Lafayette, CA
Pipeline Tree Review

Pacific Gas and Electric

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Contents

Abbreviations

ASCA: American Society of Consulting Arborists
CP: Cathodic Protection
CIS: Close Interval Survey
CTLA: Council of Tree and Landscape Appraisers
ECDA: External Corrosion Direct Assessment
FPB: Fusion Bonded Epoxy
ISA: International Society of Arboriculture
IVM: Integrated Vegetation Management
PCM: Pipeline current mapping
PG&E: Pacific Gas and Electric Company
ROW: Right-of-way
SCC: Stress Corrosion Cracking
TRAQ: Tree Risk Assessment Qualification

Executive Summary

PG&E retained CNUC to contribute to determining whether 207 trees identified within PG&E pipeline rights-of-way in Lafayette, California city limits should be removed. CNUC's participation was part of a panel of four subject matter experts, one arborist and one engineer hired by PG&E, and an arborist and engineer retained by the City of Lafayette. CNUC provided the arboricultural perspective on behalf of PG&E. The subject matter experts convened to discuss and review the status of the 207 trees. Of the 207 trees, CNUC advocates removing 135 trees that have been rated to be in poor condition or to pose an unacceptable risk to the pipeline.

Eighty-eight of these have been rated in poor condition, while 47 are in fair or better condition but pose an unacceptable risk to the pipeline. In addition, CNUC recommends retaining 54 trees that are rated as acceptable risks and are rated to be in fair or better condition. The remaining 18 trees were dead when inventoried or have subsequently died and have been removed.

Introduction

The City of Lafayette and PG&E convened a panel of four subject matter experts to review whether 207 trees growing on or adjacent to PG&E gas transmission pipelines should be removed. Two arborists formed a tree advisory team. Michael Baefsky of Trees, Bugs Dirt Landscaping Consulting and Training represented the City. Mr. Baefsky is an International Society of Arboriculture (ISA) Certified Arborist (WE0222A), registered Consulting Arborist (with the American Society of Consulting Arborists--ASCA) #456, and he is an ISA Tree Risk Assessment Qualified (TRAQ). Randall Miller of CNUC was retained by PG&E. Mr. Miller is an ISA Board Certified Master Arborist (IL0225BU), and ISA Certified Utility Specialist (IL0225BU), ISA Tree Risk Assessment Qualified (TRAQ), principal author of the ISA Integrated Vegetation Management (IVM) Best Management Practices, and coauthor of *Utility Arboriculture: The Utility Specialist Certification Study Guide*. The panel also included two engineer advisors. Richard Kuprewicz of Acufacts was retained by the city, and Ben Mittelstadt of Dynamic Risk was engaged by PG&E. The group of subject matter experts convened seven meetings between November 2021 and May 2022. This report offers CNUC's resulting arboricultural perspective.

Background

Literature Review

In 2012, PG&E commissioned an arboricultural consulting firm, Randall Frizzell & Associates, to investigate tree root interference with their pipelines. Randall Frizzell & Associates produced a literature review and technical white paper on the potential for tree roots to interfere with and damage pipelines. The arborists who prepared the review are known to Michael Baefsky and Randall Miller as prominent, not only in California, but also nationally and internationally. Notably, the investigative team included Dr. Larry Costello, the principal author of *Oaks in the Urban Landscape*—the definitive urban forestry text on California oaks—as well as the root management best management practices from the International Society of Arboriculture.

The technical white paper included some important observations regarding the potential damage tree roots can cause to natural gas transmission pipelines lines, including:

- Characteristics of tree root systems depend on complex interactions between tree genetics, soil conditions, and tree age and health
- It is impossible to predict the exact location and extent of tree roots, but several attributes can inform management practices:
    - Large roots are usually located within 10 feet of the tree trunk

- Small roots can extend more the three times the radius of the dripline (the area under the branches of a tree)
- Most roots occur in the upper 20-inches of soil and 90% or more of tree root systems are in the upper 3-feet

Randall Frizzell & Associates further observed that soil used as backfill in pipeline trenches often creates an environment conducive to root growth. Since it has been broken up, it has greater pore space and is more richly oxygenated than surrounding soil, making it easier for roots to penetrate. Moreover, pipelines can cool the surrounding soil, which can condense water near the pipe, further enhancing growing conditions for roots.

