A

Todd Prager & Associates LLC

Tree Risk Assessment for the Davis-Meeker Oak

Date: February 7, 2025

Site Address: 7525 Old Highway 99 SE
Tumwater, Washington 98501

Prepared for: Lisa Parks, City Administrator
City of Tumwater
555 Israel Road SW
Tumwater, WA 98501

Prepared by: Rick Till
ISA Board Certified Master Arborist® PN-8358B
ISA Qualified Tree Risk Assessor®

Todd Prager
ASCA Registered Consulting Arborist® #597
ISA Board Certified Master Arborist®, WE-6723B
ISA Qualified Tree Risk Assessor®

Table of Contents

Executive Summary

The City of Tumwater contracted with Todd Prager and Associates LLC to perform a Level 3 Advanced Tree Risk Assessment for the Davis-Meeker Oak, a 66-inch diameter (DBH) Oregon white oak (*Quercus garryana*) and City of Tumwater-designated heritage tree. The advanced assessment included a thorough climbing inspection of the tree, sonic tomography testing at eight locations on the main stems of the tree, and a root crown excavation. The assessment also included a review of historic site conditions. The new information was used to categorize risk using the International Society of Arboriculture's tree risk assessment process. Based on that process, all but one tree part was rated as *low* risk, and one tree part was rated as *moderate* risk during the next three-year timeframe.

For additional analysis, our firm also employed the VALID Tree Risk-Benefit Management System and TreeCalc, a tree failure and risk modeling software. The VALID system concluded that the risk to public and property is acceptable. The TreeCalc program model of the tree has a safety factor of 6.27 times the strength required to withstand normal weather conditions.

In the spring of 2023, an 18-inch-diameter branch fell from the tree from about 43 feet above the ground, landing along and within Old Highway 99. A Level 3 Advanced Tree Risk Assessment was previously completed which included aerial inspections and sonic tomography. Based on the Level 3 Assessment the tree was determined to be high risk. Mitigation alternatives were considered, but the final recommendation from the City's contracted tree professional was to remove the tree.

Based on the additional findings from this tree risk assessment, the risk mitigation options are:

- ***Retain, Manage, and Monitor***: Implement up to three management alternatives which include pruning, cabling, root zone enhancement, decorative fencing/landscaping to restrict access, and ongoing monitoring. The residual risk will remain at low or low/moderate levels for each tree part with each of these tree management alternatives.
- ***Tree Removal***: This option will eliminate all risk associated with the tree.

A table of pros and cons for the risk mitigation alternatives are presented in this report. In weighing the various costs and benefits, a reasonably prudent management alternative is Option B which involves:

- Tree retention;
- Reduction pruning to reduce risk of branch failure;
- Installing supplemental support to further reduce risk of branch failure and reduce likelihood of target impacts;
- Root zone management to improve soil and root zone conditions; and
- Ongoing monitoring on a five year or less interval to proactively address ongoing risks.

Background

Figure 1 Davis-Meeker Oak Location Map.

In May 2023 an 18-inch diameter branch failed unexpectedly from the Davis-Meeker Oak, an approximately 400-year-old Oregon white oak and City of Tumwater-designated heritage tree. The tree is located on the west side of Old Highway 99 SE, just outside the shoulder of the southbound lane, as depicted in Figure 1. To the southwest of the tree is an access lane and hanger for Olympia Regional Airport. The City's contract arborist assessed the failed branch and tree soon after the failure occurred. The initial inspection of the branch found fungal mycelium on the surface of the fracture point of the branch. The presence of this fungi led to the hypothesis that a white-rot fungi on the upper attachment point of the branch contributed to the failure. The fungi was not tested to identify the species or genus of fungi present. Additional factors considered for the failure were "inclusions and end-weight."

A visual inspection of the lower trunk found an open decay cavity near ground level on the north/northeast[1] side and the use of a mallet to "sound" the trunk indicated interior decay to at least 6-feet above grade. Two increment core samples were taken from 3-feet above grade. The exact locations were not documented. These cores found 4-inches and 5-inches of sound wood depth respectively. The City's contract arborist had assistance in performing additional advanced assessments of the tree, including a climbing (aerial) inspection of the trunk and branches, and sonic tomography which uses sound waves to create a cross-sectional image of the trunk at the base. The aerial inspection included the use of a mallet for additional sounding the tree for decay. The climbing inspection found symptoms that were believed to be consistent with a hollow trunk along the main stem and northeastern codominant stem of the tree. The southwestern codominant stem was thought to have solid interior wood upward toward the larger scaffold branches. The sonic tomography found substantial decay at the base of the tree, but also concluded there was sufficient sound wood to support the tree at its current size. Based on the sonic tomography, aerial inspection, and sounding, the City's arborist concluded that the east stem was hollow and had an increased risk of failure. Based on concerns about the feasibility of implementing mitigation measures, the final recommendation was to remove the tree.[2]

Our firm was hired to perform additional advanced tree risk assessments and provide a second opinion based on the additional information. Core concerns expressed by the City of Tumwater are the risk of tree failure impacting people travelling along Old Highway 99 and concern about the history of branch failures during calm weather conditions.

[1] The cardinal directions listed in the original arborist report appear to have used Old Highway 99 as bearing for due north. As a result, the descriptions appear to shift north slightly. For example, the only open decay cavity is located on the north side of the tree, not the northeast side of the tree.
[2] For additional information, reference the October 10, 2023 arborist report from Sound Urban Forestry, on file with the City of Tumwater.

Assignment

The assignment of our firm for this tree risk assessment and memorandum is as follows:

1. **Data Analysis and Risk Categorization**: Analyze site and tree information collected via background research and during the site visits to determine 1) likelihood of failure, 2) likelihood of impact, 3) likelihood of failure and impact, and 4) consequences of failure for each tree part, condition of concern, and assessed target using the International Society of Arboriculture's tree risk assessment process. Based on this information, determine the overall risk rating of the tree from low, moderate, high, to extreme.
2. **Mitigation Options**: Using the risk categorization results and risk ratings for each tree part and target of concern, provide risk mitigation options to reduce risk. Risk mitigation options may include but not be limited to cabling, bracing, reduction pruning, periodic future inspection intervals, target protection, target restrictions, and soil, pest, or disease treatments. An overall residual risk rating for the tree is to be provided on a scale of low, moderate, high, to extreme based on the mitigation options. Specifications and cost estimates for mitigation options will be determined in collaboration with other professionals as needed that can complete the work.
3. **Level 3 Advanced Tree Risk Assessment Report**: Provide an arborist report as the final deliverable and include a detailed summary of the project background and history, data collection, tree and site conditions, tree parts and conditions of concern, target information, risk categorization for each tree part and target of concern, risk rating for each tree part and target of concern, mitigation options, residual risk after mitigation is applied, and specifications and cost estimates for each risk mitigation treatment. The report is to be organized in a clear and concise format, include photos and maps as supplemental exhibits, and include additional detailed data such as sonic tomography results as attachments to the report.

Limitations

Tree risk assessments are based on the tree and site conditions at the time of assessment. Any changes to the tree or site parameters merit a reassessment. Trees need to be visually re-assessed if site parameters change (i.e., nearby trees are removed, a severe weather event occurs, construction occurs within the root system, etc.). Additionally, tree risk assessments are not guarantees that a tree will not fail within the stated risk assessment time frame. Trees that appear healthy may fail from structural defects or decay that cannot be visually detected. Moreover, any tree, whether it has visible weakness or not, will fail if the forces applied exceed the strength of the tree or its parts. Additional extreme weather conditions can cause unpredictable responses from trees. The tree risk assessment process is limited to the historically normal range of weather conditions, including "normal" storm events. We cannot make reliable assessments of risk in response to extreme weather.

Risk Assessment Overview

This report applies the American National Standards Institute (ANSI) A300 standards[3], the methodology from International Society of Arboriculture's (ISA) Tree Risk Assessment

[3]American National Standards Institute. (2017). *ANSI A300 (Part 9) - 2017 Tree Risk Assessment a. Tree Failure.* A revision of ANSI A300 (Part 9) – 2011.

Manual,[4] and the ISA Best Management Practices: Tree Risk Assessment.[5] Supplemental risk assessment systems are also provided for informational purposes, including the VALID Tree Risk-Benefit Management System and TreeCalc, a tree failure and risk modeling software.

The ISA uses a qualitative risk assessment methodology rather than a quantitative assessment based on numeric values. Trees are diverse, living organisms that grow and adapt to environmental conditions, including weather and the natural presence of decay fungi. The result is that forecasting risk of trees entails a substantial amount of uncertainty and variance between tree risk assessors. As the ISA Tree Risk Assessment Manual states "[i]t should be recognized that *inherent subjectivity and ambiguity* are limitations of the qualitative approach. To increase reliability and consistency of application, it is important to provide clear explanations of the terminology and significance of the ratings defined for likelihood, consequences, and risk."[6] Research has documented that the tree risk assessment process, while achieving substantial improvements in recent years, continues to have variance in risk rating conclusions from qualified professionals.[7]

Due to the enormous diversity of trees and the diversity of people managing trees, there is ample space for respectful and professional disagreement regarding individual tree risk assessments and management decisions. This is particularly the case when tree risk assessors are providing information to risk managers charged with making decisions about trees with a history of failures. The inherent uncertainty in forecasting future failures can make management decisions even more challenging.

The following sections describe the tree risk assessment process and key terms to guide the reader. Notably, the ISA tree risk assessment process does not factor in the benefits associated with retaining trees. This assessment provides a framework for assessing and managing risk that can be considered within the greater context of the benefits or value of the trees to the tree owner or manager. The risk from individual trees should be viewed in the context of the baseline risk posed by living amongst trees generally. Ultimately, the tree owner or manager has authority and responsibility to decide the acceptable level of risk compared to the tree benefits. The arborist can only provide risk ratings and a range of mitigation options to inform decision making.

Tree Risk Assessment Methodology

Tree risk assessment is conducted using a systematic approach to identify, analyze, and evaluate the likelihood of tree failure and impacting a target combined with an estimation of the severity of consequences. When performing a tree risk assessment, an arborist's task is to evaluate the

[4]International Society of Arboriculture. (2017). *Tree Risk Assessment Manual* (2nd ed.) Champaign, IL: International Society of Arboriculture.
[5] Smiley E.T., Matheny N., Lilly, Sharon, L. (2017). *Best Management Practices Tree Risk Assessment* (2nd ed.). International Society of Arboriculture.
[6] International Society of Arboriculture (2017) at 7 (emphasis added).
[7] Koeser, A., Smiley, E.T. (2017). Impact of Assessor on Tree Risk Assessment Ratings and Prescribed Mitigation Measures. *Urban Forestry & Urban Greening Vol. 24*, 109-115; Klien, R.W. et al. (2023). Evaluating the Reproducibility of Tree Risk Assessment Ratings Across Commonly Used Methods. *Arboriculture & Urban Forestry 49(6)*, 271–282.

condition of the tree and the context of the site, taking note of how any defects or unusual features the tree and/or the site may have or pose to the stability of the tree or parts of the tree.

From the collection of data, the arborist then uses four factors to calculate the overall risk rating: (1) the likelihood of failure, (2) the likelihood of impact, (3) the likelihood of failure and impact, and (4) the consequence of failure. The risk rating can be low, moderate, high, or extreme. According to the ISA *Tree Risk Assessment Manual,* the arborist should recommend risk mitigation for high and extreme risk trees and may recommend mitigation for low and moderate risk trees.[8] The risk assessment findings for each factor are included in Attachment 1 as well as definitions for the applicable terms.

Site Assessment
The site assessment includes all features that can affect tree growth and stability, including local weather and wind patterns, soil types, geography, land use and development, frequency of use, and client objectives. A detailed site assessment is provided below.

Time Frame
A tree risk assessment must include a timeframe for forecasting the risk. Time frames between one and five years are typical.[9] This serves as the timeframe for assessing the potential failure. Ongoing monitoring recommendations may vary based on the tree, the site context, and the tree manager's preferences. Generally, additional assessments are recommended on three-to-five-year intervals or after severe weather events. For easily accessible trees, annual visual inspections from the ground can be practical. Advanced assessments, including climbing inspections or sonic tomography, would not be required unless additional changes to the tree are discovered during regular monitoring.

The risk assessment timeframe was set at three years for the subject tree (note: the VALID system automatically sets a timeframe of one year).

Targets
A *target* is defined as any person, object, or service disruption within reach of a falling tree or part of a tree, that may be injured, damaged, or disrupted. If a target is within 1- to 1.5-times the height of the tree being assessed, it is typically included in a risk assessment. This parameter is based off the ISA's Basic Tree Risk Assessment process and is a good guideline when considering what property or who may be impacted by a tree or tree part failure. Depending on context, targets within a factor of 1.5-times or more the height of the assessed tree may be evaluated to address the potential for a tree to fracture and throw debris or slide down a slope after failure.

For the Davis-Meeker Oak, the primary target of concern is people occupying vehicles traveling on Old Highway 99. Additional targets of concern are the airport hanger to the southwest and people and vehicles occupying the adjacent parking areas.

[8] ISA Tree Risk Assessment Manual, p. 132.
[9] ISA Tree Risk Assessment Manual, Appendix 1, Using the ISA Basic Tree Risk Assessment Form.

Likelihood of failure and likelihood of impact

Likelihood of failure is the chance of a tree or tree part failing within the stated time frame of three years. Factors affecting likelihood of failure include site conditions (prior ground disturbance, loss of adjacent trees), response growth (a tree's natural strengthening to normal loads), tree health, tree species, load (wind exposure and lever forces), and any defects or decay in the tree. The likelihood of failure is predicated on historically normal weather conditions, including historically normal storms, but excluding severe or abnormal storms. Severe ice and wind storms are generally not considered historically normal weather conditions. Severe weather is normally excluded from consideration because these weather events and individual tree responses are unpredictable.

Likelihood of impact assesses that once the tree or tree part with the defect has failed, what is the likelihood of the tree or tree part impacting the target. Factors for assessing likelihood of impact include occupancy rates including how long targets are exposed to potential tree failures, location within a target zone, protection factors such as structures or other trees that may reduce potential for certain targets to be impacted, and direction of fall. For the purposes of this assessment, it is assumed that a target with occasional or rare occupancy is not occupied.

The combined likelihood of failure and impact is determined by the likelihood matrix in the ISA *Best Management Practices: Tree Risk Assessment* and ranges from unlikely, somewhat likely, likely, to very likely.

Consequences of failure

The consequence of failure is the level of damage associated with a tree or tree part failure that has struck a target of concern. Factors considered include the size of the tree or tree part, fall distance, protection factors, and target value/damage. Consequences of failure range from negligible, minor, significant, to severe.

Risk Ratings

The risk rating for each tree is determined through a risk rating matrix in the ISA *Best Management Practices: Tree Risk Assessment* that combines the likelihood of a tree failing and striking a target with the consequences of failure. The outputs for risk are low, moderate, high, and extreme.[10]

- **Low** – "Some trees with this level of risk may benefit from mitigation or maintenance measures, but immediate action is not usually required."
- **Moderate** – "The tree risk assessor should recommend mitigation. The decision for mitigation and timing of treatment depends upon the tolerance of the tree owner or manager."
- **High** – "This combination of likelihood and consequences indicates that the tree risk assessor should recommend mitigation measures be taken. The decision for mitigation and timing of treatment depends on the risk tolerance of the tree owner or risk manager." The priority for action is lower than extreme risk trees.

[10] ISA Best Management Practices: Tree Risk Assessment, p. 41.

- **Extreme** – "The tree risk assessor should recommend that mitigation measures be taken as soon as possible. In some cases, this may mean restricting access to the target zone area to avoid injury to people."

These ratings are used, in combination with the tree owner or manager's risk tolerance, to prioritize any actions. Mitigation options and recommendations are provided after risk ratings are established. A residual risk rating may be provided based on mitigation options provided.

Site Assessment: Land Use, Geography, and Normal Weather.

The site assessment is used to identify potential factors that may affect the likelihood of tree failure and likelihood of impacting a target.

The Davis-Meeker Oak is located within favorable habitat for Oregon white oak. The soils at the specific site are loamy fine sand or loamy sand to a depth of 60 inches, as shown in Attachment 2. These are very favorable soils for root growth and tree health. The south Puget Sound region includes notable Oregon white oak habitat and has been the subject of long-term Oregon white oak management research. Of particular interest, in western Washington the USDA Forest Service has been conducting a long-term oak management study since 2001, which provides invaluable information on managing Oregon white oaks, failure patterns, and recovery.[11]

The Davis-Meeker Oak is located within a few feet west of Old Highway 99 adjacent to the Olympia Regional Airport. Old Highway 99 is a major transportation corridor assumed to have constant occupancy for the purposes of this tree risk assessment report. Of note, even if the occupancy rate were categorized as frequent, the likelihood of impact rating discussed below would not be altered. People within vehicles travelling along Old Highway 99 are the main target of concern evaluated within this report, though additional targets are also evaluated. The nearest building, an aviation hanger, is approximately 70 feet southwest of the tree. The surrounding landscape is a combination of airport runways, transportation and access routes, aviation hangers, associated parking, open fields, forest, and suburban development.

Normal weather conditions are documented as winds predominantly from the south and southwest with infrequent winds exceeding 20 miles per hour. Wind roses provide a graphic depiction of wind direction, speed, and frequency. Below is wind rose data from the Olympia Regional Airport from 1970 to 2024 showing the predominant wind direction and frequency of various wind speeds (Figure 2).[12] Wind speed data from the airport during recent storm events was also reviewed by our firm. This included the November 2024 bomb cyclone and a high wind event in December that cause local tree failures. During those events wind speeds were not recorded exceeding 30 miles per hour.[13] Notably, wind speeds increase at greater altitudes, so wind speeds aloft are generally higher than the speeds measured at weather stations. As a result, taller trees are exposed to greater wind speeds. Combined with longer lever arms, taller trees are subjected to substantially greater loads on their root systems and lower trunks. The Davis-

[11] Slesak R.A., Brodie1 L.C., Harrington C.A. (2024) Continued response of Oregon oak to release treatments 20 years after initiation in western Washington, United States. Restoration Ecology Vol. 32, No. 4, e14130.
[12] Instruction for wind rose data available at https://www.climate.gov/maps-data/dataset/wind-roses-charts-and-tabular-data (Accessed October 14, 2024).
[13] See generally https://www.wunderground.com/history.

Meeker Oak likely experiences higher wind speeds than those recorded at the airport, but not the substantially increased wind speeds experience by taller growing species, such as Douglas-fir (*Pseudotsuga menziesii*). Note that tree failures are not always directly tied to weather events. Tree failures may occur from other conditions such as root, branch, or trunk decay, soil failures such as landslides, root damage from construction or other root disturbances, and structural issues such as included bark (bark imbedded in a branch union), overextended branches with excessive end weight, or low live crown ratios (height of live foliage to total tree height). Trees with defects or other suboptimal conditions may be more prone to failure during various weather events. In addition, tree failures may be initiated during a weather event with the ultimate failure occurring days, weeks, or months after the initial event.

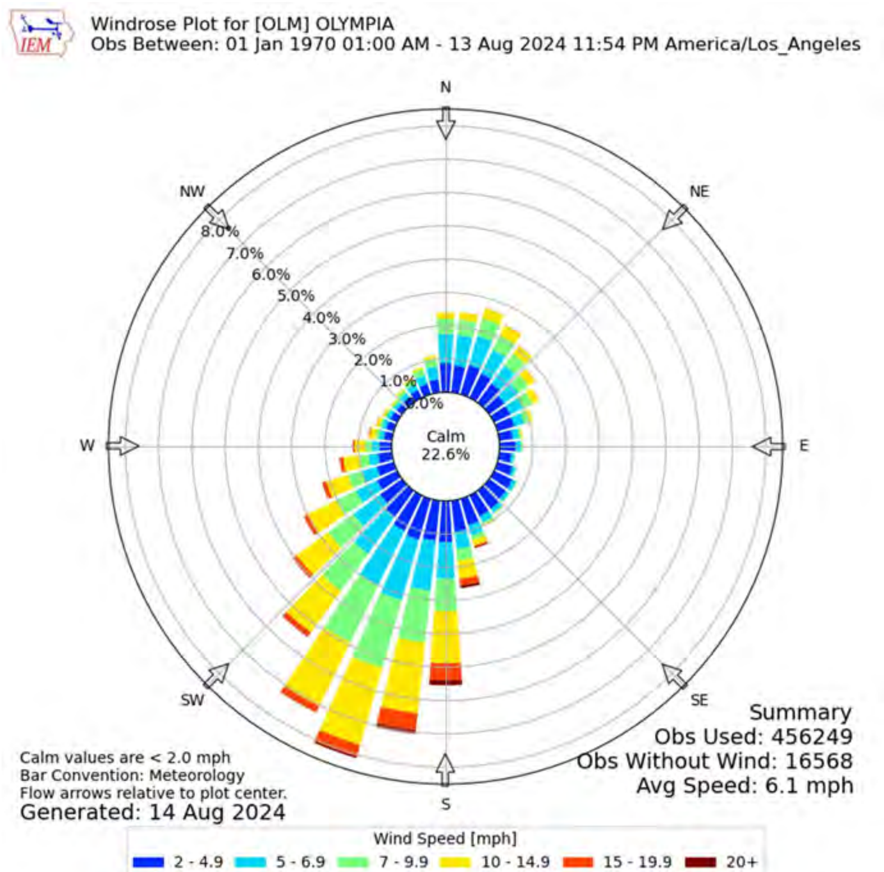


Figure 2 Wind rose for average annual wind at the Olympia Regional Airport.

Tree Observations

The primary tree inspection and measurements were performed on October 11, 2024 in conjunction with sonic tomography and the aerial climbing inspection. The root crown excavation and inspection occurred on December 13, 2024. Additional visits to photograph the tree were performed when traveling through the area as needed. Additional observations were collected by reviewing Google street view historic images to identify approximate windows of time when changes occurred to the tree.[14] The images were cross-referenced with available work orders for tree work supplied by the City of Tumwater.

Measurements

The Davis-Meeker oak was measured as 66-inches diameter at breast height (DBH, at 4.5 feet above ground level). Notably, this measurement was taken from the then-existing grade, which included at least one foot of fill. As such, the measurement may be a slight under-estimate of DBH. Tree height and crown dimensions were measured using a Nikon Forestry Pro II Laser Rangefinder/Hypsometer. The tree height was measured as approximately 85 feet and was corroborated with a measuring tape during the aerial inspection.

The crown radius varies by direction from the tree as follows

- Towards the southwest (directly toward the hanger): 57 feet.
- To the northwest: 27 to 30 feet.
- To the northeast (directly across Old Highway 99): 40 feet.
- To the southeast (parallel to Old Highway 99): 42 feet.

The mass of the crown is to the south or southwest of the central trunk. The crown is split into three stems, which are depicted in Figure 3 and Attachment 3. The approximate outline of the crown and the three primary stems are depicted in the aerial photo in Attachment 4. The main trunk forks at approximately 16 feet into a southwest and northeast stem. The southwest stem arches to the southwest toward the hanger. The northeast stem forks again at approximately 33 feet into a central stem that forms the top of the tree and a second branch system that extends to the east and southeast. The central stem has a historic decay pocket on the south side at approximately 46 feet that is used as a nesting cavity by kestrels (*Falco sparverius*). The cavity is also identifiable from a cascara (*Frangula purshiana*) sapling growing from the cavity. The east/southeast branch system forks into two branches, one extends directly over Old Highway 99 and the second extends to the south/southeast parallel to Old Highway 99.

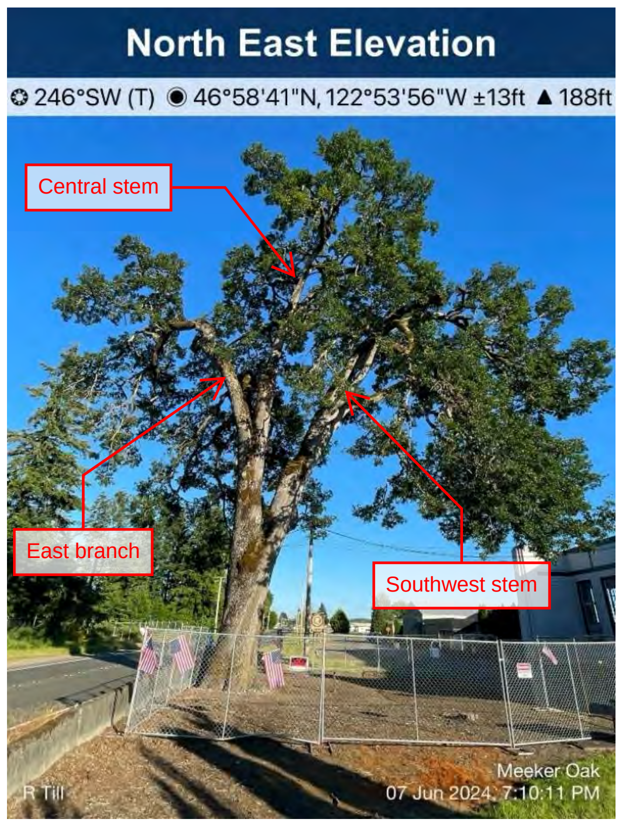


Figure 3 View of tree anatomy and crown shape.

[14] Google street view historic photos include October 2008, October 2011, July 2015, August 2017, November 2018, June 2019, October 2022, May 2023, and August 2024.

