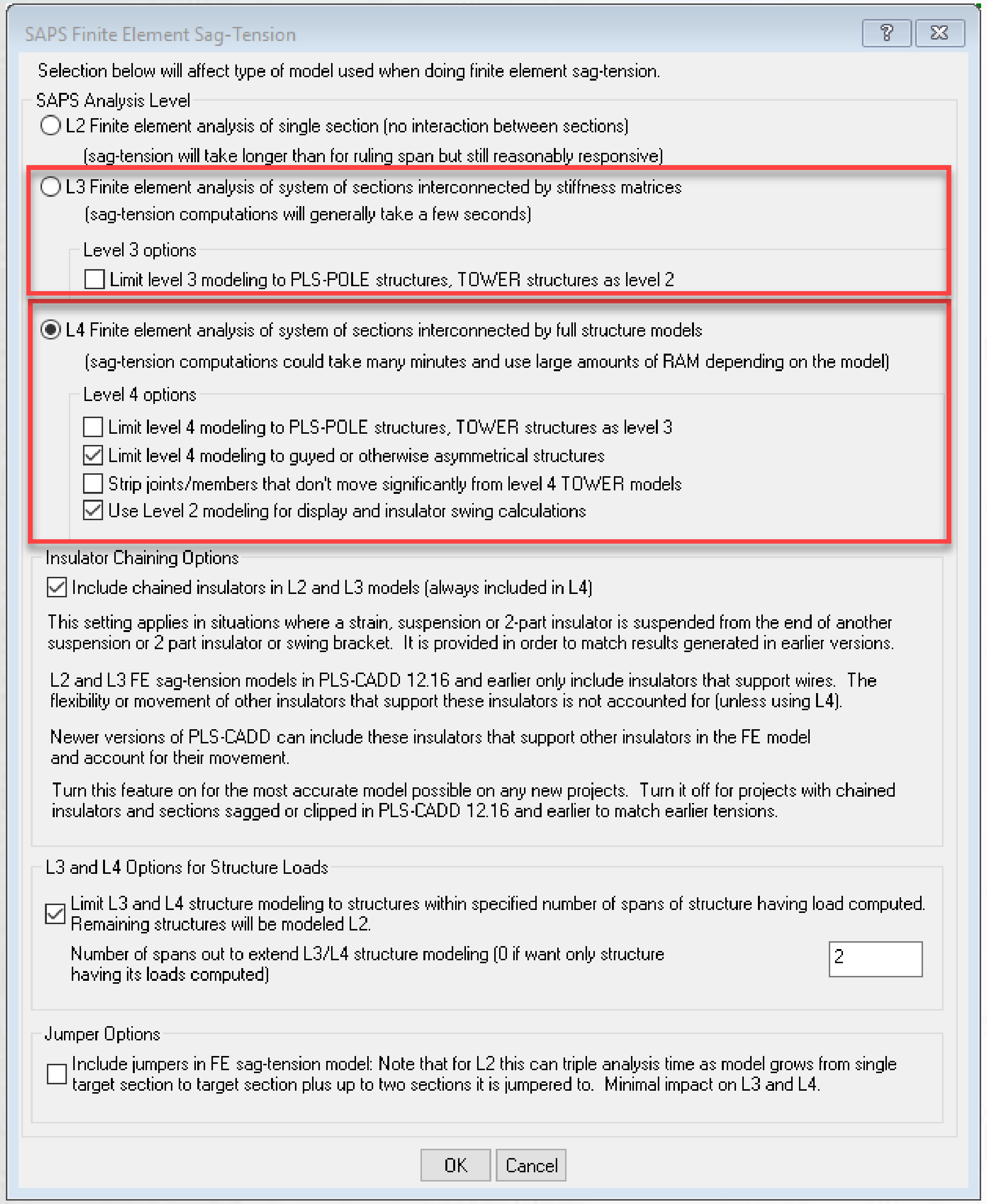
# Example Reports and Settings – Fall-In

