Root of the Problem

When trees invade pipelines in the right of way

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In the United States, one of the growing challenges for public utility rights of way is tree roots and their impact on infrastructure. Trees can cause problems because they have potentially invasive roots that can apply significant pressure to pipeline joints and coatings.

With the increasing social pressure to accommodate trees within rights of way, it's become essential that policies be developed that address construction methods and mitigate the increased risk to underground infrastructure like pipelines.

Recently, the San Diego County Water Authority (SDCWA) identified the need for a formalized tree management policy to minimize potential risk factors. However, with very little data available on the effects of tree roots on large diameter pipelines in the United States, research was needed. This prompted a connection with some international experts who have done extensive research on the impacts that tree roots can have on infrastructure.

In October 2010, William Busch, SR/WA, Acting Director of Right of Way for the SDCWA, visited the Institute for Underground Infrastructure (IKT) in Gelsenkirchen, Germany, an institute that specializes in researching and testing tree effects on underground utilities. In identifying which tree management policies have been effective, IKT has proven itself a valuable resource.

TREES AND PIPELINES

The SDCWA owns and operates large water pipelines that measure up to nine feet in diameter. The pipelines are often located deep underground and buried with six to eight feet of cover. The construction materials can vary from welded steel pipe to pre-stressed concrete pipe with rubber gasket joints. Pipeline failures can release tremendous volumes of water and have the potential to cause extensive damage.

Using a proactive approach, the SDCWA created an aggressive pipeline inspection program that includes internal inspections, weekly right of way patrols and acoustical fiber optic monitoring using internal sensors that listen for pipeline deterioration. Managing encroachments is also an important component of pipeline protection.

In the late 1980s, SDCWA began to give increased attention to encroachments. Although easement language prohibited many intrusions, a lack of enforcement strategy prior to that time resulted in many prohibited uses. Property rights were being eroded, and underground pipelines were potentially endangered. This sometimes leads to serious regional water service interruptions.

Encroachment management initially focused on significant intrusions like houses, walls and pools. In the past, little attention had been paid to trees. Trees are generally a prohibited use in most of the SDCWA easement documents. However, some older easements reserve to the owner, usually those with avocado or citrus groves, the right to retain and plant trees. SDCWA easement documents date back to the late 1940s when the first transmission pipelines were installed. Now, almost 70 years later, these areas are increasingly urbanized, and there are thousands of volunteer and planted mature trees in the rights of way. Many of the trees are pine, oak and eucalyptus, all of which have the potential to cause damage to pipelines and penetrate pipeline coating materials and rubber gasket joints.

The best scenario from a management standpoint would be to have "tree-free" rights of way. However, history has shown that the subject of trees can elicit both emotional reactions and environmental concerns. Rather than adhere to a broad, unpopular policy of prohibiting trees, it may be possible to employ construction methods that guide tree roots away from pipelines.

Tree roots are known to invade joints in small diameter wastewater pipelines.

RISK FACTORS

Some trees are so large and perilously close to houses that, if an urgent removal was required, it could take a day or more. This kind of delay could exacerbate flooding and interrupt regional supply if it was necessary to excavate a broken pipeline. Certain types of trees with extensive roots would slow the excavation process, thus delaying urgent repairs. There is also a concern that roots could penetrate cracks in mortar coatings and work their way into pipeline joints, especially where there are rubber gaskets.

The SDCWA rights of way range from 20 to 150 feet wide and extend for nearly 200 miles. Some easements are now in backyards or managed open spaces. Completely clearing these trees from such an extensive and sensitive area would be environmentally irresponsible and could create a firestorm of protest. There is increasing demand for more trees to mitigate carbon emissions and greenhouse gasses. It is anticipated that there will be increased pressure over time to accommodate trees in public rights of way.