In agreement with the City's prior contract arborist, the Davis-Meeker Oak visually appears to be in good health, with healthy crown density, leaf color, leave size, and internode growth. The tree visually has a fair structural condition rating based on the codominant unions with included bark and history of failures.

Sonic Tomography and Advanced Modeling

Sonic tomography readings were taken at eight locations along the trunk of the tree using an Arbotom® impulse tomograph. Sonic tomography uses sound waves to create a cross-section image of a tree to detect areas of dense and less dense (decayed) wood where the readings are taken. The Arbotom® system for our tree risk assessment uses different computer modeling and color coding than the system employed for the prior tree risk assessment. The complete sonic tomography report is included as Attachment 5. A visual summary of the sonic tomography readings referencing the approximate locations and significant trunk features is included as Attachment 3. A summary table of the sonic tomography readings and the wood strength loss findings is included as Attachment 6, which also includes a side-by-side comparison of the recent tomography and the tomography completed as part of the prior tree risk assessment.

The main conclusion from the sonic tomography is that the reading at 18 inches above ground modeled substantial decay and strength loss between 14% and 21% depending on direction of loading. The reading depicts less than 80 percent of the trunk is hollow. At the height of the measurement, a four-inch sound wall would equal an 80 percent trunk hollow. Notably, this reading is corroborated by the increment core measurements taken during the original tree risk assessment, which found sound wood at a depth of four and five inches at two locations along the lower trunk.

The reading just below the kestrel cavity, at approximately 45 feet, modeled a strength loss of between 6% and 19% depending on the direction of the load. The other six readings did not model any substantial loss of strength. The other readings along the trunks did locate less dense wood and a likely decay column in the central stem. This included a reading below the primary union, one reading on the southwest stem, and five readings on the central stem. However, the modeling did not depict a substantial loss of strength.

The sonic tomography reading at the base corroborates the sonic tomography performed during the prior assessment. The two systems employ different color coding and a different number of sensors. There is slight variation in mapping, but both models depict a comparable amount of decay and sound wood.

Additional advanced modeling was performed using TreeCalc, a proprietary tree risk modeling software. The modeling and an explanation of the theory supporting the modeling approach is described in Attachment 7, which explains why hollow trees with a large diameter and relatively short height can maintain high safety factors. The modeled safety factor based on the percentage of hollow trunk was calculated at 6.27, meaning the tree has 6.27x the minimum strength needed to support the crown during modeled conditions. This residual safety factor was the calculated result modeling of an 80 percent hollow tree. The same result was generated when modeling an 80 percent hollow tree with an additional 20 percent opening in the trunk. The sonic tomography for the Davis-Meeker Oak, as corroborated by increment core samples reported by the City's contract arborist, is less than 80 percent hollow. Importantly, TreeCalc does not model trees with a greater than 80 percent hollow trunk. In excess of 80 percent hollow, the modeling does not accurately replicate the biomechanics of how trees fail.

Aerial Inspection and Historic Record Review

The aerial inspection included a close examination of most of the above ground tree parts. A visual summary of that inspection is included as Attachment 8. Notable findings include the following, listed from the lowest point of the aerial inspection to the highest point:

- Main codominant union at approximately 16 feet:
  - The union has included bark and an accumulation of debris that is supporting small plants.
  - Probing the inclusion with a ¼ inch metal probe encountered strong resistance, indicating intact wood between the two stems.
- Historic failure to southeast at approximately 26 feet:
  - According to Google street view, this failure occurred between October 2011 and October 2015. In October 2015 the wound shows oxidization, which would be consistent with at least one year of exposure to open air.
  - The historic failure to the southeast may have occurred during a severe ice storm that occurred in January 2012. A local Oregon white oak research project documents substantial damage to Oregon white oak in the region due to that storm event.[15] In that study the mean crown damage for three study groups ranged from 21 percent to 29 percent crown damage.
  - The current condition shows robust wound wood growth and minimal signs of decay on the face of the wound.
- Second codominant union at approximately 33 feet:
  - This union has included bark and some accumulation of debris.
  - Removal of some of the debris revealed tightly included bark and a seam that transitioned into a non-included bark union.
  - Probing the inclusion with a ¼ inch metal probe encountered strong resistance, indicating intact wood between the two stems.
  - The southeastern fork of this stem splits again within two feet of the primary union. This fork appeared to not have included bark.
- May 2023 failure to northwest at approximately 44 feet:
  - Fungal mycelium was present on the top portion of the injury. A sample was taken and sent to Oregon State University for analysis, which tested positive for a *Stereum* species. That report is included as Attachment 9. *Stereum* are not considered a pathogen, the implications of which are discussed further below.
  - The failure point was adjacent to one old pruning wound with some associated decay along the left margin of the recent failure. A second pruning wound with some decay was located approximately a foot above the 2023 failure point. These injuries can lead to wood dysfunction and decay that may contribute to failures.

[15] Slesak R.A., Brodie1 L.C., Harrington C.A. (2024) Continued response of Oregon oak to release treatments 20 years after initiation in western Washington, United States. *Restoration Ecology Vol. 32*, No. 4, e14130.

  - There was substantial wound wood response along the top right margin of the wound. The amount of wound wood growth indicates either very rapid wound wood response or that the wound may have been initiated before June 2023.
  - There are variations in the color of oxidation on the face of the wound, indicating a variability when the surface was exposed to air or possible dieback of adjacent wood.
- Southeast cavity at approximately 46 feet:
  - The cavity is substantially decayed. A column of decay extends up the center of the stem above and below the opening.
  - The opening has robust wound wood and favorable response growth. The bark indicates the wound wood has transitioned from new, smooth bark indicating a recent wound to furrowed mature bark indicating a very old injury and strong adaptive growth.
  - The crown mass is centered to the south/southwest away from Old Highway 99, reducing the likelihood of failure striking a vehicle on the road.
- The primary branch extending over Old Highway 99 from the union at 33 feet:
  - The branch has two substantial pruning wounds within approximately 15 feet of the attachment point, but no visible decay into heartwood. One significant pruning wound appears in Google street view images in August 2017, which would be consistent with the City's maintenance records documenting a branch failure and pruning in March of 2017. Notably, the Olympia Airport weather station recorded wind gusts up to 36 miles per hour at 2:54 in the afternoon on March 5, 2017.[16]
  - There is a relatively recent branch failure, likely from 2022. Google street view shows the torn branch first appearing in October 2022. City of Tumwater records document removing of parts of the tree on July 16, 2022.

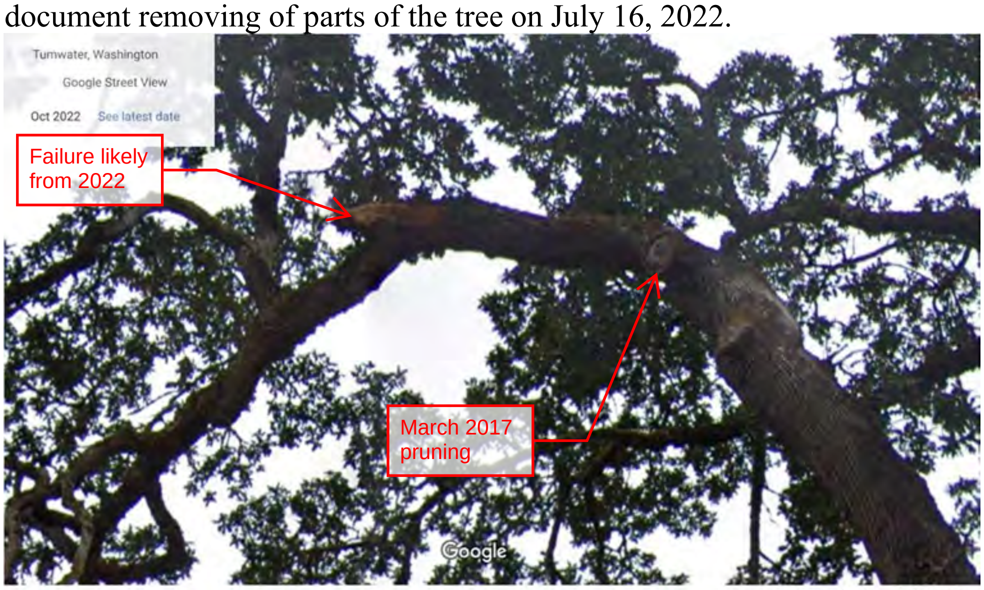


Figure 4 October 2022 view of branch over Old Highway 99.

  - Notably, branches that failed or were removed in 2017 may have provided support or weather protection to the branch that failed in 2022.

[16] https://www.wunderground.com/history/daily/us/wa/tumwater/KOLM/date/2017-3-5

  - Review of weather records did not show an abnormal weather event in the immediate timeframe.
  - The pruning wounds and failure point does not appear to have compromised the strength of the remaining branch. However, the entire branch system is asymmetrical, which can increase the twisting or torsion forces on the lower branch. There is healthy wound wood response and no visible decay, indicating a positive response to the injury.
  - There is one piece of deadwood greater than 3 inches in diameter hanging over Old Highway 99.
- The southwest crown:
  - This southwest crown has two substantial stem failures. One failure is flushed with sprouts, the other appears to be dead but well attached.
  - According to Google street view, these failures first appear in October 2022 and not earlier than June 2019. This timeframe is consistent with the City of Tumwater records documenting tree work in July 2022.
  - Review of weather records did not show an abnormal weather event in the immediate timeframe.
  - There are multiple branch unions with codominant attachments with included bark. The area below these branches is rare occupancy, reducing the likelihood of striking a target.

Root Crown Excavation

A photographic summary of the root crown excavation is included as Attachment 10. The root crown excavation removed back filled river rock to a depth of approximately 1 to 2 feet. All rock cobbles and soil were removed from immediately adjacent to the tree and to a depth where the top of the root flare was visible. One small dead and decayed root was located. The remaining portions of the root crown and accessible roots did not show signs or symptoms of outward decay. One decay cavity that was visible at the prior ground level was assessed further. The cavity did not extend below the prior grade and was closing with robust response growth.

All buttress areas and sinuses between buttress were probed with a ¼ inch metal probe. No signs of decay were encountered, such as cavities, soft wood, or delaminating bark. The areas between buttress roots had closed around several rocks, which were pried out with tools or left in place to avoid damaging bark. The portion of the root flare near the road was not as well developed. The presence of fencing and the Jersey barrier created a partial limit to the inspection. This required manual feeling and probing with hand tools and did not result in any signs or symptoms of decay.

Overall, there were no signs or symptoms of decay and no visually apparent reason to suspect decay on the underside of any of the buttress roots or lateral roots.

Discussion

Analysis of the 2023 branch failure and implications for remaining branches

Identifying the likely cause or causes of the 2023 branch failure can assist in identifying whether similar risk factors are present in the remaining portions of the tree. Factors to consider include the presence and species of decay fungi occurring within the tree, the condition of branch attachments, wounds (either pruning wounds or failure points) near the attachment point, and obvious signs of initial failure such as cracks.

The species of fungi can make a critical difference in diagnosing the risk of failure. Wood decay fungi fall into several categories based on the type of wood they consume. Trees are composed of wood in different conditions based on hydration and chemical composition. The outer layer is living sapwood that transmits water and nutrients to the leaves while also having the capacity to actively respond to injury and the introduction of wood decay organisms. As the sapwood ages, it eventually dies and becomes heartwood (or ripe wood). In oaks the heartwood is filled with chemicals that have a greater resistance to some decay fungi. Some fungi specialize in specific types of wood: live sapwood, dead sapwood, or heartwood. Fungi that can kill and consume live sapwood are considered *pathogenic* while fungi that can only consume dead wood are considered *saprophytic*.

The wood decay fungi that was present on the face of the 2023 failure tested positive as a *Stereum* species. *Stereum* species are considered saprophytic on sapwood, meaning they generally only feed on dead sapwood. Some species may have a limited ability to consume heartwood. Common *Stereum* includes fungi that decay dead branches while they remain in the tree. *Stereum* are not known to *cause* the death of branches but rather are a *correlation* to sapwood death and possible heartwood decay.[17] Notably, there may be additional decay fungi present in the tree. However, the presence of the fungi is more likely to be the result of prior injuries or failures rather than a primary cause of the 2023 branch failure.

Historic pruning injuries adjacent to the branch attachment are likely to have contributed to a reduction in the strength of the attachment and the introduction of *Stereum* fungi (see Attachment 8, Figures 11, 12, and 13).

The branch attachment was codominant but did not have included bark. Google street view images show that the branch extended laterally a substantial distance, which would have subjected the branch to substantial level forces.

One significant concern is that the historic branch failures have occurred during calm weather conditions in spring or summer. These failures are sometimes described as summer or sudden limb drop. Unfortunately, there is no agreed upon definition of the sudden limb drop phenomenon. Some literature requires that the failure is not associated with any preexisting defect.[18] In the present case, the 2023 failure appears to be associated with a previously existing defect or damage in conjunction with a long, overextended lateral branch creating substantial lever forces on the branch attachment.

---

[17] Glaeser J.A. and Smith K.T. (no date) *Decay Fungi of Oaks and Associated Hardwoods for Western Arborists*. The Britton Fund. Pages 14–15 (early version of this publication is available at https://www.nrs.fs.usda.gov/pubs/jrnl/2010/nrs_2010_glaeser_003.pdf. Costello, L.R., Hagen B.W., Jones K.S. (2011). *Oaks in the Urban Landscape: Selection, Care and Preservation.* University of California Agriculture and Natural Resources. Page 168. See for example, TMI Fungi (https://www.tma-fungi.co.uk/72.html) for a description of *Stereum gausapatum*.

[18] Costello L.R. (no date) *Sudden Branch Drop: A Case for Closer Inspection*. University of California Cooperative Extension.

The 2023 failure shows signs that a crack may have occurred before it ultimately failed in June 2023. Evidence of this includes:

- The presence of the *Stereum* mycelium at the top 1/3 of the wound, which would be consistent with a fungus growing into space created by a partial failure.
- Variation in the oxidization of the wound indicating exposure to the air at different times.
- The robust wound wood growth along the right side of the injury, possibly indicating that a crack had formed prior to 2023.
- Three additional substantial failures occurred in 2022 according to review of historic Google street view images. This includes two upright stems in the southwest crown and one large branch over Old Highway 99. Attachment 3 depicts the one of the upright stem failures and the failure over the road. Attachment 8, Figures 25 and 26 are photos of the aerial inspection of the failure over the road, which also show the amount of wound wood growth that helps estimate the duration since the injury. City of Tumwater work orders document tree work in July 2022. Review of weather records did not show any abnormal weather immediately preceding these failures. However, these types of failure are normally associated with extreme weather.

There remains substantial uncertainty as to the cause of the prior branch failures. The prior failures are consistent with the primary cause of most tree failures, which is severe weather. The inspection of the tree in its existing condition did not find indicators that additional failures are probable or imminent under normal weather conditions.

Central decay column

The Davis-Meeker Oak does have substantial decay at the base and likely a central column of decay extending up the central stem. According to advanced metrics and the visual assessment, it appears that the remaining sound wood is sufficient to support the tree during historically normal weather conditions.

To facilitate consideration of the hollow portions of the tree, description of relative strength of a hollow tree provided by the VALID Tree Risk-Benefit Management System is included as Attachment 7. In short, trees with large diameters can maintain robust safety margins despite being substantially hollow. To support the analysis, modeling from the TreeCalc program is included as Attachment 7. The modeling predicts that if the Davis-Meeker Oak had no decay, then it would have a safety factor of 11.16 (i.e. a multiple of 11.16 times greater strength than needed to withstand modeled loads). When the model includes hollowing the trunk to 80 percent the residual safety factor is 6.27. The sonic tomography and increment boring confirms that the tree is less than 80 percent hollow. If future decay exceeds this threshold, alternative analysis would be needed to determine whether the safety factor could be calculated.

Risk Ratings

The full risk rating analysis is included as Attachment 1. As described above, following the ISA *Best Management Practices: Tree Risk Assessment* definitions is critical to applying the system. The definitions and the risk matrices drive the risk rating outcomes. For example, if the likelihood of failure is rated as *possible*, the final rating will not be higher than *moderate* even if the likelihood of impact is high and the consequences are severe.

Based on the assessment, it is not anticipated that any tree parts would fail during historically normal weather conditions within the next three years. As a result, no tree parts met the *probable* likelihood of failure category. *Possible* likelihood of failure is when “failure may be expected in extreme weather conditions, but it is unlikely during normal weather conditions within the specified time frame.” Given the history of branch failures during ice storms, this is an appropriate rating for the probability of failure. One could argue that the tree also meets the definition of *improbable*: “the tree or tree part is not likely to fail during normal weather conditions and may not fail in extreme weather conditions within the specified time frame.” However, a possible rating appears to be more consistent with the plain language understanding of the terms.

Of the scenarios assessed, three generated *moderate* risk ratings. This included the following risks:

- The northeast branch failing and impacting an occupied vehicle on Old Highway 99.
- The southwest codominant stem failing and striking the hanger.
- The whole tree failing and striking the hanger (the risk of whole tree failure impacting a person in a vehicle on Old Highway 99 was rated as low)

Notably, the area of greatest concern is the risk to people using Old Highway 99. The risk to the public is captured best by the risk of the northeast branch system failing. Of note, the rating for whole tree failure striking a person using Old Highway 99 was rated as low while the risk to the hanger was rated as moderate. This difference is due to the likelihood of impact to people using Old Highway 99 is *medium* while the likelihood of impacting the hanger is *high*. The different categorization is based on the determination that the center of mass and higher likelihood direction of whole tree failure is to the southwest.

The risk of whole tree failure and the risk of the northeast branch failing were also run through the VALID tree risk-benefit program. This system uses International Standards Organization’s “ISO 31000 - Risk Management” and the “Tolerability of Risk Framework” (ToR) as a risk-benefit management tool. The system uses proprietary math combined with subjective assessment by a trained arborist to generate risk ratings ranging from acceptable, tolerable, not tolerable, or not acceptable. An explanation of that system and the risk ratings is included as Attachment 11. That program generated an overall *acceptable* risk rating, meaning that the risk to the public is within a range that is acceptable within the ISO risk management and ToR framework. This was in part supported by the TreeCalc program, which modeled a safety factor 6.27 based on the approximate dimensions of the tree and the extent of decay in the lower trunk.

Risk Mitigation Options

All trees pose a risk if a target is present. The tree owner or manager has ultimate authority for adopting an acceptable level of risk and prioritizing mitigation measures. All mitigation options have trade-offs between enjoying the benefits of trees and accepting some risk exposure. It is valuable to consider the range of options in the context of a baseline level of risk that is commonly accepted when living amongst trees. Nonetheless, tree risk managers do have a duty to take reasonably prudent measures to protect the public from injury.

To facilitate planning, the tree risk assessment process focuses mitigation on either target management or tree management. Risk management can be target based, such as removing targets or limiting access, or tree based, ranging from removal to pruning and cabling. Removal is also an option depending in the risk tolerance and priorities of the tree risk manager. The following risk mitigation options present the range of management decisions to mitigate the low to moderate risk rating of the subject tree parts. Option 7 (Tree Removal) would eliminate all risk. Aside from Option 7, Options 1 through 6 are reasonably prudent alternatives to removal that can be used in combination to reduce risk to low or low/moderate levels as described in the residual risk ratings for each tree part in Attachment 1. Cost estimates are provided for each risk mitigation option that involves tree work based on our experience.

1. **Basic pruning and monitoring.** Basic pruning would involve removing deadwood 2-inches and larger over target areas. This would include any deadwood over Old Highway 99 and over parking and travel corridors.
    a. ***Estimated Cost*:** Excluding traffic control, the cost of limited deadwood pruning would be less than ½ day of work or approximately $2,000.
2. **Target management.** Limiting access along Old Highway 99 is not feasible. Limiting access to space within the dripline or within 1x the height of the tree on the airport side may be feasible.
    a. Install decorative fencing, such as split rail fencing, along the edge of asphalt in the parking area.
    b. Remove three parking spaces to the south of the tree to mitigate the risk of whole tree failure striking a car. Restoring the soil in three parking spots would also improve available rooting habitat and support tree health.
    c. Relocate the power service line to the hanger to a location outside the drip line of the tree.
    d. ***Estimated Cost*:** Consult an engineer and contractor.
3. **Reduction pruning.** Well considered reduction pruning could reduce the risk of branch, stem, or whole tree failure. The benefits of risk reduction must be balanced against the impacts of removing photosynthetic capacity from the tree and diverting energy away from root and trunk growth to wound response. For portions of the tree that pose a greater risk, the balance may tip towards greater reduction. For portions where risk is lower, the balance may tip towards removing less material. The following pruning specifications should be considered:
    a. ***Pruning objective*:** Public safety, tree health/retentional, support natural retrenchment process.
    b. ***Pruning system*:** natural target pruning
    c. ***Specifications*:**
        i. All pruning should be required to comply with ANSI pruning standards and ISA best management practices for pruning. Contractor should review ANSI A300 pruning standard, Annex B-5.1, which provides a sample retrenchment pruning specification. Additional retrenchment theory guidance can be found in *Trees: A Lifespan Approach*.[19]

[19] Dujesiefken. D, Fay N., de Groot J., de Berker N. (2016). *Trees: A Lifespan Approach*. Available at https://www.ancienttreeforum.co.uk/wp-content/uploads/2017/04/Trees-a-lifespan-approach-Nev-Fay-et-al.pdf

ii. For branches over Old Highway 99, emphasize risk reduction. Target 1-inch to 3-inch diameter cuts with a maximum cut of 6-inches in diameter. Minimize live foliage removal to less than 15 to 20 percent in any single pruning cycle to the extent feasible. Do not remove crossing/self-bracing branches without addressing risk of subsequent failure. Retain crossing branches as needed.
iii. For the central stem, emphasize breaking apical dominance. Target 1-inch to 2-inch reduction cuts with a maximum cut size of 4-inches. Limit live foliage removal to less than 10 percent in any single pruning cycle.
iv. For the southwest stem, emphasize length reduction on branches with poor attachments. Target 1-inch to 4-inch reduction cuts. Limit live foliage removal to less than 10 percent of any individual branch system.
v. General specifications:
    1. Prune to maintain natural structure and branch architecture. Consider opening up portions of the crown to allow light penetration to support interior foliage, including epicormic growth.
    2. Do not remove interior foliage other than incidental to safe tree access.
    3. Employ heading cuts under 2-inches in diameter to growth nodes as needed. For storm damaged limbs, larger heading cuts may be appropriate to allow for crown regeneration and limit decay into main stems.
    4. Remove dead wood 2-inches and larger with the exception of the large, fractured branch in the northwest crown. Inspect the branch stub for indications of epicormic growth and stability. Consider leaving as habitat feature.

d. ***Estimated cost*****:** $5,000 to $12,000 for one to two days of work.
    i. Include at least one expert climber with advanced pruning skills and one aerial lift (spider lift or at least a 55-foot vertical reach bucket truck) with highly skilled pruning arborist.
    ii. Additional costs for traffic control.

e. ***Monitoring and ongoing maintenance costs*****.** City arborist to inspect tree for deadwood and response growth annually. Remove deadwood as needed. Additional pruning doses may be warranted in five-to-10-year cycles with costs potentially ranging from $2,000 to $10,000.

4. **Supplemental Support Systems.** Installing cables, bolts, or props is a common strategy for mitigating the risk of tree failure. The southeast stem growing directly over Old Highway 99 is the primary branch that could benefit from supplemental support. Dynamic or static cables could be installed to provide supplemental support to branch systems of concern. The following factors should be considered in cable installation:
    a. Dynamic systems are not intrusive and allow for more natural tree movement and, theoretically, allow greater natural response growth. Monitoring, maintenance, and replacement costs are higher.
    b. Static systems require drilling and can allow for the spread of decay. The systems restrict tree movement more than a dynamic system. Long-term monitoring and maintenance costs are generally lower.

c. Installation should follow the ANSI and ISA Best Management Practices to the extent practical. The ideal location pursuant to the best management practices would be two thirds the distance above the potential failure point being supported. However, given the architecture of the tree and location of cavities, the optimal location may substantially lower than the two thirds rule of thumb.
d. ***Estimated cost*:** $1,200 to $4,000, contingent on design and materials.
e. ***Monitoring*:** Annual inspection of cables from ground, aerial inspection every three to five years or as recommended by manufacturer's instructions. Replace dynamic cables as needed or within manufacturer directions. This may entail cable replacement costs of $1,500 to $4,000 repeating every eight years.

5. **Root zone management.** Additional soil management should be performed within the root zone.
   a. The root crown excavation left the soil grade adjacent to the tree at an acceptable level, but did not remove river cobble further from the root flare. These materials should be removed to gently slope the grade from the root crown towards the surrounding landscape. Work should be supervised by a qualified arborist to ensure work does not cause unnecessary damage to fine roots occupying shallow root areas.
   b. The area could be planted with a native bunchgrass and wildflower mix to replicate the native Oregon white oak savannah ecosystem.
   c. Soil testing could be conducted to determine if there are any nutrient deficiencies.
   d. Soil density tests could be performed to determine if compaction is an issue.
   e. ***Mulching*:** Installing a layer of organic mulch 2- to 4-inches thick wherever feasible will improve rooting conditions and assist with tree health and root anchoring.
   f. ***Estimated cost*:** $100 for one yard of mulch delivered to the site. Labor to spread mulch would be an estimated $1,080; total estimated costs of $1,180.
6. **Monitoring.** Unless otherwise stated, the tree should be monitored and a tree risk assessment completed at least every five years by a qualified arborist. In addition, a qualified consulting arborist should be contacted after storm events if movement of the soil and/or roots around the base of the trunk, or cracks in the trunks or major branches is observed or suspected to complete a tree risk assessment.
   a. ***Estimated Cost*:** $800 to $1,500 for a Level 2 basic visual tree risk assessment from the ground and a written arborist report. $3,000 to $6,000 or more for Level 3 advanced assessment depending on the techniques such as sonic tomography, root crown excavation, aerial inspection, etc.
7. **Tree removal.** Tree removal is a mitigation option to eliminate all risk.
   a. ***Estimated Cost*:** $16,000 to $30,000 for removal and wood processing. Traffic control not included.

