Arborist Network
Connecting people and trees™

Preliminary Tree Assessment report

Site Address:	Gordon St and Riding Lane Coffs Harbour NSW
Prepared For:	Ken Welham **Coffs Harbour City Council** 2 Castle Street COFFS HARBOUR NSW 2450
Prepared On:	29th January 2019
Report Number:	CD2008
Prepared By:	**Mark Hartley** Senior Consulting Arborist- AQF Level 8 Grad Cert Arboriculture (1st Class Honours) Dip Hort (Arboriculture) with Distinction Dip Arboriculture, Dip Horticulture LMAA; LMISA; LMIPS ISA Certified Arborist WC-0624 (since 1990) Registered Consulting Arborist™ #0005 ISA Tree Risk Assessment Qualified Registered QTRA user (No. 807) Member - Society of Risk Analysis Australia & NZ
Prepared on behalf:	**The Arborist Network** 58 South Creek Road Shanes Park NSW 2747 Phone (+612) 9835 1234 Email: *reports@arboristnetwork.com.au*

Table of Contents

Copyright Release

Executive summary

The client is proposing a major redevelopment to the east of a large tree that is of high value to the community. The community has expressed the view that the tree should be retained and kept healthy. The tree is a comparatively mature Hill's Weeping Fig growing in an opening between a concrete driveway, parking bays and access way, and a one-way lane.

The works involve the construction of a new building that will have basement parking and will vary between 3 and 5 storeys above ground. Construction will occur closer than the Indicative Tree Protection Zone suggested by the Australian Standard AS4970 – 2009 *Protection of tree of development sites.* This places a burden on this report to demonstrate that the tree will remain viable. This report achieves this outcome by considering the proposed works against similar projects and against the even greater impact associated with transplanting trees of this size and species.

While the proposed works are likely to have an impact on the tree, the extent of the impact can be readily managed without unduly impacting on the proposed works. Managed well, the proposed works have the potential to result in an improvement in the trees health and longevity.

Brief

The author has been asked to:

- visit the site,
- assess existing site conditions,
- assess the current health of the tree,
- undertake a Preliminary Tree Assessment,
- assess and discuss the impact of the proposed development on the tree,
- provide some generalised guidelines and input to assist the design team.

Information Provided

The client has advised that:

- the proposed development to the east of the tree involves three to five stories above ground and several levels of basement parking
- the long-term retention of the tree in a healthy and structurally sound condition is an essential outcome of the proposed works.

Plan Name	Drawn By	Date
Detail Survey	Blairlanskey Surveys	January 2018

Method

A site inspection was carried out on the 11th January 2019 and the site related observations contained in this report arise from the inspection on that date. This report follows the basic process outlined in the Australian Standard AS4970-2007 *Protection of trees on development sites* (the Standard) for undertaking a Preliminary Tree Assessment.

The tree was inspected from the ground and involved inspection of the external features only. A **V**isual **T**ree **A**ssessment (**VTA**)[1,2] was performed. The inspection did not include any invasive, diagnostic or laboratory testing.

The identification of the tree was made on broad the features visible from the ground at the time of inspection. It was not based upon a full taxonomical identification or comparison against a herbarium specimen.

[1] **VTA** – Visual Tree Assessment, as referenced below, is a systematic inspection of a tree for indicators of structural defects that may pose a risk due to failure. The first stage of this assessment is made from ground level and no aerial inspection is undertaken unless there are visual indicators to suggest that this is merited. Details of the visual indicators are contained in *The Body Language of Trees* by Mattheck & Breloer (1994). The use of a Visual Tree Assessment is widely used and standardised approach. Invasive and other diagnostic fault detection procedures will generally only be recommended when visual indicators of potential concern are observed.

[2] **Mattheck, C & Breloer, H** 1994 *Field guide for visual tree assessment (VTA),* Arboriculture Journal 18:1-23

Observations

The tree is a comparatively mature and healthy Hill's Weeping Fig (*Ficus microcarpa* var. 'Hillii".) or commonly referred to as a Hill's Fig. It has a relatively upright multi-stemmed form with several included junctions[3] typical of this species.

The tree has a trunk diameter of approximately 1.8 metres and has a canopy spread of approximately 30 metres. The canopy was full although one small portion of the upper canopy being somewhat sparse. There were numerous short areal roots throughout the tree. The surface roots diminished in number and size the further they got from the buttress.

The tree is in an opening approximately 5.5 metres wide east to west and proximately 6 metres north to south. There is what appears to be a concrete pit to the south of the tree. The trunk is close to the north eastern corner of the opening and the roots and buttress of the tree has displaced the adjacent kerb.

The site is relatively flat. There is a parking station to the east and a large portion of the area under the canopy of the tree is hardstand.

While no soil tests were available, the surface soil appeared to be a sandy loam. The results of eSpade tests in the area suggest that the soils are strongly profiled and tend to be a silty clay loam over progressively coarser material.

[3] An included junction (also called an incision, or included branch, or bark inclusion) is usually formed when the angle between the stem and a branch or between two stems is acute (usually less than 25^{O}). This acute angle can result in the bark being pinched between the two parts causing the localised death of the tissue. This means that there is a loss of connectivity when compared with the ideal junction.

Where an inclusion results in insufficient strength a healthy tree will compensate for this by producing extra tissue at the side of the join. This adaptive growth by the tree usually results in an attachment that is more than adequate in normal weather conditions. However, it is more likely to be the weakest point and thus fail during severe loading (usually inclement weather). Trees that are severely loaded and that don't have inclusions will usually have parts fail further away from the junction.

Discussion

The importance of trees to local community groups and the particular importance of this tree means that this report needs to provide information for a number of different audiences. It needs to assure the Council and the community that the tree can be retained and how that can be achieved. It must also inform the client and the design team about the basic principles and concepts that need to be considered in the design process. This also means that the report must contain both informative or educational content as well as prescriptive content.

General matters

The species well distributed throughout the Asia Pacific tropical regions. The variety is native to tropical Queensland and its identity was first published in 1891[4] suggesting that the variety was discovered in the late 1800's. Coffs Harbour is well out of the range of this variety.

Fig trees are fertilised by wasps. Most species of figs having their own unique pollinating species. Hill's Fig is pollinated by *Eupristina verticillata.* This wasp is only just reaching the Brisbane region. As a result, it is almost certain that this specimen has been planted.

Given the soil type and climactic conditions of the area, the history of the species and comparing the tree with other trees of the same species I would estimate the tree to be at least 70 years old and no older than 140 years.

The proposed basement works will result in the loss of roots that are currently growing within the building footprint. In addition, the construction of the above ground portion means that a number of branches need to be pruned to provide clearance between the building and the

This species of tree is very tolerant of construction activities and this often leads to this species being transplanted[5] when it is in the way of development.

There seems to be some uncertainty about the soil type that may be present near the tree. This uncertainty will be resolved by a geotechnical report. If this hasn't already been performed it may be appropriate to consider obtaining a chemical analysis of the soil at the same time.

Tree protection and the standard

The Australian Standard AS4970 – 2009 *Protection of trees on development sites* (the Standard) is commonly used to provide guidance on tree protection on sites such as this. It must be understood that this standard is largely informative in its nature and not normative. This means that much of the standard is not intended to be prescriptive but rather to provide guidance.