- Select Falling Tree analysis
- Select vegetation point feature code(s)
- Confirm clearances
- Confirm weather condition(s) for analysis
- Options available for range of structures, report info and graphical markers

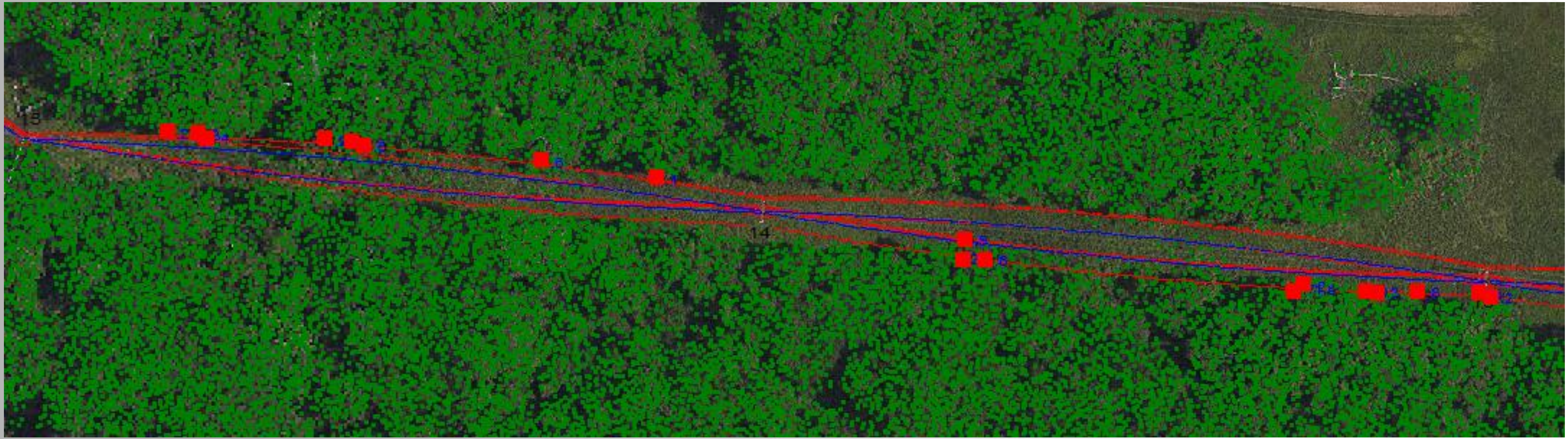


# Including Structure Deflection in Calculations

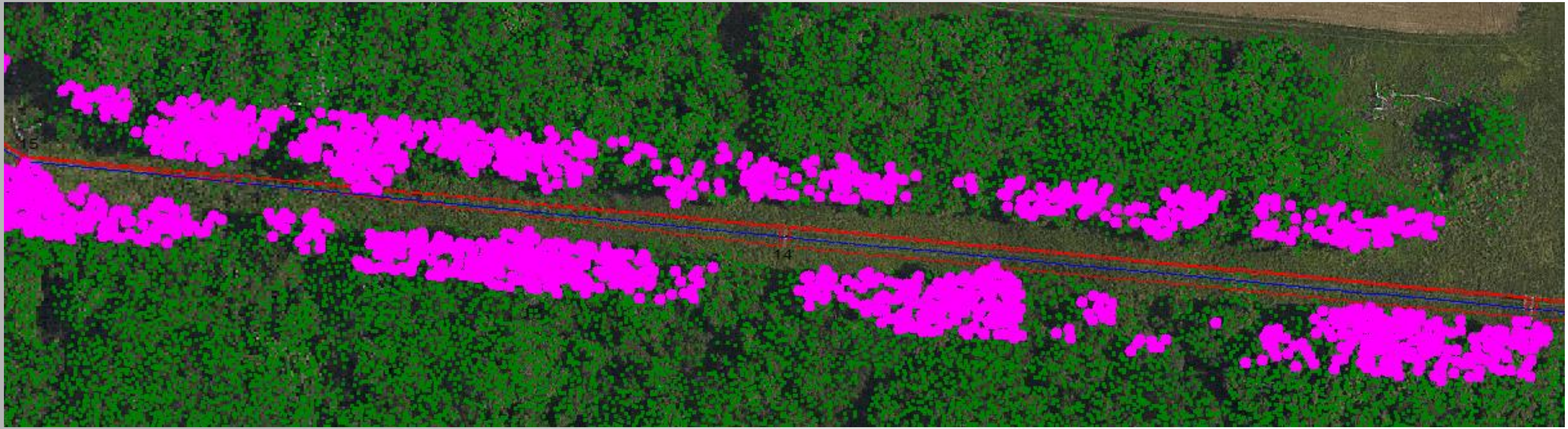
- Can be used with Grow-In or Falling Tree analysis
- Structures must be modeled in PLS-POLE or TOWER
- Select either L3 or L4 analysis in *Criteria/SAPS Finite Element Sag-Tension*
- Then run the Grow-In or Falling Tree Analysis