The investigators found that indirect damage is common, as tree roots grew to compromise pipe coating, potentially exposing the pipe to corrosion (Figure 1). They note that smaller roots can cause this type of damage 100 or more feet from the tree trunk (Randall Frizzell and Associates, 2012). They further observed that in rare cases, large roots contacting a pipeline can exert enough force to damage pipelines when the root flexes as the tree responds to or is toppled by high wind or an earthquake. These later conclusions are corroborated by Mattheck et al. (*The Body Language of Trees,* 2015) who determined that hydrotropic growth can direct roots to pipes. They note that roots are attracted to the top of pipes on the predominately leeward side of prevailing winds and under it on the windward side. This windward growth leverages the pipe as an anchor. So as wind blows, tree roots that have grown in proximity to pipes on the predominately leeward side impose compression forces on the pipe, while those on the windward side have the potential to lift it. Mattheck argues that both forces could damage pipelines. Finally, Appendix C of the Pipeline & Hazardous Material Safety Administration's report *Partnering to Further Enhance Pipeline Safety in Communities Through Risk-informed Land Use Planning* (PIPA, 2010) devotes space to describing why trees are incompatible with pipelines, and provide examples, such as the photo in Figure 1, to substantiate this argument.

Field Study by Randall Frizzell & Associates and Dynamic Risk

The Frizzell & Associates technical white paper was followed in 2015 by a field study undertaken cooperatively by Randall Frizzell & Associates and Dynamic Risk Assessment Systems, Inc. The intent of the study was to examine the interaction between tree roots and pipelines on PG&E's system and involved 53 excavations. PG&E retained Dynamic Risk to provide technical support during the excavations and assess potential threats caused by tree root interaction with pipelines. A two-volume report resulted, which largely verified the 2012 literature review.

The study found that:

1. *At approximately 75% of the locations where pipelines and tree root systems co-existed, tree roots damaged the external coating on the pipeline. The susceptibility for external corrosion to occur on the pipeline increased because the primary protective barrier, namely the external coating, was compromised.*