The standard suggests an Indicative Tree Protection Zone (TPZ) with a radius of 12 times the Diameter at Breast Height (DBH) of the tree. Furthermore, it allows for an incursion of 10% of the area provided that the same area lost by the encroachment can be provided contiguously

[4] **Bailey FM** 1891 Botany Contributions to the Queensland Flora. *Botany Bulletin.* Department of Agriculture, Queensland

[5] https://www.youtube.com/watch?v=886fm8ihgDU

to the TPZ. If this can be achieved and the TPZ enclosed as outlined in the standard, then an Arboricultural Impact Assessment is not required.

In short, the standard suggests that if a setback between the works and the tree can be kept to twelve times DBH (and only a minor incursion is required), then no further arboricultural input is required other than enclosing this area.

Fortunately, the standard makes clear in section 3.3.4 that major encroachments are permissible. In this situation, it is the role of the project arborist to "demonstrate the tree will remain viable," and this is where an arborist's skills, knowledge, and experience is required.

It should be noted that, for a good reason, 3.3.4 accepts a possible encroachment into the "*indicative Structural Root Zone*" (SRZ). There are many arborists, for example, who have seen significant damage occur within the SRZ of a tree and have seen the tree flourishing decades later.

To assist the reader a few supporting images of significant encroachments have been included as Appendix 2. While it could be argued that these are exceptions to the rule this is not the case. This report does not suggest that trees are generally tolerant of complete abuse and neglect. Rather, it suggests that trees are living organisms, like humans, that can deal with significant trauma and survive provided they receive appropriate care.

Perhaps the best example of tree trauma and survival is bonsai. Here both roots and canopy are hacked, the stems are injured, and decay promoted, and the soil volume is severely limited. In spite of this, the net effect is that the life expectancy of the bonsaied tree is often better than its non-bonsaied counterpart.

AS4970 and the Structural Root Zone

Amongst other things, the standard provides an algorithm to determine the SRZ. The SRZ algorithm is based on a data set of trees that failed and does not consider the trees that did not fail. It does not consider the support of any remaining roots outside the SRZ. Likewise, it does not consider the impact of root morphology or the distribution of roots.

The function of the indicative SRZ provided in the Standard is to alert the assessor to the possibility that the works may be impacting on roots that provide structural support. It is important to note that the standard does not prohibit works occurring within the SRZ. In fact, 3.3.4 of the standard states "*If the proposed encroachment is… inside the SRZ … the project arborist must demonstrate that the tree(s) would remain viable*". The standard continues in 3.3.6 to state, "*There are many factors that affect the size of the SRZ (e.g. tree height, crown area, soil type, soil moisture).*"

The particular algorithm provided in the Standard is based on an unpublished field study with an unknown method (Mattheck 1994, p 95 & 187)[6]. The data produced by the field study used to derive the algorithm involved trees that failed (Mattheck 1994, pp 83, 84) but we remain uninformed about the conditions under which failure occurred or what other factors may have contributed to the failures.

[6] **Mattheck, C. Breloer, H** 1994, *The body language of trees: a handbook for failure analysis*, Her Majesty Safety Office, London

It has been suggested by numerous authors that cutting three times trunk diameter from the base of a tree will seldom have any long-term impact on a tree. In saying this, it is assumed that a modicum of aftercare will be provided to assist the tree.

Smiley (2008[7], 2017[8]) and others have taken a more methodical approach which has involved progressively cutting root plates and looking for changes in the forces required to adjust the angle of the stem.

It is interesting to note that unlike Mattheck, Smiley found that trees with different root morphologies were affected differently by the same extent of root cutting. Most importantly, Smiley (2017) demonstrated that cutting in a straight line three times trunk diameter from a tree had little effect on tree stability regardless of root morphology. However, depending on the root morphology, cutting in a straight line as close as one times trunk diameter had little effect on trees with a more vertical root system.

From an anatomical perspective, roots that are constantly providing structural support for a tree must be located closest to the trunk. To provide support, these roots have a higher percentage of lignified tissue. At the same time because they are closest to the trunk, they also have the highest volume of water-conducting tissue (vessels).

For structural roots to perform the above functions, and for the support system to grow over time, means that these roots need to rapidly increase in taper as they get closer to the trunk. This gives rise to the term Zone of Rapid Taper (ZRT). Wilson (1964)[9] states that the ZRT is usually within two metres of the trunk of a large tree.

Horizontal roots can usually be cut up to the zone of rapid taper (Hamilton 1989)[10]. Hamilton advises that caution should be exercised when cutting large sinker roots close to the tree. However, based on Smiley (2017), excavation is not likely to cause a structural issue for most trees if it occurs as close as two to three times trunk diameter away from the tree, provided that the excavation is limited to one side only.

Hamilton summarises the situation as follows:

Severe root pruning of landscape trees does not adversely affect the value of the tree to the general public. Growth reduction and unacceptable appearance from root severance can be of a relatively short duration if the tree has strong vigour and vitality. Trees re-establish their root-shoot balance by enhancing root generation at the expense of shoot growth. With the development of new roots, water imbalances in the tree improve and photosynthesis and shoot growth rates increase

---

[7] **Smiley ET**, 2008 *Root Pruning and Stability of Young Willow Oak* Arboriculture & Urban Forestry 2008. 34(2):123–128.

[8] **Smiley ET**, 2017 *Root and stem cutting and its impact on tree stability* Proceedings of Arboriculture Australia May 2017 Canberra

[9] **Wilson B**, 1964 *Structure and growth of woody roots of Acer rubrum L*. Harvard Forest Paper 11 Harvard University Petersham, MA

[10] **Hamilton WD,** 1989 Significance of Root Severance on Performance of Established Trees, Arboricultural Journal, 13:3, 249-257

Management of the impact for the long term

The loss of roots and some area of infiltration will have an impact on the tree. Ideally this impact should be compensated for as a part of the design process. The easiest and most obvious compensation is to capture some of the stormwater from the new structure and to uses this to provide supplementary irrigation for the tree.

An equally desirable goal in the design process would be to increase the infiltration around this tree. This can be done, for example, by moving the curb further from the tree, or deleting one or more car parking space or a driveway or by altering the finished surface under the canopy of the tree.

Caution needs to be exercised when looking at the use of porous surface. While many of these systems function appropriately, they often require considerable excavation and, in this instance, excavation may damage roots. On the other hand, systems that can be installed on the existing grade may not be suitable for commercial applications. In addition, care needs to be exercised when removing existing surfaces to prevent damage to any roots that may be just below the surface.

There is the potential for an included stem to fail at some stage in the future. Although this unlikely it would to some extent detract from the tree. The likelihood of this occurring can be significantly reduced by encouraging the development of prop roots (something like that which has occurred naturally at Sawtell). This process would require an increase in the open area around the tree.

Opening some of the area to the north of the tree and moving the kerb another metre from the tree would be ideal. However, whilst desirable this is not essential.

Maintaining a 10 -15 cm mulch over any exposed soil under the tree is also an important part of this process for many reasons.

- Mulch increases moisture penetration into the soil and reduces moisture loss from the soil associated with evaporation.

- As mulch breaks down to microparticles it helps to form organic clays that have a very high water-holding capacity even greater than that of mineral clays.

- As mulch breaks down it releases essential solutes into the soil. Every solute required by a tree can be found in a chipped tree.