To help facilitate decision making, we have prepared potential pros and cons of four different mitigation alternatives in Table 1 below. In weighing the various costs and benefits, a reasonably prudent management alternative is Option B which involves:

- Tree retention;
- Reduction pruning to reduce risk of branch failure;

- Installing supplemental support to further reduce risk of branch failure and reduce likelihood of target impacts;
- Root zone management to improve soil and root zone conditions; and
- Ongoing monitoring on a five year or less interval to proactively address ongoing risks.

However, as stated previously, the tree owner or manager has ultimate authority for adopting an acceptable level of risk and selecting mitigation measures.

Risk Management Alternatives (note: numbers correlate to mitigation options 1 through 7)	**Pros**	**Cons**
A. Basic Prune (1) / Root Zone Management (5) / Monitor (6)	• Retains historic tree • Low initial cost • Limits removal of live foliage, retains tree vitality, maximizes response growth • Potential to improve tree root health	• May require greater ongoing investment and redundant costs with reduction pruning or removal • No substantial change in risk of live branch failure. • Does not anticipate and proactively prune tree to address changes resulting from recent failures
B. Reduction Prune (3) / Supplemental Support (4) / Root Zone Management (5) / Monitor (6)	• Retains historic tree • Moderate initial cost • Uncertainty for ongoing costs, but potential to be lowest cost option over the long-term if retaining the tree • Potential to substantially reduce risk of branch failures • Monitoring may be limited to inspections from ground in conjunction with periodic aerial inspection of cable • Cabling decision can be deferred until after pruning and development of a final cabling plan	• Removes live foliage and temporarily reduces photosynthetic capacity which can cause tree to go into decline • Uncertainty for ongoing costs, but potential to be highest cost option if tree goes into decline or additional failures occur necessitating removal • Residual risk may remain moderate • Requires ongoing monitoring and some uncertainty for maintenance schedule • Selection of supplemental support system (static and intrusive versus dynamic and non-intrusive) has separate pros and cons, such as more frequent aerial inspections

Risk Management Alternatives (note: numbers correlate to mitigation options 1 through 7)	**Pros**	**Cons**
C. Target Management (2) / Reduction Prune (3) / Supplemental Support (4) /Root Zone Management (5) / Monitor (6)	• Retains historic tree • Moderate initial cost • Potential to substantially reduce risk of branch failures • Monitoring may be limited to inspections from ground in conjunction with periodic aerial inspection of cable • Cabling decision can be deferred until after pruning and development of a final cabling plan • Reduces risk of target impacting parked cars, power service line, and people visiting the tree • Restoring the soil in three parking spots would also improve available rooting habitat and support tree health.	• City does not have direct control to make changes in the target zone such as installing fencing and removing parking spaces • Does not address risk zone of greatest concern, Old Highway 99 • Removes live foliage and temporarily reduces photosynthetic capacity which can cause tree to go into decline • Likely the highest cost among the tree retention options when factoring in costs of fence installation and parking space removals • Residual risk may remain moderate • Requires ongoing monitoring and some uncertainty for maintenance schedule • Selection of supplemental support system (static and intrusive versus dynamic and non-intrusive) has separate pros and cons, such as more frequent aerial inspections
D. Removal (7)	• One time cost • Eliminates all risk	• Loss of historic tree • High initial cost associated with tree removal

Conclusion

The additional assessments of the Davis-Meeker Oak included a thorough climbing inspection, sonic tomography on eight locations along the trunk, and a root crown excavation. The ISA visual tree risk assessment process concluded that the highest rated risk is *moderate* for a branch failure in normal weather striking an occupied vehicle causing severe consequences.

Based on the additional findings from this tree risk assessment, the risk mitigation options are:

- ***Retain, Manage, and Monitor***: Implement up to three management alternatives which include pruning, cabling, root zone enhancement, decorative fencing/landscaping to restrict access, and ongoing monitoring. The residual risk will remain at low or low/moderate levels for each tree part with each of these tree management alternatives.
- ***Tree Removal***: This option will eliminate all risk associated with the tree.

A table of pros and cons for the risk mitigation alternatives are presented in this report. In weighing the various costs and benefits, a reasonably prudent management alternative is Option B which involves:

- Tree retention;

- Reduction pruning to reduce risk of branch failure;
- Installing supplemental support to further reduce risk of branch failure and reduce likelihood of target impacts;
- Root zone management to improve soil and root zone conditions; and
- Ongoing monitoring on a five year or less interval to proactively address ongoing risks.

Please contact Todd Prager if you have any questions about the information provided in this report.

Sincerely,

Rick Till
ISA Board Certified Master Arborist® PN-8358B
ISA Qualified Tree Risk Assessor
rick@toddprager.com
503-750-6599

Todd Prager
ASCA Registered Consulting Arborist #597
ISA Board Certified Master Arborist, WE-6723B
ISA Qualified Tree Risk Assessor
ASCA Tree & Plant Appraisal Qualified
AICP, American Planning Association
todd@toddprager.com
971-295-4835

Enclosures:

Attachment 1 – Tree Risk Assessment Matrices Overview
Attachment 2 – NRCS Soil Map and Soil Types
Attachment 3 – Visual Summary of Sonic Tomography Report
Attachment 4 – Aerial Photograph with Crown Map
Attachment 5 – Sonic Tomography Report
Attachment 6 – Table of Sonic Tomography Readings and Comparison to Tree Solutions
Attachment 7 – TreeCalc Evaluation
Attachment 8 – Aerial Inspection Summary and Photos
Attachment 9 – OSU Plant Clinic Report
Attachment 10 – Root Crown Excavation Summary and Photos
Attachment 11 – VALID Tree Risk-Benefit Strategy and Ratings
Attachment 12 – Assumptions and Limiting Conditions

Todd Prager & Associates LLC

Attachment 1 - Tree Risk Assessment Matrices Overview

Davis-Meeker Oak, Tumwater, Washington

Based on assessments that occured in October and December 2024

Common Name	Scientific Name	DBH[1] (in)	C-Rad[2] (ft)	Height	Condition[3]	Structure[3]	Tree Part Assessed	Target[4]	Direction to Target	Distance (ft)	Likelihood of Failure[5]	Likelihood of Impact[6]	Combined likliehood of failure and impact[7]	Consequence of Failure[8]	Risk Rating[9]	Comments	Risk Mitigation Action Options	Residual Risk After Mitigation
Oregon white oak	*Quercus garryana*	66	27' to northwest, 40' to northeast, 42' to southeast, 57' to southwest	85	good	fair	whole tree	Old HWY 99 - people	NE	3	possible	medium	unlikely	severe	low	higher probability direction of whole tree failure is away from road, which reduced likelihood of impact and overall risk rating	root zone management to maintain/improve tree vitality, crown reduction	low
								Hanger	SW	71	possible	high	somewhat likely	significant/ severe	moderate	constrant occupancy and higher probability direction of failure. Both significant and severe consequences generate moderate risk rating		
								Parking area - vehicles	SW and NW	60 to 75	possible	medium	unlikely	significant	low	reduced occupancy rate reduces likliehood of impact		
								parked area - people	NW, W, S, SE	40	possible	low	unlikely	severe	low	low occupancy rate reduces likelihood of imapcting a person		
							first order codominant stem to NE (road side)	Old HWY 99 - people	NE	3	improbable	high	unlikely	severe	low	likelihood of failure is rated as *improbable* due to reduced crown on NE stem and absence of substantial decay above and below the union; increasing the rating to *possible* would increace risk rating to *moderate*	reducing the crown, primarily the branch over the road, and cabling	low
							first order codominant stem to SW (hanger side)	hanger	SW	71	possible	high	somewhat likely	significant	moderate	likelihood of failure compared to NE stem is greater due to larger crown; both significant and severe consequences of failure generate moderate risk rating	reducing the SW crown and cabling, relocate electric service drop	low
								parking area - vehicles	SW and NW	60 to 75	possible	medium	unlikely	signicant	low	likelihood of impact rated as medi		
								parking area - people	NW, W, S, SE	40	possible	low	unlikely	severe	low			
							second order codominant stems to NE/E	Old HWY 99 - people	NE/E	3	possible	high	somewhat likely	severe	moderate	likelihood of failure is rated as primarily due to indications of included bark and risk of ice storm failure	reduction pruning and/or cabling could reduce likliehood of failure to improbable	low/moderate
							second order codominant stems to SW	hanger	SW	71	possible	low	unlikely	minor	low	hanger at edge of area of potential impact, impact to power line minor (excluding risk of a line induced fire to hanger)	Relocate power service line beyond drip line of tree; reduction pruning	low
								parking area - vehicles	SW and NW	60 to 75	possible	very low	unlikely	significant	low	parking areas are locatred outside drip line of tree		
								parking area - people	NW, W, S, SE	40	possible	very low	unlikely	severe	low	occupancy rate within drip line of tree is very low		
							central stem above kestrel cavity	Old HWY 99 - people	NE	3	possible	medium	unlikely	severe	low	crown weight is to SW and protection factors from lower limbs reduce likelihood of impact whichk reduces overall risk	limited reduction pruning to lower lever force, but maintain stem vitality by retaining as much foliage as possible	low
								hanger	SW	71	possible	very low	unlikely	minor	low	hanger beyond 1x of failure point		
								parking area - vehicles	SW and NW	60 to 75	possible	very low	unlikely	significant	low	parking areas are locatred beyond likely impact area, protection factors reduce likelihood of impact		
								parking area - people	NW, W, S, SE	40	possible	very low	unlikely	severe	low	occupancy rate within drip line of tree is very low		

Todd Prager & Associates LLC

Attachment 1 - Tree Risk Assessment Matrices Overview

Davis-Meeker Oak, Tumwater, Washington

Based on assessments that occured in October and December 2024

[1] **DBH** is the trunk diameter in inches measured at 4.5 feet above ground level per International Society of Arboriculture (ISA) standards. Please note that trees with ivy may have an inflated DBH.

[2] **C-Rad** is the approximate crown radius in feet.

[3] **Condition** and **Structure** ratings range from dead, very poor, poor, fair, to good. Condition is a rating of tree health and structure is a rating of tree anotomy and defects.

[4] A **target** is defined as any person, object, or service disruption within reach of a falling tree or part of a tree, that may be injured, damaged, or disrupted. If a target is within one times the height of the tree being assessed, it is typically included in a risk assessment. Depending on context, the height may be multiplied by a factor of 1.5 or more to address the potential for a tree to fracture and throw debris or slide down a slope after a failure.

Target assessment includes analysis of static targets (houses), movable targets (benches), and mobile targets (people or cars). Assessing mobile targets should include an evaluation of the *occupancy rate* , or the amount of time people or other targets occupy a space where a tree may fail. Occupancy rate can be *constant* , *frequent* , *occasional* , or *rare* . Buildings and permanent structures have constant occupancy rate whereas people using streets, driveways, yards, and playgrounds may have rare to frequent occupancy. Very busy roads can be classified as having constant occupancy. Generally speaking, the lower the occupancy rate the lower the likelihood of being struck by a tree and the lower the risk rating.

Target assessment also includes an evaluation of *protection factors* , such as whether structures or other trees may prevent the tree from impacting the target. For example, a group of trees may protect a house from the worst consequences of a tree failure. Or a house may protect people in the house from direct physical harm, although not necessarily psychological harm, from a tree falling on the house.

[5] **Likelihood of failure** is categorized in one of four levels:
Improbable – "the tree or tree part is not likely to fail during normal weather conditions and may not fail in extreme weather conditions within the specified time frame."
Possible – "failure may be expected in extreme weather conditions, but it is unlikely during normal weather conditions within the specified time frame."
Probable – "failure may be expected under normal weather conditions within the specified time frame."
Imminent – "failure has started or is most likely to occur in the near future, even if there is no significant wind or increased load. The imminent category overrides the stated time frame."
ISA Tree Risk Assessment Manual, p. 124.

[6] **Likelihood of impact** is categorized at four levels:
Very low – "the chance of the failed tree or tree part impacting the specified target is remote."
Low – "there is a slight chance of the failed tree or tree part will impact the target.
Medium – "the failed tree or tree part could impact the target but is not expected to do so."
High – "the failed tree or tree part is likely to impact the target."
ISA Tree Risk Assessment Manual, p. 42, 126.

[7] **The combined likelihood of failure and impact** is calculated by the TRAQ matrix:

Matrix I. Likelihood matrix.

Likelihood of Failure	Likelihood of Impact			
	Very low	Low	Medium	High
Imminent	Unlikely	Somewhat likely	Likely	Very likely
Probable	Unlikely	Unlikely	Somewhat likely	Likely
Possible	Unlikely	Unlikely	Unlikely	Somewhat likely
Improbable	Unlikely	Unlikely	Unlikely	Unlikely

[8] **Consequences of failure** are categorized at four levels:
Negligible – "No personal injury, low-value property damage, or disruptions that can be replaced or repaired."
Minor – "minor personal injury, low- to moderate-value property damage, or small disruption of activities."
Significant – "substantial personal injury, moderate- to high-value property damage, or considerable disruption of activities."
Severe – "serious personal injury or death, high-value property damage, or major disruption of important activities."
ISA Tree Risk Assessment Manual, p. 43, 129–130.

[9] **The risk rating** are categorized by four levels and are determined by the risk rating matrix:
Low – "Mitigation is generally not required. Mitigation or maintenance measures may be desired for some trees, because it is sometimes possible to reduce risk even further at very low cost, but the priority for action is low."
Moderate – "The tree risk assessor may recommend mitigation and/or retaining or monitoring. The decision for mitigation and timing of treatment depends on the risk tolerance of the tree owner or manager. In populations of trees, moderate-risk trees represent a lower priority than high- or extreme-risk trees."
High – "This combination of likelihood and consequences indicates that the tree risk assessor should recommend mitigation measures be taken. The decision for mitigation and timing of treatment depends on the risk tolerance of the tree owner or risk manager." The priority for action is lower than severe risk trees.
Extreme – "The tree risk assessor should recommend that mitigation measures be taken as soon as possible. In some cases, this may mean recommending or implementing immediate restriction of access to the target zone area to avoid injury to people
ISA Tree Risk Assessment Manual, p. 132.

Matrix 2. Risk rating matrix.

Likelihood of Failure & Impact	Consequences of Failure			
	Negligible	Minor	Significant	Severe
Very likely	Low	Moderate	High	Extreme
Likely	Low	Moderate	High	High
Somewhat likely	Low	Low	Moderate	Moderate
Unlikely	Low	Low	Low	Low

Attachment 2
NRCS Soil Map and Soil Types

Soil Map—Thurston County Area, Washington
(Davis-Meeker Oak Soil Type)

Map Scale: 1:676 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 10, 20, 40, 60

Feet: 0, 30, 60, 120, 180

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

Soil Map—Thurston County Area, Washington
(Davis-Meeker Oak Soil Type)

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Thurston County Area, Washington
Survey Area Data: Version 18, Aug 27, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 26, 2023—Aug 14, 2023

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
73	Nisqually loamy fine sand, 0 to 3 percent slopes	0.8	100.0%
Totals for Area of Interest		**0.8**	**100.0%**

Thurston County Area, Washington

73—Nisqually loamy fine sand, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2ndc8
Elevation: 160 to 1,310 feet
Mean annual precipitation: 40 to 60 inches
Mean annual air temperature: 50 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Nisqually and similar soils: 85 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Nisqually

Setting

Landform: Terraces
Parent material: Sandy glacial outwash

Typical profile

H1 - 0 to 5 inches: loamy fine sand
H2 - 5 to 31 inches: loamy fine sand
H3 - 31 to 60 inches: loamy sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Ecological site: R002XA006WA - Puget Lowlands Prairie
Forage suitability group: Droughty Soils (G002XS401WA)
Other vegetative classification: Droughty Soils (G002XS401WA)
Hydric soil rating: No

Minor Components

Yelm

Percent of map unit: 3 percent

Hydric soil rating: No

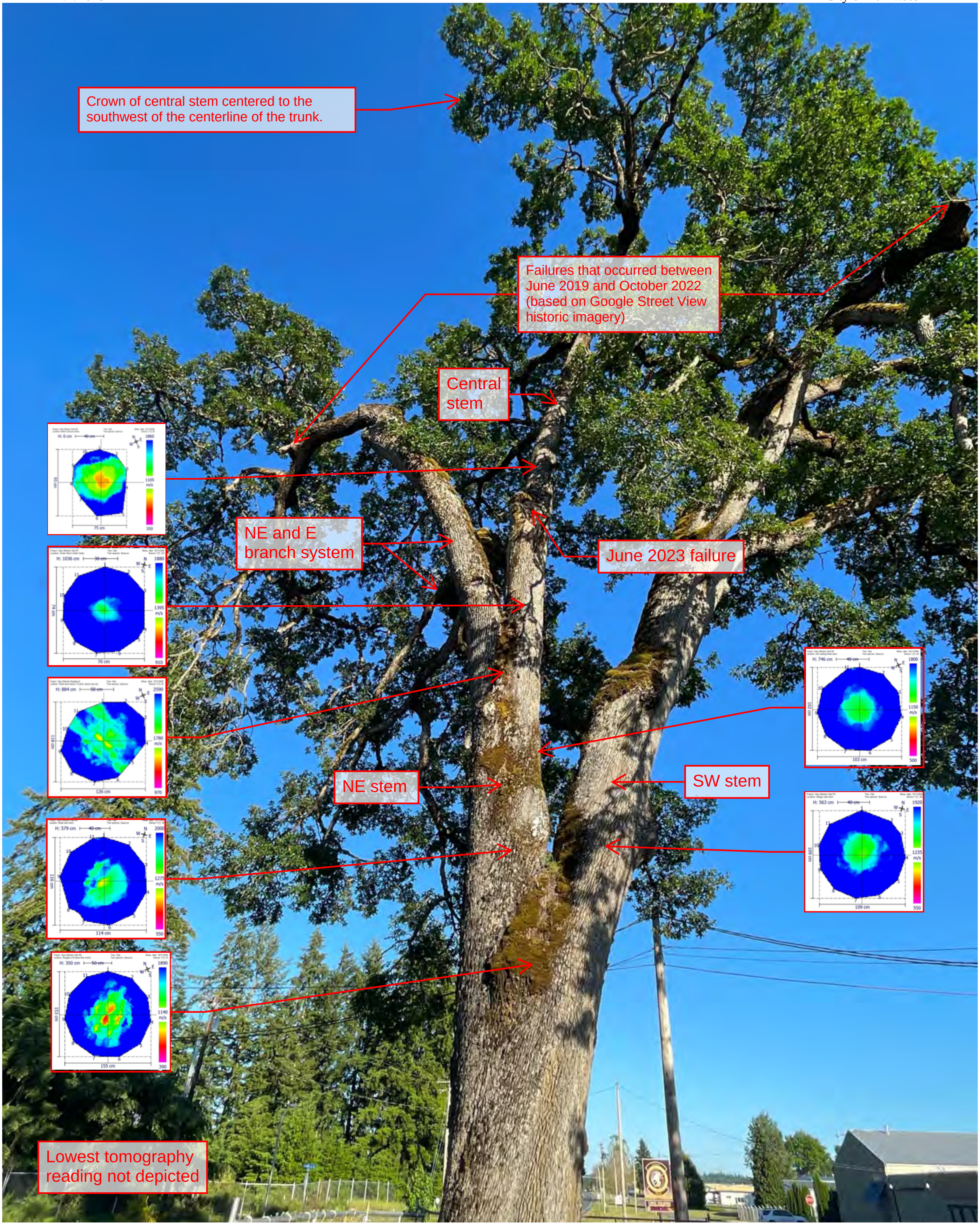
Norma

Percent of map unit: 2 percent
Landform: Depressions
Other vegetative classification: Wet Soils (G002XS101WA)
Hydric soil rating: Yes

Data Source Information

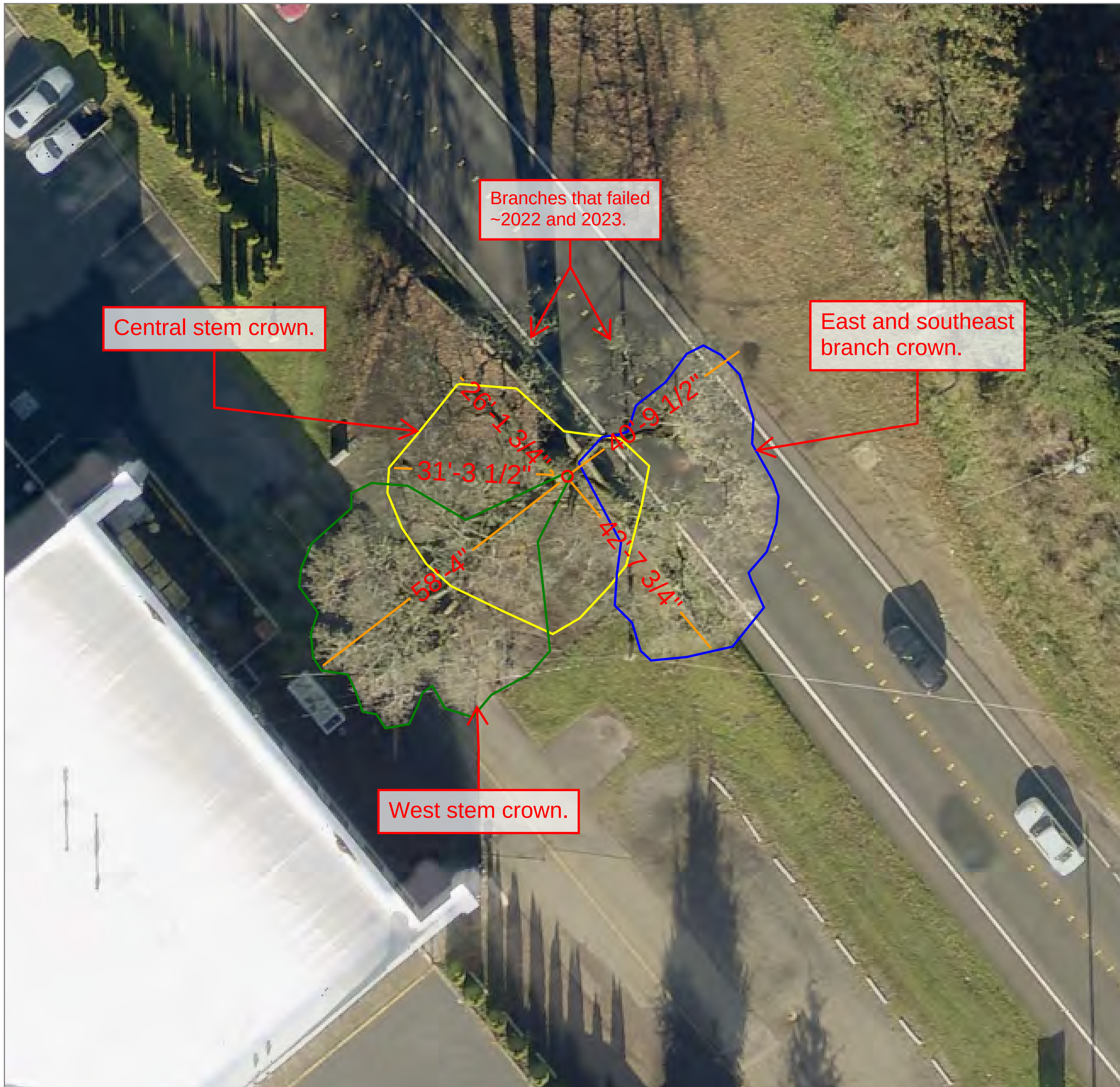
Soil Survey Area: Thurston County Area, Washington
Survey Area Data: Version 18, Aug 27, 2024

Attachment 3
Visual Summary of Sonic Tomography Report



Arrow locations are approximate. Refer to sonic tomography report for specific heights for each measurement. Orientation of images does not necessarily match orientation of tree in the photo.

Attachment 4
Aerial Photograph with Crown Map



Davis-Meeker Oak (2020)

Legend

Scale 1: 557

0 25 50
Feet

Map Created Using GeoData Public Website

Published: 10/16/2024

Note:

THURSTON COUNTY
WASHINGTON
SINCE 1852

Thurston County GeoData Center

NEW DAY ARBORIST

Arbotom Report: Sonic tomography using non-destructive stress-wave sensors.

