COMMITTEE EV-018 (formerly BD-068)

DR AS 4970

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Draft for Public Comment Australian Standard

LIABLE TO ALTERATION—DO NOT USE AS A STANDARD

BEGINNING DATE FOR COMMENT:	**12 December 2008**
CLOSING DATE FOR COMMENT:	**13 February 2009**

Protection of trees on development sites

STANDARDS Australia

Draft for Public Comment
Australian Standard

The committee responsible for the issue of this draft comprised representatives of organizations interested in the subject matter of the proposed Standard. These organizations are listed on the inside back cover.

Comments are invited on the technical content, wording and general arrangement of the draft.

The preferred method for submission of comment is to download the MS Word comment form found at http://www.standards.com.au/Catalogue/misc/Public Comment Form.doc. This form also includes instructions and examples of comment submission.

When completing the comment form ensure that the number of this draft, your name and organization (if applicable) is recorded. Please place relevant clause numbers beside each comment.

Editorial matters (i.e. spelling, punctuation, grammar etc.) will be corrected before final publication.

The coordination of the requirements of this draft with those of any related Standards is of particular importance and you are invited to point out any areas where this may be necessary.

Please provide supporting reasons and suggested wording for each comment. Where you consider that specific content is too simplistic, too complex or too detailed please provide an alternative.

If the draft is acceptable without change, an acknowledgment to this effect would be appreciated.

When completed, this form should be returned to the Projects Manager, Chandima Nawela/Ashwini Sharma via email to ashwini.sharma@standards.org.au.

Normally no acknowledgment of comment is sent. All comments received electronically by the due date will be put before the relevant drafting committee. Because Standards committees operate electronically we cannot guarantee that comments submitted in hard copy will be considered along with those submitted electronically. Where appropriate, changes will be incorporated before the Standard is formally approved.

If you know of other persons or organizations that may wish to comment on this draft Standard, could you please advise them of its availability. Further copies of the draft are available from the SAI Global Customer Service Centre listed below and from our website at http://www.saiglobal.com/.

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Draft for Public Comment

STANDARDS AUSTRALIA

Committee EV-018 (formerly BD-068)—Arboriculture

Subcommittee EV-018-00-02 — Protection of Trees on Development Site

DRAFT

Australian Standard

Protection of trees on development sites

Comment on the draft is invited from people and organizations concerned with this subject. It would be appreciated if those submitting comment would follow the guidelines given on the inside front cover.

This document is a draft Australian Standard only and is liable to alteration in the light of comment received. It is not to be regarded as an Australian Standard until finally issued as such by Standards Australia.

PREFACE

This Standard was prepared by the Standards Australia Technical Committee EV-018, Arboriculture.

This Standard provides guidance for arborists, architects, builders, engineers, land managers, landscape architects and contractors, planners, building surveyors, those concerned with the care and protection of trees, and all others interested in integration between trees and construction.

This document describes the best practices for the planning and protection of trees on development sites. The procedures described are based on plant biology and current best practices as covered in recently published literature.

The assistance obtained from the 1991 and 2005 editions of BS 5837, *Trees in relation to construction—Recommendation*, along with Matheny and Clark (1998) and Mattheck and Breloer (1994) is greatly acknowledged.

The term ‘informative’ has been used in this Standard to define the application of the appendix to which it applies. An ‘informative’ appendix is only for information and guidance.

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FOREWORD

Landscape design is an important component of most development. Established trees of appropriate species and sound structure are beneficial components of the urban forest and a potential asset to any development site. Trees may be retained because of their—

(a) aesthetic qualities;

(b) heritage values;

(c) urban ecosystem benefits, including—

  (i) stormwater impact reduction;

  (ii) shade and heat reduction qualities;

  (iii) wildlife habitat;

  (iv) carbon dioxide absorption;

  (v) particulate pollution capture;

  (vi) salt wind protection; and

(d) social and psychological values.

A living tree is a dynamic organism that needs specific environmental conditions to continue healthy, stable growth. It is rarely possible to repair stressed and injured trees, so substantial injury must be avoided during all stages of development, design and construction. For trees to be retained and their requirements met, procedures must be in place to protect trees at every stage of the development process. This should be taken into account at the earliest planning stage of any outdoor event or development project where trees are involved.

Trees and their root systems may occupy a substantial part of any development site and because of their potential size, can have a major influence on planning the use of the site.

Existing trees of appropriate species and sound structure can significantly enhance new development by providing immediate benefits such as shade and stormwater reduction as well as giving an appearance of maturity to complement new development.

Most trees will take many years and possibly decades to establish but can be injured or killed in a very short time. This frequently occurs because their vulnerability is not commonly understood. This is especially so in relation to tree root systems which cannot usually be seen. Irreparable injury frequently occurs in the early stages of site occupation. Remedial measures put into place after tree injury routinely fail.

Early identification and protection of important existing trees on development sites is essential from the outset and will avoid the problems of retaining inappropriate trees.

Successful long term preservation of trees on development sites depends on an acceptance and acknowledgment of the constraints and benefits that existing trees generate. Protecting trees in accordance with this Standard may marginally increase design and construction costs, so this should be considered in project budgets and contracts. However, the immediate gains and ecological benefits of retaining mature trees to enhance new developments will accrue if the measures detailed in this Standard are applied.

STANDARDS AUSTRALIA

Australian Standard
Protection of trees on development sites

S E C T I O N 1 S C O P E A N D G E N E R A L

1.1 SCOPE

This Standard gives guidance on the principles to be applied to achieve a satisfactory relationship between trees and structures. It follows, in sequence, the stages of planning and implementing the provisions that are essential to allow development to be integrated with trees.

This Standard aims to assist those concerned with trees in relation to development to form balanced judgements. It does not present arguments for or against development, or for the removal or retention of trees. It does not promote, endorse or refute the monetary value of trees or provide a cost analysis argument for their retention or removal. Where development is to occur, the Standard provides guidance on how to decide which trees are appropriate for retention, and on the means of protecting those trees during construction work. The Standard does not address the means of incorporating new trees into the developed landscape.

1.2 OBJECTIVE

This Standard gives guidance to horticulturists, arborists, architects, builders, engineers, land managers, landscape architects, contractors, planners, certifying authorities, building surveyors, those concerned with the care and protection of trees, and all others involved in the management of trees and development.

1.3 REFERENCED DOCUMENTS

The following documents have been used in the preparation of this standard

AS
1319 Safety signs for the occupational environment

4373 Pruning of amenity trees

4687 Temporary fencing and hoardings

1.4 DEFINITIONS

For the purpose of this Standard, the following definitions apply:

DRAFTING NOTE: Review all definitions at the end of review of document.

1.4.1 Crown protection zone (CPZ)

A specified area above ground and at a given distance from the trunk set aside for the protection of the crown (branches and foliage) to provide for the viability of a tree to be retained where it is potentially subject to damage by development.

NOTE: Establishment of these areas may include pruning, tying-back of branches or other protection measures at the edge of the CPZ to prevent conflict between branches and works.

1.4.2 Determining authority

Those bodies responsible for issuing approvals to others to carry out activities.

1.4.3 Development

Development includes the following:

(a) The use of land (e.g. festival events, use of park areas and other events) that requires approval.

(b) The subdivision of land.

(c) The erection of a building.

(d) The carrying out of a work.

(e) The demolition of a building or works.

(f) Road works.

(g) The installation of utilities and services.

(h) Any other act, matter or thing as defined by the relevant legislation.

1.4.4 Diameter at breast height (DBH)

The nominal trunk diameter at 1.4 m above ground level determined from the circumference of the trunk divided by *pi* (π), in metres (see Appendix A).

1.4.5 Project arborist

The person responsible for carrying out the tree assessment, report preparation, consultation with designers, specifying tree protection measures, monitoring and certification. The project arborist will be suitably experienced and competent in arboriculture, having acquired through training, qualification (minimum Australian Qualification Framework (AQF) Level 5, Diploma of Horticulture (Arboriculture)) and/or equivalent experience, the knowledge and skills enabling that person to perform the tasks required by this Standard.

1.4.6 Root protection zone (RPZ)

A specified area below ground and at a given distance from the trunk set aside for the protection of tree roots to provide for the viability and stability of a tree to be retained where it is potentially subject to damage by development.

NOTE: Establishment of these areas may include root investigation and mapping, root pruning and installation of root barriers or other protection measures at the edge of the RPZ to prevent conflict between roots and works.

1.4.7 Structural root zone (SRZ)

The area around the base of a tree required for the tree's stability in the ground. The woody root growth and soil cohesion in this area are necessary to hold the tree upright, so the entire profile (depth) of the root zone is included in the structural root zone. The SRZ is nominally circular with the trunk at its centre and is expressed by its radius in metres.

This zone considers a tree's structural stability only, not the root zone required for a tree's vigour and long-term viability, which will usually be a much larger area.

1.4.8 Tree

Long lived woody perennial plant greater than (or usually greater than) 3 m in height with one or relatively few main stems or trunks.

1.4.9 Tree protection zone (TPZ)

The combined area of the root protection zone (RPZ) and crown protection zone (CPZ) as an area set aside for the protection of a tree.

1.4.10 Vigour

Ability of a tree to sustain its life processes, as used in the Standard for calculating the minimum RPZ (see Table 2).

NOTE: The term 'vigour' in this document is synonymous with commonly used terms such as 'health' and 'vitality'.

1.4.11 Work

Any physical activity in relation to land that is specified by the determining authority.

SECTION 2 PLANNING AND THE TREE MANAGEMENT PROCESS

2.1 TREE MANAGEMENT PROCESS

The success of the tree management process will depend on the cooperation of all involved in the design and development team. In particular, it is essential for those involved in site works to appreciate the need for maintaining the area of protection around the trees.

An example of the tree management process in relation to the stages of a typical development is set out in Table 1.

NOTE: Appendix B outlines potential damage to trees on development sites.

2.2 DETERMINING AUTHORITIES

Legal controls and liabilities under common law should be considered at the earliest stages of potential site development.

NOTE: Trees may be protected by legislation. Where development is proposed, additional protection may be appropriate and can be enforced by the determining authority.

Determining authorities have an important role in encouraging and enforcing the processes outlined in Table 1 by means of existing regulations, such as tree bonds and restrictions on use.