FORMULATING A POLICY

To establish reasonable parameters for removing or retaining trees, the first step was to define which trees and circumstances cause the greatest risk. Some trees are known to be a

problem because they retard access to pipelines in the event of an urgent repair. Large trees that overhang utility lines or structures can take many hours to remove. This would cause precious time delay in an urgent repair situation where property and safety are at risk and water service needs to be restored.

Pipeline condition is also a factor when formulating a policy. A prudent manager needs to focus on the areas of greatest risk. Pipeline inspection data is useful in identifying areas where tree encroachments might be of greatest concern based on the condition of the pipeline.

Empirical data was sought by the SDCWA to help establish guidelines for a defensible tree management policy. Of particular interest was information that might quantify the pressure that roots can exert, data regarding species of trees that might be most invasive, and underground pipeline construction techniques that might help alleviate or minimize the adverse affects of invasive tree roots.

RESEARCH ON ROOT PENETRATION

In Europe, when the operators of underground infrastructure systems first met with people from municipal parks and garden departments, there was lively discussion on the conflicts between tree roots and buried utilities. Over time, there has been an open exchange of knowledge and an interdisciplinary approach to this dilemma. An impartial and pragmatic approach led to foundational research regarding the effects of trees on buried conduits and underground power lines in urban locations.

"This is a field where the biologist, engineer and right of way manager can partner..."

In repairing a large pipeline, extensive excavation may be required.

Over the past few decades, the vital processes of trees have been extensively researched. We know that the volume of space occupied by the root system must have a balanced relation to the volume of the crown. Excessively small root space generally results in inhibited growth of the above-ground parts of the tree. As diverse as the demands made by the various species of tree on their habitat may be, their roots invariably prefer sites that provide a good supply of oxygen and moisture. Knowledge concerning the relationships between root growth and interactions with underground infrastructure is spreading only gradually among the responsible system operators.

The Institute for the Underground Infrastructure (IKT) started its research into the subject of root penetration in 1998. At that time, the prevalent opinion was that roots penetrate into waste-water conduits solely in search of water. The causal factor was thus clear: leaking waste-water lines, from which water was escaping, attracted roots to the leaks. Furthermore, the occurrence of root penetration was frequently attributed, in engineering terms, to an excessively low pressure used to force sealants into the pipe joint. Biological aspects are not taken into account in investigating the causes, with the result that only highly idealized mechanical methods are used for analysis of the root resistance of pipe joints. These methods generally ignore the special failure mechanisms resulting from the interaction of the pipe and the roots.

CHARACTERISTICS OF ROOT SYSTEMS

The capability for root regeneration differs among the various tree species. The above-ground parts of gymnosperms, for example, are generally much less capable of regenerating than those of the angiosperms. Observing cases of failure

Even the smallest gaps in pipeline joints are susceptable to root invasion.

in the context of root-intrusion in sewers and drains, and the specific search project for damage to drains and other conduits caused by gymnosperms, such as conifers, indicated that they penetrate only in exceptional cases. This led to the working hypothesis that the root growth of gymnosperms and angiosperms (like deciduous trees), differs in terms, particularly in their regeneration behavior following root trimming. The resultant working hypothesis was that the regenerative capability of the various species of trees may provide a measure of their aggressiveness.

In investigating the regeneration process in trees of differing related families, a series of tests demonstrated that the plants studied reacted differently to the trimming of their roots. Some exhibited a significant capacity for regeneration (Thuja, Ginkgo, Acer, Ailanthus), while others manifested a notably low (or none) regenerative capability (Taxus, Pinus). Analysis of the newly-formed roots generates in an ascending order, starting with the Taxus (Yew) and Pinus (pine), progressing via Ginkgo and Ailanthus through to Acer (maple) and Thuja.

The cause of this differing behavior is not specific to the larger family, but rather a function of the properties of the particular tree species. In renewal campaigns, it is therefore necessary to take into account that the mere selection of the larger gymnosperm family is not sufficient to prevent root penetration.