- Microorganisms that are involved in breaking down the mulch provide a part of a tree’s natural defence system. Bigger organisms also help cultivate the soil and improve the soils infiltration rate

Ideally, fresh arborist chip should be used as the mulch. This would normally need to be replenished every 6 -12 months. Some form of retention system will need to be installed to retain the mulch. Flexible systems such as treated pine or coir logs have their advantages as these are not readily damaged by the roots. However, a more rigid system is possible but will require suitable engineering.

Pressure from roots

In order to appropriated design around a tree it is important to take into consideration the pressure exerted by tree roots. Macleod and Cram (1996) state that tree roots exert a pressure in the order of 800 – 900 kPa[11] [12], dependant on species. They also provide calculations that demonstrate that roots can readily lift light structures such as driveways and pathways. Roberts, Jackson & Smith (2006)[13] state that root tree are incapable of penetrating through soil compacted to 2.5 mg/m^3.

This means that any structure can be designed to be root-proof although this may add considerably to the cost of construction. In some instances, it is also likely to require the use of alternate materials and innovative design.

Most critical is the basement wall closest to the tree and the new hard surface that have roots beneath them. The basement wall is vulnerable because tree roots can exert a pressure significantly greater than that applied by soil alone.

When it comes to pavements the issue relates to the surface being comparatively light and easily lifted. Fortunately, in the case of this tree most of the roots appear to be at such a depth below ground that they are not affecting the overlying pavement. This morphology is likely to be the result of the sandy soils that do not readily facilitate lateral movement of water.

There is, however, a mass of roots around the tree in the area that is open. This has resulted in some damage to the adjacent kerb and roots may have contributed to the movement of the concrete slab adjacent to the tree. The proposed works may allow for this to be repaired and relocated perhaps 50 to 100 cm further away from the tree.

Gutters

As a result of Work Health and Safety requirements, the cleaning of gutters on a multistorey building is becoming more problematic. The tree will shed leaves that will fall onto the building so consideration should be given to installing a gutter system that will not be significantly impacted by leaves. This could include installing one or more of the following:

- a quality leaf screening system
- Tornado Rain Heads' to increase the flow and reduce blockages, and
- installing one or more syphon-based diverters such as Gutter Pumper®, and
- installing overflow spouts that allow for the discharge of water in the event of a blockage taking place.

---

[11] The turgid pressure applied by most cells, either plant or animal, is within the same order of magnitude. If the force in the opposite direction is too great the cell will rupture or be unable to divide. As a result, there are upper end limits on the mass that can be lifted by roots.

[12] MacLeod R D. and Cram W J., 1996. Forces Exerted by Tree Roots, Arboriculture Research Information Note, 134/96/EXT

[13] Roberts J., Jackson N. and Smith M., 2006, Tree Roots in the Built Environment, The Stationary Office, Norwich

Understanding roots

All roots start as '**pioneer roots'**, pushing their way through the soil in order to take advantage of newly available soil moisture and solutes that are in the zone that they have entered (hence the term pioneer). Cell division at the tip of the root and cell elongation behind this tip creates the pressure to push the roots. This '**zone of elongation**' is typically a few millimetres to less than 100 mm in length.

Cell elongation uses water, and the presence or readily available water, solutes (soluble nutrients), and soil temperature (generally around 16 ^{O}C for most temperate trees) stimulates root growth. Whilst elongating cells can absorb some water, at best they only take up sufficient to meet the water needs associated with cell elongation.

Once the roots have fully elongated single-celled hairs develop on the surface of the root and these roots with '**root hairs**' to form '**absorbing roots.**'

'Absorbing roots' are responsible for the uptake of nearly all the water and the majority of solutes used by the tree. They are highly ephemeral, often lasting only a few weeks. However, in association with beneficial fungi, they can last a year or more.

Where trees are already growing well, we can typically assume that soluble nutrients are present at satisfactory levels. Likewise, we can assume that the soil surface temperature often exceeds 16 degrees Celsius most of the year and that at depth, the soil temperature does not vary significantly throughout the year. The biggest limiting factor, therefore, is usually the ready availability of water.

A percentage of these pioneer/absorbing root structures survive the various environmental stresses and within a few weeks or so they become woody.

'**Woody roots**' are effectively underground branches. These roots can be a little under a millimetre in diameter and can grow to be hundreds of millimetres in diameter over time. Their bark prevents them from drying out, but as a result, they are restricted from being able to absorb water and solutes from the soil to any great extent.

Whilst many young woody roots die as a result of disease, environmental damage or competition; they have the potential to be long-lived, sometimes lasting for hundreds of years. Woody roots act as the connection between the absorbing roots and the rest of the tree

'Structural roots' make up only a small portion of the woody roots. These roots provide physical support for the tree. They grow directly from the trunk (first-order lateral roots) or are roots that branch close to the trunk. These roots provide support in compression and tension. They have a greater content of lignified cells and, as a result, tend to be much thicker to allow for strength, as well as transport.

In response to the forces of compression and/or tension, these structural roots develop an asymmetric shape rather than the normal circular shape. As the roots grow further from the trunk, they get rapidly thinner (zone of rapid taper) and more circular in shape.

In fast draining sandy soil on this site, the root system is likely to have a large number of sinker roots and rapid rood division. Roots are likely to extend downwards until bedrock rock or a permanent water table is reached.

Damage to roots

Damage to larger roots inside the zone of rapid taper is extremely undesirable and, in most circumstances, should be avoided. These are woody roots, and therefore excavation is more significant in its impact than careful constructing over the top of these roots.

Depending on the amount of root division, the cutting of a woody root with a diameter of 25mm could conceivably result in the death of many millions of root hairs. This loss of absorbing roots has a direct impact on a tree's ability to absorb water and solutes. In addition, it can impact on hormone production, resulting in reduced growth above ground until the root/foliage ratio is restored to its ideal levels.

The loss of roots can result in wilting or thinning of the foliage, the loss of foliage and death of smaller branchlets and sometimes the death of specific larger branches. The ready availability of soil moisture is important in minimising this impact.

Not only do higher soil moisture levels, reduce the energy expended to absorb water, it also stimulates new root development. The faster that sufficient new roots are developed, the less the impact on normal function

Roots are often close to the surface, and therefore construction activity can indirectly impact on the health of roots through direct damage or soil compaction. Even regular pedestrian activity has an effect on the roots close to the surface. In addition, altering of levels by adding fill has the potential to alter the movement of water into the soil and in some circumstances, can cause the soil to become anoxic, in turn causing the death of the roots and potentially the death of the tree.

By far the easiest and most efficient way of limiting construction damage to trees is to establish and enclose a Root Protection Area (RPA) using a rigid fence. The function of this fence is to protect the tree, and the roots in particular, by eliminating or restricting all construction activity in this area.

Methods of Tree Protection

It is important that we understand the processes and methods of tree protection. For that reason, a number of images have been included in Appendix 5 along with the information in this section to assist in ensuring that appropriate implementation of tree protection.

Protect the roots

As already explained the purpose of establishing a Tree Protection Zone is more than concerned with protecting the trunk of the tree. A Tree Protection Zone's primary function is the protection of the roots of the tree.

The most appropriate method of protecting a tree is to establish an exclusion zone using some form of rigid temporary fence (a Tree Protection Zone or TPZ). Whilst it may seem easier to use a flexible fabric barrier fence, these products tend to fail over time and are easily pushed out of the way or damaged. In comparison, damaging a rigid fence requires more of a hit can damage machinery and involves the cost of repair or replacement of the damaged fence.