When development has been approved, planning conditions may be imposed for the management of trees.

TABLE 1

STAGES IN DEVELOPMENT AND THE TREE MANAGEMENT PROCESS

Stage in development	Tree management process	
	Matters for consideration	Actions
Planning (Sections 2 and 3)		
Site acquisition	Legal constraints	
Detail surveys	Council plans and policies Planning instruments and controls Heritage Threatened species	Existing trees noted on survey plan
Tree assessment	Hazard/risks Quality assessment Life expectancy (see Clause 2.3.2)	Evaluate trees suitable for retention or removal Provide preliminary arboricultural report and generic offsets to guide development layout
Preliminary development design	Condition of trees Proximity to buildings Location of services Roads Level changes Building operations space Long-term management	Planning selection of trees for retention

(*continued*)

TABLE 1 (*continued*)

Stage in development	Tree management process	
	Matters for consideration	**Actions**
Development submission	Identify trees for retention through comprehensive arboricultural impact assessment of proposed construction (see Clause 2.3.3.4). Determine tree protection measures Landscape design	Provide arboricultural impact assessment including tree protection plan (drawing) and specification
Development approval	Development controls Conditions of consent	Review consent conditions relating to trees
Pre-construction (Section 4)		
Initial site preparation	State based OHS requirements for tree work Approved retention/removal AS 4373—Pruning of amenity trees Specifications for tree protection measures	Compliance with conditions of consent Tree removal/tree retention/transplanting Tree pruning and/or remediation Certification of tree removal and remedial work Establish/delineate TPZ Install protective measures
Construction (Section 5)		
Site establishment	Temporary infrastructure	Locate temporary infrastructure to minimise impact on retained trees Certification of tree protection measures
Site work	Demolition, bulk earthworks, drainage	Maintain protective measures Certification of protection measures
Construction work	Liaison with site manager, compliance	Maintain protective measures
Implement hard and soft landscape works	Installation of irrigation services Control of compaction work Installation of pavement and retaining walls	Remove selected protective measures as necessary Remedial tree works Supervision and monitoring
Practical completion	Tree health and condition Deviation from approved plan	Remove all remaining tree protection measures Remedial tree works Certification of tree protection
Post construction (Section 6)		
Defects liability/ maintenance period	Tree vigour and condition	Maintenance and monitoring Final certification of tree vigour and condition

NOTE: Owing to variations in planning legislation this Table is a general indication of the process only.

2.3 PLANNING

2.3.1 Site survey

A detailed survey should be made showing all existing site features having regard for other policy areas of the determining authority.

The survey plans should include—

(a) location of all individual trees or groups of trees and other vegetation;

(b) location of trees on land adjacent to the development site that may be impacted by the development;

(c) crown spread, which should be measured and drawn to scale, defining the actual crown spread rather than illustrative circles;

(d) other features, such as streams, creeks, watercourses, buildings and above and below ground services;

(e) spot heights of ground level throughout the development site and specifically including level at the base of individual trees as a basis for evaluating changes in soil level around retained trees; and

(f) tree numbers, for identification.

NOTES:

1 Before commencing this survey, advice should be sought from the project arborist to determine/identify all items relevant for inclusion in the survey.

2 Other vegetation may need to be surveyed to meet specific provisions of the determining authority or legislation.

2.3.2 Tree assessment

A tree assessment provides the basis for deciding which trees might be suitable for protection. All trees included in the site survey should be assessed by the project arborist. In making this assessment, particular consideration for each tree should be given to—

(a) accurate botanical identification of the species;

(b) the vigour and condition;

(c) any structural defects;

(d) the current and future size and form;

(e) the tree's life expectancy;

(f) suitability within the context of the proposed site development;

(g) heritage and/or cultural values;

(h) ecological and habitat considerations;

(i) the location relative to existing site features, e.g. its function as a screen or as a landmark feature; and

(j) other matters relevant to the site, e.g. surface roots.

NOTES:

1 These criteria should also be recorded for trees surveyed on adjacent properties.

2 This may require input from other specialists.

3 Consideration should be given at the time of tree assessment as to the means by which trees will be identified onsite, by a temporary, non-injurious method.

2.3.3 Tree assessment reports

2.3.3.1 *General*

As tree protection is most effective when it is considered from the outset of any development project, the process is likely to require several reports at different stages. The most crucial reports are described below.

2.3.3.2 *Preliminary arboricultural report*

The preliminary assessment of the trees should take place at the beginning of the project, once any site surveys have been completed. The purpose of this assessment is to provide information on the trees; species, condition, suitability and quality assessment. This information is to be used by planners and designers, in conjunction with any planning controls and other legislation, to develop the design layout in such a way that trees selected for retention are provided with enough space. The preliminary report is not intended to be the comprehensive tree protection report.

The report should list all the trees, providing the following details:

(a) Species.

(b) Common name.

(c) Location (usually numbered on a site survey plan).

(d) Dimensions (height, crown spread and DBH).

(e) Age class.

(f) Vigour.

(g) Structure.

(h) Quality assessment and any relevant comments.

The schedule should also include other relevant details such as trunk lean, varied location of the DBH measurement, defects and appropriate remedial work required.

Once data have been collected, trees (or groups of trees) should be placed into categories based on their suitability for retention.

Further information on method for categorizing trees according to their suitability for retention may be found in the document listed in Appendix E..

Trees that are suitable for integration within the new development should be identified and marked on the detailed survey plan. This plan should also show the location of tree protection zones, trees to be transplanted and trees to be removed. Tree protection zones are to be calculated as shown in Section 3.

2.3.3.3 *Design review*

During the design development and documentation stages there should be ongoing review of architectural, engineering, services and landscape drawings to determine the potential impact on trees proposed to be retained.

To avoid the redirection of services after works have commenced, service corridors should be established at the planning stage. Detailed plans showing the routing of all services (above and below ground) in the proximity of the trees are essential and should also allow the access space required for installation.

Consideration should be given to elements required during the construction stage, such as scaffolding, temporary access roads, stockpiling materials, site sheds, temporary services and sediment control measures as well as the permanent elements of the development such as onsite water detention and storage.

2.3.3.4 *Arboricultural impact assessment*

The arboricultural impact assessment will be prepared once the final layout is completed. The report will identify any possible impacts on trees to be retained and recommend measures necessary to protect the trees throughout all demolition and construction stages. Review of architectural, hydraulic services and landscaping plans should be included to provide an accurate impact assessment. If these plans are not available for review, it should be clearly stated in the report methodology. Specification of tree protection measures, as described in Section 4, should be included in the documentation.

The report will include a tree protection plan showing the tree protection zones for trees being retained, taking into account the matters referred to in Section 3 and other protection measures. A copy of this plan will form part of the development plans.

NOTE: It is recommended that the location of tree protection measures should also be shown on other documents such as demolition, bulk earth works, construction and landscape drawings.

SECTION 3 DETERMINING THE PROTECTION ZONES OF THE SELECTED TREES

3.1 GENERAL

The tree protection zone (TPZ) is the principal method of protecting trees on development sites. It is an area set aside from disturbance from construction works, enabling sufficient parts of a tree and its growing environment to be undisturbed, so that the tree will remain stable and viable.

3.2 DETERMINING THE TREE PROTECTION ZONE

3.2.1 General

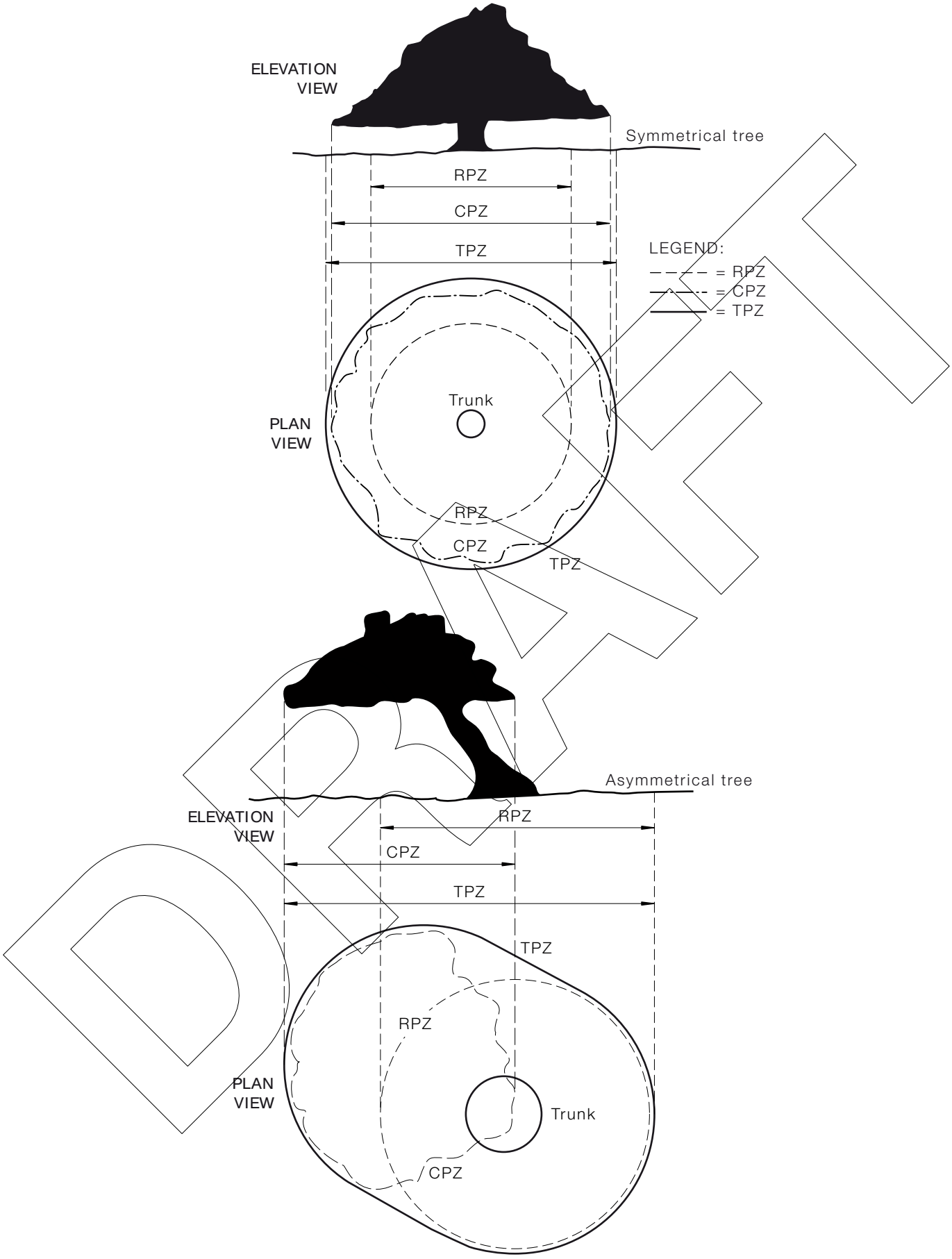
Trees should be physically protected at all stages of development. The tree protection zone (TPZ) is determined by a combination of the areas of primarily the root protection zone (RPZ) and to a lesser extent, the crown protection zone (CPZ) considering the proposed construction methods and structures. These zones are illustrated in Figure 1.