The potential invasiveness of roots related to the anatomical structure was analyzed by measuring root pressures in primary roots. In all cases, lower root pressure was measured in gymnosperm than in angiosperm roots. The lower root pressures may provide an explanation of the phenomenon that gymnosperm roots penetrate only in exceptional cases.

ROOT AND SOIL INTERACTIONS

The installation and operation of buried supply and disposal systems, as well as the planting and nurturing of green urban areas, are the basic factors which make healthy and enjoyable living possible in towns and cities. While both activities are significant and worthwhile, conflicts with parks and gardens departments have continued to surface, primarily because system operators are untrained in the growth behavior of roots and their interaction with supply and disposal lines and their trenches.

In addition to damage caused by roots to piping systems, root damage is also caused by engineering work in the conduit and/or cable trenches. In many cases, trees are also planted in the immediate vicinity of supply and disposal lines, which stems from a lack of awareness of the presence of the lines.

The results obtained in the study on root-intrusion in sewers and drains illustrated that the trenches of supply and disposal pipelines are an attractive environment for roots. Differences in compaction, adequate porosity and adequate ventilation are some of the reasons. In addition, soil moisture was not a deficiency factor in the cases examined. From the system operator's viewpoint, root growth in pipe trenches is an undesirable side effect which may result from the selection of a particular bedding material.
The barrier effect of highly compacted substrates on growing roots led to the working hypothesis that tree roots could be kept away from buried lines and conduits via the use of a corresponding material. Initial planting tests performed in 2003 using bentonite, a clay-based material, had already

The Institute for Underground Infrastructure in Germany specializes in researching and testing the effects of tree roots on underground utilities.

indicated that root growth in well-ventilated substrates can be restricted. Low-porosity filling materials used in pipe and conduit trenches are, in principle, considered suitable for shielding these elements from roots. Against this background, more extensive investigations into the protection of pipes and cables, via the use of root-repelling filling materials, are planned.

The tests performed have helped improve our overall understanding of the growth processes of roots in the soil and in the pipe joint. These results will be used in creating a fact sheet on tree locations, drains/sewers and other underground lines. The fact sheet will also incorporate the findings from the German Association for Water, Wastewater and Waste, which has been working in this field since May 2006. Scheduled for release in 2011, the sheet will include specific guidelines for the management of roots and infrastructure using current research results and will help minimize conflicts between system operators and municipal parks and gardens departments in the future.

CONCLUSIONS

As the desire to accommodate trees in rights of way continues to grow, public agencies will face an increased risk to their underground infrastructure unless formalized tree management policies are developed. Forward-thinking agencies will continue to develop policies that account for new construction methods, while recognizing the root growth attributes of varying tree species. Ideally, this will lead to appropriate landscape methods that do not adversely affect or cause failure to their underground utilities. The basis for such policies needs to be founded on solid research, much of which is currently being developed in Europe.

The lessons learned from the IKT research is helping us to understand the risks associated with tree roots that put pressure on pipeline joints and coatings. Combining this research with our knowledge of pipe construction materials and pipeline conditions can go a long way in helping managers establish focused criteria for tree removal or denial, as opposed to a broad policy that prohibits trees.

Research shows that it is possible and prudent to employ construction methods that guide tree roots away from pipelines. This is a field where the biologist, engineer and right of way manager can partner to generate the data and information required for a well-founded tree encroachment policy. Growing interest in this topic has spurred an educational breakout session at IRWA's 2011Annual International Education Conference in Atlanta, Georgia.

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Bill is the Right of Way Supervisor for the San Diego County Water Authority. He served as Chair of IRWA's International Local Public Agency Committee and holds a degree in forest management. Previously, Bill spent 16 years with the U.S. Forest Service, acquiring road easements and managing intermingled ownerships.

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Thomas holds the Chair for Biodiversity and Evolution of Plants at the Ruhr-University Bochum, Faculty for Biology and Biotechnology, Germany. Since 1998, he has been IKT's botanical counterpart researching the impact of tree roots on underground infrastructure. He is also member of the German Association for Water, Wastewater and Waste.