Sometimes, however, it may become necessary to work within or to gain access through a Tree Protection Zone. To do this, we need to develop a method to stop soil compaction and prevent direct physical damage to roots. A simple action such as walking on the same spot half a dozen times or more can lead to soil compaction. Pushing a full wheelbarrow will cause compaction in the first instance. It does not take long for that damage to accumulate and harm the roots of a tree.

There are a number of ways to protect roots against compaction and physical damage. We can divide these into two simple groups:

- Systems that share the load, and
- Systems that are fully load bearing.

Load-sharing surfaces are temporary and usually lightweight systems. Load-sharing surfaces sometimes can be as simple as mulch beneath plywood or planks or the use of scaffolding, to heavier duty systems such as the use of plastic or metal road plates or even rail decking. Photographs in Appendix 4 show that these can be enough to protect a delicate egg from breaking.

Fully load-bearing structures include finished structures such as the slab of a building, a driveway or a pathway. Obviously, each of these has a limit to the weight that it can bear and if this is exceeded the structure and things beneath it can be damaged. Load bearing systems can also include scaffolding and temporary bridging structures.

Protect the trunk

In most instances, enclosing of the Tree Protection Zone ensures that the trunk of a tree cannot be damaged. Sometimes, however, work needs to take place within the Tree Protection Zone and, as a result, there is a risk of impact to the trunk. Damage to the trunk is extremely undesirable. Where it is possible to treat the wound treatment is time critical and is very expensive. When treatment is not possible or is ineffective, a trunk injury can lead to long-term structural and physiological problems.

Where possible operating machinery or performing activities that may result in an impact to the trunk of the tree should be avoided. Where this is not possible, it is important to protect the trunk. Strapping pieces of timber to the trunk of the tree has been the traditional method for achieving this task.

Conservation of Momentum (as demonstrated by Newton's cradle) tells us that this force is basically transferred through the pieces of timber to the trunk of the tree often providing little to no protection and in some circumstances actually resulting in increased damage.

In response to the failure of timber to absorb impact, hessian or carpet underlay was used and whilst these improved the situation the timber still lacked the ability to absorb any of the energy. The use of fabric wraps also carried new problems; in particular, they often held moisture, and this moist material was in constant contact with the trunk.

A more appropriate system needs a hard, but flexible outer surface bonded to a soft impact absorbing material that has a low water holding capacity. This system is better at absorbing the energy of an impact similar to a bicycle helmet. Just as with a bicycle helmet, if the impact damages the protection system it needs to be repaired or replaced, and at the same time, the trunk of the tree needs inspecting.

Lastly, prevention is the best process. When machinery is operating in close proximity to the trunk using an observer can greatly reduce the likelihood of impact. To be effective, the observer should maintain direct visual contact with the tree and the machine and should have direct audio contact with the operator. (Two-way earmuff systems are useful for this task).

Protection of the canopy

The canopy of the tree is often the part of the tree that is least harmed in the construction process. Even so, there are two ways that the construction process can harm the canopy. The first is by direct impact between equipment and the branches of the tree, and the second is from incorrect or excessive tree pruning.

Avoiding impact between machinery and branches simply requires care. When machinery needs to operate near branches, an independent observer should be used. The observer should maintain direct visual contact with the machine and the branches of the tree and should have direct audio contact with the operator.

All pruning cuts should be made as illustrated in the Australian Standard AS 4373-2007 “Pruning of Amenity Trees.” Anyone who does not fully understand this standard or who has not had the proper training to perform pruning should not attempt this work. The project arborist may instruct site personnel to make temporary cuts for later rectification by an arborist. These instructions should be carefully followed.

Tree Protection Plan (Specifications)

Design Issues

#	Recommendation	Reason
1	Along the boundary line under the canopy of the tree use contiguous piling or similar.	To minimise drying of the soil around the remining roots.
2	Where possible increase the open space around the tree.	To allow for increased water infiltration and to allow for further growth of the tree.
3	Design for an irrigation system to provide additional moisture for the tree.	To compensate for root loss associated with the excavation of the basement.
4	Consider the design of the roof drainage to allow for the leaf drop.	To minimise blockages associated with leaf fall onto the roof.
5	All copies of the plans should include a copy of the Tree Protection Plan (drawing) and a note on each and every plan or drawing to "check the Tree Protection Plan (drawing)."	Tradespeople often read plans rather than written details. Including the Tree Protection Plan (drawing) in the plan set will help the awareness of all tradespeople.

Note: The following draft specifications will need to be added to, adjusted and finalised during the detailed design phase and incorporated into the construction management plan.

Pre-construction

6	Appoint a project arborist to oversee and certify all works in the Tree Protection Zones.	A project arborist is needed to supervise and oversee the care and protection of the trees.
7	Establish a 'tree protection' policy document for inclusion as a part of the site induction.	Ensuring all site personnel are aware of the tree protection requirements.
8	A copy of this Tree Protection Plan including the Tree Protection Plan (drawing) **must** be on site prior to any work commencing on the site AS 4970-2009 (5.2).	To ensure that documentation is present and available as a reference for all site personnel. **Note**: The Tree Protection Plan (drawing) can be found in Appendix 2..
9	Prior to commencing work on the site, establish a Tree Protection Zone around the trees using a 1.8-metre high rigid temporary fence.	Fences create "no-go" zones, show the importance of the trees and help prevent soil compaction and root damage.
10	Apply a 15 - 20 cm layer of arborist mulch over the surface of each Tree Protection Zone.	Mulch provides some protection to the roots and helps to manage soil moisture.
11	Attach signs to the Tree Protection Zone as detailed in section 5 of the Generic Tree Protection Guidelines attached as Appendix 4.	Signs help to remind people why the fence is there and what should not be happening in that zone.
12	Use TrunkGuard™ or a similar system of 100mm wide boards with thick polystyrene foam bonded to one side to protect the trunk.	To provide an additional level of protection for the trunk during adjacent demolition and construction works.
13	Correct and complete installation of Tree "Protection measures **are** to be certified by the project arborist" AS 4970-2009 (5.3.2).	This is to ensure the tree protection is correct and completed in accordance with the Tree Protection Plan.

Preparatory tree maintenance

14	Remove all larger weeds by hand – do not spray herbicides to control the weeds.	Weeds compete with the tree and herbicides can damage the tree's roots on contact.
15	Apply a 15 - 20 cm layer of arborist mulch over the surface of each Tree Protection Zone	Mulch provides some protection to the roots and helps to manage soil moisture.
16	Install a temporary automated irrigation system to the open area.	Increasing soil moisture will stimulate new roots.
17	An AQF Level 3 Arborist **must** perform any canopy pruning with all final cuts made in accordance with AS4373-2007. The arborist must **not** use climbing spikes.	To ensure the arborist makes correct cuts and that the tree is not unnecessarily damaged. It is preferable to use an AQF Level 5 arborist for this work.