The determination of the tree protection zone should involve—

(a) identifying an area of ground around the tree that should remain undisturbed (root protection zone) and ensuring that it is feasible to maintain protective measures undisturbed around all such areas throughout the construction period (see Clause 1.4.6); and

(b) identifying an area around the tree crown that should remain undisturbed (crown protection zone) and ensuring that it is feasible to maintain protective measures undisturbed around all such areas throughout the construction period (see Clause 1.4.1).

The TPZ is plotted to include the RPZ and CPZ. A site plan showing TPZs should be drawn.



NOTE: Refer to Clause 3.2.1 for calculation of RPZ.

FIGURE 1 INDICATIVE TREE PROTECTION ZONE

3.2.2 Determining the root protection zone

3.2.2.1 *General*

The purpose of the RPZ is to protect the area of roots required to maintain the tree's vigour and stability during the development process and into the long term. The RPZ is calculated for each tree based on its age class and vigour class. Each tree may be fenced off to form an enclosure with the tree at the centre, or an existing structure may be utilized, being retained such as a wall or fence.

Table 2 provides the means for determining RPZ based on the age and vigour of the tree, as assessed by the project arborist.

The minimum radius of the RPZ is determined by multiplying the DBH, in metres, by the appropriate multiplier, given in Column 3 of Table 2.

TABLE 2

CALCULATING THE MINIMUM RPZ (EXCEPT FOR PALMS, CYCADS AND TREE FERNS, SEE CLAUSE 3.2.2.2)

Tree age	Tree vigour	RPZ radius (m)
Young trees (age less than 20% of life expectancy in situ)	Good vigour	6 × DBH
	Poor vigour	9 × DBH
Mature trees (age between 20% and 80% of life expectancy in situ)	Good vigour	9 × DBH
	Poor vigour	12 × DBH
Over mature trees (age greater than 80% of life expectancy in situ)	Good vigour	12 × DBH
	Poor vigour	15 × DBH

NOTES:

1 Radial distances are measured from the centre of the stem at ground level.

2 The RPZ distances in this table are based on a good species tolerance to site disturbance. There are no scientific data of tree tolerances for Australian conditions.

3 No tree should have RPZ less than 2 m or greater than 15 m.

3.2.2.2 *The RPZ of palms and other monocots, cycads and tree ferns*

The RPZ of palms and other monocots, cycads and tree ferns must be 1 m outside the dripline edge of the crown.

3.2.2.3 *Variations to the RPZ*

3.2.2.3.1 *General*

The RPZ distances determined by Table 2 indicate the standard RPZ distances that can be applied to all trees without further site investigation or consideration of other factors. It may be possible to encroach into or make variations to the standard RPZ if this is done by the project arborist considering relevant factors in Clause 3.2.2.3.3.

3.2.2.3.2 *Minor encroachment (work) or variation (up to 10% of the area)*

Variation or encroachment into the RPZ can be made where it affects no more than 10% of the total RPZ area, including any 'shadow' effects (see Appendix D), and where there is is no impact on the structural root zone (SRZ), see Clause 3.2.2.3.4. While such variations must be made by the project arborist considering relevant factors in Clause 3.2.2.3.3, they will generally not require detailed investigation such as root mapping. The area lost to any variations or encroachment into the RPZ should be compensated for elsewhere in the RPZ. The figures in Appendix D demonstrate some examples of possible encroachment into the RPZ up to 10% of the area.

NOTE: Encroachments may include services and utilities (see Clause 4.5.7).

3.2.2.3.3 *Major encroachment or variation (greater than 10% of the area or into the SRZ)*

Where encroachment into the RPZ would affect more than 10% of the RPZ area (including any 'shadow' effects, see Appendix D) or would encroach into the SRZ, the project arborist must demonstrate that the tree(s) would tolerate any resulting impacts. This will involve thorough root investigation by non-destructive methods (e.g. root excavation with compressed air or hand tools, ground penetrating radar, etc.) and consideration of relevant factors listed below. It must be demonstrated that any variations or encroachment into the RPZ (including SRZ) would not affect structural roots and would not adversely affect a tree's vigour, stability or its long-term viability.

Factors to consider when determining impacts of major encroachment into the RPZ:

(a) Location and distribution of the roots to be determined through non-destructive investigation methods (pneumatic, hydraulic, hand digging, root mapping). As these methods vary in the speed at which the roots are exposed, it is imperative that the roots already exposed be kept moist and are not allowed to dry out. Ideally, photographs should be taken and a root zone map prepared for future reference. On the same day, the roots should be covered back over with soil to the previous level.

NOTE: Often referred to as root mapping, the exact location, size and nature of tree roots can easily be established by carefully moving the soil away from the roots. This can be done by hand with simple garden tools, or with specifically designed equipment that directs high pressure air to move the soil away from the roots. Regardless of the method, the roots must not be cut, bruised or frayed during the process.

(b) The loss of root mass resulting from the works: number of roots and size of roots.

(c) Tree species and tolerance to root disturbance.

NOTE: Currently this is based on anecdotal experience.

(d) Age, vigour and size of the tree.

(e) Lean of the tree.

NOTE: Roots on the tension side are likely to be most important for supporting the tree and are likely to extend for a greater distance.

(f) Soil type, soil cohesion, topography and drainage.

(g) The presence of existing or past structures or obstacles affecting root growth.

(h) Site factors.

When siting a structure near to a tree, the future growth of the tree, both above and below ground should be taken into account. Precautions should be taken at the planning and design stage to avoid future conflict between trees and new structures.

This is particularly important when the root zone is growing (or will extend into) a soil which has a reactive clay content. Techniques such as localized pier and beam (bridged), screwpile footings or tree root and soil moisture control barriers may be appropriate.

NOTE: This situation may also require collaboration between the project arborist and the geotechnical or structural engineer. Further information is provided in the documents listed in Appendix E.

3.2.2.3.4 *Structural root zone (SRZ)*

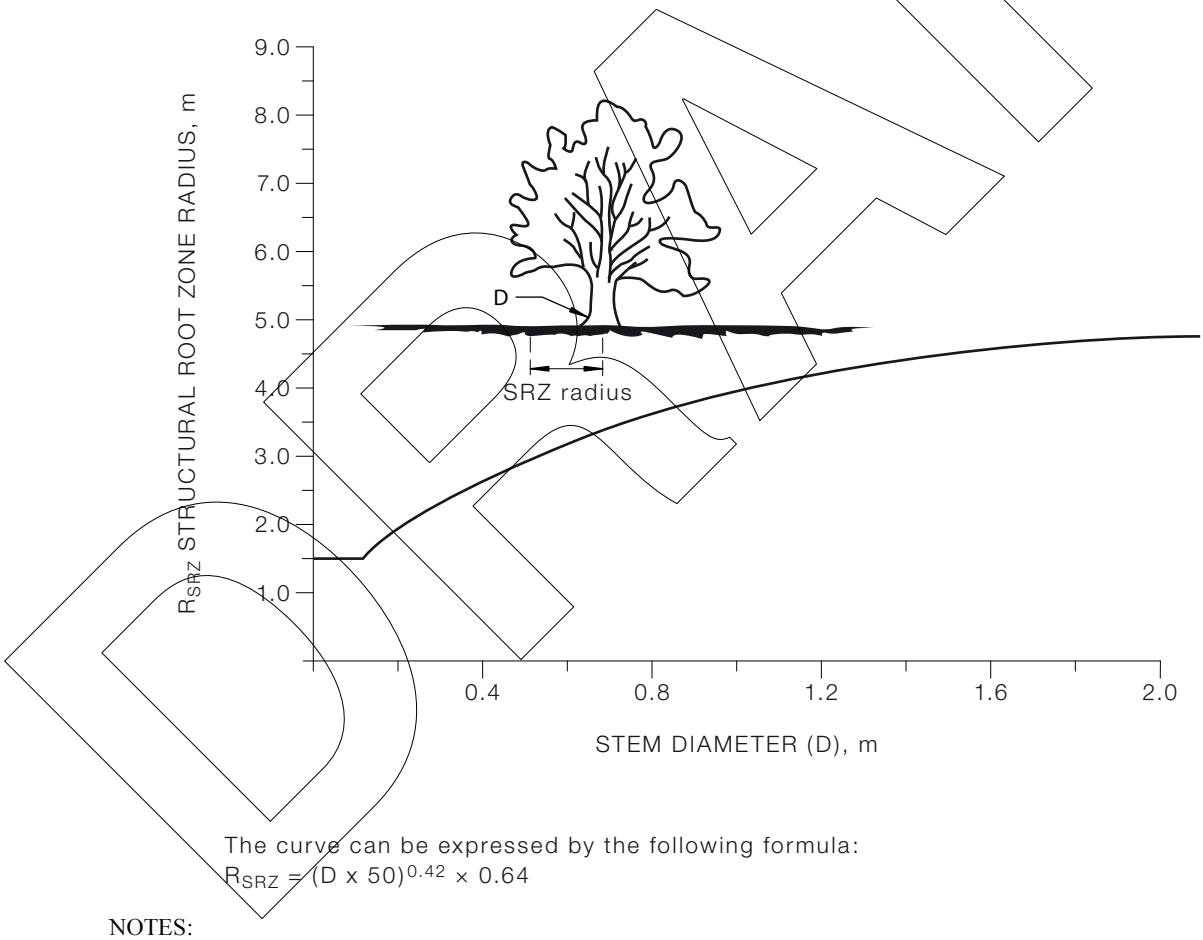
The structural root zone is the critical area required for tree stability and does not consider tree health, which will generally require a much larger area. While there are many factors that affect the actual size of the structural root zone (e.g. tree height, crown area, soil type, soil moisture, etc.), the area determined using the trunk diameter provides a general guide indicating where structural roots are likely to be located. Only thorough root investigation would show the actual location of these roots. Determine SRZ radius from the trunk diameter (measured immediately above the root buttress) using the following formula or Figure 2.

$$\text{SRZ radius} = (D \times 50)^{0.42} \times 0.64$$

where

D = trunk diameter, in metres, measured above the root buttress

NOTE: The SRZ for trees with trunk diameters less than 0.15 metres will be 1.5 metres (see Figure 2).