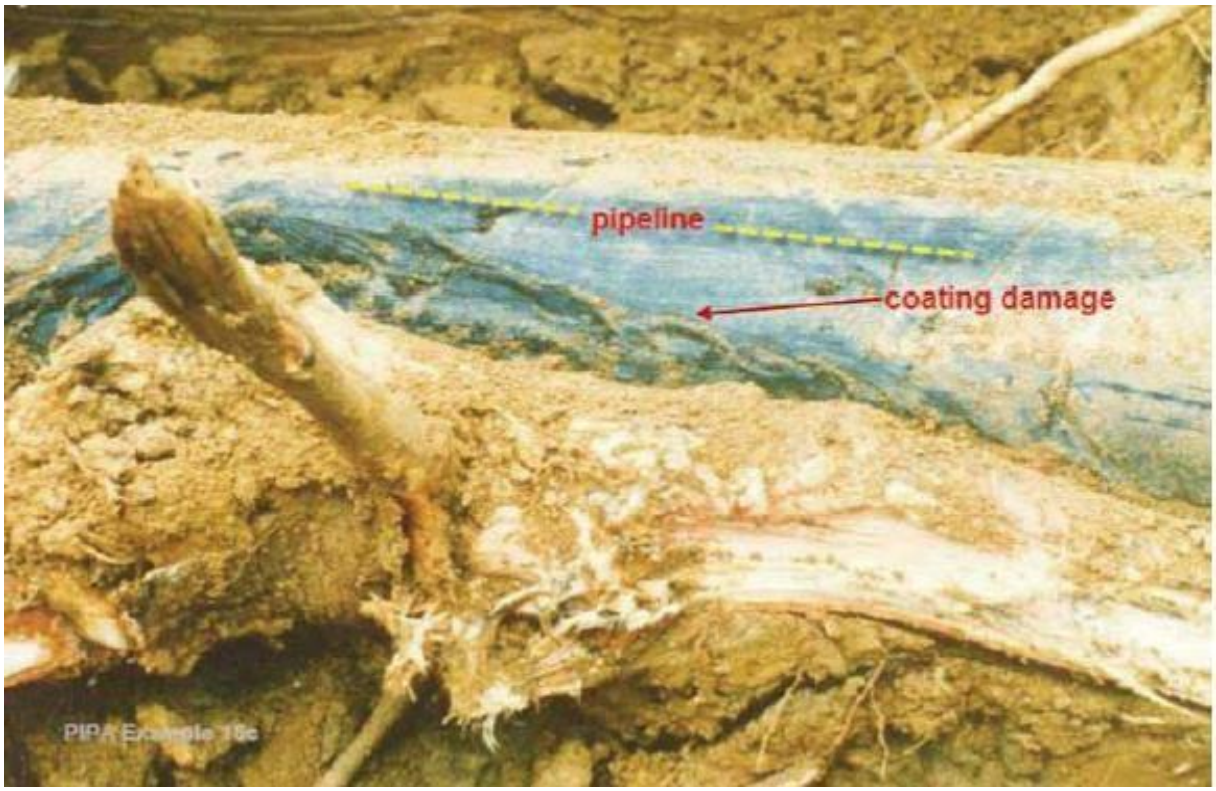

Figure 1. A root growing along a buried pipeline that has damaged the coating (Figure 11 from Randall Frizzell & Associates 2012--photo from PIPA 2010).

2. *External corrosion was evident at 15 of the 40 sites (or approximately 38%), where coating damage was present. While external corrosion was evident in these locations, there was insufficient data collected in this study to substantiate or eliminate a direct causal linkage between the presence of tree roots and external corrosion initiation and/or growth.*[1]

3. *Available data provided no direct evidence that the presence of live tree roots in contact with the pipe increased the susceptibility to the initiation of stress corrosion cracking (SCC). However, by virtue of a failed protective coating, the susceptibility for cracking does increase.*

4. *There was insufficient data collected in this study to draw any conclusions as to whether the presence of dead tree roots in contact with the pipe has any impact on pipeline integrity.*

5. *Above ground surveys are not significantly affected by the presence of tree roots. In most cases, above ground surveys correlated with excavation results where coating holidays were observed at sites identified by above ground surveys. Likewise, intact coating was observed at sites where above ground surveys did not produce an indication. Using a Close Interval Survey (CIS) as a sole*

[1] These instances of corrosion were identified at excavations undertaken before the full data recovery protocol was in place. Bacteria counts were not collected at any of the 15 sites and above ground surveys were conducted at only 2 of the 15 sites.

measure of the effectiveness of cathodic protection (CP) in the presence of tree roots, however, may have limitations. In addition, the effectiveness of External Corrosion Direct Assessment (ECDA) does not appear to be adversely affected by the presence of tree roots. ECDA is an assessment method that relies upon above ground surveys. ECDA is used to determine whether external corrosion is a potential integrity concern at specific locations along the pipeline. It requires at least two types of surveys be conducted as part of the assessment, e.g., CIS, alternating current voltage gradient (ACVG), direct current voltage gradient (DCVG), and pipeline current mapping (PCM). The above ground surveys performed as part of this Tree Root Study relied upon at least two above ground survey methods and the correlation between those techniques and locations where coating damage was observed indicates the presence of tree roots does not appear to render ECDA ineffective.

6. *The ability to cathodically protect buried pipe does not appear to be adversely affected by tree roots. This finding is based on the fact that tree roots do not apparently shield CP, and calcareous deposits[2] were identified on the pipe. Nonetheless, CP is designed to mitigate corrosion, and adequate CP may not always be able to prevent or eliminate corrosion in cases where the external coating has failed.*

7. *While CP effectiveness and CP monitoring are not significantly affected by the presence of tree roots, it is evident that tree roots can damage the external coating of the pipe such that CP is required to mitigate corrosion.*

8. *There is the potential for tree roots to structurally damage the pipeline, including inducing increased bending strains, if tree roots are uprooted by external forces. While this was not observed at any of the 53 sites, one site in particular (Hall Road) clearly demonstrated the significance of this potential threat. The root ball was located directly above the pipe and the pipeline was fully encapsulated by the Valley Oak tree roots. In a similar situation, if external forces and events (such as seismic, high winds) caused movement of the tree and tree roots, the forces created by such movement could damage the buried pipeline.*

9. *The distance from the tree to the buried pipeline and the depth of the buried pipeline appear to be two primary attributes that can be used to predict potential interaction of tree roots with the buried pipeline. While the PG&E ROW Standard establishes guidelines with recommended offset distances for ranges of tree sizes (DBH), the data from this study suggests the z-factor, which considers both lateral offset and depth of cover may provide additional value in predicting the potential interaction of tree roots with buried pipelines. Given the limited breadth of data gathered in this Tree Root Study, however, PG&E may elect to collect and analyze further data on z-factor before modifying the ROW Standard.*