During site works

18	Have the project arborist perform inspection not less than monthly and at the critical checkpoints listed below as per AS 4970-2009 (5.4.1)	To monitor tree health, to be present at critical checkpoints, and to ensure that the Tree Protection Plan is being followed.
19	If an inspection reveals a breach of the Tree Protection Plan, the project arborist **must** specify any remedial works and the timeframe in which these works must be completed.	To ensure that all problems are appropriately rectified and that any remedial works required are carried out in a timely manner.
20	If at any stage an inspection reveals the Tree Protection Plan (Specifications) has not been complied with, site inspections **<u>must</u>** be carried out weekly thereafter.	This is to provide additional supervision to help avoid repeat problems and to ensure the correct and timely performance of remedial works.
21	Maintain natural ground level within the Tree Protection Zone. Do not trench, stockpile materials or change grades within this zone.	To prevent unnecessary or unauthorised damage to the trunk, roots, and branches of the tree
22	Maintain the Tree Protection Zone until construction work is completed.	To provide protection for the duration of the works that impact on the tree.
23	Machinery access is **not** permitted in the Tree Protection Zone to perform landscaping works	To avoid damage caused by machinery as a part of landscaping activities.
24	An observer **must** be present during excavation or the demolition of any structure within 3 metres of any part of the tree	This reduces the likelihood of accidental impact to the tree. **Note:** Using the project arborist is strongly recommended.
25	Cleanly cut any root that, is greater than 20mm in diameter, and that need to be cut or removed	This is to avoid tearing of roots and helps improve new root generation.
26	Where roots are cut as a part of item 25 the cut end should be kept moist using a root oasis, temporary hoarding. or a root curtain.	This is to ensure that cut roots do not dry out and stimulates new root generation.
27	Provide notification to the Site Arborist, the Council, and the Certifier not less than 7 days before removing the Tree Protection Fences.	This allows a check to be undertaken to determine if the remaining works are likely to adversely impact on the trees.

Critical checkpoints

28	Have the project arborist present at the following checkpoints: • During demolition of the existing structures within 3 metres of any part of the tree • During the removal of any hard surface under the canopy of the tree[14] • During the installation of piling along the boundary under the canopy of the tree • Prior to forming any cap beam under the tree • Prior to erecting and decommissioning any scaffolding under the canopy of the tree. • Prior to cutting any root greater than 10 cm in diameter Note: These can form part of the periodic inspections specified in item 18

Load sharing and load-bearing surfaces

29	Any load sharing surface for pedestrian and light machinery access **must** be comprised of plastic road plate on top of a 10 – 15 cm mulch layer.	To allow for suitable load sharing. **Note:** 19 mm may be used where only pedestrian access is required.
30	Use a geotextile fabric below the mulch to allow for the later removal of the mulch, in areas where turf will be laid.	To allow mulch to be removed by hand and to limit root growth into the overlying mulch.
31	Remove all much by hand starting from closest to the tree and moving outwards.	To minimise the impact on roots as a result of the removal of the load sharing surface.
32	A load bearing surface shall be constructed using Megadecking, Durabase mats, JLA bogmat. or continuous dragline.	This is to ensure that the surface is sufficiently robust to share the load of heavy equipment.
33	Where the surface levels below a Temporary Load Bearing Surface needs to be adjusted this shall be achieved using sand or other suitable material applied to the surface.	This is to ensure that excavation does not take place in order to install a Temporary Load Bearing Surface.
34	Once a road or parking bay has been completed it shall be deemed to be a Load Bearing Surface.	This means that these finished surfaces can be used as an alternative.
Note: If concerns exist that the works will damage the finished surface the same work will almost certainly damage the tree roots, and a temporary surface must be used		

[14] The canopy of the tree shall be taken to mean the canopy of the tree before any pruning works take place.

Post Construction

35	At practical completion, the project arborist **should** "assess tree condition and provide certification" that the tree protection works have been in accordance with the Tree Protection Plan.	This is to provide a completion to the document trail for the certifier and or the certifying authority.
36	"Certification **should** include a statement on the condition of the retained trees, details of the deviations from the approved tree protection measures and their impacts on [the] trees" and provide specifications for any remedial or rectification work required.	This is to comply with AS 4970-2009 (5.5.2). It provides a documented record of the final condition of the tree. It audits and certifies the correction of any problems.
37	Have the project arborist inspect quarterly and report (for whichever is greater) for: • 12 months after completion of works, or • 12 months after achieving stable growth.	To ensure the long-term recovery of the tree is certain.

Should you require any further information, do not hesitate to call our office for assistance.

Mark Hartley
Senior Consulting Arborist- AQF Level 8
Grad Cert Arboriculture (1st Class Honours)
Dip Hort (Arboriculture) with Distinction
Dip Arboriculture, Dip Horticulture
LMAA; LMISA; LMIPS
ISA Certified Arborist WC-0624 (since 1990)
Registered Consulting Arborist™ #0005
ISA Tree Risk Assessment Qualified
Registered QTRA user (No. 807)
Member - Society of Risk Analysis Australia & New Zealand

Appendix 1: Site images

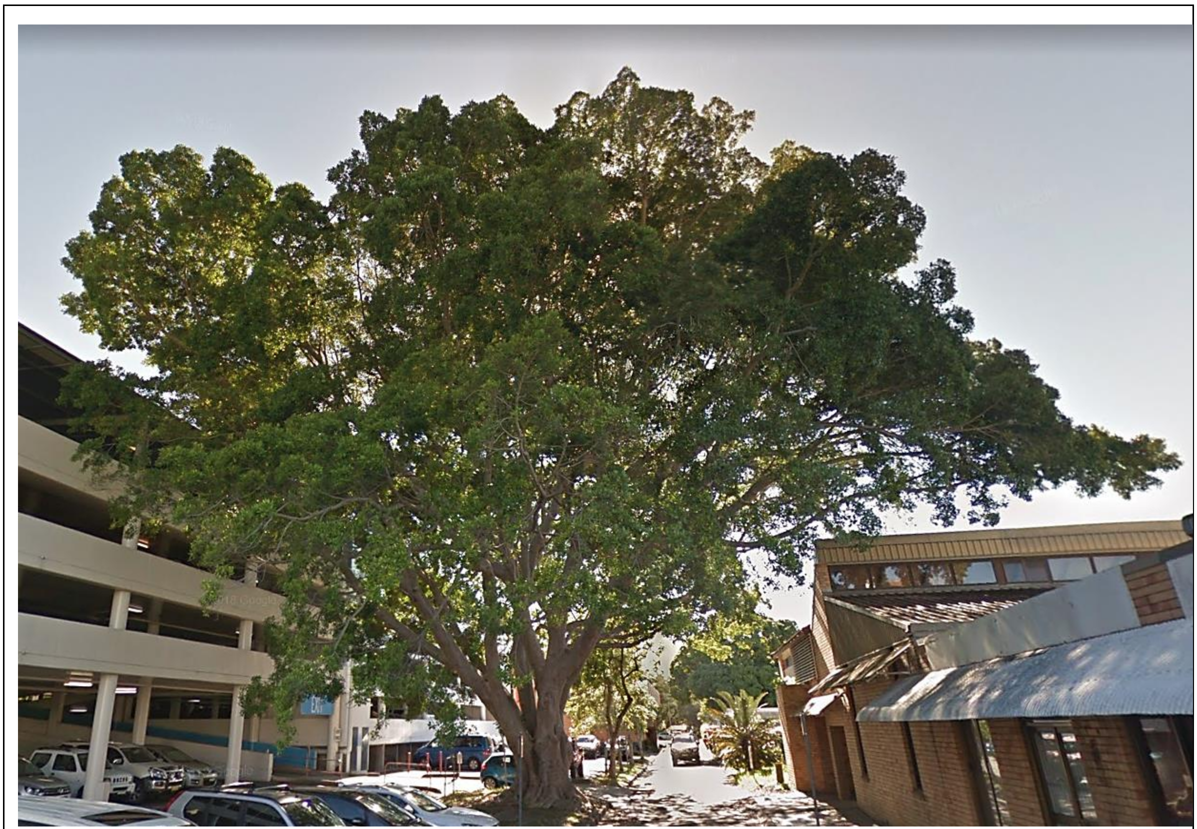


Image 1: Looking to the north and showing the extent of canopy overhang.