NOTES:

1 R_{SRZ} is the structural root zone radius.

2 D is the stem diameter measured immediately above root buttress.

3 The SRZ for trees less than 0.15 metres diameter shall be 1.5 metres (see Figure 2).

4 The SRZ formula and graph do not apply to palms, other monocots, cycads and tree ferns.

FIGURE 2 STRUCTURAL ROOT ZONE

3.2.2.4 *Determining the crown protection zone*

As tree crowns are commonly injured during construction by machinery such as excavators, drilling rigs and trucks, the purpose of the CPZ is to ensure the retention of the above ground parts and form of the tree to provide for its long-term viability.

Where a CPZ is required, the perimeter of the CPZ will usually be located one metre outside the perimeter of any crown that is to be protected.

Allowance for additional set back from the edge of the crown may be required for the erection of scaffolding.

In some cases, a CPZ will not need to be considered, as proposed works would not affect the crown.

NOTE: The CPZ can be greater or less than the RPZ.

3.2.2.5 *Modifying the crown protection zone*

The CPZ may be varied by the project arborist by considering relevant factors in Clause 3.2.2.3.3. If pruning is required, it must comply with AS 4373 and should be undertaken before the establishment of the CPZ onsite.

NOTE: Establishment of these areas may include pruning, tying-back of branches or other protection measures at the edge of the CPZ to prevent conflict between branches and works to the satisfaction of the project arborist.

3.2.2.6 *Form of tree*

The existing form and the symmetry of the tree should be considered during the design and construction phase, taking into account the shape of a tree crown is influenced by the availability or restriction of space and light, or other contributing factors within its growing environment (see Figure 3).

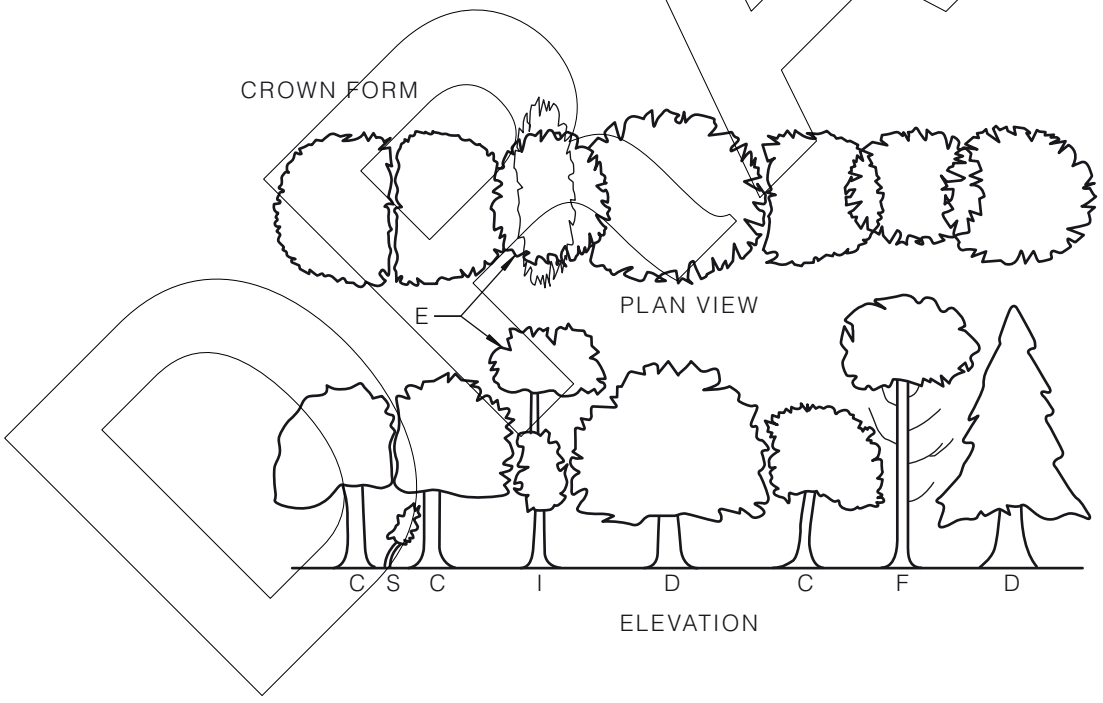


FIGURE 3 FORM OF TREE

SECTION 4 TREE PROTECTION MEASURES

4.1 GENERAL

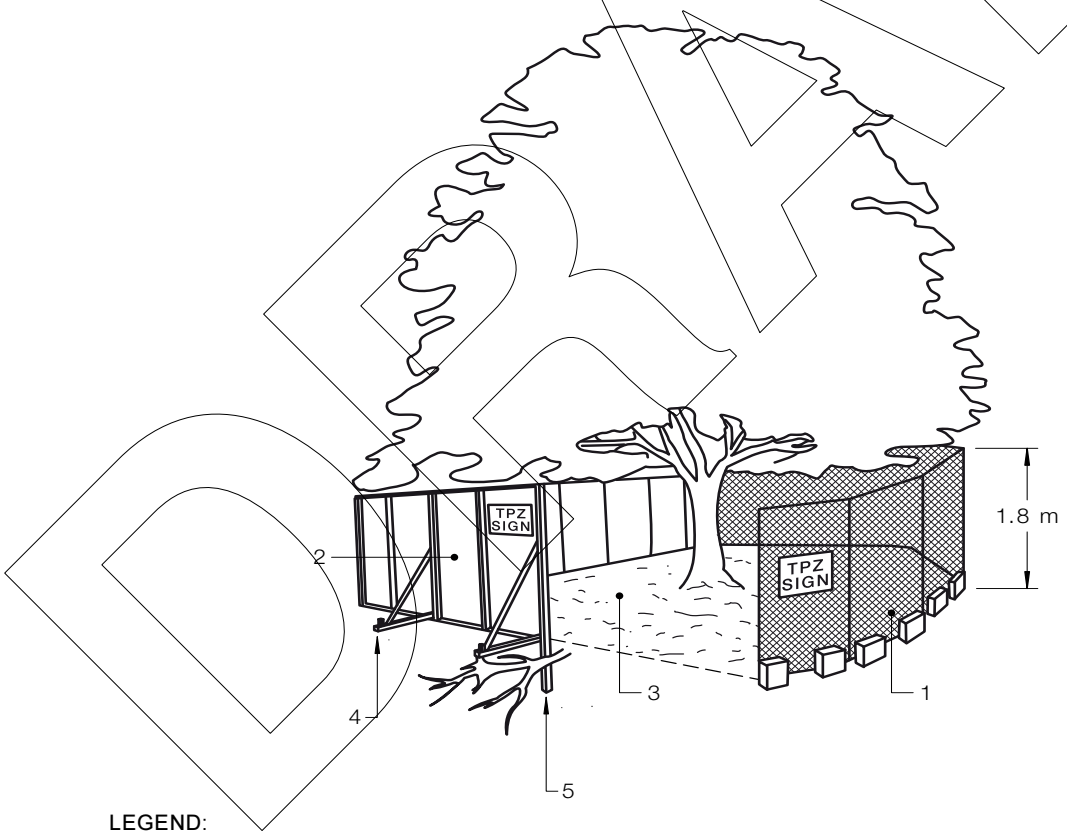
Tree protection measures are the activities and structures used to protect the tree protection zone as described in Section 3. Each site will have different tree protection requirements. The specific advice of the project arborist should be sought where necessary.

A TPZ is determined by setbacks calculated for each tree based on its age class, vigour class and crown spread (where necessary) and each tree fenced off to form an enclosure around the tree with the tree at its centre, or may utilize an existing structure being retained such as a wall or fence.

The TPZ should be secured by a lockable gate to restrict access and the area identified with signage. The area of the TPZ should be mulched except where turfed, and kept free of weeds. Where encroachment is required within the TPZ this should be done only with the approval of the project arborist.

4.2 SIGNAGE

Signs identifying the TPZ should be placed around the edge of the TPZ and be visible from within the development site. The lettering on the sign should comply with AS 1319, see Appendix C for an example.



LEGEND:

1 Chain wire mesh panels with shade cloth (if required) attached, held in place with concrete feet.
2 Alternative plywood or wooden paling fence panels. This fencing material also prevents building materials or soil from entering the TPZ.
3 Mulch installation across surface of TPZ. No excavation, construction activity, grade changes, surface treatment or storage of materials of any kind is permitted within the TPZ.
4 All supports and bracing should be outside the TPZ.
5 Excavation for supports should avoid damaging roots whenever possible.

FIGURE 4 PROTECTIVE FENCING

4.3 RESTRICTED ACTIVITIES WITHIN THE TPZ

Activities to be excluded from the TPZ include—

(a) storage of materials;

(b) preparation of chemicals, including preparation of cement products;

(c) parking of vehicles and plant;

(d) refuelling;

(e) dumping of waste;

(f) cleaning of equipment;

(g) placement of fill;

(h) lighting of fires;

(i) soil level changes; and

(j) temporary or permanent installation of utilities and signs.

NOTE: Any encroachment into the TPZ requires additional tree protection measures in consultation with a person suitably experienced and competent in arboriculture.