10. *While additional investigation of the impact of tree roots on various coating types is warranted, the current data indicates PG&E can consider coating as an attribute for predicting the interaction with tree roots. Of the 47 sites where the external coating types were either hot applied asphalt or coal tar enamel, coating damage was identified at 40 sites (or 85%). For the*

[2] Calcareous deposits are the result of the cathodic protection polarization process and indicate cathodic protection is affecting the buried pipe.

six remaining sites where the external coating type was polyethylene tape, zero sites were identified with coating damage. Note that this finding does not imply that polyethylene tape exhibits low susceptibility to damage by tree roots. Other variables, e.g., depth of cover, pipe segment vintage, soil conditions, tree type and diameter may have contributed to this condition. The reason for this difference was not resolved as part of this study. None of the sites within this program contained pipe with fusion bonded epoxy (FBE) or other external coating types.

11. *The vegetation offsets and proximity guidelines set forth in PG&E's ROW Standard are consistent with findings to date.*

To summarize, Randall Frizzell & Associates and Dynamic Risk found that direct damage to PG&E pipelines by tree roots was unlikely, but possible. However, they found a high incidence (75%) of tree roots causing damage to pipeline coating where trees are growing in proximity to pipelines. Further, external corrosion occurred at 38% of those sites (Figure 2). That, along with the literature review and observations by Mattheck et. al (2015) offer strong arboricultural evidence that tree roots have the potential to damage pipes. The determination of the level of risk caused by such damage is not arboricultural. So, CNUC defers to the accompanying Dynamic Risk report for an engineering discussion attendant to pipeline risk caused by tree root interference.

Figure 2. Tree roots causing coating damage to RWVIM-107-13 (Weber Lane) pipeline. (Figure 3 from Dynamic Risk 2015).

Integrated Vegetation Management Best Management Practices

Best practices for pipeline integrated vegetation management advocate removing trees growing in the defined right-of-way (Miller 2021). The recommendation is not only a consequence of the potential damage caused by tree roots to pipes as described above, but also to facilitate visual inspection and to allow access for maintenance or repair. Those best practices are consistent with recommendations in Pipeline and Hazardous Material Safety Administration's (PHMSA) Safety Stakeholder Communication's website.

The IVM best practices recommend managing linear rights-of-way (electric utility, pipeline, railroad and roadway) in zones. Standard practice establishes a treeless zone, a border zone comprised of shrubs and small trees, and an outer zone where larger trees may be allowed. Safety is the primary reason for managing in zones. The best practices preclude species that could interfere with or damage critical infrastructure, obstruct lines of site for inspection, or impede access for maintenance. They recommend that rather than considering treeless zones to be sacrifice areas, advantage should be taken to use them as areas of opportunity to promote stable plant communities that will simultaneously provide habitat for pollinators and early succession wildlife and be consistent with the use of critical infrastructure on the site wherever possible (Miller, 2021).

PG&E Practices

The PG&E pipeline encroachment standard specifies the classic "pipe-border zone" model (Figure 3). The pipe zone is managed as a treeless area to prevent roots from interfering with pipelines, maintain access for maintenance, and identify the pipeline location in the right-of-way. This approach is compatible with accepted vegetation management practices, which advise that the width of the treeless zone should be determined by the operator (Miller, 2021; Miller and Kempter, 2018).

Figure 3. PG&E's pipe safety zone and border zone (Figure 1 from PG&E 2017). The figure depicts the classic pipe zone border zone approach.

The PG&E approach is based on the observation listed in #9 in the *Field Study by Randall Frizzell & Associates and Dynamic* Risk section (above) that the distance to the buried pipe and its depth below the ground are crucial in determining whether trees are likely to interfere with and potentially compromise underground pipelines. PG&E's process is detailed in their *Utility Procedure: TD-4490P-03* (PG&E, 2017a). Dynamic Risk (2015) recommended applying the Pythagorean theorem to determine a "z factor" in identifying trees for removal. The "z-factor" is the hypotenuse of a right triangle formed with the horizontal distance of a tree to the point on the soil surface directly above a pipe on one leg, and the distance from the soil surface down to the depth of the pipe on another. Dynamic Risk observed that where the hypotenuse between the tree and pipe was less than 5- feet, coating damage occurred in over 90% of the observations in their study, and where it was between 5- and 10- feet, it was observed in two-thirds of the cases.