Image 2: Roots affecting the kerb.

Image 3: Looking at the tree from the north.

Image 4: What appears to be a concrete pit or old slab to the south of the tree.

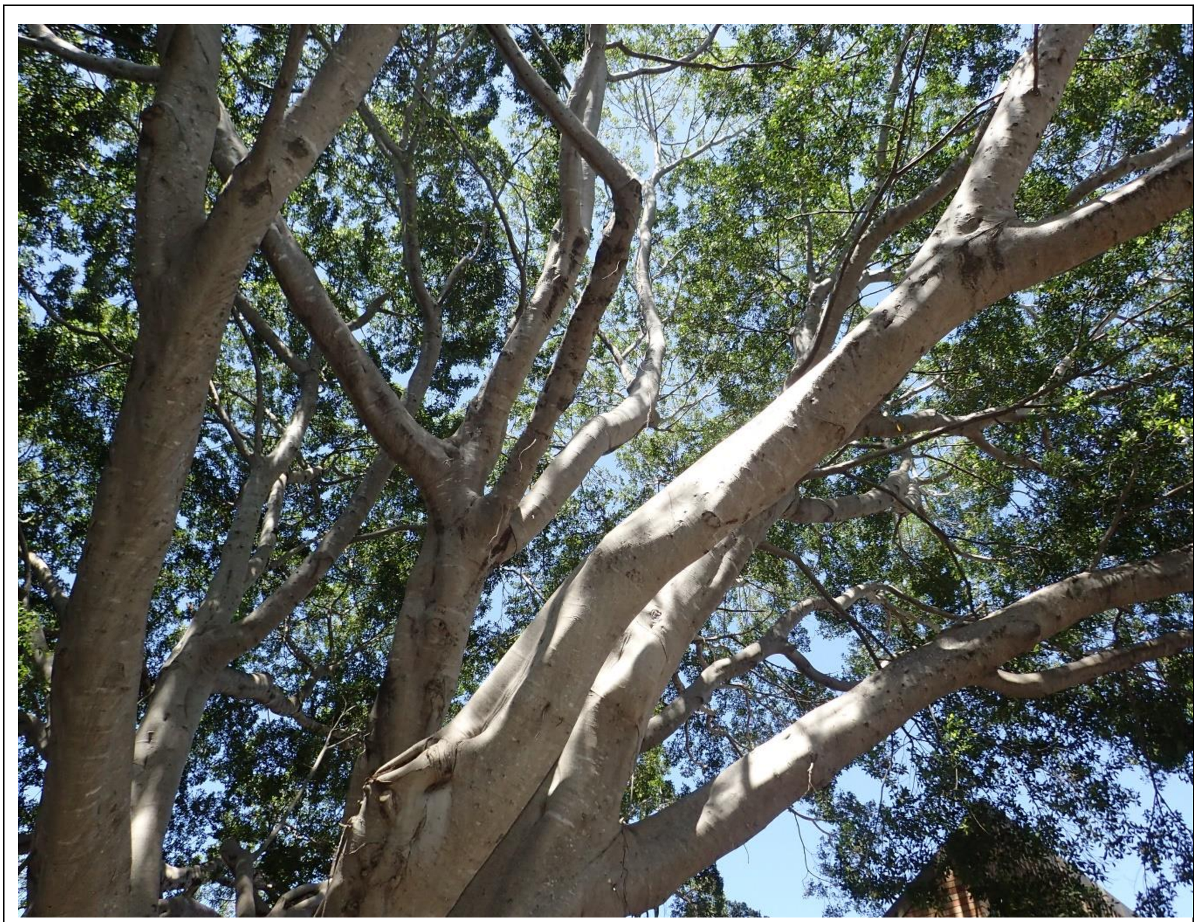


Image 5: The tree has many small areal roots that would readily form prop roots if encouraged.

Appendix 2: Supporting images

Figure 6: Substantial root cutting on a Camphor Laurel that occurred 6 or 7 years before (image 2011)

Figure 7: The tree set back a bit but has been slowly recovering (image 2011) tree last inspected 2015.

Figure 8: Stressed Moreton Bay fig, Susan Street Auburn with Brush Box in the foreground Sept 2008

Figure 9: 40% of the canopy was removed to make way for a multi-storey car park with two levels below ground (Image September 2008)

Figure 10: Two basement levels excavated 3 metres from the centre of the trunk. (Image June 2009) Note that there is a classroom to the rest and bitumen to the south and east

Figure 11: Note that there is a classroom to the rest and bitumen to the south and east (Image July 2009)


Figure 12: Not everything on the project was ideal – e.g. compaction, spoil and rubbish. (Image January 2010)


Figure 13: Nothing but irrigation and October 2013

Figure 14: Root morphology is heavily influenced by soil texture

Appendix 3: Determining the Tree Protection Area

A simple solution

Over the last two decades, there has been an increasing awareness of the need to protect appropriately and care for trees on development sites. There have been conferences, workshops as well as publications written on the subject. Most notably these include British Standard BS 5837: 2005, “Trees and Development” by Matheny N & Clark J and “Protection of Trees on Construction Site” by Hartley M. These publications all focus on minimising damage to the root system of the tree by establishing appropriate **T**ree **P**rotection **Z**ones **(TPZ).**

The British Standard provides Matheny and Clark as the source of the formula for calculating the radius of the tree protection zone. Interestingly Matheny and Clark site the British Standard as the source of the formula. Such a circular argument is of concern, particularly when the Matheny and Clark include many examples of their successful encroachment of their Tree Protection Zone in their text.

Matheny said, ***“It is not that common that we get that much space.”*** and ***“With tolerant species, we can squeeze that down by half or two-thirds”.*** (ISA Annual Conference 2007) Mathematically that suggests that the Tree Protection Zone could potentially contain as little as 12% of the root volume provided for using either formula.

Calculations and tables in the first two publications aimed at providing a Tree Protection Zone sufficiently large enough to ensure that the health of the tree is not adversely impacted and achieves this without the need for arboricultural input other than ensuring the maintenance of the protection zones. The British Standards or Trees and Development are ideal documents to be applied by anybody regardless of their understanding of plant physiology.

Matheny rightly states, **“*Because the tree is an individual the table is not enough. You need to consider all the factors*.”** (ISA Annual Conference 2007) If we are to find benefit in the **TPZ** given in either the British Standard or Trees and Development, it is that this is a **TPZ** that can be determined by <u>any person and without any arboricultural input</u> since it is a simple formula. Anyone able to measure the trunk diameter and follow the formula can calculate the **TPZ**.