Assumptions and Limiting Conditions

1. This report is in no way to be considered a complete hazard tree evaluation, nor does the consultant take any responsibility for the inactions of others in dealing with this matter.
2. Any legal description provided to the consultant is assumed to be correct.
3. It is assumed that this property is not in violation of any codes, statues, ordinances, or other governmental regulations other than those that may be identified in this report.
4. The consultant cannot be responsible for information gathered from others involved in various activities pertaining to this project. Care has been taken to obtain information from reliable sources.
5. The consultant cannot be responsible for work conducted by any other arborist, contractor or worker attempting to fulfill the requirements and/or specifications contained in this report.
6. Loss or alteration of any part of this report invalidates the entire report. Ownership of any document by the intended client shall only be valid after full payment for such document(s) has been received by New Day Arborist LLC.
7. The production of this report by New Day Arborist, LLC is a complete production in accordance to the scope of work requested by the client. Any additional tasks, including reproduction of report, phone consultation, production of additional documents, arbitration, deposition, testimony , or any other related service shall be billed at the standard rates for such services as determined by the current Fee Schedule of New Day Arborist, LLC, and will be the responsibility of the client.
8. Any and all claims, losses, expenses, injuries, or damages arising out of or any way related to this report or this agreement by reason or any act or omission, including breach of contract or negligence not amounting to a willful or intentional wrongdoing shall not exceed the total compensation received by New Day Arborist under this Agreement.

Arborist Disclosure Statement

Arborists are tree specialists who use their education, knowledge, training and experience to examine trees, recommend measures to enhance the beauty and health of trees, and attempt to reduce the risk of living, working and playing near trees. Clients may choose to accept or disregard the recommendations of the arborist, or to seek additional advice.

Arborists cannot detect every condition that could possibly lead to the structural failure of trees. Trees are living organisms that fail in ways that we do not fully understand. Conditions are often hidden within trees or below ground. Arborists cannot guarantee that a tree will be healthy or safe under all circumstances, or for a specified period of time. Likewise, remedial treatments, like any medicine, cannot be guaranteed. Even healthy trees with little to no observable defect or disease can begin to fail when wind speeds exceed average high annual wind speeds, and under snow and ice loads; such events cannot be managed or predicted.

Treatment, pruning and removal of trees may involve considerations beyond the scope of the arborist's services such as property boundaries, property ownership, site lines, disputes between neighbors, and other issues. Arborists cannot take such considerations into account unless complete and accurate information is disclosed to the arborist. An arborist should then be expected to reasonably rely upon the completeness and accuracy of the information provided.

The graphs in this report are based on tests using the Arbotom impulse tomograph. The Arbotom works on the principle of stress wave timing, which the software transfers into impulse velocities. Impulse velocities within wood are highly correlated with the density of the wood and can therefore be used to gain information on wood quality. Dense wood transmits stress waves better than wood that is damaged by decay or cracks. This wood will show as blue on the following graphs. Subsequently lower velocities through the wood correspond with yellow, red, and purple and indicate an area where there is decay, compromised wood, or an area where stress waves were required to travel around a crack. Cracks and fissures may show as lower velocities due to stress waves traveling around the crack (Stress waves take a longer path through the wood resulting in longer runtimes). This means that wood on either side of the crack may be sound, but reads as compromised due to longer travel times of stress waves resulting in lower velocities.

The following is an explanation of the strength loss in this report:

Stability of trees, and especially their strength, is not only affected by wood quality, but also by its geometrical form. Compared to a circular cross-section form, an elliptical cross-section can bear different loads, depending on the direction of force. You can compare this to a board which can bear a higher load on its narrow side than on its broad side.

Internal decay reduces the cross-sectional area of the trunk or branch, and therefore reduces the moment of resistance. If the decay reaches 50% of the radius, the resulting bending stress is hardly affected. At 30% residual wall thickness, the stress of the outer fibers will be raised by almost one third. At 10% residual wall thickness, the stress reaches 3 times the amount appearing in the sound trunk at the same load. In trees with non-circular cross-sections, the calculation becomes even more complex. It must be mentioned that we are talking here about relative changes only. The absolute bending stress can only be calculated if the bending moment, thus the amount and height of wind load is known. In the practice of tree assessment, the trunk form, as well as the precise form and location of decay must be known to evaluate the hazard safety.

(The ARBOTOM® Mechanic Graph is based on this concept. It enables the assessment and visual presentation of the relative moment of resistance for trees with any cross-sectional geometry. Decayed areas are taken into consideration as well as the different tension and compression strength of wood (the compression strength is half the tension strength of wood in average).

The ARBOTOM software presents the moment of resistance as a graph for all wind directions. The value at 0° corresponds to the wind from the opposite direction (180°). If the curve bends out at a certain position, the moment of resistance reaches its minimum at this point. The red indicates the precise direction:

- **Geometric moment Wg**: without consideration of internal decay and other damages shows as a green line
- **Weighted moment Ww**: with consideration of internal decay and other damages shows as a red line
- **Relation moment**: Residual moment of resistance (Ww/Wg), a measure for the remaining bending resistance of the trunk/branch under consideration. A reduction of values to the 50% line means that the tree has lost 50% of its ability to resist wind loads shows as a blue line.

The following report contains sonic tomography results on one Oak

Location:
7529 Old Hwy 99 SE
Tumwater, WA 98501

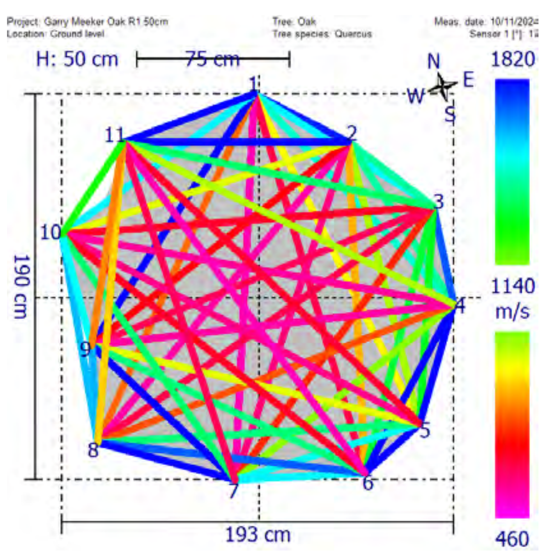
The following pictures and tests were taken on: 10.11.24

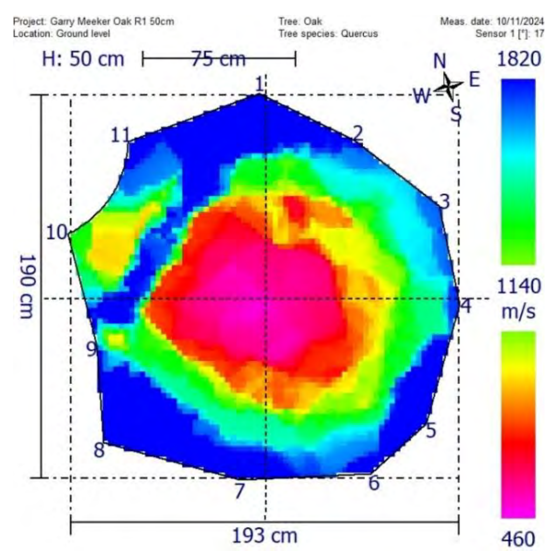
Table of Contents:

Color Codes Explained:

The colors in the graphs are directly related to the density of the wood, and the velocity that the sound is moving at that point. The higher the velocity, the more dense the wood is. The lower the velocity, the less dense the wood. Intermediate numbers indicate wood that is still holding wood, and structurally maintaining strength, but at a lower capacity than the highest

The lines on the left graph indicate the velocity between two sensors. The graph on the right extrapolates the line graph, and fills in the gaps. Sound is having to take a longer path around the red area to get from one sensor to another, and that decreases the velocity.

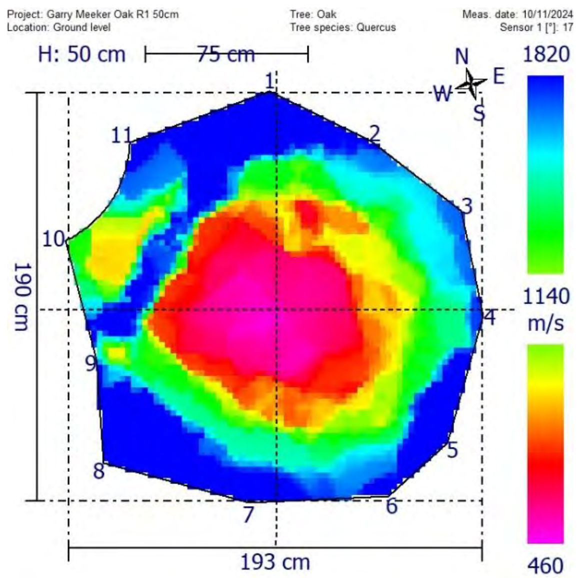




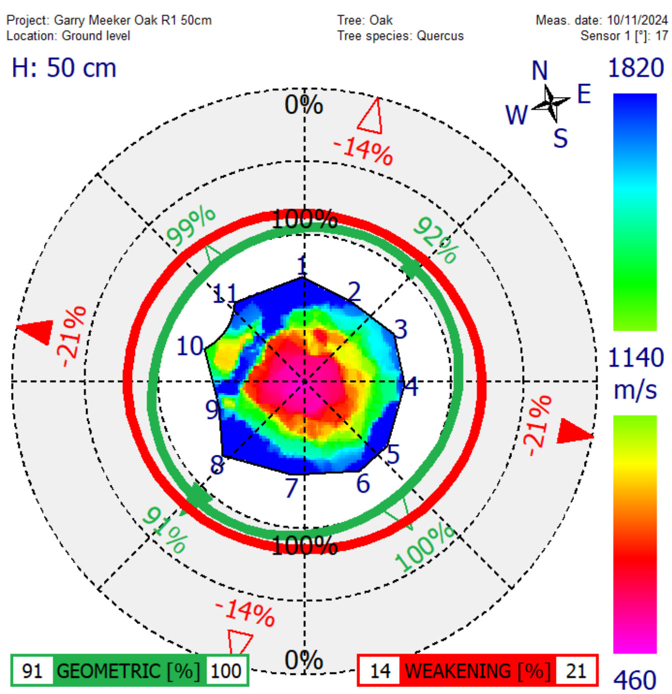
Oak – Reading 1- 50cm

Below are pictures and the resulting graphs of the first reading taken on this tree. Eleven sensors were used to take this reading. Sensor number one was placed on the north side of the tree. Sensors were placed in locations to best represent the shape of the tree.

Below are graphs of the tree at 50cm. These graphs show the cellular connectivity through the stem. The blue indicates a higher velocity of sound through the wood. Red indicates a lower velocity, which is related to less dense wood due to cracks or decay.



At this level there is significant compromised wood throughout the stem. The wood decay fungi that is affecting this tree has created a significant amount of compromised wood.

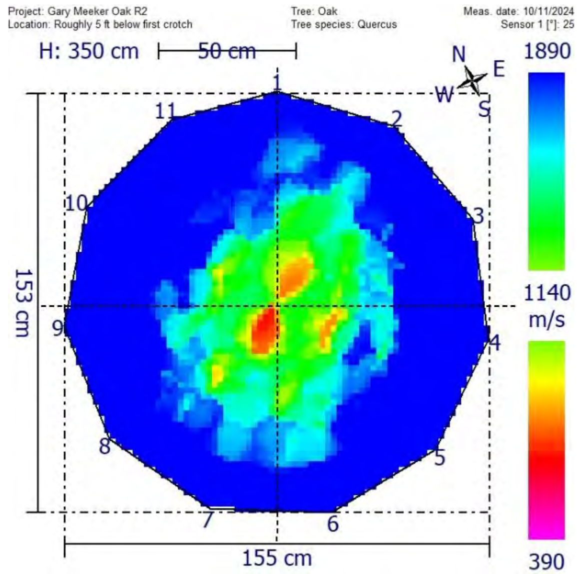


At this level there is between 14% and 21% strength loss depending on direction.

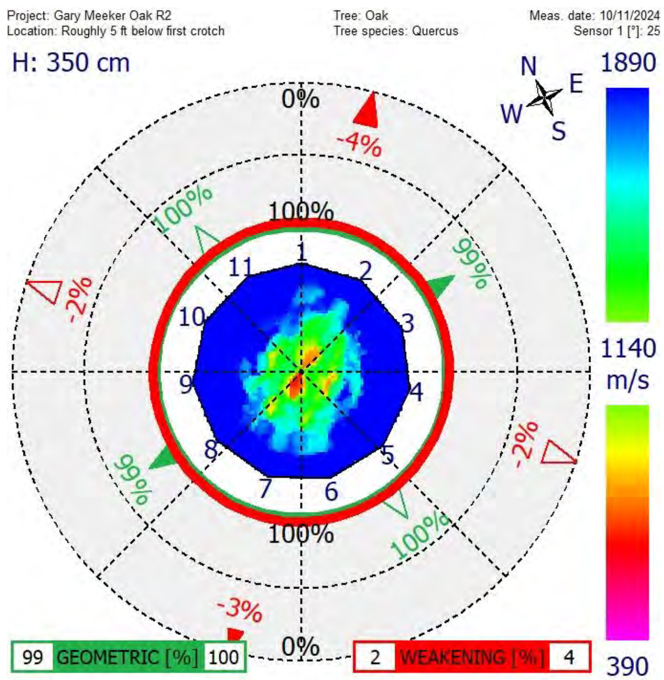
Oak – Reading 2- 350cm

Below are pictures and the resulting graphs of the second reading taken on this tree. Eleven sensors were used to take this reading. Sensor number one was placed on the north side of the tree. Sensors were placed in locations to best represent the shape of the tree. Reading two was taken below the first primary crotch.

Below are graphs of the tree at 350cm. These graphs show the cellular connectivity through the stem. The blue indicates a higher velocity of sound through the wood. Red indicates a lower velocity, which is related to less dense wood due to cracks or decay.



At this level there is a small amount of compromised wood in the center of the stem. The green indicates where the co-dominant inclusion is causing a weak attachment point.

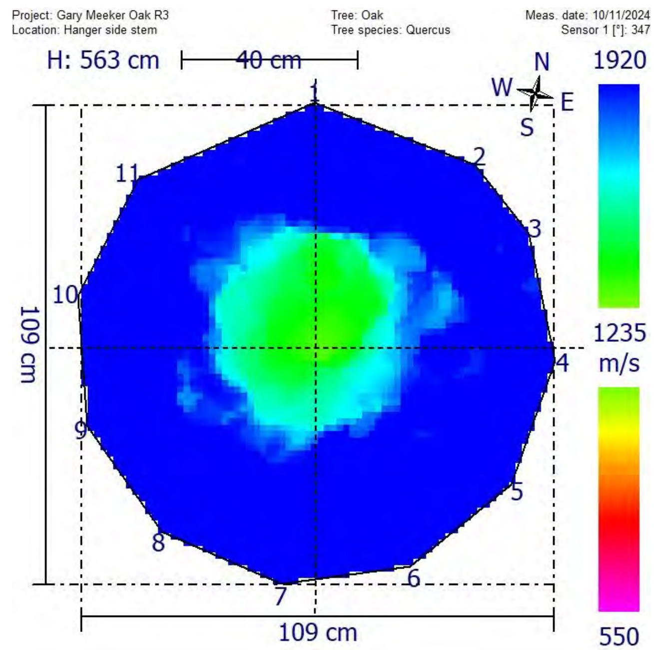


At this level there is between 2% and 4% strength loss. This is low strength loss.

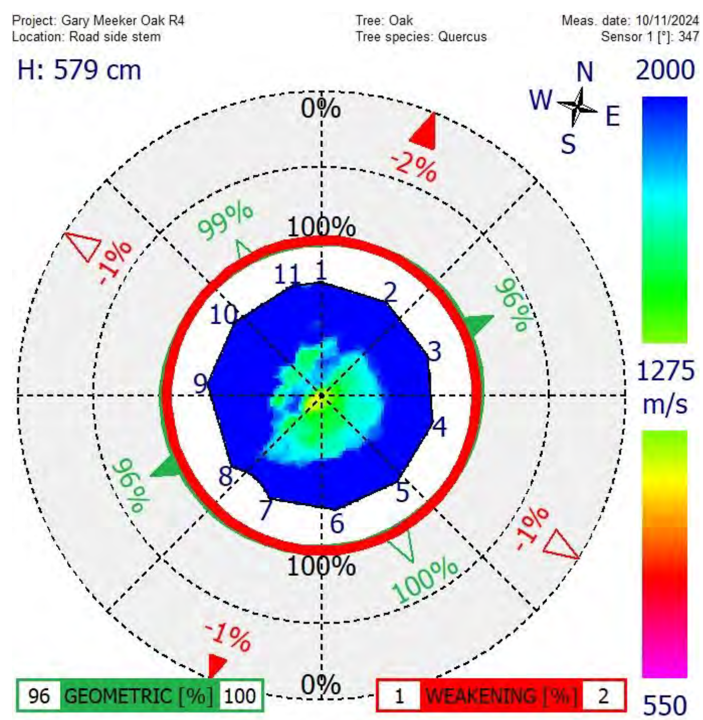
Oak – Reading 3- 563cm

Below are pictures and the resulting graphs of the third reading taken on this tree. Eleven sensors were used to take this reading. Sensor number one was placed on the north side of the tree. Sensors were placed in locations to best represent the shape of the tree. This reading was taken on the SW stem, just above the first crotch.

Below are graphs of the tree at 536cm. These graphs show the cellular connectivity through the stem. The blue indicates a higher velocity of sound through the wood. Red indicates a lower velocity, which is related to less dense wood due to cracks or decay.



At this level there is no sign of compromised wood.



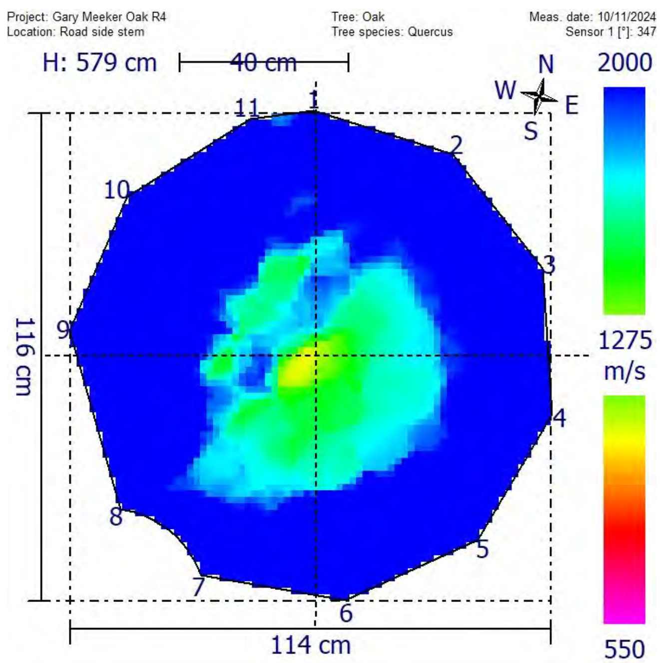
At this level there is between 1% and 2% strength loss. This is minimal strength loss.

Oak – Reading 4- 579cm

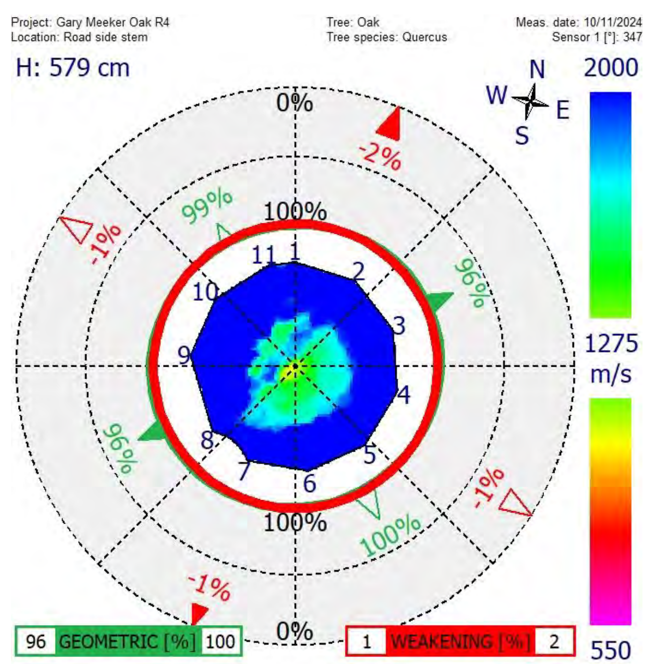
Below are pictures and the resulting graphs of the fourth reading taken on this tree. Eleven sensors were used to take this reading. Sensor number one was placed on the north side of the tree. Sensors were placed in locations to best represent the shape of the tree. This reading was taken on the northern stem roughly one foot above the crotch.

NEW DAY
ARBORIST

Below are graphs of the tree at 579cm. These graphs show the cellular connectivity through the stem. The blue indicates a higher velocity of sound through the wood. Red indicates a lower velocity, which is related to less dense wood due to cracks or decay.



At this level there is no sign of compromised wood.

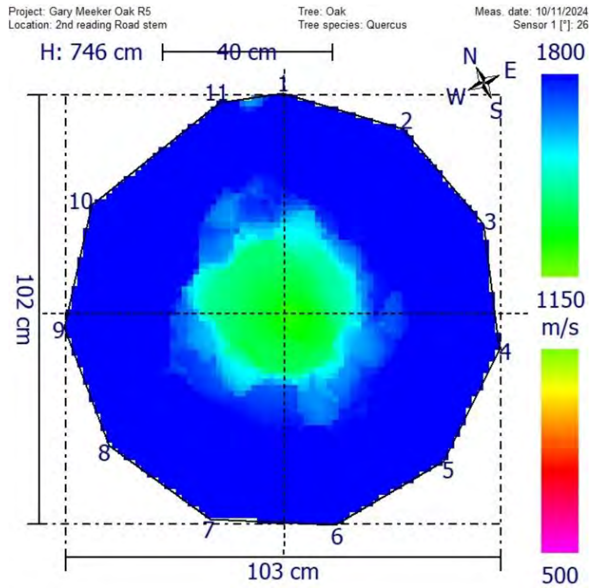


At this level there is between 1% and 2% strength loss. This is minimal strength loss.

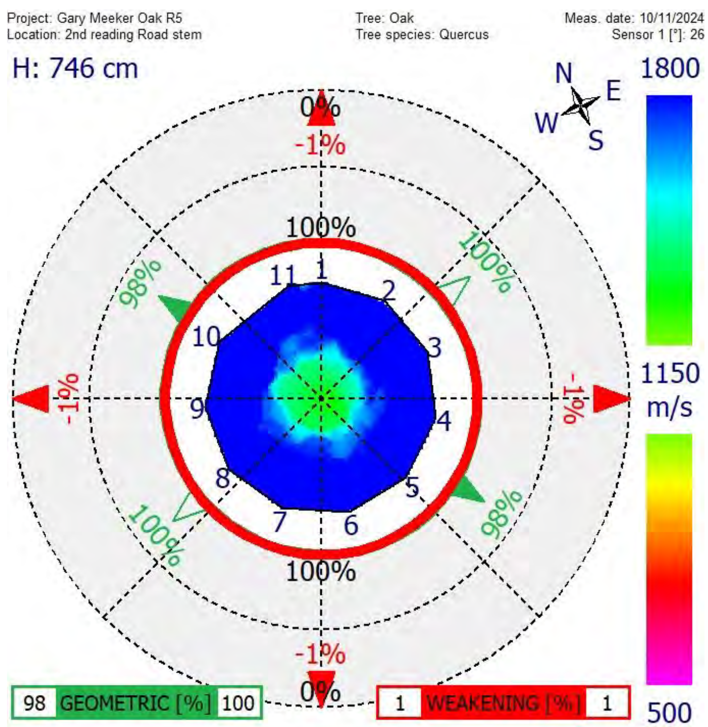
Oak – Reading 5- 746cm

Below are pictures and the resulting graphs of the fifth reading taken on this tree. Eleven sensors were used to take this reading. Sensor number one was placed on the north side of the tree. Sensors were placed in locations to best represent the shape of the tree. This reading was taken on the northern stem placed just below the tear out on the NE side.

Below are graphs of the tree at 746cm. These graphs show the cellular connectivity through the stem. The blue indicates a higher velocity of sound through the wood. Red indicates a lower velocity, which is related to less dense wood due to cracks or decay.



At this level there are no signs of compromised wood.

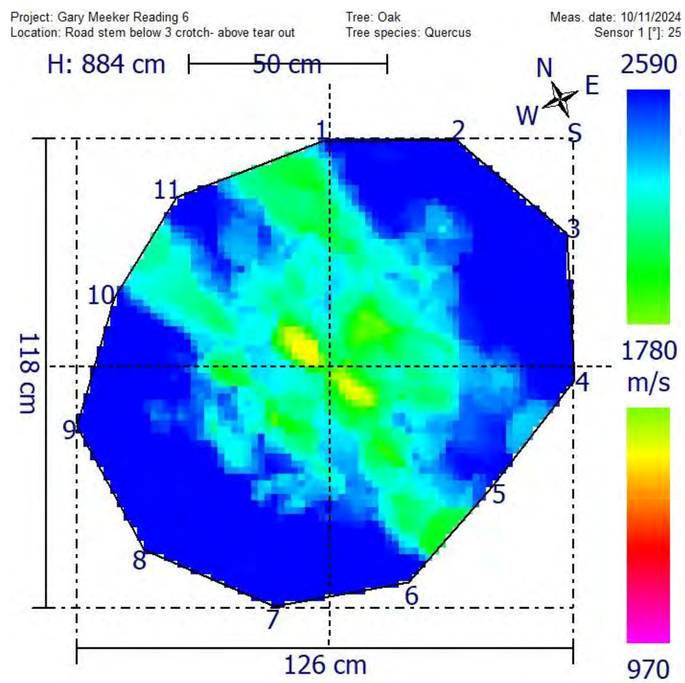


At this level there is less than 2% strength loss. This is minimal strength loss.