4.4 PROTECTIVE FENCING

The TPZ will usually be delineated by protective fencing. Fencing needs to be erected before any materials or machinery are brought on the site and before any demolition or development, including erection of site sheds, is commenced (except for tree removal, pruning or remediation). Once erected, protective fencing should not be removed or altered without prior approval by the project arborist.

The fencing needs to be sturdy and not readily moved or blown over to ensure the protection area is not altered once established. Fencing used needs to be self-supporting and be of a minimum height of 1.8 metres and type (such as chain wire or reinforcing mesh fencing) to restrict access by persons and equipment, and to prevent depositing of waste materials and storage of materials. Shade cloth or similar should be attached to cover open type fencing (such as chain wire or reinforcing mesh fencing) to reduce the transport of dust, other particulate matter and liquids into the protected area.

Where fence posts are placed in the ground within the RPZ/TPZ, they should not be driven and be located so as to avoid damage to roots with a diameter greater than 20 mm. The TPZ should be secured by a lockable gate to restrict access.

Existing perimeter fencing may be suitable as part of the protective fencing, where appropriate.

Figure 4 indicates example of protective fencing.

Refer to AS 4687 for further details on protective fencing.

NOTE: Where possible, measures should also be taken to protect the root zone outside the TPZ. If roots outside the TPZ must be removed, they should be pruned with a final cut to undamaged wood to promote root growth and to minimize entry to decay causing pathogens.

4.5 OTHER TREE PROTECTION MEASURES

4.5.1 General

In some situations, encroachment within the tree protection zone may be necessary. In such cases, other protection measures may be appropriate. These may include mulch, temporary suspended structures, strapped boards and steel plates. Where machinery operation near a

tree's trunk is unavoidable, protection to the trunk and branches should be installed. See Figure 5.

4.5.2 Weed removal

All weeds should be removed by hand or poisoned with minimal use of herbicide and without soil disturbance.

4.5.3 Mulching

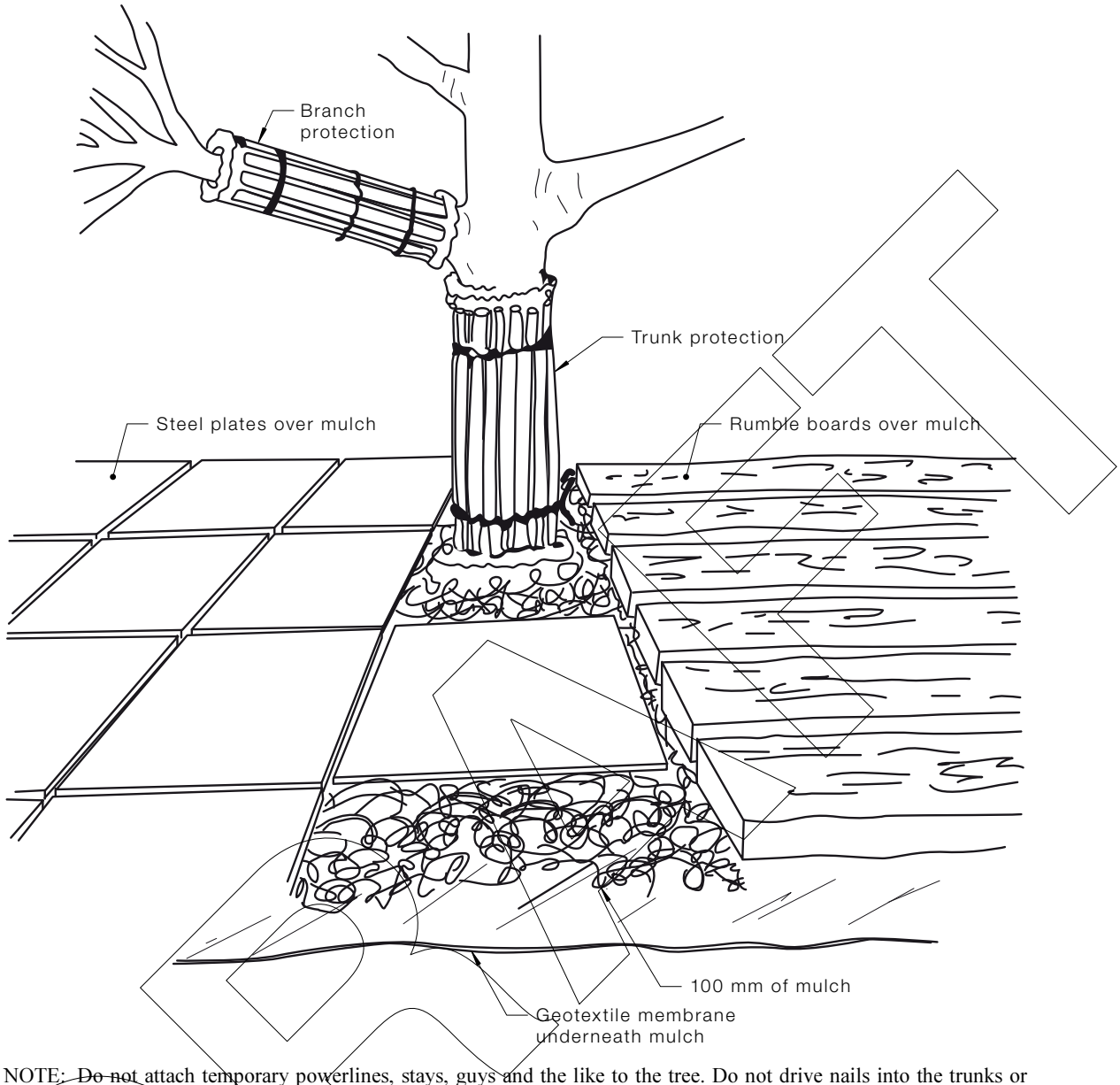
The area within the TPZ should be mulched. The mulch must be maintained at a uniform cover of 100 mm depth using organic material such as hardwood chips. Silt fencing may need to be installed around the edges of the fence in readily eroded soil or on steep sites. Where the existing landscape within the TPZ is to remain unaltered (e.g. garden beds or turf) mulch may not be required.

4.5.4 Watering

Temporary irrigation or watering may be required within the TPZ. An irrigation system should be installed and maintained by a competent individual. Soil moisture levels should be regularly monitored by the project arborist.

4.5.5 Trunk and branch protection

Where necessary, install protection to the trunk and branches of the trees as shown below. The positioning of protection is to be specified by the project arborist. A minimum height of 2 metres is recommended. Protection is illustrated in Figure 5.



NOTE: Do not attach temporary powerlines, stays, guys and the like to the tree. Do not drive nails into the trunks or branches.

FIGURE 5 METHOD OF INSTALLING TRUNK AND ROOT PROTECTION

4.5.6 Root protection during excavation

If roots are encountered during any excavation as part of the works and need to be cut, roots should be cleanly cut to avoid disturbance to surrounding roots. All cuts will be clean cuts made with sharp tools such as secateurs, pruners, handsaws or chainsaws. It is unacceptable for roots to be 'pruned' with machinery such as backhoes or excavators. Seek advice from the project arborist if roots greater than 50 mm diameter are encountered during excavation further from the tree. Wounds should not be treated with dressings or paints.

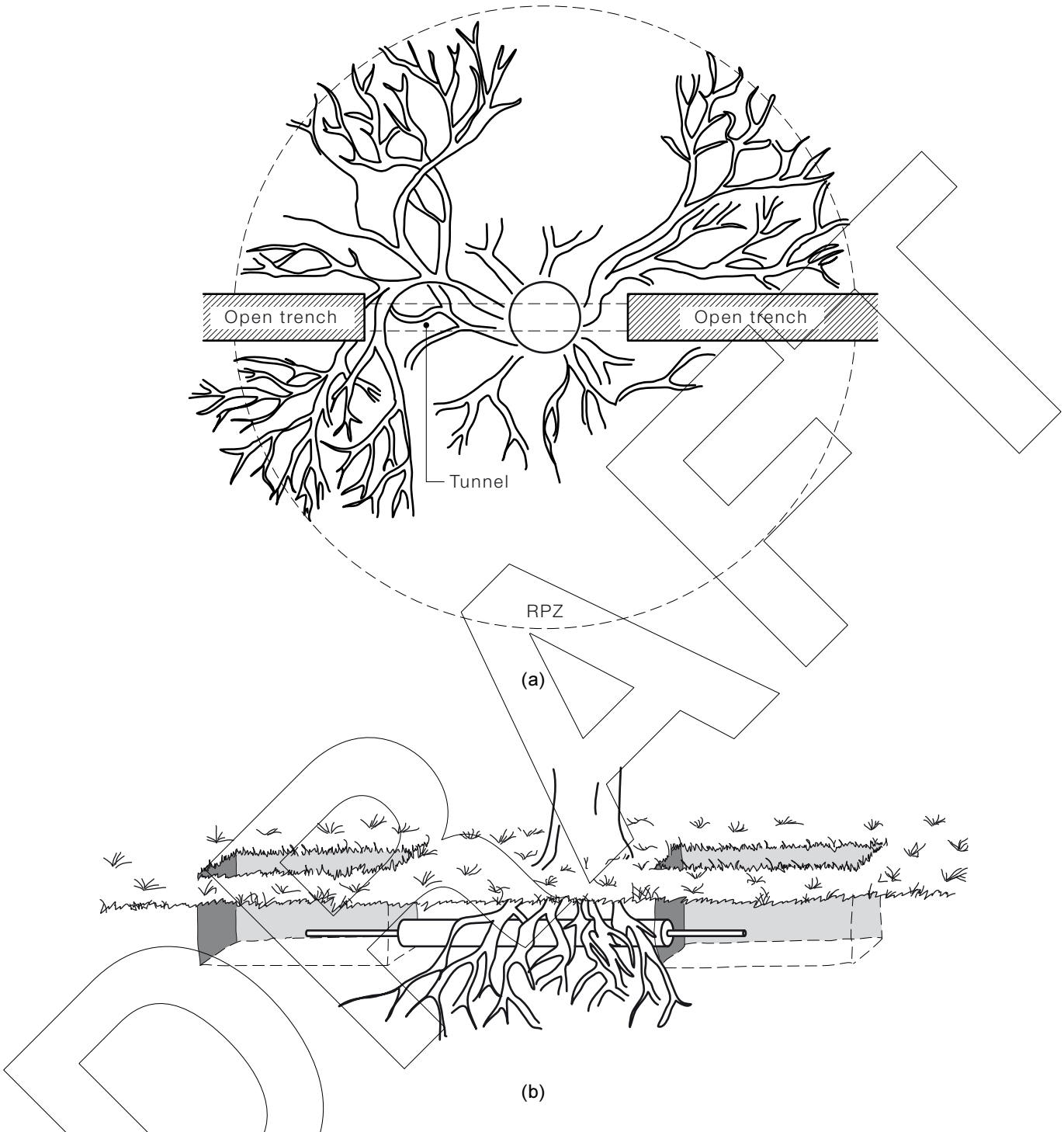
Where soil profiles within the TPZ are exposed by excavation, temporary root protection should be installed to prevent roots drying out. Root protection may include a jute mesh sheeting or hessian (as a triple layer) over exposed roots and excavated soil profile, extending to the full depth of the root zone. Root protection sheeting should be pegged in place and kept moist during the period that the root zone is exposed.