A suitably experienced consulting arborist is often able to support a smaller **TPZ** when combined with appropriate arboricultural care, and some provision is given in the British standard for this to take place. This makes no sense unless the formula for calculating the **TPZ** in the British Standard is prefaced with a note saying that this is the point at which arboricultural input is required. Regrettably the British standard does not say this, and as a result, it becomes overly prescriptive.

An arboricultural solution

Land and development costs along with the environmental impact of urban sprawl make it undesirably burdensome to sterilise vast areas of land to enclose an optimum **TPZ**. It is often far more cost effective to provide even the highest level of Arboricultural care possible to a tree to ensure that it thrives and prospers in the long term than to establish a **TPZ** that is unnecessarily large.

It makes logical sense to adopt a **M**inimum **T**ree **P**rotection **Z**one that is based on the size of a root plate required to transplant the same tree. Transplanting of large and even very old trees has been carried out with enough frequency and over such a long period that we have a good understanding how transplanted trees respond to root loss. A success rate of 97% can be expected when a transplant is properly undertaken with appropriate ongoing care.

Perhaps the 3% failure rate could be considered as unacceptable, but it is likely that a percentage of these would have died within a few years in any case. Matheny again points out ***"Transplanting is a far greater impact – if we are going to transplant it, we might as well keep it where it is and squeeze the protection zone."*** (ISA Annual Conference 2007) A transplanted tree will undoubtedly undergo a greater degree of stress than a tree that is retained with an identically sized root plate that is appropriately protected and cared for.

The site constraints, more often than not, are likely to benefit from a **TPZ** that is smaller than that specified by the British Standard and Trees and Development. Using a smaller **TPZ** means that there will be a requirement for appropriate levels of arboricultural care. This approach may give rise to the question "What is the minimum area required by the tree?" There is, unfortunately, no absolute answer to this question but there are some important benchmarks to be considered.

- The protection should be sufficient to allow the maintenance of the tree, with appropriate arboricultural input. In the past, this was called the **C**ritical **R**oot **Z**one **(CRZ)** and frequently relates to the size of the root plate that would be required to transplant the tree successfully. In most instances is an area with a radius of 5 times the trunk diameter. This document refers to this at the **M**inimum **T**ree **P**rotection **Z**one (**MTPZ).**

- Depending on the tree's response to root damage, it is possible to come even closer to the tree particularly when construction impact is going to be limited to one side or better still to one quadrant of the Critical Root Zone **<u>and</u>** the provision of an additional area around the remaining area of the root zone can be protected.

- The extent of any excavation should not result in the structural instability of the tree. A number of formula and test exist to determine the size of the **S**tructural **R**oot **Z**one (**SRZ**). There is however generally no need to consider the issue of structural stability if work is performed outside the **MTPZ**. In most circumstances, it is undesirable and often unwise to cut roots located in the Structural Root Zone.

There must be sufficient soil volume to allow the tree to grow to maturity with appropriate ongoing care. If the goal is to have little ongoing care, this will undoubtedly take a greater soil volume than a tree that will be extensively maintained (such as a tree growing in a rooftop planting).

The approach of AS 4970-2009

In August 2009, Standards Australia released AS4970-2009 Protection of Trees on Development Sites. In its preface, this document acknowledges its reliance on the British Standard and Matheny and Clark. This standard suggests an "*Indicative*" **TPZ** with a radius 12 times trunk diameter. As already discussed, there is no question that this will provide adequate protection of the tree in almost all conceivable situations. It achieves this by suggesting an **ITPZ** encloses and potentially sterilises an enormous area.

The standard does acknowledge that it may be possible to encroach on this **ITPZ** if the project arborist can demonstrate that the "*trees will remain viable*." As already stated, we can successfully transplant most trees in good health and vigour, so the use of a reduced sized **TPZ** when combined with appropriate care, has been demonstrated by several hundred years of successful tree transplanting. (Mathematically the standard sized root plate for a transplant has less than 20% of the root area of the **ITPZ** specified in the AS 4970-2009.)

Of equal concern is the impact of the insistence of a **TPZ** with a radius of 12 times trunk diameter may have on tree retention and urban sprawl. Where there is a conflict between development and tree retention, a decision will need to be made to refuse the development (potentially increasing urban sprawl) or to reduce the size of the **TPZ**.

If the development is acceptable, then we need to answer the question "should we be removing trees that cannot be given the **ITPZ** given in AS 4970-2009?" The answer should be "No!" whenever there is adequate potential for retention the tree with appropriate arboricultural input.

Given that the standard has some significant issues and seeks to be "informative," it is essential the standard is not viewed as prescriptive or normative. The standard does consider some important issues such as the timing of the work, the importance of preventative maintenance and ensuring appropriate monitoring of the trees. As far as practical this document forms an important part of that process.

There is no doubt that establishing and maintaining a **TPZ** around a tree is the most important thing that a developer can do to protect a tree. In the same manner, perhaps the most significant arboricultural input that can be provided is the management of soil moisture levels. The sooner soil moisture is managed the lower the impact on a tree. Ideally, management would start before any work starts on the development.

Appendix 4: Generic Tree Protection Guidelines

1. Pre-Construction:

1.1. Prior to the commencement of construction, the consulting Arborist will issue a report outlining the following:

1.1.1. The trees that have been protected, the maintenance activities (if any) for each tree that have already been performed, that the protective fence or fences have been installed in accordance with the Arborist's Report.

1.1.2. A statement that the physical protection (items 7 and 8 of the POTOCS standards) of the trees has been performed, to the above standards or if not, any non-conformances and why. e.g. the fence around trees is incomplete because of boundary fences.

1.1.3. All trees to be removed are to be marked with a single white line around the trunk. No tree shall be so marked until council consent for its removal has been given.

1.1.4. Prior to removal one of the following will confirm the tree is to be removed by marking the tree with a single horizontal yellow or orange line. One of the following persons, Surveyor, Landscape Architect, Arborist, Project Manager, and Tree Preservation Officer, should do this.

2. Tree Protection Zones:

2.1. The trees are to be protected by a 1.8-metre high fence to be constructed within 500mm of any construction activity and to include as much of the Primary Root Zone as possible.

2.2. Where the Tree Protection Zone occurs impart on the adjacent property, the fence will stop at the boundary lines.

2.3. Provision will be made to these protection zones for pedestrian access only.

3. Maintenance activities:

Timing: Maintenance activities are to be at the commencement of the construction process by qualified Arborists and then as required during the construction period.

3.1. The following maintenance activities may be required for this site:

- Irrigation – by hand to comply with current specifications
- Soil Amelioration
- Mulching
- Crown cleaning in accordance with AS 4373-2007 *Pruning of Amenity Trees*,
- removal of trees by sectional felling and stump grinding.

3.2. Irrigation

3.2.1. Soil moisture during construction shall be maintained at not less than 60% of field capacity.

3.2.2. Irrigation is to be applied by hand. No construction activities are to take place within the Primary Root Zone until irrigation has been initiated and soil moisture reaches 70% of field capacity at a depth of 300mm.

3.2.3. On each visit, the consulting arborist shall check the soil moisture and manually check the irrigation system, when installed.

3.2.4. Soil moisture levels should be checked by physical touch or with a tensiometer.

3.3. Soil amelioration

3.3.1. An application of rooting hormones, humic acids, soil micro-flora and mycorrhizae may be applied by an arborist in accordance with the manufacturer's instructions.

3.3.2. Chemical fertilizers are to be used only after representative soil testing and based on the soil scientist's recommendations.