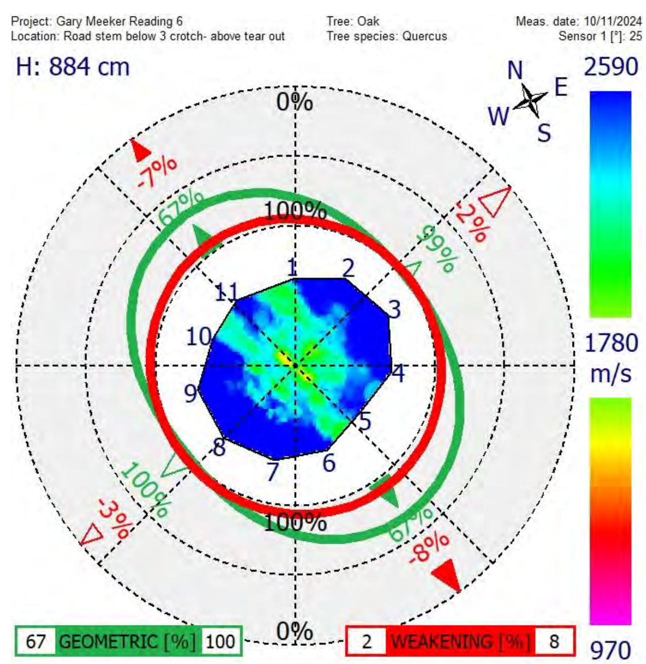
Oak – Reading 6- 884cm

Below are pictures and the resulting graphs of the sixth reading taken on this tree. Eleven sensors were used to take this reading. Sensor number one was placed on the north side of the tree. Sensors were placed in locations to best represent the shape of the tree. This reading was taken below the second crotch on the northern leader, just above the tear out on the NE side.

Below are graphs of the tree at 884cm. These graphs show the cellular connectivity through the stem. The blue indicates a higher velocity of sound through the wood. Red indicates a lower velocity, which is related to less dense wood due to cracks or decay.



At this level there is included bark throughout the center of the stem, where the three stems connect.



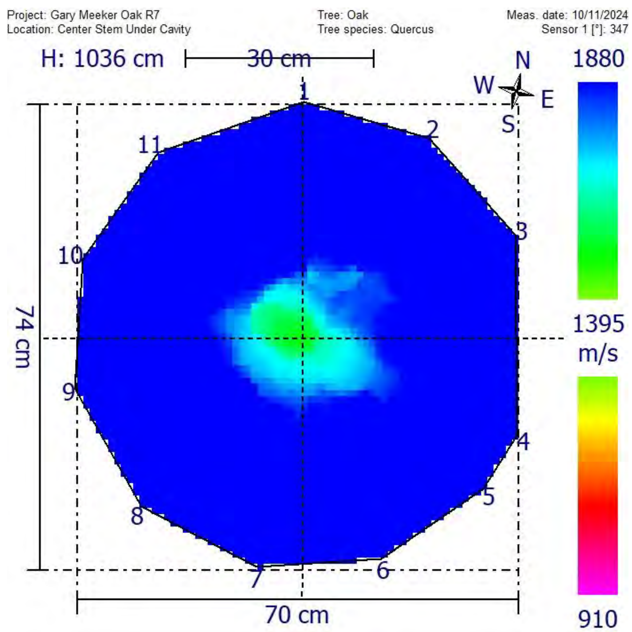
At this level there is between 2% and 8% strength loss. This is minimal strength loss.

NEW DAY
ARBORIST

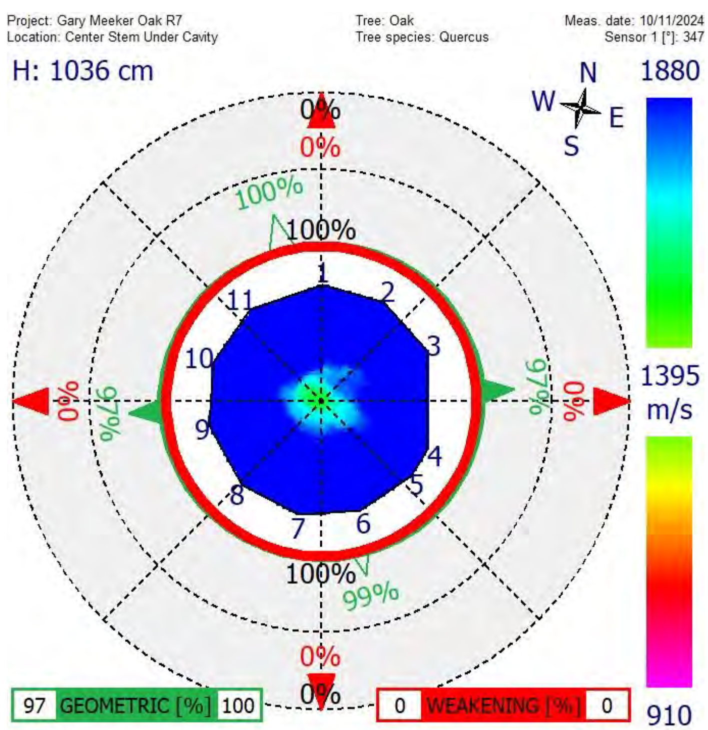
Oak – Reading 7- 1036cm

Below are pictures and the resulting graphs of the seventh reading taken on this tree. Eleven sensors were used to take this reading. Sensor number one was placed on the north side of the tree. Sensors were placed in locations to best represent the shape of the tree. This reading was taken on the northern stem, just above the 3 stemmed crotch.

Below are graphs of the tree at 1036cm. These graphs show the cellular connectivity through the stem. The blue indicates a higher velocity of sound through the wood. Red indicates a lower velocity, which is related to less dense wood due to cracks or decay.



At this level there is no sign of compromised wood.

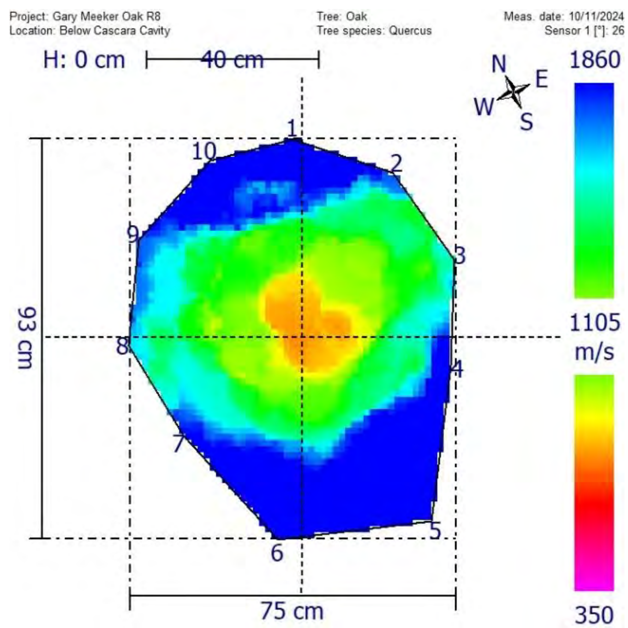


At this level there is no strength loss.

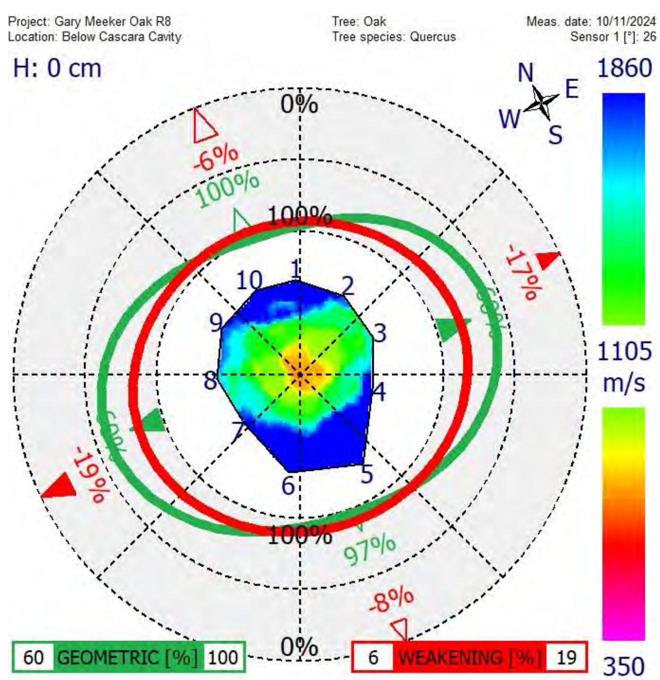
Oak – Reading 8- 1381cm

Below are pictures and the resulting graphs of the eighth reading taken on this tree. Eleven sensors were used to take this reading. Sensor number one was placed on the north side of the tree. Sensors were placed in locations to best represent the shape of the tree. This reading was taken on the northern stem, just below the topmost tear out.

Below are graphs of the tree at 1381cm. These graphs show the cellular connectivity through the stem. The blue indicates a higher velocity of sound through the wood. Red indicates a lower velocity, which is related to less dense wood due to cracks or decay.



At this level there is less dense wood in the center of the stem. The center yellow spot indicates where the cavity above extends too.



At this level there is between 6% and 19% strength loss. This is minimal strength loss.

NEW DAY
ARBORIST

Discussion

This tree was tested at eight different levels to try and focus on the weakest possible locations. Reading number one is the only location with substantial compromised wood.

Please let me know if you have any questions regarding the results of this report.

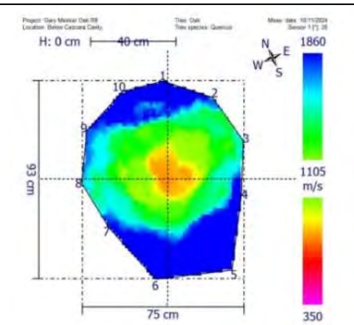
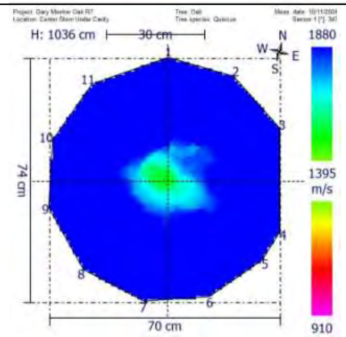
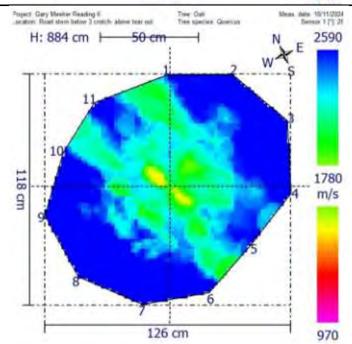
Thank you.

Garrett Day
360.980.1536
Garrett@newdayarborist.com
ISA Certified Arborist PN-8037A
ISA Tree Risk Assessment Qualified
WA Contractors Lic: NEWDADA871PP
Or CCB: #201733

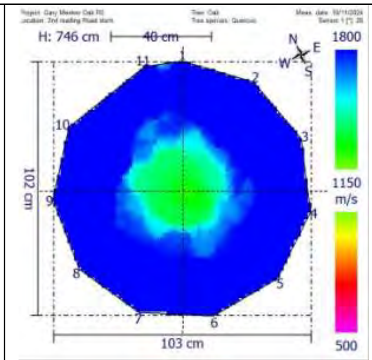
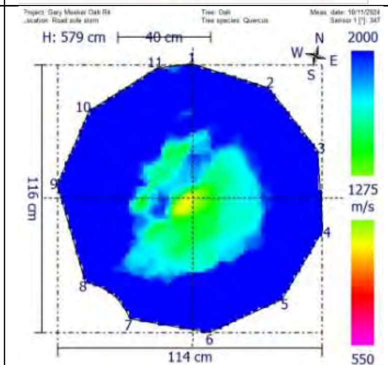
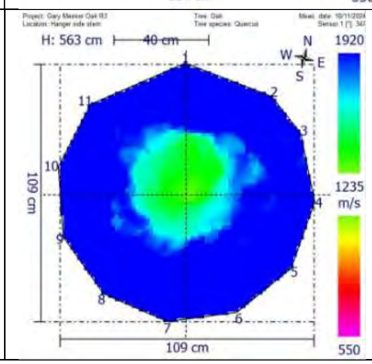
NEW DAY ARBORIST

Attachment 6

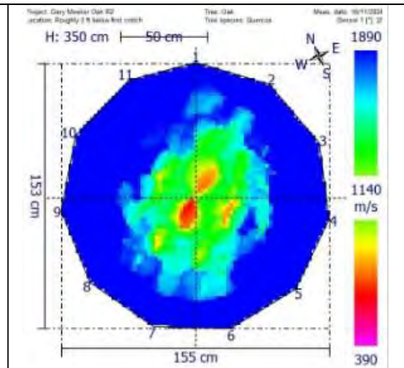
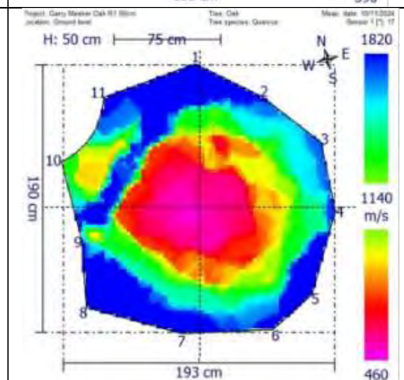
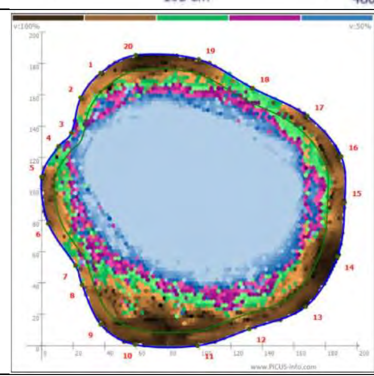
Table of Sonic Tomography Readings and Comparison to Tree Solutions

Reading No.	Height	Location Description	Tomography Reading	Narrative Results
8	1381 cm/ 45.3 ft	Stem 1, below kestrel nest, above 2023 failure		At this level there is less dense wood in the center of the stem. The center yellow spot indicates where the cavity above extends too. At this level there is between 6% and 19% strength loss. This is minimal strength loss.
7	1036 cm/ 33 ft	Stem 1, above 2nd codominant stem.		At this level there is no sign of compromised wood. At this level there is no strength loss.
6	884 cm/ 29 ft	Stem 1, below 2nd codominant union, above SE branch failure (Jan. 2012)		At this level there is likely included bark within the center of the stem, where the codominant stems connect. At this level there is between 2% and 8% strength loss. This is minimal strength loss.

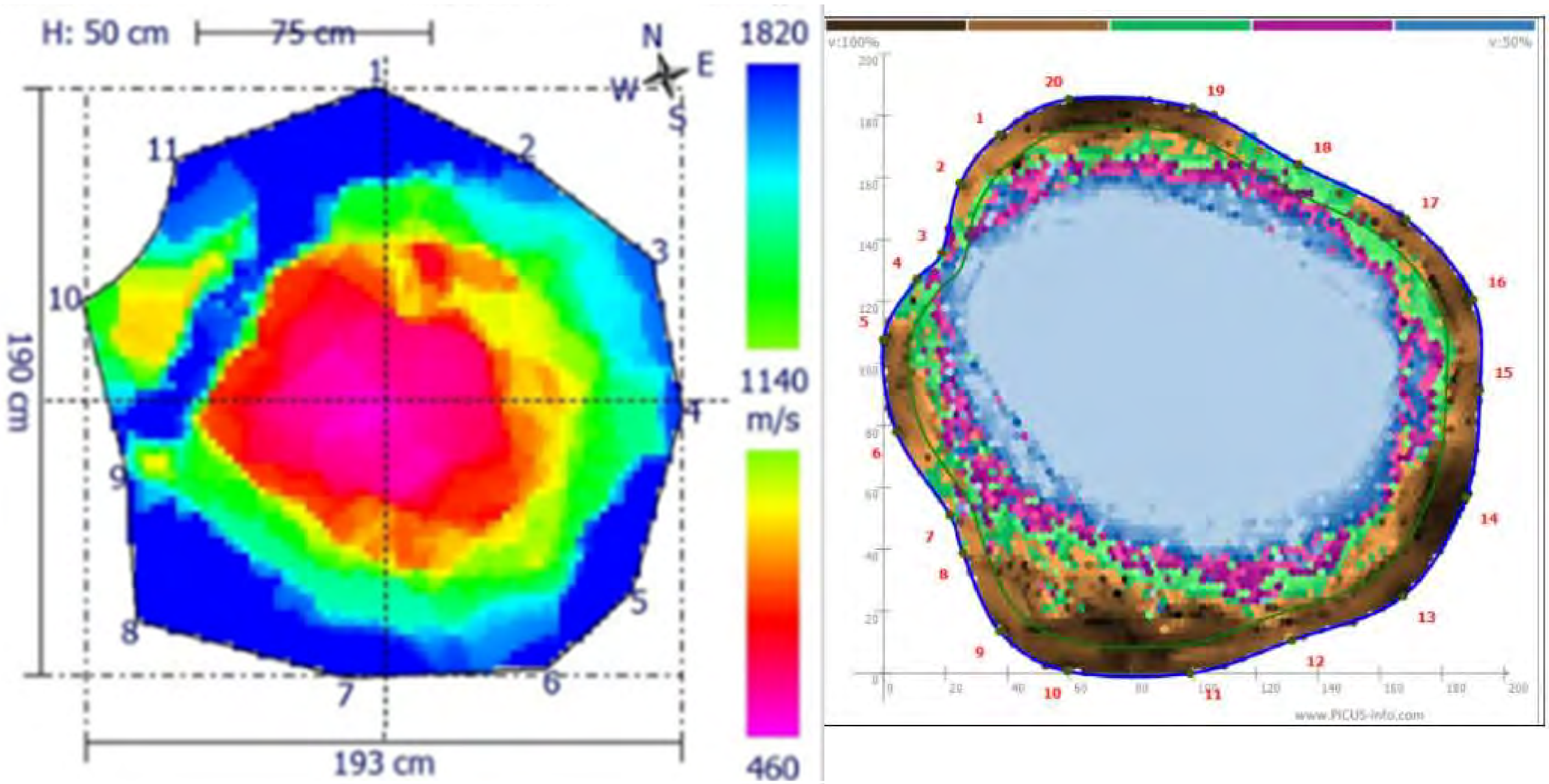
Attachment 6
Table of Sonic Tomography Readings and Comparison to Tree Solutions

5	746 cm/ 24.5 ft	Stem 1, below SE branch failure (Jan. 2012)		At this level there are no signs of compromised wood. At this level there is less than 2% strength loss. This is minimal strength loss.
4	579 cm/ 19 ft	Stem 1, above 1st codominant union.		At this level there is no sign of compromised wood. At this level there is between 1% and 2% strength loss. This is minimal strength loss.
3	563 cm/ 18.5 ft	Stem 2, above 1st codominant union.		At this level there is no sign of compromised wood. At this level there is between 1% and 2% strength loss. This is minimal strength loss.

Attachment 6
Table of Sonic Tomography Readings and Comparison to Tree Solutions

2	350 cm/ 11.5 ft	Main stem below codominant union.		At this level there is a small amount of compromised wood in the center of the stem. The green indicates where the co-dominant inclusion is potentially reducing the strength of the attachment point. At this level there is between 2% and 4% strength loss. This is low strength loss.
1	50 cm/ 1.6 ft	Main stem near ground level.		At this level there is significant compromised wood throughout the stem. A wood decay fungi has created a significant amount of compromised wood and hollow trunk. At this level there is between 14% and 21% strength loss depending on direction.
1	50 cm/ 1.6 ft	Main stem near ground level.		Tree Solutions sonic tomography reading. Conclusion was that there is sufficient wood to support existing tree. The sonic tomography strength limit appears to have been set at approximately 80 percent hollow, or approximately 4-inches (10 cm) of sound wood based on the tree's diameter at the measurement point.

Attachment 6
Table of Sonic Tomography Readings and Comparison to Tree Solutions



Side-by-side comparison of the 2024 sonic tomography reading using the Arbotom® system and the 2023 sonic tomography using the PiCUS system

1 Think Safety Factor, not Strength Loss

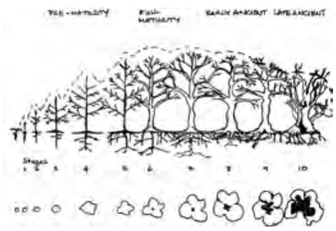
What is a tree's Safety Factor?

1 A tree's Safety Factor (SF) is a measure of its strength for a known wind load. A SF of 2 means the tree is x2 stronger than it needs to be.

2 Advanced Assessments on these trees calculate their SFs at 1.0m above ground. The early mature tree (left) is 17m high with a stem diameter of 60cm. It has a Height/Diameter (H/D) ratio of 28, and a Basic Safety Factor (BSF) of 2. The late mature tree (right) is 20m high with a stem diameter of 120cm. It has an H/D ratio of 17, and a BSF of 10. Your clue the late mature tree has a much higher BSF than the early mature tree is it has a much lower H/D ratio.

3 Our early mature tree has no decay. It's lost no strength. So, the Residual Safety Factor (RSF) 2 is the same as its BSF 2. Our late mature tree has extensive decay, is 80% hollow, with an open cavity. It's lost 60% of its strength. This tree has a BSF of 10, and a RSF of 4 (60% loss = 10 to 4). Even though the late mature tree has lost 60% of its strength from decay. With a RSF of 4, it's twice as strong as the early mature tree (RSF 2) with no decay. Which tree most concerns an Arborist?

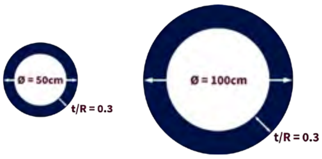
1.1 Investing in Basic Safety Factor



4 A tree's BSF changes during its life. Once a tree gets to its mature phase, crown height and spread don't change significantly. So, there's little change in wind load. Meanwhile, the stem diameter and BSF increase as the tree grows older. A tree with a high BSF can afford a lot of strength loss from decay. With **VALID**, when you carry out a Detailed Assessment on a late mature tree, that hosts significant decay, and has a low H/D ratio. You'd colour **A for Anatomy** 'green' in your Likelihood of Failure decision. As well as being green, A for Anatomy usually has the greatest influence on **Likelihood of Failure**, and is your 'base rate' colour.

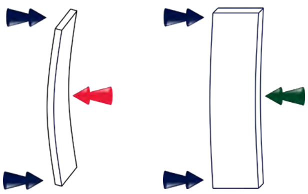
1.2 Section Modulus - why it's so important

Which stem is stiffer and stronger?



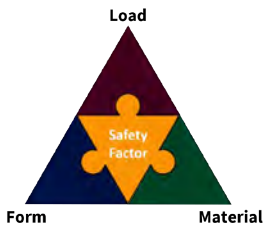
5 Section modulus is a geometric measure of the stiffness and strength of a tree's stem cross-section when bent by a wind load. The stems on the left are the same species (same material properties) and have the same crown size (same wind load). With a residual wall thickness (t) that's 30% of the stem radius (R), they have a t/R ratio of 0.3. Both stems are 50% hollow. Because of its section modulus value, the 100cm diameter stem is much stiffer and stronger. It can carry x8 more load in bending than the 50cm stem, even though they have the same t/R ratio.

Bend a ruler to see how it works



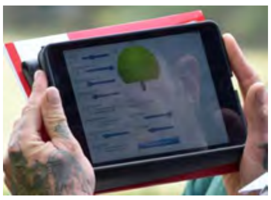
6 Bending a wooden ruler shows you how section modulus works. As the distance between the neutral axis, at the centre, to the ruler's edge increases it enjoys an increasing mechanical advantage. The further material is from the neutral axis, the more load it can carry in compression. When you put the ruler under a bending load, it's much stiffer and stronger face-on (right), than edge-on (left). The material properties are the same. The load is the same. The only difference is the geometry, and its section modulus. For the same reason, the outermost wood in a tree is the most important for its load bearing stiffness and strength.

1.3 Statics & residual wall thickness



7 Statics applies engineering principles to measure a tree's Safety Factor. We've illustrated the Statics Triangle as a puzzle on the left. When we assess t/R ratios, or residual wall thickness with tomograms or micro-drills, we're only looking at one part of the 'Form' in the puzzle. We're missing the geometric properties of shape and absolute diameter parts of the Form. The Load and Material property parts of the puzzle are completely missing. What this means is you can't make a credible decision about a tree's likelihood of failure, or the risk, based on the residual wall thickness from tomograms or micro-drills alone.

1.4 TreeCalc



8 If you have a tree with decay and significant strength loss. **TreeCalc** helps you work out your Tree's BSF. From there, you can model how hollow the tree needs to be before its RSF gets too low. If the RSF is too low, TreeCalc shows you how much height you need to reduce the tree by. When you use TreeCalc, don't forget the limits of the model. Material properties are uniform. The Geometry of the stem and hollowing is circular. Failure is in compression, and not cross-sectional flattening or cracking. Only use TreeCalc to assess how decay affects the RSF.