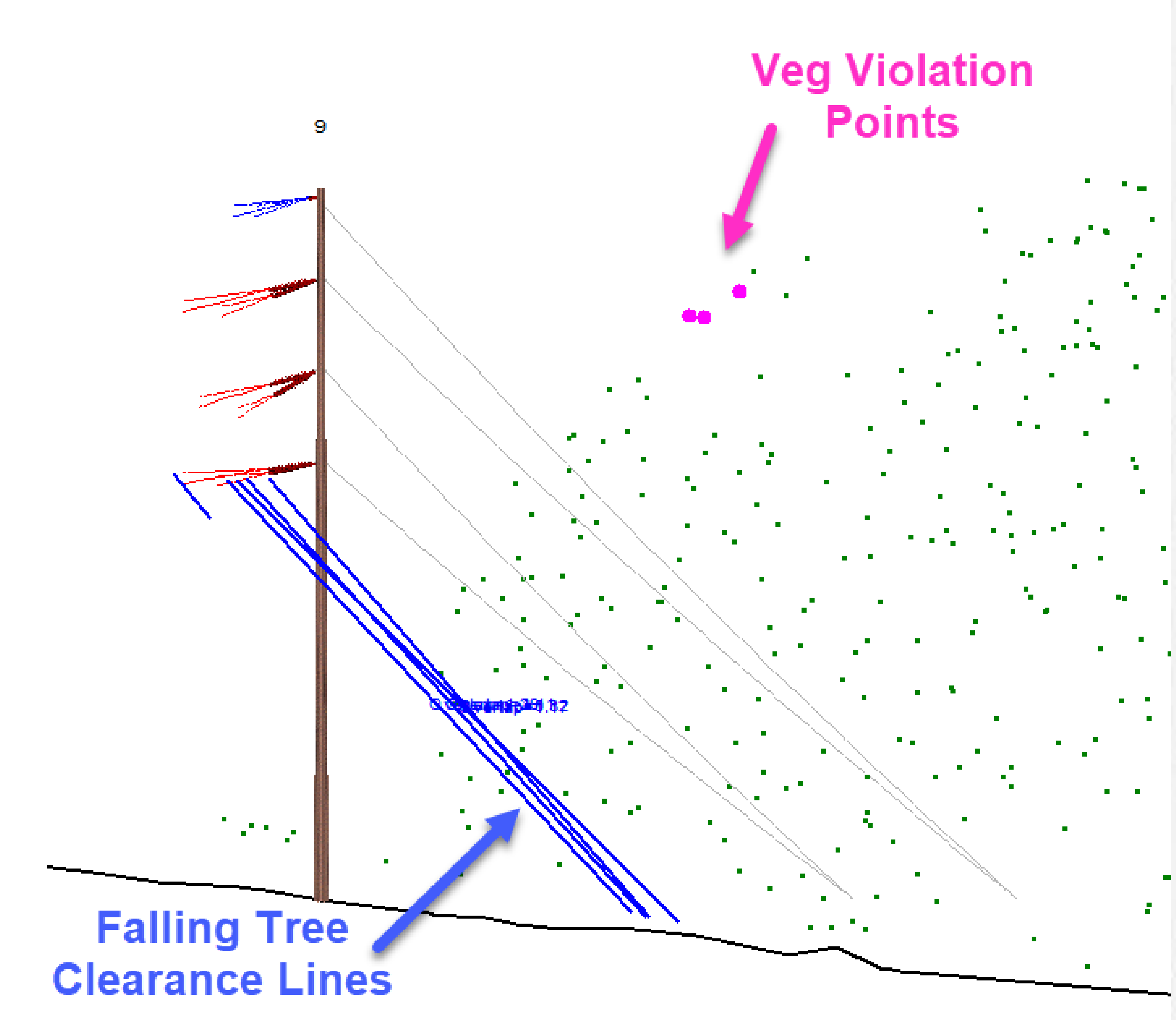
# Plan View of Grow-In Violations under Wind Condition