Other excavation works in proximity to trees, including landscape works such as paving, irrigation and planting can adversely affect root systems. Advice from the project arborist should be sought.

4.5.7 Trenching for services

If, after consideration of all alternatives, it proves essential for a service trench to pass through the RPZ, directional drilling for the service provides an acceptable solution. Provided the diameter of the borehole is small, the amount of root damage will be minimal. The borehole should be kept as deep as possible, preferably at a minimum depth of 600 mm. An assessment should be made of the likely impacts on surrounding trees prior to boring being undertaken.

An alternative solution is to excavate a narrow trench directly towards the tree, to the edge of the SRZ (see Figure 2), drilling straight beneath the tree, preferably not less than 600 mm deep, exiting on the opposite side (see Figures 6(a) and 6(b)). Provided the trench is kept as narrow as possible, the amount of root severance should be minimal.



NOTES:

1 Root mapping can be carried out to identify a clear path for open trenching and also when it is necessary to tunnel underneath roots within the RPZ.

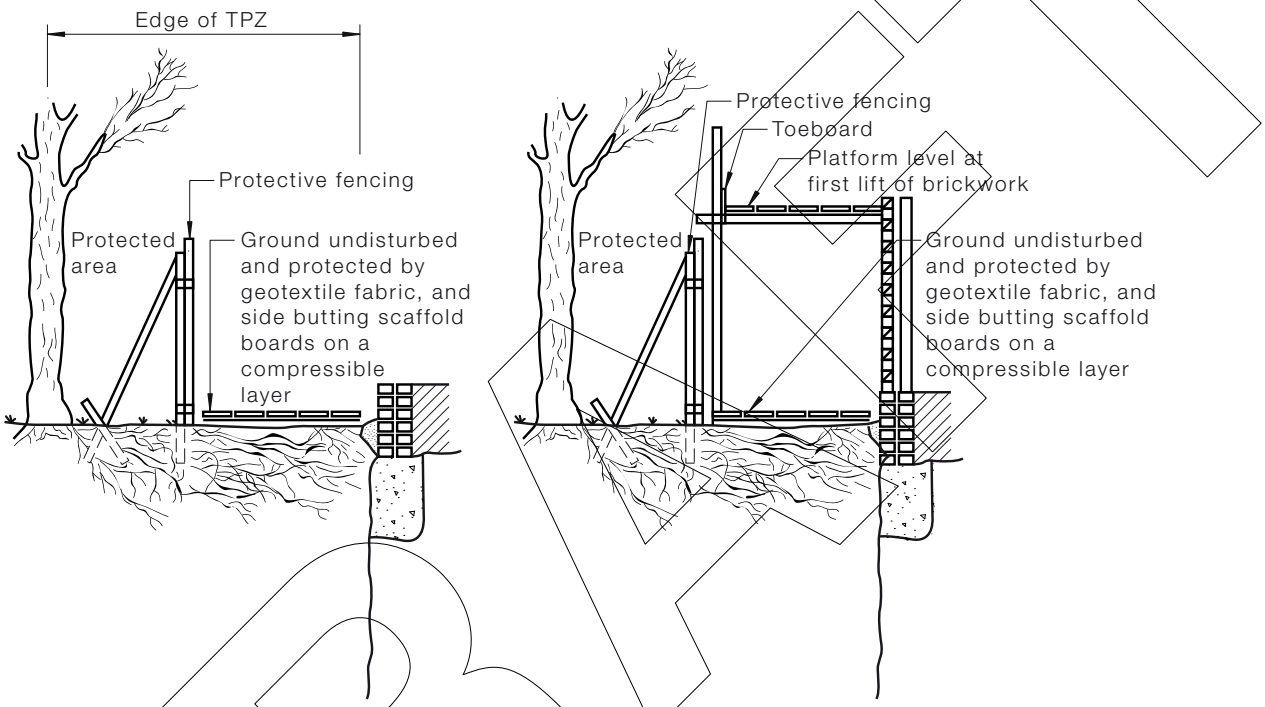
2 Where open trenching is not an option, a hydro-vacuum system can be used to remove the soil beneath roots to allow services to be threaded through the exposed roots.

3 Most trees have between four and eleven structural roots that physically support the tree in the ground. It is critical that none of these structural roots are damaged within the RPZ.

FIGURE 6 TRENCHING ALONG RADII TO MINIMIZE DAMAGE

4.5.8 Scaffolding

Generally scaffolding should be erected outside of the TPZ. Where it is essential for scaffolding to be erected within the TPZ removal of branches should be minimized. The ground below the scaffolding should be protected by boarding (e.g. scaffold board or plywood sheeting) as shown in Figure 7. On level ground where access is required, a board walk or other surface material should be installed to minimize soil compaction. Boarding should be placed over a layer of mulch and impervious sheeting to prevent soil contamination. On uneven ground, boarding can be incorporated into scaffolding. The boarding should be left in place until the building works are finished.



NOTE: Excavation required for the insertion of support posts for tree protection fencing should not involve the severance of any roots greater than 20 mm in diameter, without the prior approval of the project arborist.

FIGURE 7 INDICATIVE SCAFFOLDING WITHIN A TPZ

SECTION 5 CONSTRUCTION PHASE

5.1 TREE PROTECTION PLAN

The approved tree protection plan must be available onsite prior to the commencement of construction.

5.2 TREE REMOVAL AND PRUNING

Trees for removal should be marked onsite as per the approved tree protection plan. Before removal, it should be confirmed by the project arborist that all marked trees correspond with those shown on the schedule or plan. Other tree surgery work may also be needed as specified in the report.

It will normally be more convenient for trees nominated for felling to be removed prior to erection of protective fencing, but contractors should be instructed not to cause damage to protection areas. For example, restrict vehicle movement to that required for essential access for tree removal. Care should be taken to avoid damage to all trees that are being retained. It may therefore be necessary for trees to be felled and removed in sections.

Stumps within the TPZs of retained trees must be ground out rather than pulled or grubbed. This will avoid damaging roots of the trees to be retained.

Tree removal and remedial pruning works should be supervised and are to be certified by the project arborist upon completion.

5.3 TREE PROTECTION FENCING AND OTHER PROTECTION MEASURES

Fencing and other protection work must be in compliance with Section 4 and as detailed in the tree protection plan.

Protection measures are to be certified by the project arborist.

5.4 MONITORING AND CERTIFICATION

In order to ensure the viability of protected trees and that protection measures are being adhered to, there should be a predetermined number of site inspections carried out by the project arborist. Certification nust be carried out at critical stages during construction. Critical stages for monitoring should include the following:

(a) Installation of temporary infrastructure including bunding, sediment control works and site sheds.

(b) Demolition of existing structures, bulk earthworks and drainage works.

(c) Regular intervals during general construction works, e.g. completion of ground floor slabs, scaffolding installation.

(d) Changes in design that may encroach on the tree protection zone.

(e) Excavation within the tree protection zone.

(f) Landscape construction.

(g) Certification of tree protection at practical completion.

Matters to be monitored should include the following:

(i) Tree vigour and structure.

(ii) Tree stability.

(iii) Tree protection measures.

(iv) Nearby site works.

All site inspections should be documented.

5.5 REMOVAL OF PROTECTIVE FENCING

Removal of protective fencing should be staged so as to facilitate completion of the construction phase. Care must be taken at this stage to avoid mechanical injury or compaction.

SECTION 6 POST CONSTRUCTION

6.1 DEFECTS LIABILITY PERIOD

Completion of outstanding works following the construction period must not injure trees.

6.2 FINAL CERTIFICATION

The project arborist needs to carry out an inspection to assess the condition of trees and their growing environment, and make recommendations for any necessary remedial actions.

Following the final inspection and the completion of any remedial works, the project arborist must certify (as appropriate) that the completed works have been carried out in compliance with the approved plans and specifications for tree protection. Certification should include details of any deviations from the approved tree protection measures that have occurred throughout the entire development and any impacts on trees. Certification should include a statement on the condition and vigour of the retained trees and copies of monitoring documentation.

NOTES:

1 Remedial actions may include pruning in accordance with AS 4373 and/or soil decompaction.

2 The project arborist should have prior involvement during work or shall have access to inspection reports by others. The project arborist should also review construction drawings to determine likely root zone impacts.