Acknowledgements
Many thanks to Paul Muir and Claire Harbinson at Treework Environmental Practice, and the Baumstatik Group
They're the lead contributors to this handout from 'Likelihood of Failure' seminars we ran with them

TreeCalc
Safe trees online

Evaluation Protocol

Todd Prager and Associates
Rick Till
4106 SE 66th Ave.
97206 Portland
United States

5037506599
http://www.toddprager.com

ricktill@gmail.com, rick@toddprager.com

31.12.2024

Basic data

TreeNr.:	Davis-Meeker Oak	GPS latitude: 46.9780294
Inspector:	Rick Till	
Country:	United States	
City:	Tumwater, Washington	GPS longitude: -122.8989867
Street:	.	

Input parameters

Tree species (bot.): Quercus alba
Tree species: Oak, white

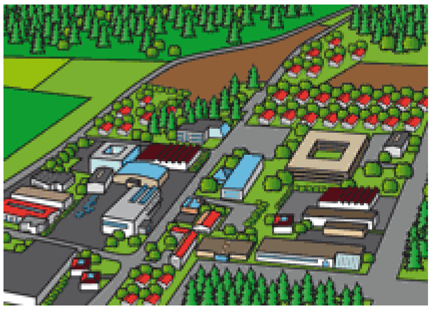
Height [ft]: 85
Stem Ø1 DBH (par.) [in]: 66
Stem Ø2 DBH (perp.) [in]: 66
Bark thickness DBH [in]: 0
Crown width [ft]: 80
Crown base [ft]: 27

Aerodyn. drag factor: 0.25
Recommendation acc. to estimated assumptions
Comp. strength [psi]: 3582.4
Recommendation acc. to Jessome 1977
Mean wind speed [mph]: 50.3

Map

Terrain category

Suburb

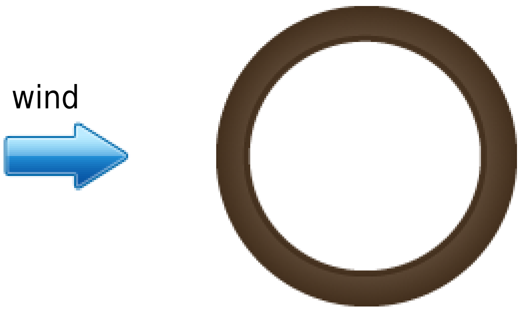


Results

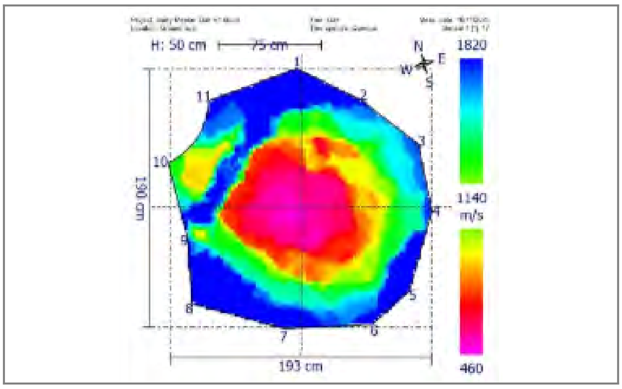
Basic safety:	11.16
Desired factor of safety:	1.5

Influence of stem geometry

closed - 20% remaining



Stem safety factor: 6.27



Summary

Basic safety:	11.16
Desired factor of safety:	1.5
Stem safety factor:	6.27

Portland, 31.12.2024

Rick Till

TreeCalc
Safe trees online

Evaluation Protocol

Todd Prager and Associates
Rick Till
4106 SE 66th Ave.
97206 Portland
United States

5037506599
http://www.toddprager.com

ricktill@gmail.com, rick@toddprager.com

31.12.2024

Basic data

TreeNr.:	Davis-Meeker Oak	GPS latitude: 46.9780294
Inspector:	Rick Till	
Country:	United States	
City:	Tumwater, Washington	GPS longitude: -122.8989867
Street:		

Input parameters

Tree species (bot.): Quercus alba
Tree species: Oak, white

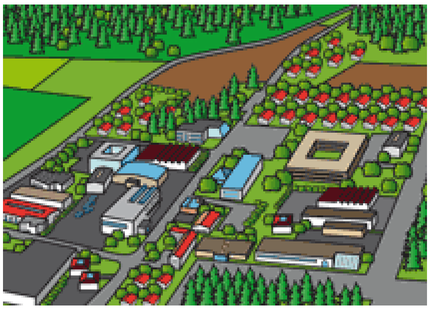
Height [ft]: 85
Stem Ø1 DBH (par.) [in]: 66
Stem Ø2 DBH (perp.) [in]: 66
Bark thickness DBH [in]: 0
Crown width [ft]: 80
Crown base [ft]: 27

Aerodyn. drag factor: 0.25
Recommendation acc. to estimated assumptions
Comp. strength [psi]: 3582.4
Recommendation acc. to Jessome 1977
Mean wind speed [mph]: 50.3

Map

Terrain category

Suburb



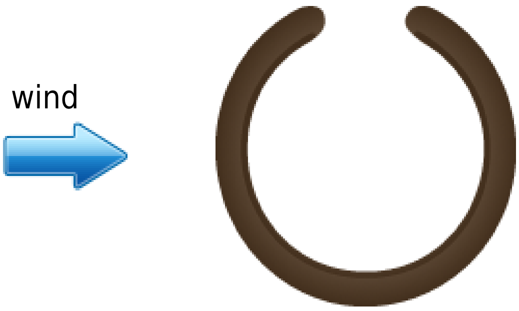
Results

Basic safety:	11.16
Desired factor of safety:	1.5

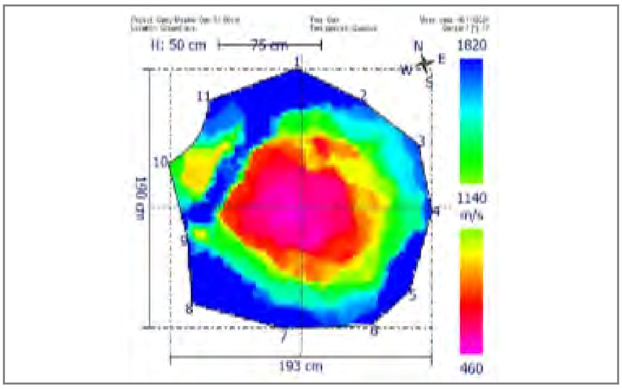
Influence of stem geometry

10% opening - 20% remaining

wind



Stem safety factor: 6.27



Summary

Basic safety:	11.16
Desired factor of safety:	1.5
Stem safety factor:	6.27

Portland, 31.12.2024

Rick Till

Attachment
TreeCalc Glossary

Aerodynamic Drag Factor:
The Cd value denotes a tree crown's air resistance. This value depends essentially on foliage and branch density, but also on the flexibility of the boughs and branches. For example: trees with a large proportion of long, thin branches and looser foliage (e.g. birch) tend to be less wind resistant than trees with dense foliage and thicker, more rigid branches on the outer edges of the crown (e.g. horse chestnut). The aerodynamic drag of trees lies between 0.35 for a rigid, completely obstructive crown, and 0.1 for a pervious, flexible crown in winter.[1]

Average Wind Speed:
The average wind speed given is measured 10 metres above ground as the mean value recorded during a period of 10 minutes. However, depending on the roughness of the terrain, sometimes much stronger gusts can occur during this interval. The tree has to be able to withstand this stress. TreeCalc applies the principles of Eurocode 1 to calculate the speed pressure that gusts exert on trees. The calculation takes into consideration both the increase in average wind speed with height, and the stronger development of turbulence closer to the ground.

A wind speed of 22.5 m/s is typical of a storm, during which the wind can quickly reach a speed of 117 km/h at 10 metres above ground on open terrain (level 12 on the Beaufort wind force scale). This is the wind speed on which tree-statics calculations are frequently based. If higher wind speeds are set, it results in a disproportionate effect on the safety factors. Wind speeds that are exceeded at a location merely by a certain residual probability can often be found in the wind zone maps in national building standards. (e.g. DIN EN 1991-4-1/NA:2010-12).

---

[1] Recommendation according to estimated assumptions [from]:
Brudi, E. & van Wassenaer, P. (2002): Trees and statics: nondestructive failure analysis. In Smiley, E. T, & Coder, Kim (Hrsg.) 2002. Tree structure and mechanics conference proceedings. Champaign Il DIN EN 1991-4-1/NA:2010-12
Horácek, P. (unpub.) Mechanical Properties of Wood of Norway Maple and White Eastern Pine
Jessome, A.P. (1977). Strength and Related Properties of Woods Grown in Canada, Forestry Technical Report. Eastern Forest Poducts Laboratory, Ottawa 37 S.
Koizumi, A. & Hirai, T. (2006): Evaluation of section modulus for tree-stem cross sections of irregular shape. In: Journal of Wood Science 52 (3).
Kretschmann, D. (2010) Chapter 5: Mechanical Properties of Wood. In: USDA Forest Service (Hrsg.): Wood Handbook. General Technical Report FPL–GTR–190.
Lavers, G. M. (1983). The strength properties of timber. 3rd edition. Building Research Establishment Report, Watford, UK 60 S.
Niklas, Karl J, & Spatz, H.-Ch. (2010): Worldwide correlations of mechanical properties and green wood density. American Journal of Botany 97 (10): 1587–1594.
Spatz, H.-Ch. (1994): Ein Kommentar zur mechanischen Stabilität hohler Bäume. Das Gartenamt (2): 92—95.
Spatz, H.-Ch. (2013): Zur Stabilität hohler Bäume. In: Deutsche Akademie für Sachverständige Grün (Hrsg.): Tagungsband Gehölzsymposium 2013 Hannover. 224-232
Wessolly, L. & Erb, M. (2016): Handbuch der Baumstatik + Baumkontrolle. Berlin: Patzer.

Attachment
TreeCalc Glossary

Basic Safety:
Basic static safety is defined according to two factors:

One factor is the level of resistance that a tree can offer against a bending force without exceeding the point of primary failure. This load limit with regard to bending is calculated using the diameter of the stem and the extent of cavities in it, as well as the characteristics of the stem's green wood (elasticity limit).

The other factor to be considered is wind pressure on the crown. This is calculated in accordance with the principles of Eurocode 1 (EN 1991-4-1), by examining wind profile, air density, the cd [crown density] value of the crown, and the roughness of the surrounding terrain. If a tree's load capacity exceeds the specified wind load by the required safety factor, it can be categorized as sufficiently safe. If the wind pressure is greater than the load capacity of the stem, i.e. the tree's basic static safety value is less than 1, then it must be assumed that the tree is at risk of failing when subjected to a storm gusts.

However, it must be taken into consideration that the wind-load situation cannot, in some cases, be estimated appropriately with the approximation method on which TreeCalc is based. Therefore, before any decision is made to fell a tree, an experienced tree expert should carry out a thorough inspection of the tree or a detailed analysis using more sophisticated software (e.g. arbostat [static pull test]).

Compression Strength (psi):
Two breaking points have been defined in stress tests for wood: 1. the limit of elasticity, and 2. the final break. If, after stress has been applied, the object of the test cannot resume its former shape and remains deformed, but without having broken completely, then it has exceeded its limit of elasticity (primary failure). If an already overflexed object is subjected to further stress, final breakage will occur, with the wood fibres tearing or doubling over. In Central Europe, the compressive strength of green wood ranges between 10 and 35 MPa (Wessolly/Lavers).

Compared to dry wood, green wood can absorb more energy because of its greater flexibility; its behaviour, when stress is applied, is "better natured".

Please note:

- should material properties be missing from the list: the lime exhibits the characteristics of an "average tree" and can be used for the purpose of estimation. The safety factor needs to be adjusted for the appropriate uncertainties.
- all safety calculations in TreeCalc refer to the primary failure of a tree stem subjected to bending, i.e. the limit of the green wood's elasticity. The material values provided have been taken from catalogue publications (Jessome 1977, Lavers 1983, Wessolly & Erb 2016, Niklas & Spatz 2010, USDA Wood Handbook 2010).

Attachment
TreeCalc Glossary

Cross Section
Examples of cross sections illustrate the influence that different degrees of cavity and opening can have on a stem's load capacity. In accordance with suggestions made in literature (Koizumi & Hirai 2006) the geometric shape has been used to conclude reductions in load capacity. However, these are simplified assumptions that have been made on the basis of a mostly even, elliptical cross section with respect to uniaxial bending. Furthermore, both the effects of torsion and the deviations arising from unsymmetrical bending have been neglected; these are factors that can be of substantial importance, especially in cases of one-sided openings or irregularly shaped cross sections. For this reason it is necessary that sufficiently high safety factors be reached for the derived breaking safety of a stem.

Crown Adjustments:
The crown's shape can be adjusted on the basis of measurements of the crown's diameter vertical to the orientation of load and of the stem base. This can also be done in situ using the true-to-scale representation of the proportions shown in the graphic. The "Restore" function (top left) retrieves the original proportions of the standard shape.

The selection of a highly positioned crown base or an especially narrow crown can create structures which are extremely susceptible to oscillation (swaying). The risk of wind-induced oscillation is not displayed in TreeCalc to the same degree as it would be in more complex analytical software (e.g. ArboStat). Since highly positioned crowns are found mainly in older trees often located in tree stands anyway, the results of this type of calculation should always be examined separately.

Crown Base:
The crown base is the section at which the crown, which absorbs the greatest amount of wind energy, meets the load-absorbing part of the stem. The higher up a tree the crown base is, the higher the load centre becomes, and subsequently the greater is the entire tree's inclination to sway. The height of the crown base can be measured using a hypsometer.
It is important to note that trees with a very high crown base have a strong inclination to sway. In cases such as these, software should be used that is able – in contrast to TreeCalc – to mathematically simulate dynamic effects in trees (e.g. ArboStat).

Crown Shape:
TreeCalc provides a basic selection of typical crown shapes. They represent an approximation of the tree crown's true shape. Free forms, asymmetrical growths and irregular outlines can only be captured using complex specialist software designed for wind-load analysis (e.g. ArboStat).

Crown Width:
The broader the crown, the greater the resistance it can put up during a storm. The crown width is the distance measured from one edge of the crown to the other. The maximum crown width that can be entered into TreeCalc is 30 metres.

Attachment
TreeCalc Glossary

Desired Safety Factor
The safety factor denotes how much higher the breaking point of a tree actually is than what it is supposed to be according to a theoretical calculation based on, for example, wind load analysis and statics.

The safety factor can be defined as follows:

SF = permissible load / expected maximum load

A safety factor of 1 means that the tree has no safety reserves whatsoever on which it can draw. Analyses carried out using tree statics usually employ a safety factor of 1.5. This comparatively low safety margin is only sufficient because trees, unlike technical structures, can maintain and even increase their load-bearing reserves via annual growth increments over a long period of time. The length of time for which, for example, damage done by wood-colonizing fungus can be compensated is part of the biological assessment of the tree. If useful and target-oriented assessments are to be made with regard to traffic safety, then it is essential that experienced tree experts combine calculated safety factors with the results of their visual and biological assessments of the tree.

Height:
The tree's height needs to be measured as accurately as possible. The higher a tree grows, the higher is its load centre. The section between the load centre and the ground is the structurally effective lever arm which causes a bending moment on the stem base during a storm. The upper crown regions of tall trees are exposed to higher wind speeds, resulting in higher wind pressure. Wind speed increases disproportionately with the height of the tree, so an incorrect measurement can lead to vastly different results. Experience has shown that the most reliable results arise from measurements taken at a distance of 1.5 times the height of the tree.

Peak Wind Speed:
Storm events are described on the one hand by the mean wind speed and on the other hand by the speed of a peak gust. The most significant damaging events are usually caused by these peak gusts. Therefore, the severity of a storm is generally also defined by the gusts. If peak gusts of approx. 117 km/h (73 mph) are measured over the open landscape at a height of 10 metres, this is referred to as a "storm with gale-force winds".

Stem Diameter:
The stem diameter is measured at around a metre from the ground using a calliper or a measuring tape. Measurements taken with a calliper have the advantage that ovalizations can be recorded precisely. Ovalizations on the longitudinal axis offer greater resistance to bending than ones vertical to it. The basic principle is: the thicker the stem the better, as the resistance to bending increases exponentially with every centimetre.

Please note: all entered diameters must refer to the respective closed cross-section, e.g. please enter twice the diameter measured on the semi-section.

Attachment
TreeCalc Glossary

Stem Safety Factor:
The bending load capacity, which is based on a solid tree, will be reduced if a cavity size is selected. While the basic safety value is based on the ideal state with zero stem damage, the mathematical breaking safety is derived from the estimated load capacity of a stem which has suffered damage, e.g rot.

Terrain Category:
The more uneven the terrain across which the wind travels, the more numerous are the eddies that are created. This is how the wind speed is slowed down at the boundary layer. Consequently, an exposed tree in an open field is subject to greater stress than a tree in a town, surrounded by high buildings. At the same time, greater turbulence arises in the rougher boundary layer, and this needs to be taken into consideration when estimating wind load.

- Terrain type I: Open sea; lakes with at least 5 km of free surface in the direction of the wind; smooth, flat land with no obstacles
- Terrain type II: Land with hedges, greenery, houses or trees, e.g. farmland
- Terrain type III: Suburbs, industrial estates, woods (if there is danger of windfall for surrounding trees, select type II)
- Terrain type IV: Towns in which at least 15% of the area contains buildings with an average height of more than 15 metres

Attachment 8
Aerial Inspection Summary and Photos

First Codominant Union

The primary codominant union is located at approximately 16 feet above ground. The union has included bark. This area was inspected with a ¼ inch metal probe and resistance was encountered indicating sold wood in the interior. Spiral grain, indicating adaptive growth, is visible on the southwest trunk.

Figure 1 Inspection of first codominant union. A ¼ inch steel probe was inserted between stems and encountered solid resistance below historic debris collecting between the stems.

Attachment 8
Aerial Inspection Summary and Photos

Figure 2 Debris accumulation and plant growth between codominant stems.

Attachment 8
Aerial Inspection Summary and Photos

2012 Failure to Southeast

The following photos depict the historic branch failure to the southeast at approximately 26 feet. The failure likely occurred in January 2012.[1] There is robust wound wood growth, minimal visible decay, and insect frass at the lower margin. The second codominant union is visible in the first photo.

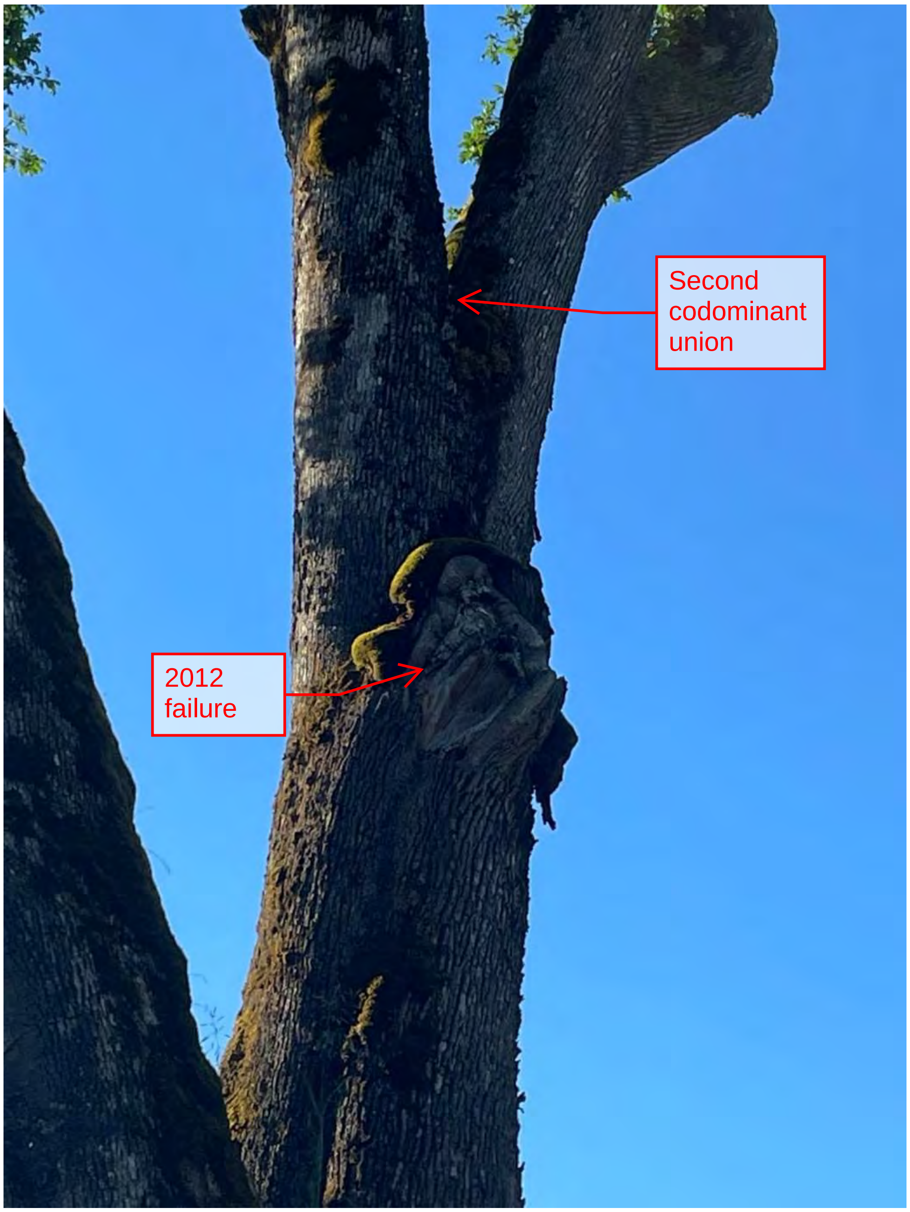


Figure 3 2012 failure and the second codominant union related to the following series of photos.

[1] A long-term research study on south Puget Sound Oregon white oaks documented a significant ice storm in January 2012. Slesak, R.A. Brodie, L.C., Harrington, C.A., Continued response of Oregon oak to release treatments 20 years after initiation in western Washington, United States, *Restoration Ecology* Vol. 32, No. 4, e14130; review of Google Street View historic shows that the limb failed sometime between October 2011 and July 2015.

Attachment 8
Aerial Inspection Summary and Photos

Figure 4 Failure on southeast side of central stem at 26 feet.

Attachment 8
Aerial Inspection Summary and Photos

Figure 5 Seam below 2012 failure. Sonic tomography found solid wood down into codominant union.

Attachment 8
Aerial Inspection Summary and Photos

Second Codominant Union

The following photos depict the second codominant union, located on the central stem where two branches extend to the east and southeast over Old Highway 99. This union is likely the primary concern for the potential for branch failure striking an occupied vehicle traveling on the road. There is a substantial inclusion, but no outward signs of cracking or decay. The attachment between the two branches extending over the road does not indicate included bark.

Figure 6 View directly down into second codominant union. Two stems over the road are on the left and central stem to the right. Union has included bark. Probing did encounter solid resistance beneath debris.

Attachment 8
Aerial Inspection Summary and Photos

Figures 7 and 8 Southwest view of attachment between two secondary stems extending over the road. Exterior signs indicate a sound union.

Attachment 8
Aerial Inspection Summary and Photos

Figures 9 and 10 Northwest view of second codominant union. Included bark transitions into sound wood attachment.

Attachment 8
Aerial Inspection Summary and Photos

June 2023 Failure

The following photo depicts the 2023 failure point. Notable observations include the wound wood growth on the top right margin, variation in color, indicating fungal mycelium and potential differences in time where the wood was exposed to air.

Figure 11 Wound wood on the top-right margin is positive response from tree. The fungal mycelium sampled from this location was identified as a Stereum species, which primarily consumes dead sap wood.

Attachment 8
Aerial Inspection Summary and Photos

Figure 12 Left margin of 2023 failure and adjacent historic wound.

Attachment 8
Aerial Inspection Summary and Photos

Figure 13 Additional view of 2023 failure and historic pruning wound.

Attachment 8
Aerial Inspection Summary and Photos

Figure 14 Historic pruning wound (covered in moss directly below watch) approximately 1 foot above the 2023 failure and below the Kestrel cavity.

Attachment 8
Aerial Inspection Summary and Photos

Kestrel and Cascara Cavity

The following photos depict the kestrel nesting cavity on the SE side of the central stem. Photos provide the approximate depth, height and width of the cavity and the width, length and circumference of the stem at the cavity. Decay extends down and up the stem at the cavity. The cavity is likely decades old, as evidenced by the extent of decay and texture of bark. Bark appears to have matured from smooth texture that indicates young wound wood to furrowed texture indicating maturity.

Figure 15 Photo depicting depth of cavity and cascara (Frangula purshiana) growing from cavity.

Figure 16 Correlating depth of the cavity, indicating substantial depth.

Attachment 8
Aerial Inspection Summary and Photos

Figure 17 Depth measurement at approximately 25 inches.

Attachment 8
Aerial Inspection Summary and Photos

Figure 18 Approximate diameter of tree measured at approximately 27 inches.

Attachment 8
Aerial Inspection Summary and Photos

Figure 19 Depth measurement at approximately 24 inches to interior edge of cavity.

Attachment 8
Aerial Inspection Summary and Photos

Figure 20 Measurement of diameter of cavity at 6 inches.

Attachment 8
Aerial Inspection Summary and Photos

Figure 21 Measurement of diameter perpendicular to cavity opening at approximately 17 inches.

Attachment 8
Aerial Inspection Summary and Photos

Figure 22 Diameter measurement of approximately 30 inches.