# Plan View of Falling Tree Violations under No Wind Condition

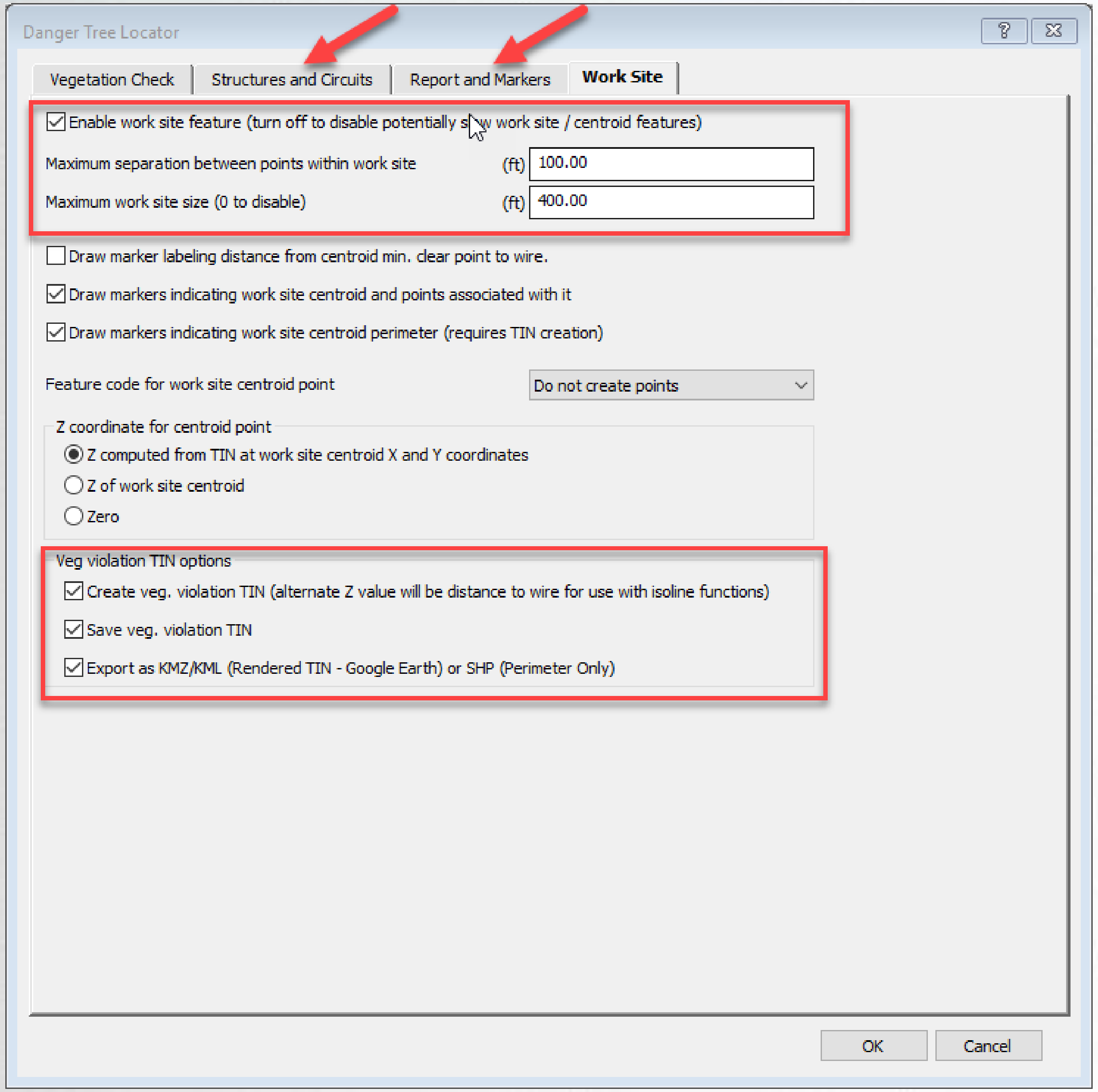


# Cross Section View of Falling Tree Violations at Angle Structure

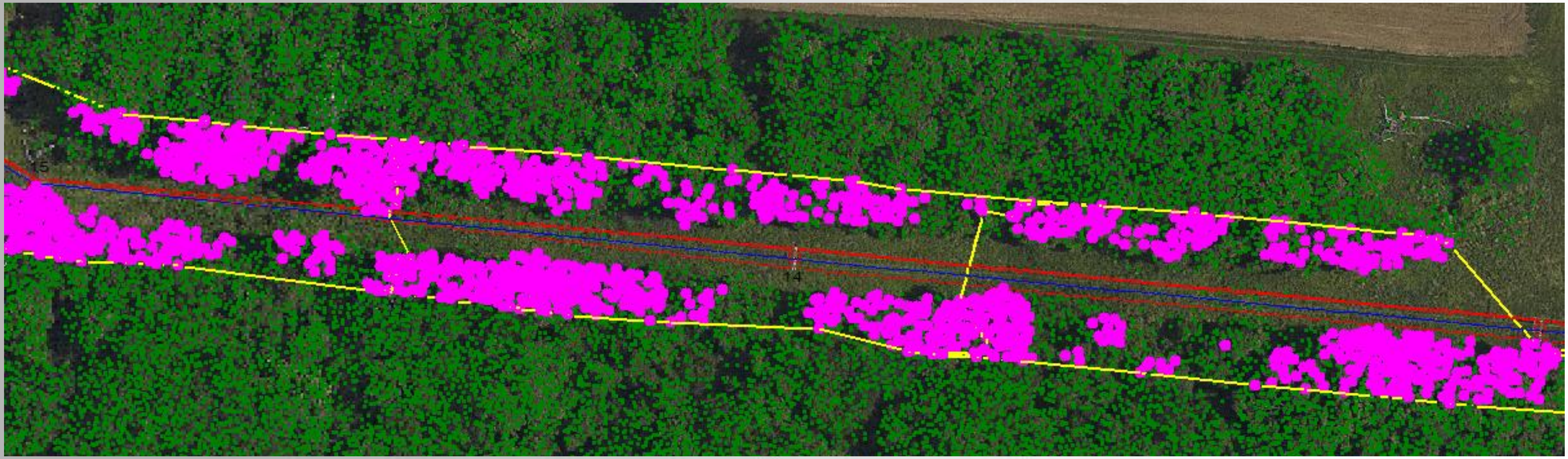


# Example Reports and Settings – Work Sites

- Can be used with Grow-In or Falling Tree analysis
- Input work site size parameters
- Options available for TIN, KMZ/KML and SHP file creation
- Options available for range of structures, report info and graphical markers



# Plan View of Work Sites for Falling Tree Violations



Advanced Sag & Tension
IEC
FAC 008/009
Materials Management
NESC
PLS-CADD®
LiDAR Modeling
Structural Analysis
CSA
Distribution
Pole Analysis
CENELEC
Transmission
NERC Ratings
Line Optimization

# Questions?

Project Estimating
FAC 003
ASCE
Joint Use
PLS-POLE
GO95
Vegetation Management
1000+ Users in 100+ Countries
Storm Hardening
IEEE
Line Ratings
TOWER
Drafting