6.3 ONGOING MAINTENANCE

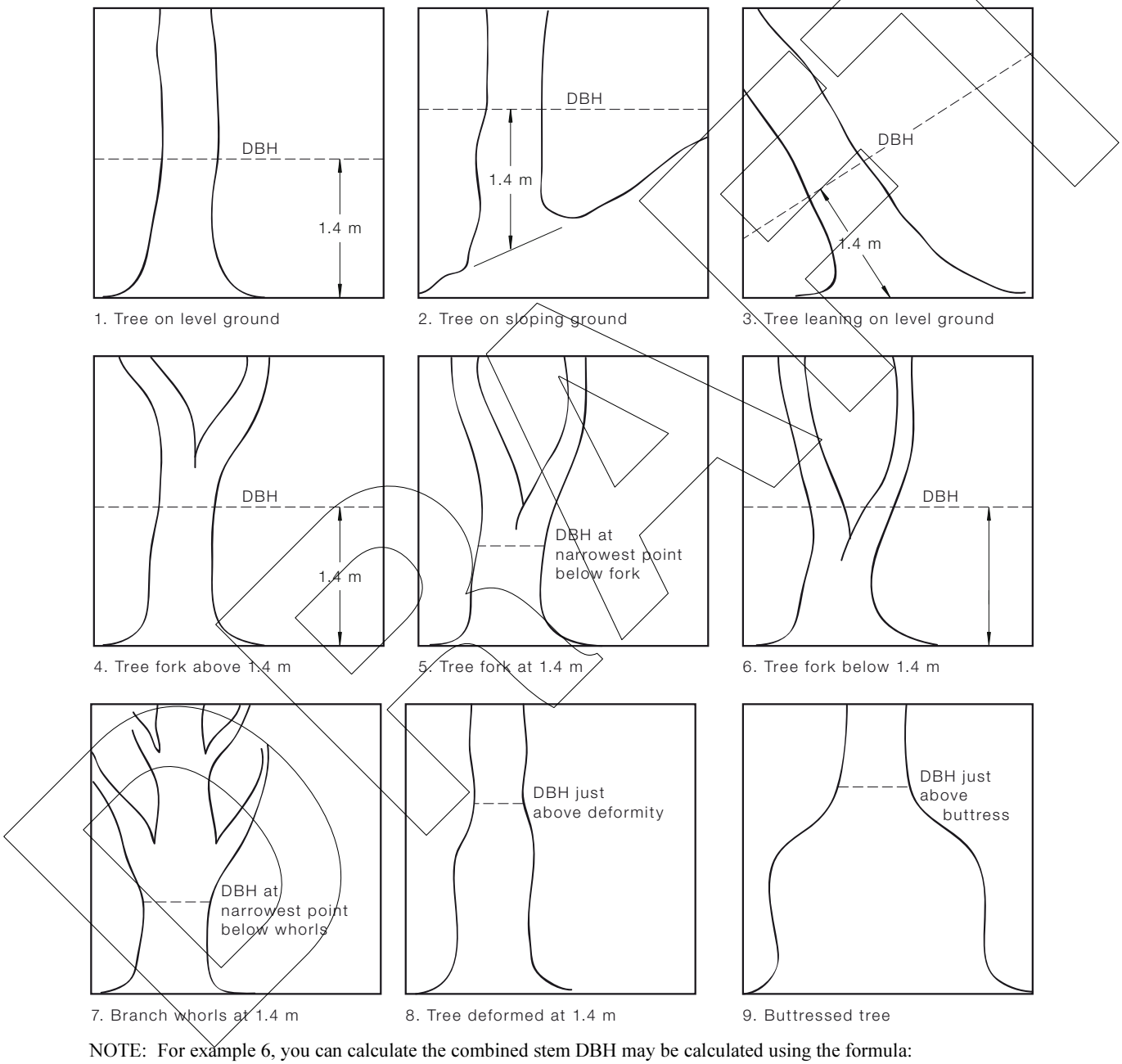
It is desirable that the project arborist should specify a monitoring and maintenance program for a predetermined time frame.

APPENDIX A

DIAMETER AT BREAST HEIGHT

(Informative)

The diversity of trunk shapes, configurations and growing environments requires that diameter at breast height (DBH) be measured using a range of methods to suit particular situations and Figure A1 provides examples.



NOTE: For example 6, you can calculate the combined stem DBH may be calculated using the formula:

$$\text{Total DBH} = \sqrt{(\text{DBH}_1)^2 + (\text{DBH}_2)^2 + (\text{DBH}_3)^2}$$

FIGURE A1 MEASUREMENT OF DBH OF A TREE

APPENDIX B

POTENTIAL DAMAGE TO TREES ON DEVELOPMENT SITES

(Informative)

B1 INTRODUCTION

Established trees of good health and vigour and condition represent an asset to any development site, particularly if landscaping is a significant component of the proposed development. Trees may be retained because of their aesthetic features, for shade, for the scale that they will give to new buildings or for their historical value.

Trees are living organisms that require certain environmental conditions in order to maintain their value as an asset. As remediation of badly stressed or damaged trees is rarely successful, damage must be avoided or minimised during the construction phase. Hence, if trees are to be retained and their requirements met, procedures which ensure the protection of trees must be in place at all stages of the development including the demolition stage.

B2 BACKGROUND BIOLOGY

B2.1 General

All plants consist of three main sections: a crown (leaves), a stem or trunk and a root system. Each one of these sections carries out specific functions necessary for the survival of the tree as all of the parts interact. A tree is in a state of physiological equilibrium between the above ground and below ground sections, so that if one of these sections is damaged, the entire tree will suffer and symptoms may appear in any part of the tree.

Thus any demolition and construction operations that occur in or around trees must be carried out in such a way as to minimize the impact on the health of the tree.

B2.2 Leaves

The main function of leaves is photosynthesis, that is, the production of sugars and oxygen. The sugars produced by the leaves (and any other green tissue) are the source of chemical energy for all living cells in the entire plant and as such are essential for the normal functioning and survival of the tree. Anything that directly or indirectly damages the leaves will interfere with photosynthesis.

B2.3 Trunks and branches

Branches and trunks are composed of many tissues with specialised functions including the bark (protection), phloem (transport of sugars from the leaves), vascular cambium (growth of new transport tissues), sapwood (transport of water and nutrients from the roots), heartwood (strength and structural support) and rays (internal transport and storage of sugars). Damage to branches or trunks may allow infection by plant pathogens (disease-causing organisms), disrupt the movement of vital materials and structurally weaken the tree.

B2.4 Roots

The main functions of roots include the uptake of water and nutrients, anchorage, storage of sugar reserves and the production of some plant hormones required by the shoots. In order for roots to function, they must be supplied with oxygen from the soil. The root system of trees consists of several 'types' of roots found in different parts of the soil and is generally much more extensive than most people think. The importance of roots is easily overlooked because they are not visible, that is 'out of sight, out of mind'. Damage to the root system is a common cause of tree decline and death and is the most common form of damage associated with development sites.

Root growth is opportunistic and takes place wherever the soil environment is favourable. The most limiting factor for root growth is air. A number of studies have indicated that roots are much more extensive than most people believe. In general roots extend outward from the trunk and occupy irregularly shaped areas 4 to 7 times larger than the projected crown area with an average diameter of one to two or more times the height of the tree. It is a fallacy that tree roots only extend to the edge of the crown.

Root systems consist of three main parts—

(a) the structural woody roots (anchorage, storage and transport);

(b) lower order roots (anchorage, storage and transport); and

(c) non-woody roots (absorption of water and nutrients, extension, synthesis of amino acids and growth regulators) (see Figure B1).

In addition to lateral root spread being underestimated, root depth in trees has also been grossly exaggerated. Deep root systems or taproots are the exception rather than the rule. Most roots of most trees are found in the very top of the soil. The vast majority of these roots are small non-woody absorbing roots which grow upward into the very surface layers of the soil and leaf litter. This delicate, non-woody system, because of its proximity to the surface, is very vulnerable to injury.

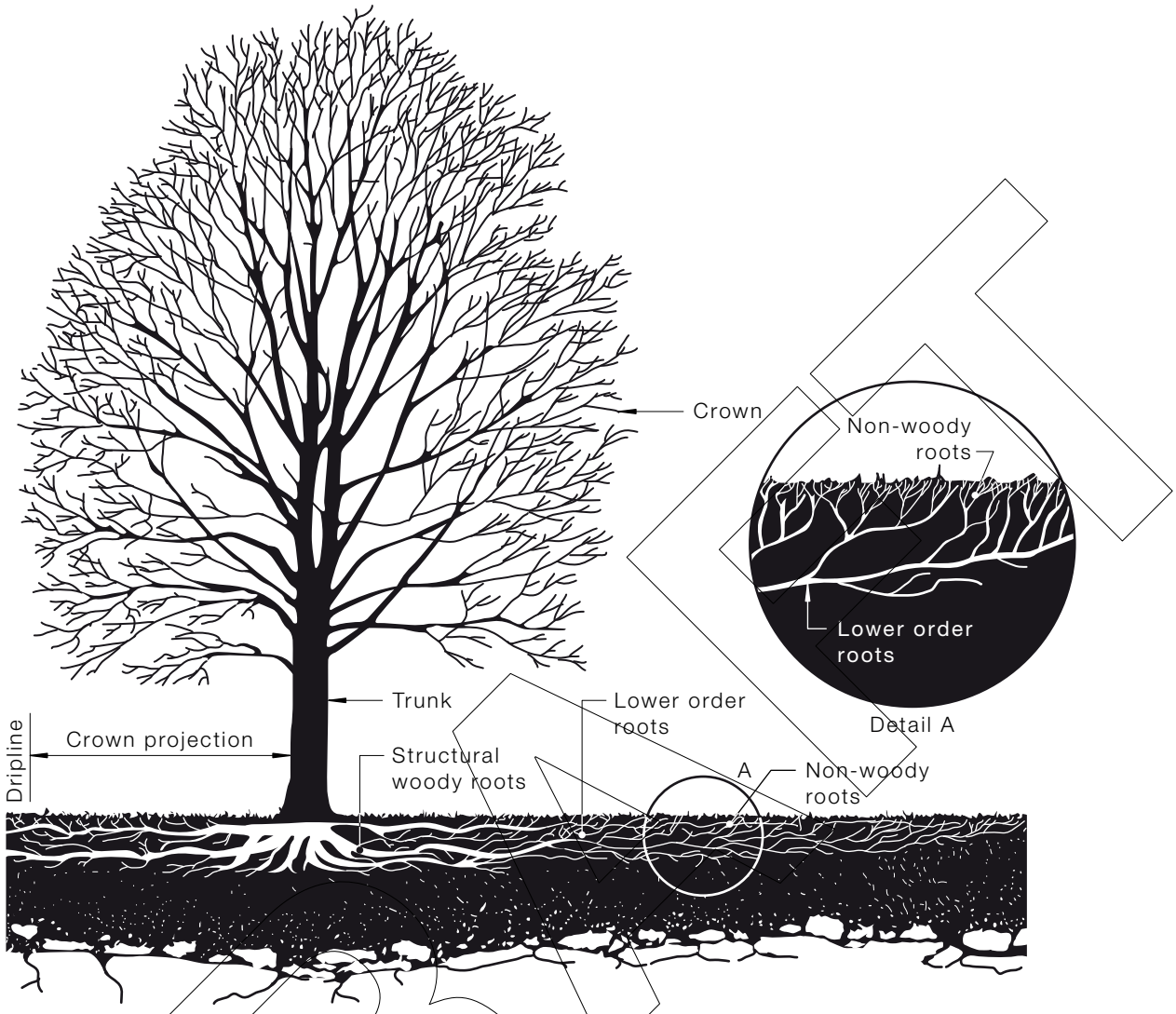


FIGURE B1 THE STRUCTURE OF A TREE IN A NORMAL GROWING ENVIRONMENT

B3 EFFECTS OF DEVELOPMENT ON TREES

B3.1 General

All parts of the tree may be damaged by development. Damage to any one part of the tree will affect its functioning as a whole. Paragraph (B3) considers the possible impact of injury on the functioning of each main section of the tree. This highlights the specific protective measures that need to be undertaken.