The PG&E screening tool seems reasonable to CNUC considering the Randall Frizzell & Associates-Dynamic Risk study. The protocol calls for classifying trees into those with a mature diameter at breast height (DBH) of 17- inches or less and those more than 17- inches. Using this technique, trees less than 17- inches in DBH at maturity will be removed if the "z-factor" is 3.6- feet or less (e.g., trees less than two feet horizontally from the pipe that is 3- feet or less underground). For larger trees at maturity, trees with a "z-factor" of 5.3- feet or less (i.e., trees less than two feet from a pipe that is 5- feet or less below ground) will be removed. CNUC considers this to be a reasonable approach, given that pipe coating damage was observed in over 90% of cases where the "z-factor" was 5- or fewer feet.

Small trees with a "z-factor" of 5.8- feet or less as well as larger trees with a "z-factor" of 10.2 - feet or less are subject to additional analysis. Monitoring means the trees may remain, provided they undergo preventative and mitigative measures (PG&E, 2017a). This process is summarized well in the accompanying Dynamic Risk report (Dynamic Risk, 2023).

Tree Appraisal and Condition Evaluation

At the request of the City of Lafayette, Michael Baefsky provided valuations of trees that PG&E considered to be removal targets due to pipeline safety and access considerations. Appraisals are critical to the process, as the city requires reimbursement for the value of any trees removed on the project, with the proceeds used for tree replacement or planting within city limits.

Mr. Baefsky located, identified, tagged with numbered metal tags, and digitally imaged 273 trees. He appraised using methodology developed by the Council of Tree and Landscape Appraisers (CTLA) in the 9th Edition of the Guide For Plant Appraisal. Baefsky subsequently adjusted the condition factor of PG&E's assessments using the 10th edition of Guide.

Randall Miller made a field visit the week of February 7, 2022, primarily in the East Bay Municipal Utility District/Lafayette Reservoir area. Miller agreed with Baefsky's assessments, based on his field visit evaluating trees that had been previously assessed.

The tree advisory group agreed that the city would be best served by removing trees in poor or very poor condition and planting replacements in accordance with the city's tree protection ordinance.

CNUC's Recommendations

Trees are incompatible with pipelines as they have the potential to cause them damage. CNUC acknowledges that determining whether interference caused by tree roots results in unacceptable safety risks to pipelines falls into the realm of engineering rather than arboricultural expertise. Consequently, CUNC defers to the accompanying Dynamic Risk report (2023), which concludes that the presence of trees on the pipeline right-of-way can increase the potential for "loss of containment failure." These findings are consistent with those from Pipeline and Informed Planning Alliance (PIPA) (2010), the field excavations by Randall Frizzell & Associates (2012) and observations by Mattheck et al. (2015).

Further, preventing damage is not the only reason to remove trees from designated pipeline rights-of-way. Enabling access and visibility for inspection are also compelling reasons to do so. Miller had difficulty following the right-of-way in places during his February 2022 visit. If the location of the pipeline is difficult to ascertain under controlled conditions, it will be even more problematic under the pressures of emergency conditions, and precious time could be lost in making critical repairs. So having a right-of-way clear of trees to facilitate location and access is not a matter that should be dismissed.

For the reasons described above, tree removal is recommended in integrated vegetation management best management practices (Miller, 2021). Consequently, CNUC considers the PG&E risk matrix and "Tier 3" analysis to be reasonable and consistent with industry best practices. So, CNUC advocates removing the 47 trees recommended for removal through the assessment process completed by Dynamic Risk (2023) and an additional 88 that have been rated to be in poor or very poor condition.

Urban Forestry Recommendation

CNUC acknowledges the dedication Save Lafayette Trees has for the urban and community forestry resources in Lafayette. CNUC notes that Lafayette is not recognized by the Arbor Day Foundation as a Tree City. Further, the city does not have a municipal arborist or forester, or a funded urban forestry department with arborists dedicated to planting, tree health care and urban forestry management. CNUC thinks the residents of Lafayette and their urban forest resources would be well served if the city dedicates itself to long-term urban forestry management. CNUC recommends that Lafayette consider establishing an urban forestry department and becoming a Tree City.

The Arbor Day Foundation requires cities to meet four criteria for Tree City status:

- Maintain a tree board or department
- Have a community tree ordinance
- Spend at least $2 per capita on municipal forestry
- Celebrate Arbor Day

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