3.4. Mulching

3.4.1. The fenced area should be mulched with seed-free mulch to a depth of at least 50mm.

3.5. Weed Control

3.5.1. Weed control shall be by hand pulling, wiping or spraying with a glyphosate-based herbicide. Material likely to be root grafted to trees to be retained shall be removed manually.

3.5.2. Weed control shall not be performed by mechanical cultivation or by scraping or back burning.

3.6. Crown cleaning

3.6.1. Crown cleaning (AS4373-1996, Pruning of Amenity Trees) shall be performed in accordance with the standard, by an arborist and in compliance with the appropriate occupational health and safety regulations. All branches down to 50mm in size shall be inspected and appropriately treated.

3.6.2. Any concerns about health or safety that are observed by the arborist on the site will be reported in writing within 7 days to the superintendent/principal/client and/or head contractor.

3.6.3. The use of spurs on live trees and internodal cutting is strictly prohibited.

3.7. Tree Removal and Stump Grinding

3.7.1. Remove trees in a controlled or sectional felling to avoid any damage to the trees to be retained.

3.7.2. All shrubs, under-scrub and woody weeds that are to be removed shall be removed by hand as per 3.4 above.

3.7.3. No tree shall be removed unless it has been marked with a horizontal white and yellow/orange line around the trunk.

4. Fences:

4.1. The fencing of the Tree Protection zone as defined in section 8.0 of the POTOCS standards should be commenced prior to the commencement of ANY work, including demolition and land clearing by earth moving machinery but may be erected after tree maintenance activities.

4.2. The fence surrounding the Tree Protection Zone must be a rigid fence not less than 1.8m high.

5. Signs:

5.1. At least every 25 metres attached to all tree protection fence there shall be a sign, a minimum of 600mm x 600mm, bearing the following phrase in red letters on a white background at least 50mm in height:

"TREE PROTECTION ZONE - KEEP OUT"

5.2. On the same sign above or on a separate sign attached adjacent, in red lettering on a white background not less than 25mm in height is to be the following:

"PROHIBITED ACTIVITIES"

Followed by the list below in black letters not less than 15mm in height.

a) Entry of machinery or people.
b) Storage of building materials.
c) Parking of any kind.
d) Erection or placement of site facilities.
e) Removal or stockpiling of soil or site debris.
f) Disposal of liquid waste including paint and concrete wash.
g) Excavation or trenching of any kind (including irrigation or electrical connections).
h) Attaching any signs or any other objects to the tree.
i) Placing of waste disposal or skip bins.
j) Pruning and removal of branches, except by a qualified Arborist.

5.3. In letters, not less than 25mm in height on the above sign should be the name of the supervising Arborist or arboricultural company or other appropriate contact and a contact phone number.

6. Root Cutting

6.1. All roots greater than 50mm in diameter that need to be removed shall be cleanly cut and kept moist at all times and shall not be left exposed to the air for more than 10 to 15 minutes.

7. Maintenance Reports:

7.1. Weekly inspections and monthly reports should be made until the end of construction.

7.2. A consulting Arborist should be on site during any excavation work within the Critical Root Zone and will report on that work in the monthly report.

7.3. A site log shall be maintained and include the date of each inspection, the person who performed the inspection, the items inspected or tested, the maintenance activities performed, any repairs undertaken or required to be undertaken, and any substantial breaches or non-conformances.

7.4. The arborist performing the inspection should sign the entries in the logbook

7.5. The log shall be maintained on the site or alternatively copies of the log entries for the month shall be submitted each month with the monthly report.

7.6. All maintenance shall continue for the 3 months after completion of construction

8. Non-Conformance Reports:

8.1. The following are non-conformances that need to be managed when they occur.

8.1.1. The removal or relocation closer to the tree of all or part of any protective fence prior to landscaping.

8.1.2. The performing of any activity noted as prohibited on protection zone signage

8.1.3. The failure to maintain adequate soil moisture or the failure in the operation of the irrigation system.

8.1.4. Mechanical damage to the trunk, stems, branches, or retained roots.

8.1.5. The sudden and abnormal or premature shedding or decline of the tree.

8.2. **Substantial breaches and non-conformances**:

8.2.1. Any breach or non-conformance of the tree protection zone, by any party, shall be notified in writing within 2 working days of it being first observed.

8.2.2. Notification of any non-conformance should be made in writing to the site foreman, the consent authority, and any independent certifier.

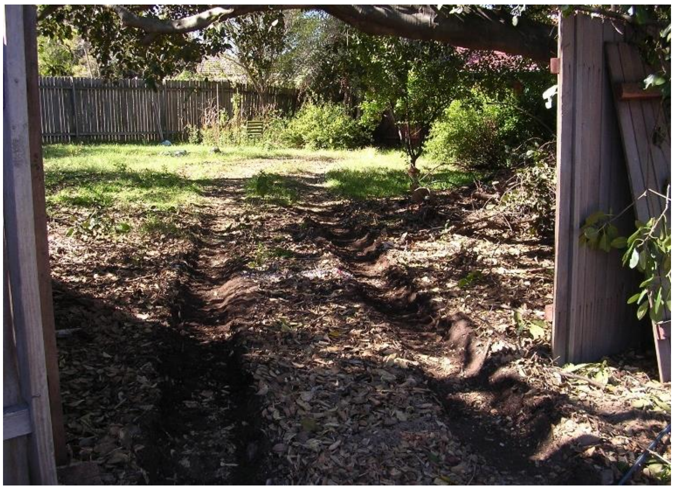
Appendix 5:

Protection of Trees on Construction Sites

Establishing a Tree Protection Zone

Good Work	Poor Work
 **Photo 1:** The fence should be rigid and hard to move.	 **Photo 2:** This style of fence is too easily damaged and collapses when hit.
 **Photo 3:** The TPZ is mulched where appropriate and weed free.	 **Photo 4:** Put the fence where it should be! The TPZ is not for storage.
 **Photo 5:** The purpose of the fence is to isolate the tree from the works and to protect the roots.	 **Photo 6:** Woven fences seldom work particularly when space is limited.

Protecting the roots

Good Work	Poor Work
 **Photo 7:** Like an egg tree roots are delicate and easily damaged.	 **Photo 8:** A single movement of a truck can cause significant damage to the absorbing roots.
 **Photo 9:** The load-sharing surfaces should be designed to take the load that will travel over it.	 **Photo 10:** Without appropriate protection, the soil is compacted, and roots are broken and damaged.
 **Photo 11:** The goal is to ensure that there is minimal impact on the roots that are being protected.	 **Photo 12:** Keep equipment away from the tree by using appropriate tree protection.

Protecting the trunk

<table>
<tr><th>Good Work</th><th>Poor Work</th></tr>
<tr><td>
Photo 13: TrunkGuard is designed to absorb impact just like a bicycle helmet.</td><td>
Photo 14: Trunk damage is usually irreparable and frequently causes long-term problems!</td></tr>
<tr><td>
Photo 15: It is flexible for a better fit and is attached using screws to avoid even light impact.</td><td>
Photo 16: Even the installation of a poorly designed system can injure a tree!</td></tr>
<tr><td>

Photo 17: Able to withstand and absorb moderate construction impact - not that this should happen!</td><td>
Photo 18: This serves little purpose at all! It does not protect the roots or the trunk of the tree.</td></tr>
</table>