B3.2 Crown damage

The canopy of trees can be directly or indirectly damaged. Indirect damage will occur as a result of trunk and or root damage and will not be discussed here.

Usually, foliage may be lost or damaged on development sites by pruning or mechanical injury by trucks, cranes, excavators and so on. The removal of leaves reduces the level of photosynthesis and thus the production of sugars. This in turn reduces the tree's capacity to function normally and to withstand stresses imposed by a change in its environment.

Incorrect techniques of pruning such as lopping or flush cutting may produce wounds that are potentially susceptible to infection by wood decay organisms. Similarly, mechanical damage to branches by machinery, etc. will also create wounds. Trees automatically respond to wounding and in doing so use stored sugars. Any wound places an additional load on trees that will inevitably be stressed during construction.

B3.3 Trunk damage

Trunks of trees may be wounded mechanically during demolition and construction work. This not only predisposes a tree to potential decay but it also interferes with the transport of water, nutrients and sugars throughout the tree. Serious impacts may structurally weaken the tree.

B3.4 Root damage

Root damage is the most common cause of damage to trees on development sites. As already mentioned in Paragraph B2.4, roots are far more extensive and closer to the surface than commonly thought. Roots can be damaged in the following ways:

(a) Removed during grading, excavation and trenching for foundations services, etc.

(b) Mechanically wounded, crushed or torn.

(c) Compaction by machinery, storage of materials, and installation of work sheds.

(d) Soil buildup.

(e) Laying of pavements.

(f) Chemical contamination of the soil by solvents, fuel, oil, diesel, herbicides, cement waste, etc.

(g) Changes in air levels through changes in drainage patterns.

Apart from the actual removal of roots during excavation or trenching, soil compaction is one of the major causes of root damage on development sites. Compaction is defined as the loss of large pore spaces (macropores) within the soil with a net loss of total pore space. Macropores are essential for the exchange of gases between the soil air and the atmosphere (aeration) and the removal of excess water from the soil (drainage).

Compaction results from loads or stress forces applied to the soil as well as shearing forces. Both foot traffic and vehicle traffic exert both forces on soils. Vehicle traffic may cause significant compaction at depths of 150–200 mm (the area in which most absorption roots are located). The degree of compaction will depend on weight of vehicles, number of movements, soil moisture levels and clay content. Soil handling, stockpiling and transporting also tend to lead to the breakdown of soil structure and thus to compaction. Vibration as a result of frequent traffic or adjacent construction activities will also compact soils.

The effects of compaction include—

(i) reduced aeration (oxygen levels decrease and carbon dioxide concentration increases to perhaps toxic levels);

(ii) low oxygen levels discourage root growth and thus the uptake of water and nutrients;

(iii) reduced infiltration of water into the soil and more run-off;

(iv) increased run-off increases soil losses by erosion;

(v) low oxygen levels also lead to chemical changes in the soil which can reduce the availability of some plant nutrients; and

(vi) the reduction in the number and diversity of beneficial soil organisms (including mycorrhizal fungi).

In summary, the effects of root loss or damage by any means could include—

(A) loss of stability if primary or even secondary woody roots are cut;

(B) reduction in water and nutrient uptake;

(C) an eventual loss of leaves, reduced photosynthesis and thus sugar production;

(D) decay as a result of wounding; and

(E) predisposition to soil borne pathogens.

It is commonly observed that trees may take many years to decline and eventually die from root damage.

B4 CONCLUSIONS

The negative impacts of development on trees are cumulative and very difficult to remediate after development is completed. The best way to ensure the long term retention of valuable living assets on development sites, i.e. established trees, is to follow the guidelines outlined in this Standard.

Additional guidance may be found in the documents listed in Appendix E.

APPENDIX C

TREE PROTECTION ZONE SIGN EXAMPLE

(Informative)

A tree protection zone (TPZ) sign provides clear and readily accessible information to indicate that a TPZ has been established. Figure C1 provides an example of a suitable sign.

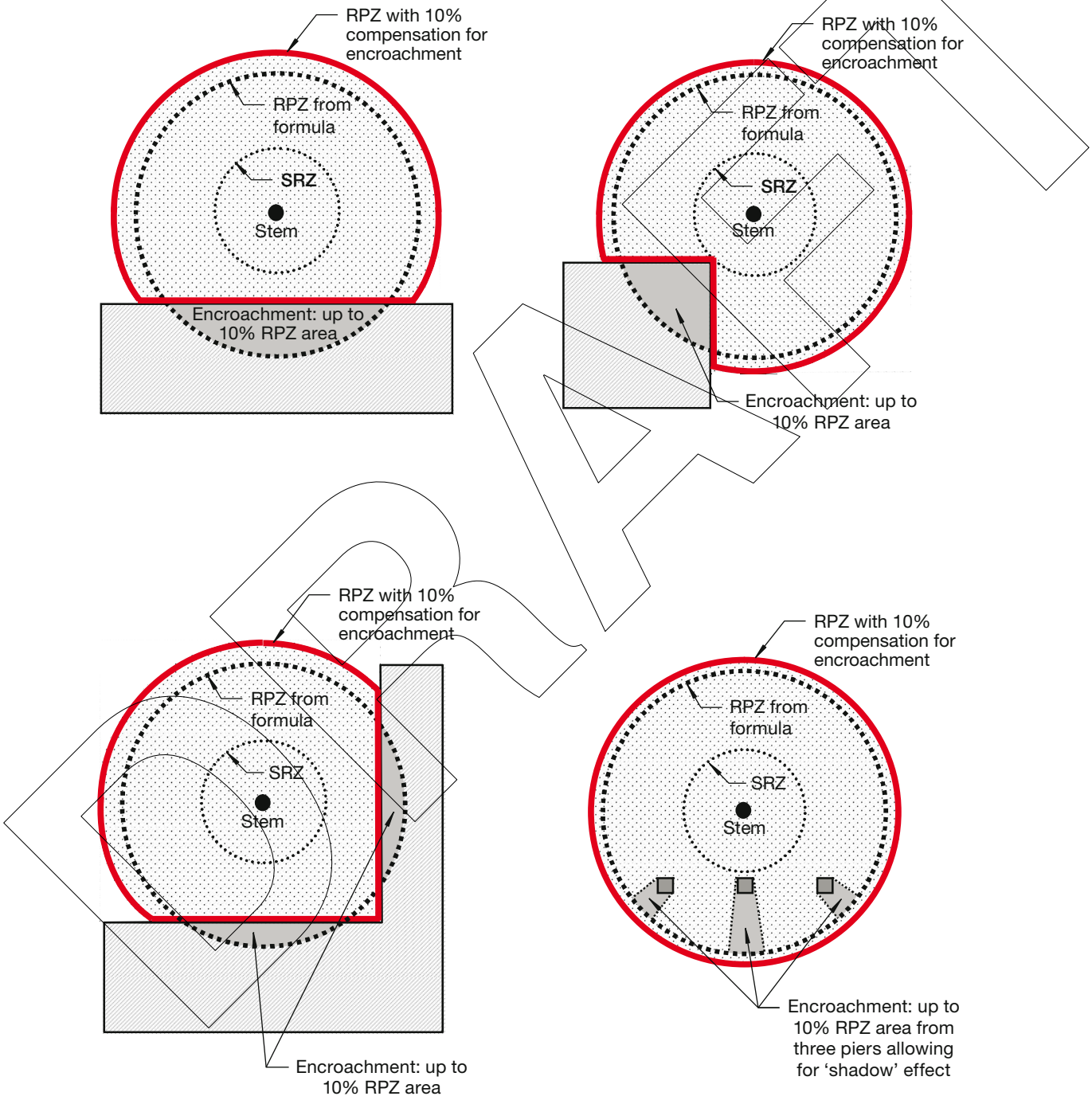
FIGURE C1 TREE PROTECTION ZONE SIGN

APPENDIX D

ENCROACHMENT INTO ROOT PROTECTION ZONE

(Informative)

Encroachment into the root protection zone (RPZ) is sometimes unavoidable. Figure D1 provides examples of RPZ encroachment by area, to assist in reducing the impact of such incursions.



NOTE: Less than 10% RPZ area and outside SRZ. Any loss of RPZ compensated for elsewhere.

FIGURE D1 EXAMPLES OR MINOR ENCROACHMENT INTO RPZ

APPENDIX E

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During the development process, Australian Standards are made available in draft form at all sales offices and through affiliated overseas bodies in order that all interests concerned with the application of a proposed Standard are given the opportunity to submit views on the requirements to be included.

The following interests are represented on the committee responsible for this draft Australian Standard:

Australian Council of National Trusts
Australian Institute of Building Surveyors
Australian Institute of Horticulture Inc.
Australian Institute of Landscape Architects
Australian Local Government Association
Australian Pipeline Industry Association
Australian Property Institute
Energy Networks Association
Institute of Australian Consulting Arboriculturists
International Society of Arboriculture (Australia Chapter)
Local Government Tree Resources Association
National Arborists Association of Australia
Nursery and Garden Industry Australia
Parks and Leisure Australia
TAFE NSW
The University of Melbourne
Water Services Association of Australia

Additional interests participating in preparation of Standard:

National Trusts NSW
Wollongong City Council

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