Attachment 8
Aerial Inspection Summary and Photos

Figure 23 Probe inserted down into cavity in a central column of decay.

Attachment 8
Aerial Inspection Summary and Photos

Figure 24 View vertically up the cavity.

Attachment 8
Aerial Inspection Summary and Photos

Primary branch extending over Old Highway 99

These following two photos are of an old failure on the primary branch overhanging Old State Route 99. The failure is visible driving southbound. The failure occurred between June 2019 and October 2022.[2] Based on the visual inspection, the failure does not appear to have significantly weakened the remaining branch. Additional pruning wounds lower down the same stem did not show signs of decay and did show vigorous wound wood growth.

Figure 25 Carabiner used for scale. Note two to three years of wound wood growth around margin of injury.

[2] Google Street View Historic Imagery

Attachment 8
Aerial Inspection Summary and Photos

Figure 26 View from above failure showing extent of sound wood supporting remaining stem.

Rick Till

From:	'OSU Botany and Plant Pathology' <diagnostics@plantclinic.bpp.oregonstate.edu>
Sent:	Tuesday, October 29, 2024 2:31 PM
To:	Rick Till
Subject:	Plant Specimen Diagnostic Report # 2024-1887

OSU Botany and Plant Pathology
Attn: Plant Clinic
2701 SW Campus Way
Corvallis, OR 97331
Phone: 541-737-3472
Email: ohkuram@oregonstate.edu

PLANT SPECIMEN DIAGNOSTIC REPORT   Specimen # 2024-1887

SUBMITTED BY	Rick Till Todd Prager & Associates 4106 SE 66th Ave Portland, OR 97206 rick@toddprager.com
PLANT	Oregon Oak *(Quercus garryana)*
METHOD SUBMITTED	MAIL
VARIETY	
CLASS	TREE- Landscape
INTERNAL LAB NO.	
LAB FEE	$87.00
REPLY FROM LAB	October 29, 2024
PHONE	(503) 750-6599
COUNTY	THURSTON, WA
PLANT MATERIAL	
RECEIVED BY LAB	October 17, 2024
CONDITION UPON ARRIVAL	
DIAGNOSTICIAN(s)	Mana Ohkura Victor Sahakian
GENERAL OBSERVATIONS	[Submitter Comments:] A large diameter limb failed in June 2023. Mycelium were observed on the edge of the failed limb. No samples were obtained at that time. These samples were pulled from the trunk where the branch detached. The failure occured at approx. 30' on the stem, which should eliminate root/butt rot fungi. I suspect the branch had a partial failure during a snow event, then a dead wood/heart rot fungi explored the fracture looking for suitable material. So potentially Laetiporus or similar fungi?
DIAGNOSTIC TECHNIQUE(S)	__ Bioassay __ Biochemical __ Culture __ Image __ Incubation __ Lab Test X Microscope X Molecular __ Nematode Extraction __ Serological __ Soil Analysis X Visual Observation
GROWER INFORMATION	City of Tumwater Tumwater, WA
REFERRAL INFORMATION	

Diagnosis/Recommendations

Diagnosis: Wood rot fungus *(Stereum sp./spp.)*

Category: FUNGAL

Comments: Thank you for submitting the Quercus sample. We received a small piece of trunk where the failed branch was attached. The wood was discolored light brown.

We tested for several wood decay pathogens by PCR and it tested positive for Stereum. The fungus was likely introduced through wounds or bark injury as you suspected.

Please let me know if you have any questions.
Kind regards,
Mana Ohkura

Questions or comments about this service should be directed to Mana Ohkura, Plant Clinic Director, at ohkuram@oregonstate.edu.

Invoices are sent separately.

Mention or omission of product names does not imply endorsement or exclusion; product names are included as examples only. Always read, understand, and follow all label instructions before application. The applicator assumes all liability for following the label and any application activities or outcomes.

Oregon has a broad open-records law. Any email communications to/from this address may be subject to public records requests.

Attachment 10
Root Crown Excavation Summary and Photos

Root crown excavation employed an "air spade" that uses compressed air to remove fine soil. The objective of excavating the root crown is to uncover the natural root flare, which would ideally be located near the surface of surrounding grade, and inspect the root crown and roots for any signs or symptoms of decay, including pathogenic and saprophytic wood decay fungi.

The inspection revealed adequate to robust buttress root growth around the entire tree. One historic decay cavity was revealed to be closing with substantial wound wood growth.

Figure 1 Root crown excavation employed an "air spade" that uses compressed air to remove fine soil. The excavation involved alternating between air spade removal of soil with hand removal of river cobble that was backfilled over the root flare after a prior root crown excavation. The project archaeologist oversaw all work.

Attachment 10
Root Crown Excavation Summary and Photos

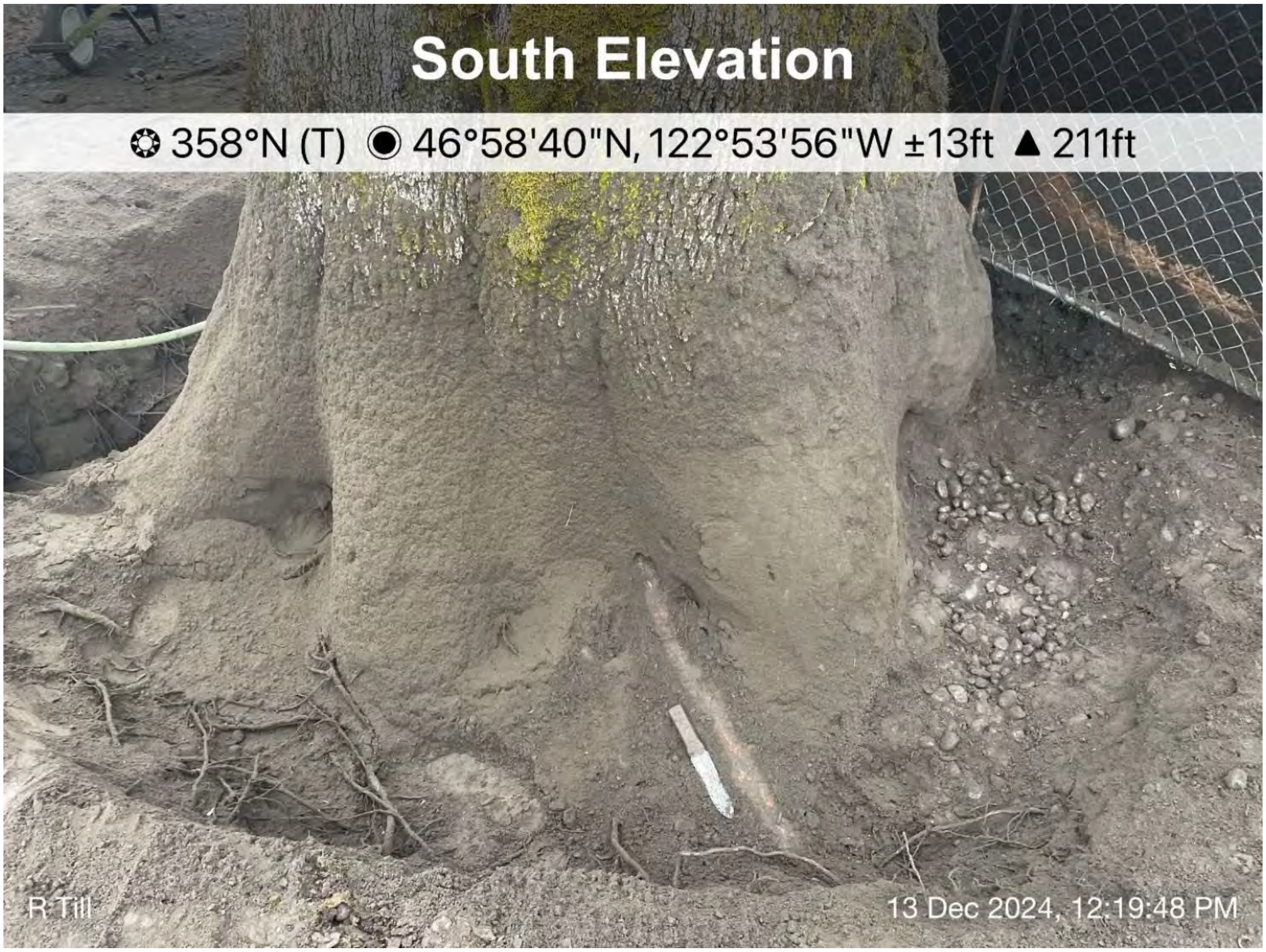


Figure 2 Southeast side excavated to significant lateral root. Performed additional probing to locate solid buttress roots and solid integrity of wood between buttress roots.

Attachment 10
Root Crown Excavation Summary and Photos

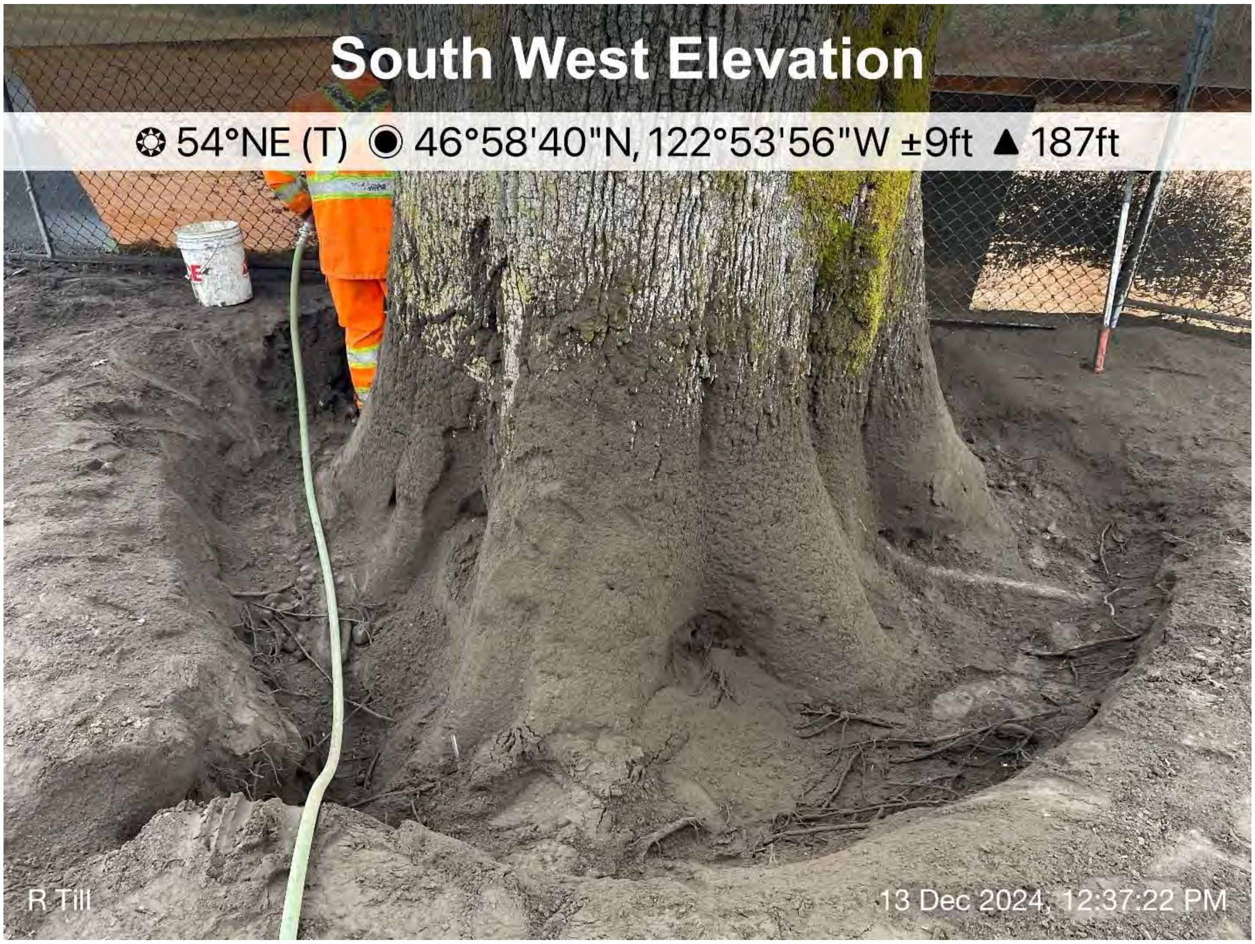


Figure 3 Full view of excavation from southwest. All visible portions were inspected and no indicators of decay identified.

Attachment 10
Root Crown Excavation Summary and Photos

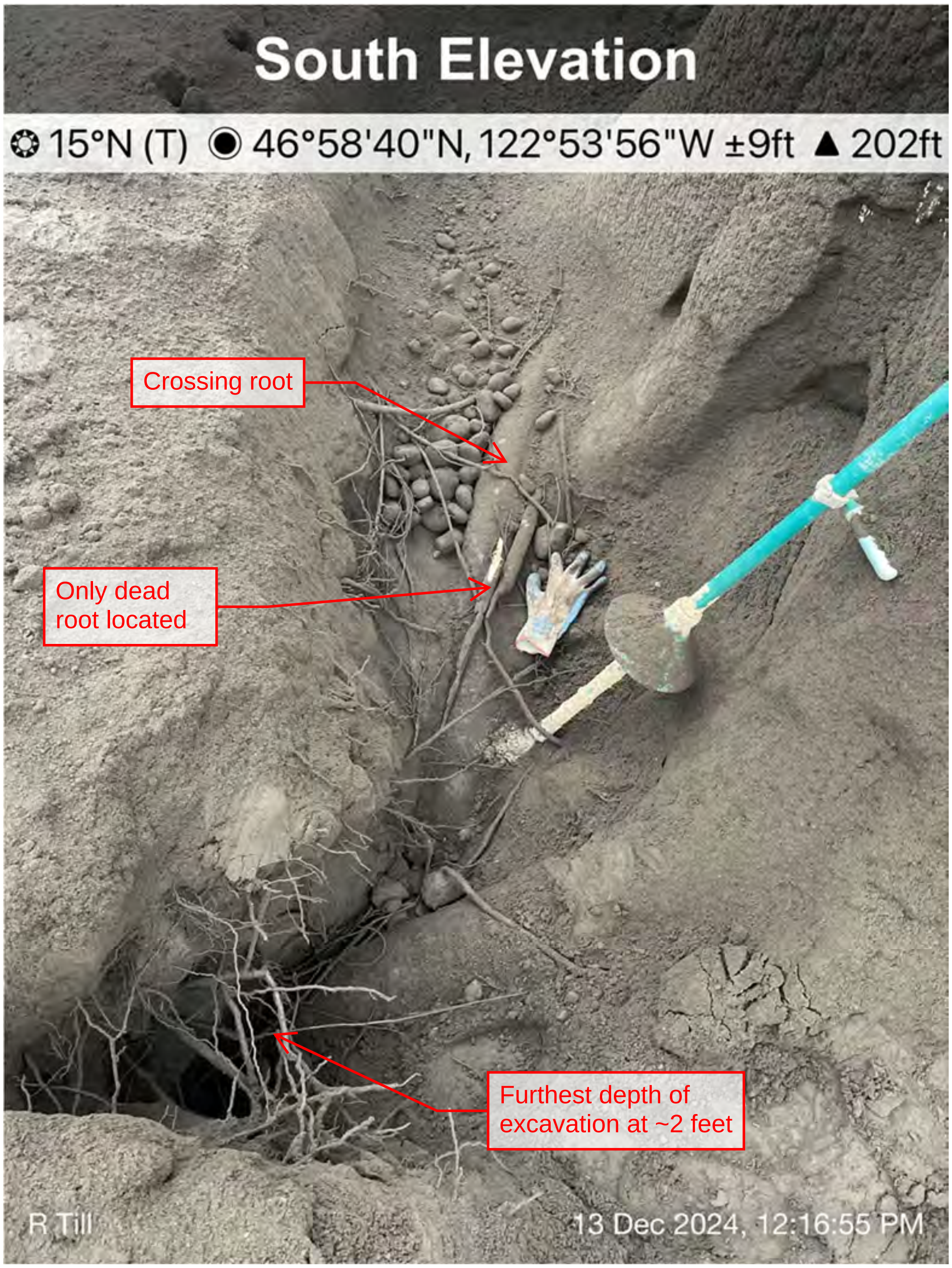


Figure 4 Traced one buttress root and did not locate any signs of concern. One, ~1-inch diameter dead root was located (visible to the left of the glove). One ~4-inch root crosses a primary buttress root, which could limit buttress root expansion.

Attachment 10
Root Crown Excavation Summary and Photos

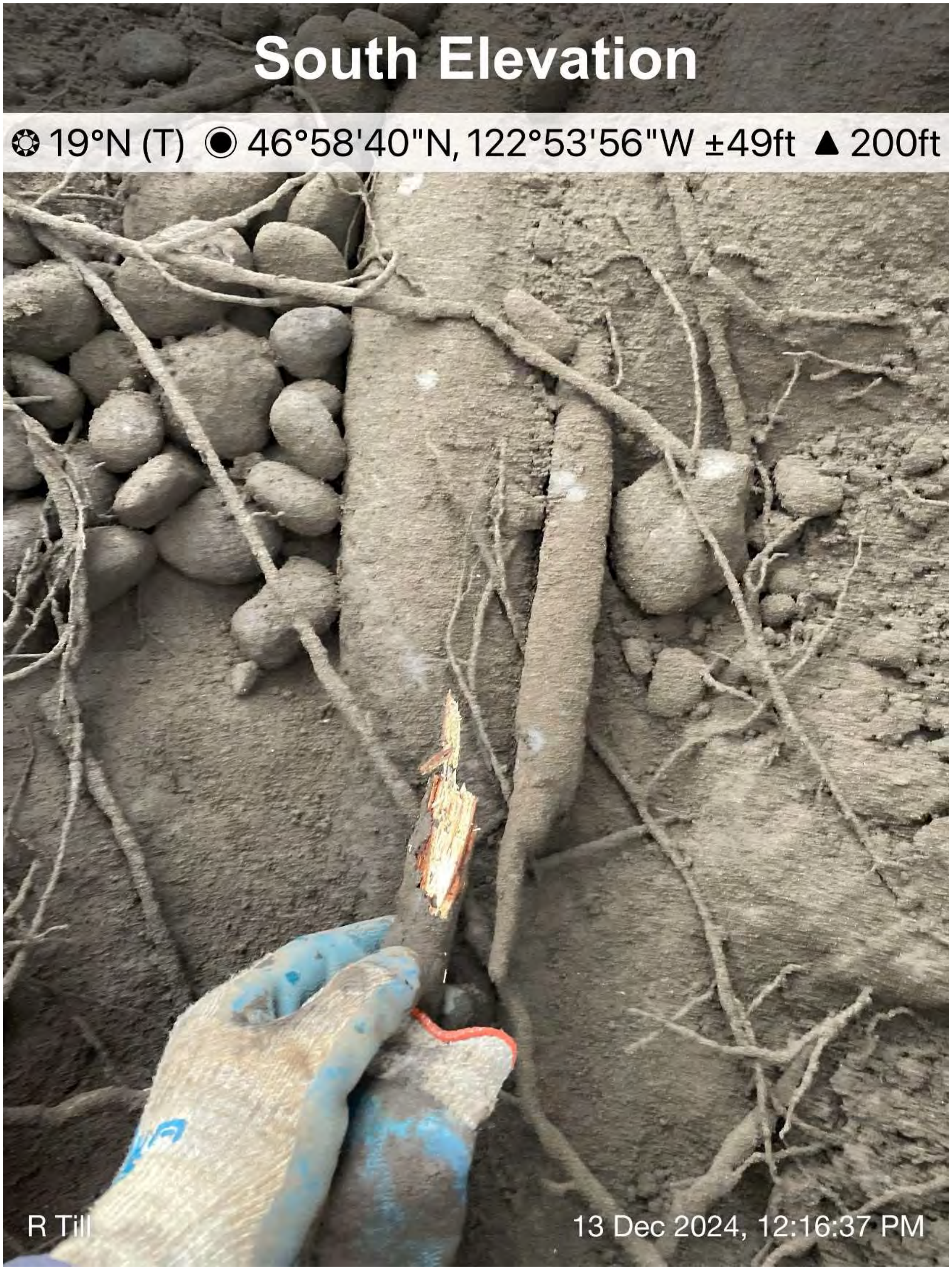


Figure 5 Dead root and crossing root.

Attachment 10
Root Crown Excavation Summary and Photos

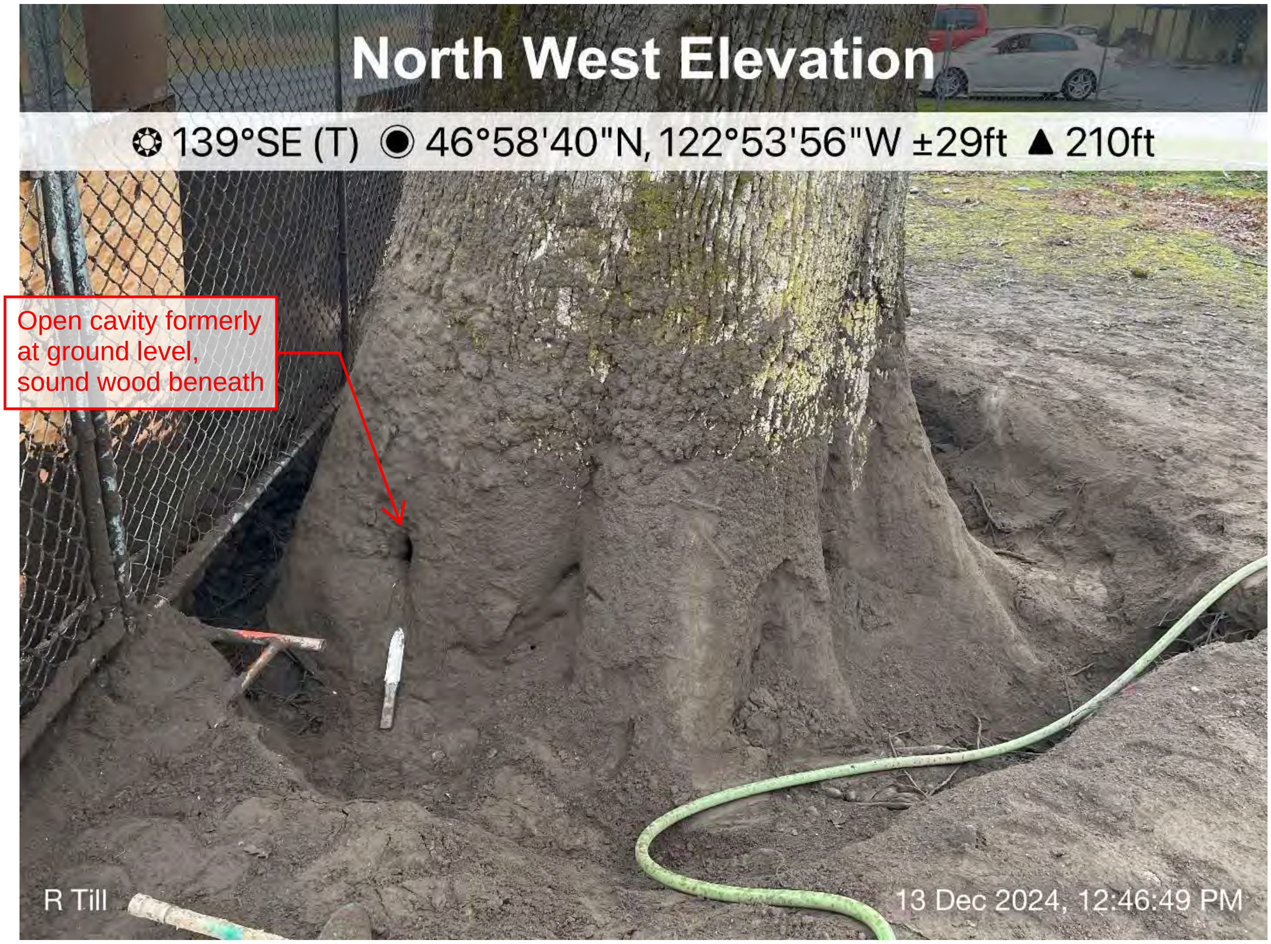


Figure 6 View from northwest. Wood below the cavity is sound. Hand inspected cavity and substantial wood present. Probes creases/sinuses between buttress lobes and did not identify signs of decay.

Attachment 10
Root Crown Excavation Summary and Photos

Figure 7 Street side excavation uncovered sound wood and adventitious roots. Buttress flare was not as pronounced, but otherwise no concerning signs. Depth of excavation was hindered by fence.

Attachment 10
Root Crown Excavation Summary and Photos

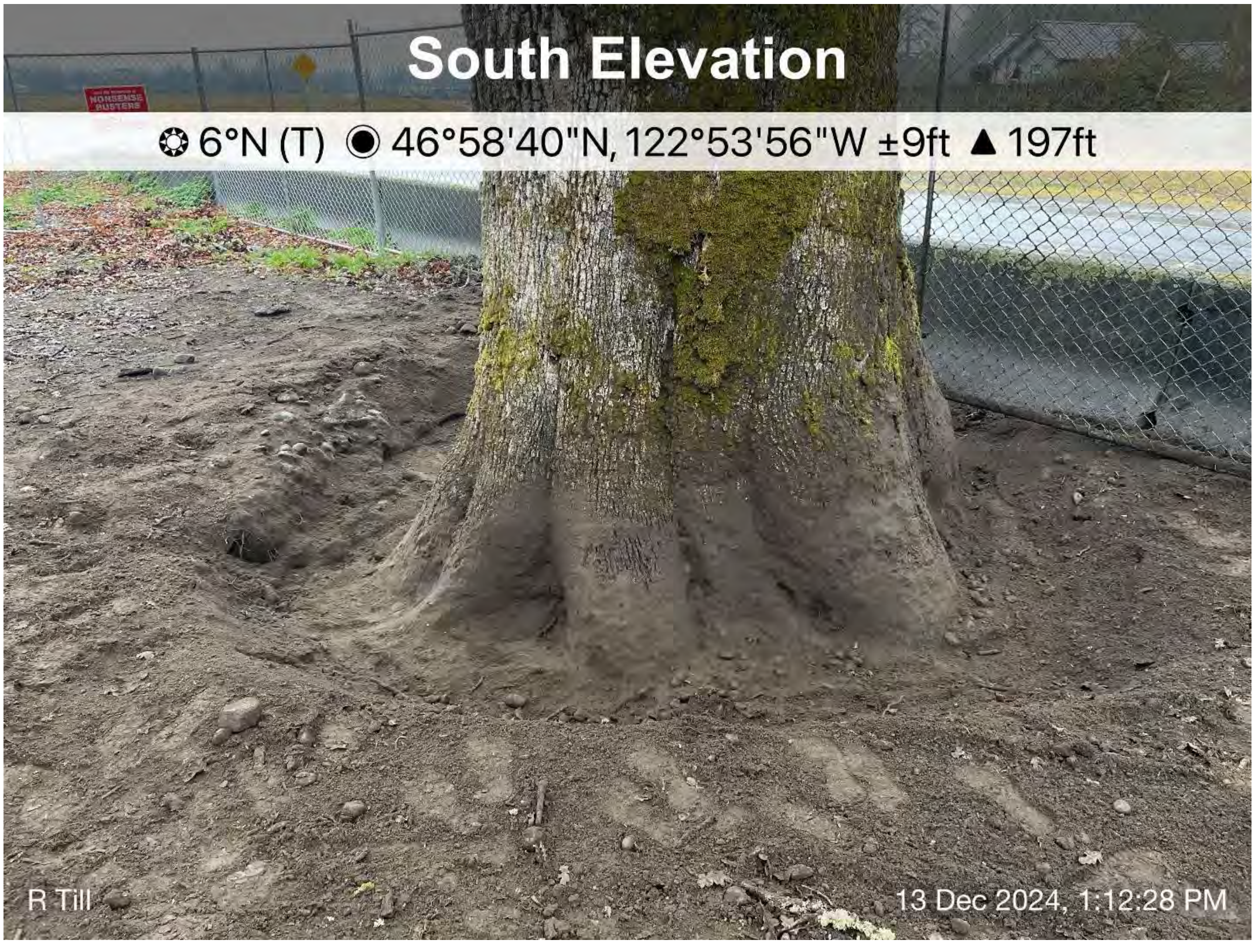


Figure 8 Temporary finished grade.

Attachment 10
Root Crown Excavation Summary and Photos

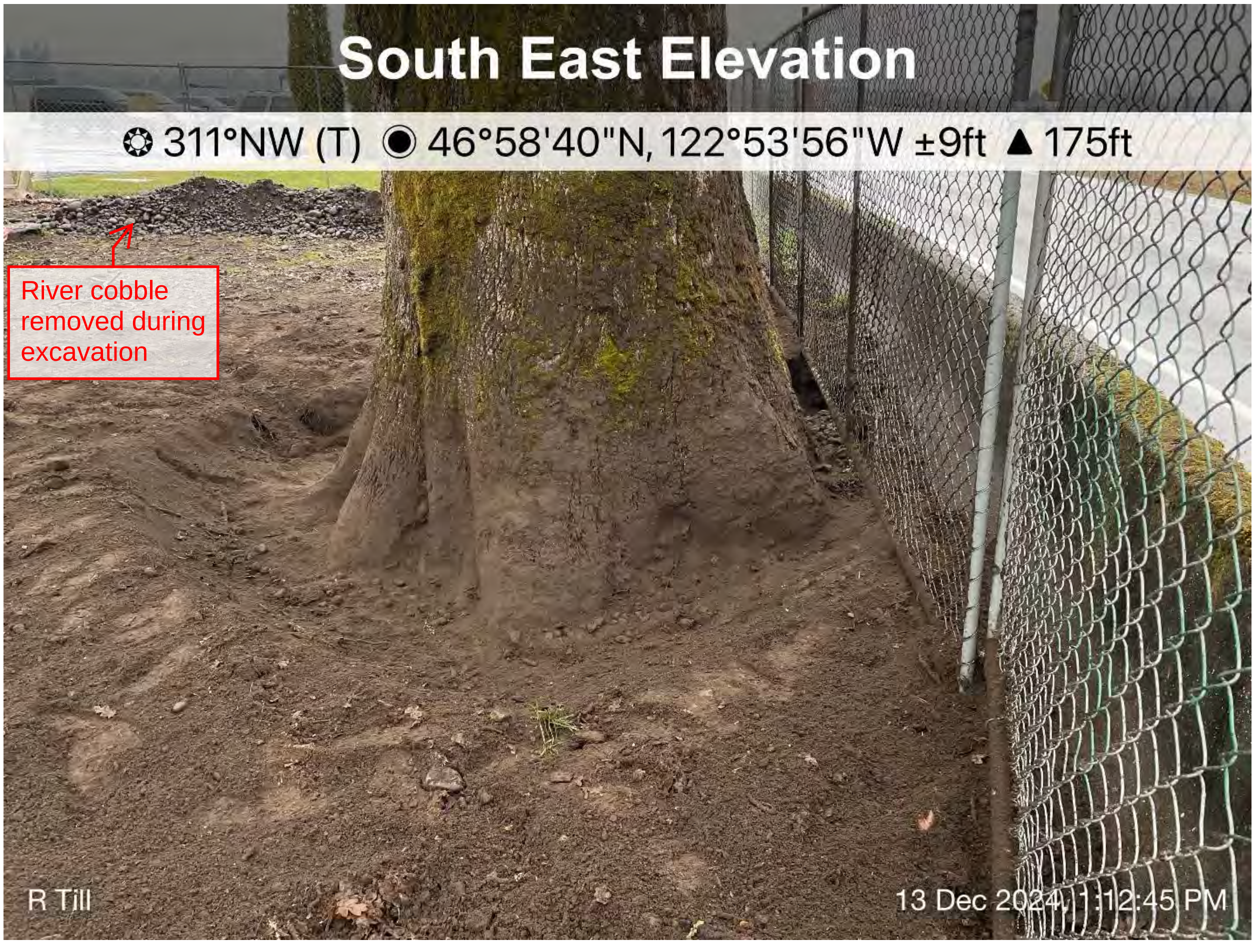


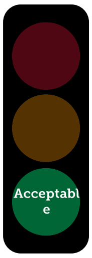
Figure 4 Temporary finished grade with river rock that was removed stacked in background.

Summary

Risk

Oregon White Oak (Whole Tree)

Highest Risk	**Acceptable**
Risk Reduction	See primary report
Tree Management	See primary report
Review Year	**2024**
Date Assessed	2025-01-04 17:53
Assessed By	Rick Till
Phone Number	(503) 750-6599
Email	rick@toddprager.com



Tree Details and Location

Species	Height (m)	Stem Ø (cm)	Crown Ø (m)
Oregon White Oak Quercus garryana	26	168	24

Risk Inputs

Likelihood of Occupation

Traffic

O
1
Very High

Consequences

Tree | Stem | Branch | Deadwood

C
1
Very High

Likelihood of Failure

VITALITY	V	crown density, woundwood, response growth	G	Healthy foliage, good wound wood and response growth, buttress root growth
ANATOMY	A	wood properties, architecture, H/D ratio	G	Very good H/D ration of 15, visible root flare
LOAD	L	exposure, changes to the tree, changes around tree	A	Load reduced by recent failures, but torsion risk may have increased, no changes to surrounding landscspe
IDENTITY	I	species profile, age of wounds, CODIT	G	Species has low failure profile, good compartmentalizer, lower trunk wounds greater than 10 years
DEFECT	D	soundwood, decay - extent, feature or fault	A	Lower trunk hollow 80% or less, TreeCalc models safety factor of 6.27, exceeding 80% hollow would fall outside modeling reliability

F
4
Low

Notes

See primary rrport

Oregon White Oak (Stem Over Road)

Summary

Highest Risk	**Acceptable**
Risk Reduction	See primary report
Tree Management	See primary report
Review Year	**2024**
Date Assessed	2024-10-09 14:50
Assessed By	Rick Till
Phone Number	(503) 750-6599
Email	rick@toddprager.com

Risk

Acceptable

Tree Details and Location

Species	Height (m)	Stem Ø (cm)	Crown Ø (m)
Oregon White Oak Quercus garryana	26	168	24

Risk Inputs

Likelihood of Occupation

Traffic

70 Speed Limit

O: 1 Very High

Consequences

Tree | Stem | Branch | Deadwood

C: 1 Very High

Likelihood of Failure

VITALITY	V	crown density, woundwood, response growth	G
ANATOMY	A	wood properties, architecture, H/D ratio	A
LOAD	L	exposure, changes to the tree, changes around tree	A
IDENTITY	I	species profile, age of wounds, CODIT	G
DEFECT	D	soundwood, decay - extent, feature or fault	A

Healthy foliage, good wound wood and response growth, signs of positive buttress root growth.

H:D ratio of 15.45 is very good. Very good root flare. Stem union with included bark over road is the primary anatomical concern

Failures in the last 5 years altered exposure of remaining crown. Surrounding landscape is unchanged.

Species is strong compartmentalizer. Fungi identified in crown is saprophytic, not pathogenic, included bark not a critical risk factor

Crown inspection did not identify visible decay near unions. Interior decay does not appear to compromise strength

F: 4 Low

Notes

See primary report

Tree Risk-Benefit Validator

VALID

Validator | Tree Risk-Benefit Management Strategy

v9.1

1 Establishing the context

Trees give us many benefits that we need

1 The more obvious benefits that trees give us are visual beauty in the landscape, wood, and the various crops they produce. Wildlife habitat, pollution filtering, and reducing weather and climate change effects are additional values. Trees also have important social value as part of our culture, history, or because they commemorate an important event. As if all these benefits aren't enough. There's an ever-expanding body of scientific evidence that shows trees are essential for our physical health, mental wellbeing, and quality of life.

The overall risk to us from trees and branches falling is extremely low

2 Compared to other everyday risks we readily accept, the overall risk to us from branches or trees falling is extremely low. Our annual risk of being killed or seriously injured is less than one in a million. That's so low, we're at greater risk driving on about a 400km/250mi round trip to visit friends for a weekend than from branches or trees falling over an entire year. Given the number of trees we live with, and how many millions of us pass them daily, being killed or injured by a tree is a rare event. A rare event that usually happens during severe weather.

We can't be an insurer of nature or eliminate the risk from trees

3 Of course, we can't be an insurer of nature. Trees are living structures that sometimes shed branches or fall during severe weather. Since we need the many benefits from trees, we have to accept we can't remove all of the risk. Leaves, bark, cones, nuts, fruits, and small diameter deadwood regularly fall from trees. This natural debris is an Acceptable or Tolerable risk.

1.1 Duty of care

Reasonable
Proportionate
Reasonably practicable

4 We have a duty of care to manage the risk from our trees. The duty also says we should be reasonable, proportionate, and reasonably practicable when managing the risk. That means there's a balance we need to strike between the many benefits trees provide, the risk, and the costs of managing the risk. By taking a balanced approach, we don't waste resources by reducing risk - and losing benefits - when the risk is already Acceptable or Tolerable.

We all have a responsibility to make reasonable decisions

5 We're all expected to act reasonably and responsibly. We can manage our exposure to the higher risk from tree failure that happens during severe weather by not going outside. If we go out during severe weather, we're choosing to accept some of the risk.

1.2 Risk tolerance

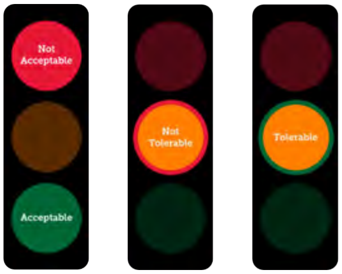
What's an Acceptable or Tolerable level of risk from our trees?

6 The Tolerability of Risk Framework (ToR) is an internationally recognised approach to making risk management decisions. It's used by duty holders where they manage a risk that's imposed on the public. ToR defines Broadly Acceptable and Unacceptable levels of risk. Between these levels is a region where the risk is Tolerable if it's 'as low as reasonably practicable' (ALARP). Put simply, ALARP means the risk is Tolerable if the costs of the risk reduction are much greater than the value of the risk reduction.

1.3 Risk ratings

Risk ratings are as easy to understand as traffic lights

7 VALID has applied 'ISO 31000 - Risk Management' and the 'Tolerability of Risk Framework' (ToR) to tree risk-benefit management and assessment, which we've adopted. In ISO risk terms, our 'objectives' are to grow, maintain, and conserve trees because of the many benefits they give us we need. And, to manage the risk from tree failure to an Acceptable or Tolerable level. We're going to manage the risk from our trees with **Passive Assessment** in all zones of use. And **Active Assessment** in zones of high confluence (high use + large trees). We have four easy to understand traffic light coloured risk ratings to show how we'll manage the risk.



Red — **Not Acceptable** risks will be reduced to an Acceptable level

Amber — **Not Tolerable** risks will be reduced to an Acceptable level, but with a lower priority than red Not Acceptable risks

Amber — **Tolerable** risks will not be reduced, but may require an increased frequency of assessment than green Acceptable risks

Green — **Acceptable** risks will not be reduced

What is Passive Assessment?

Trees with the highest risk are the easiest to spot

Be watchful after storms

When a tree has a risk that might not be Acceptable or Tolerable. It'll usually have an Obvious Tree Risk Feature you can't help but notice. Passive Assessment is simply picking up on these obvious risk features as you go about your day-to-day routine. If you see anything like these features on your trees, get in touch with us.

Root failure

Storms can break tree roots without blowing them over

Signs to look out for are

Change in angle of the trunk
Large cracks in the soil
Hump in the ground on one side

Hanging branches

Don't forget to look up

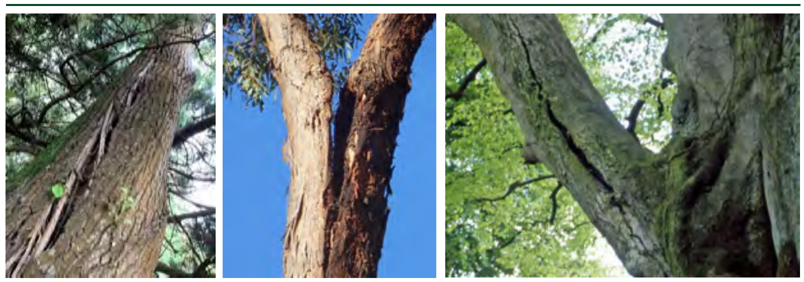
Branches can break during storms and still hang on

Sometimes they can get stuck up there for quite a while

A crack or split into the wood, beyond the bark

When trees bend and twist in storms the wood can split and crack

Vertical cracks in the bark are just the tree growing well there's no need to worry



Decline & death

To stay healthy and strong trees need 'solar panel' leaves to make food

When trees suffer they often have much less leaf cover and many dead branches

Standing dead trees have great habitat benefits but need checking

Decay fungi fruiting bodies

To decay fungi these 'fruits' are like apples to an apple tree

Decay fungi and trees mostly live happily together creating essential habitat for wildlife

Fungi can sometimes 'eat' too much wood and weaken the tree

Photographs
Jake Miesbauer, Michael Richardson, Roy Finch, Mark Hartley, Rick Milson, Andrew Benson, David Abrahams
Felicity Cloake & Wilf, David Humphries, Jack Prynn, Moreton Arboretum, Josh Behounek, Jan Allen

2 What is Active Assessment?

Trained assessors (Validators) looking for risks that are not Acceptable or Tolerable

8 Active Assessment is when we're looking for risks that might not be Acceptable or Tolerable. It's also triggered when **Passive Assessment** has picked up a tree that needs a closer look. Active Assessment has 3 levels to it that increase in depth of evaluation. The 3 levels are Basic > Detailed > Advanced.

Risk ratings are limited by the level of assessment

9 Risk ratings have limitations that depend on the level of assessment at which they're made. For instance, when we carry out Active Assessment at a Basic level. If there are no Obvious Tree Risk Features, the risk is Acceptable at that level of assessment. A Detailed or Advanced Assessment is a more thorough evaluation than a Basic Assessment. They might find features that weren't apparent at a Basic level, and the risk could be higher. However, carrying out a higher level of assessment, with the additional costs. When there's no obvious feature to trigger it. Isn't reasonable, proportionate, or reasonably practicable.

2.1 Basic Assessment

Finding the few trees where the risk might not be Acceptable or Tolerable

10 At a Basic level of assessment, we're looking for trees with obvious features where the risk might not be Acceptable or Tolerable. We're also keeping an eye out for features that might increase the likelihood of failure. We can evaluate the significance of these features with VALID's Tree Risk App, and will carry out a Detailed Assessment when it's necessary. Rarely, we may come across emergency work, and we'll let you know about this as soon as we can.

Tree alerts you raise from Passive Assessment

11 If you raise an alert from **Passive Assessment**. We'll decide whether the tree needs a closer look at this Basic level of assessment.

We'll assess the trees from easily accessible ground

12 We'll assess trees from easily accessible ground, by foot, bike, or in a vehicle with a drive-by, and agree which one with you beforehand.

If we can't get a close enough look at a tree that we need to we'll let you know

13 If there are any trees we need to get a closer look at. But can't because of climbing plants, undergrowth, hedgerows, boundaries, basal growth, or because the ground is too difficult. We'll let you know.

The trees or what they could fall on and the type of assessment will be recorded

14 We'll record trees or what they could fall on and how we covered the ground. For example, in a park. We plot and record that we've assessed individual or groups of trees on foot. Whereas, if there are many trees beside a road. We may record that we've assessed the road, on foot. Or with a drive-by.

No Obvious Tree Risk Features The risk is Acceptable

15 Unless a tree has a feature to trigger carrying out a Detailed Assessment, the risk is Acceptable at this Basic level of assessment.

2.2 Detailed Assessment

We do a Detailed Assessment when a tree needs a closer look

16 We'll carry out a Detailed Assessment on trees that we've picked up during a Basic Assessment as needing a closer look. Or when you've asked for a Detailed Assessment on a tree.

17 We carry out Detailed Assessments with VALID's Tree Risk App, and do them from ground level.

You'll get an easy to understand one side PDF report

18 The App prints an easy to understand one side PDF report. The report includes the risk rating. Risk review year. Risk reduction work (if necessary). And any general management advice that will help you.

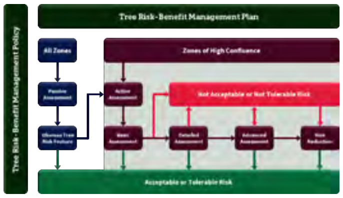
2.3 Advanced Assessment

Large and important trees might be worthy of more effort and cost

19 If we need more information about the likelihood of failure, we can carry out an Advanced Assessment. Often, we do this because you have a valuable tree which has extensive decay. The tree may have significant strength loss and we want to find out whether the tree is strong enough. Or, an aerial inspection is necessary to look at the upper stem and branches. When a tree needs an Advanced Assessment, we'll let you know what options you have. If costs are substantial, we can help you decide whether the tree has enough value and future benefits to justify the investment.

3 Simpler • Clearer • Smarter

The Strategy at a glance



20 Whether you manage or assess tree risk, we're here to help make your life less complicated and more effective.

21 From Strategy to App, we've got all your bases covered with the first complete tree risk-benefit management system. By taking out bafflegab (vague and ambiguous words) and numberwang (questionable maths that you can easily get wrong) from tree risk, we've made it...

22 "*Uncomplicated...intuitive...simpler...clearer...smarter*"

23 This is what Duty Holders, Arborists, and other team members who we've trained as Basic Validators are all saying. They're some words you'll likely use to describe how you feel after you've validated your approach to tree risk.

3.1 Tree risk-benefit management

Reasonable
Proportionate
Reasonably practicable

24 Whether you're a Government Agency, Landowner, or Homeowner you have a duty of care to manage the risk from your trees falling or dropping branches. To fulfil your duty, you should be reasonable, proportionate, and reasonably practicable about managing the risk to an Acceptable or Tolerable level.

25 VALID's got your back here with our full range of ISO 31000 compliant and common sense Tree Risk-Benefit Management Strategies. As part of our not-for-profit goals, we've released all the strategies under a creative commons license. That means they're *free* and open to *everyone*. Validators can help you customise your strategy. Or, they have an abbreviated *Validator Strategy* that covers you and them.

3.2 Tree risk-benefit assessment

VALID has been stress-tested to breaking point

26 Risk-benefit assessments are carried out under the protective umbrella of our Tree Risk-Benefit Management Strategy. The Strategy does more than 95% of your assessments for you. When you need to carry out a *Detailed Assessment*, you'll use our super smart and intuitive Tree Risk App.

27 We've built the engine of the App with a Professor of Natural Hazards & Risk Science. The Professor's an internationally distinguished expert in this field. He's test-driven the model to breaking point:

> *"We have stress-tested VALID and didn't find any gross, critical sensitivities. In short, the mathematical basis of your approach is sufficiently robust and dependable for any practical purpose."*
>
> Willy Aspinall
> Cabot Professor in Natural Hazards & Risk Science
> University of Bristol

3.3 Tree risk ratings

Risk ratings are as easy to understand as traffic lights

28 Yes, it really is that clear and easy to understand. There's no confusion about what vague and ambiguous words, or complicated numbers mean. We have four easy-to-understand traffic light coloured risk ratings.

Red **Not Acceptable** risks will be reduced to an Acceptable level

Amber **Not Tolerable** risks will be reduced to an Acceptable level, but with a lower priority than red Not Acceptable risks

Amber **Tolerable** risks will not be reduced but may require an increased frequency of assessment than green Acceptable risks

Green **Acceptable** risks will not be reduced

3.4 Tree risk-benefit management advice & training

Visit our Training page
Or get in touch for help

29 We work with Duty Holders to help them manage the risk and benefits from their trees. We also train Arborists to become **Validators**. And personnel who spend a lot of time outside, who aren't Arborists, to be **Basic Validators**.

Attachment 12 - Assumptions and Limiting Conditions

1. Any legal description provided to the consultant is assumed to be correct.
2. It is assumed that this property is not in violation of any codes, statutes, ordinances, or other governmental regulations.
3. Loss or alteration of any part of this delivered report invalidates the entire report.
4. Drawings and information contained in this report may not be to scale and are intended to be used as display points of reference only.
5. The consultant's role is only to provide information and provide options for mitigation. Inaction on the part of those receiving the report is not the responsibility of the consultant.
6. The information provided in this report includes information and recommendations for the benefit of our client's decision making. The ultimate decision of whether to retain, remove, prune, inspect, or otherwise apply treatment recommendations to a tree is the sole responsibility of the tree owner, and not the responsibility of the project arborist. If there are any questions or concerns with the information presented in this report, please contact our firm so that we can address any issues as soon as possible.
7. The following additional limitations apply to the likelihood of failure assessment:
    a. Only visible or detectible tree conditions were considered;
    b. This assessment only represents the condition of the tree and site at the time of the assessment;
    c. Any tree, whether it has visible weakness or not, will fail if the forces applied exceed the strength of the tree or its parts;
    d. This assessment only considers historically normal weather conditions that might occur during the stated timeframe; it does not consider unusual or extreme weather events;
    e. The stated likelihood of failure is not a guarantee of tree stability or instability; and,
    f. This assessment is restricted to the tree specifically addressed in this inspection report and does not include any other nearby trees that may present potential hazards to people or property.
8. The scope of work for this report is to:
    a. Data Analysis and Risk Categorization: Analyze site and tree information collected via background research and during the site visits to determine 1) likelihood of failure, 2) likelihood of impact, 3) likelihood of failure and impact, and 4) consequences of failure for each tree part, condition of concern, and assessed target using the International Society of Arboriculture’s tree risk assessment process. Based on this information, determine the overall risk rating of the tree from low, moderate, high, to extreme.
    b. Mitigation Options: Using the risk categorization results and risk ratings for each tree part and target of concern, provide risk mitigation options to reduce risk. Risk mitigation options may include but not be limited to cabling, bracing, reduction pruning, periodic future inspection intervals, target protection, target restrictions, and soil, pest, or disease treatments. An overall residual risk rating for the tree is to be provided on a scale of low, moderate, high, to extreme based on the

mitigation options. Specifications and cost estimates for mitigation options will be determined in collaboration with other professionals that can complete the work.

c. Level 3 Advanced Tree Risk Assessment Report: Provide an arborist report as the final deliverable and include a detailed summary of the project background and history, data collection, tree and site conditions, tree parts and conditions of concern, target information, risk categorization for each tree part and target of concern, risk rating for each tree part and target of concern, mitigation options, residual risk after mitigation is applied, and specifications and cost estimates for each risk mitigation treatment. The report is to be organized in a clear and concise format, include photos and maps as supplemental exhibits, and include additional detailed data such as sonic tomography results as attachments to the report.