ENGINEERED SPACE FOR TREES IN MOUNT BARKER DISTRICT COUNCIL

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Abstract

In 2010 approximately 1300 hectares of rural land in Mount Barker District Council was rezoned by the state government for residential development. Due to its attractive hills location and proximity to Adelaide the district's population is now growing at 3.5% per year, nearly 7 times the rate of metropolitan Adelaide, and it will become South Australia's second largest city within a decade. Growth has increased pressure on existing infrastructure across Mt Barker and the district's other towns, and urbanisation has encroached on large, remnant native trees. Successfully preserving and planting trees during development and infrastructure renewal and upgrading projects demands best practice. This paper presents examples of planning, engineering and urban forestry practices that have allowed mature trees to be retained and new trees to be planted through these development and renewal processes. Case studies presented include road alignment to retain remnant trees, public open space provision to preserve trees, street tree planting for traffic calming, and stormwater detention basin design to preserve existing trees and support additional planting. Case studies demonstrating engineering best practice for trees include the use of structural soil, continuous tree trenches, and retrofitting of trial species in traffic control roundabouts.

Introduction

Urban development is changing in response to human, environmental and economic factors, scientific research and technological progress. The scale of urbanisation across the globe threatens ecological systems and services (Sidemo-Holm et al. 2022; Theodorou 2022; Kii 2016), so greener, nature-based urban development options are being applied to support sustainability and biodiversity conservation (Chan & Chan 2022; Pereira & Baró 2022). The pace of this greener evolution continues to increase due to growing awareness of the essential need for human connection with nature in cities (Martin & Almas, 2022; Mills, 2022) and increasing community angst with the loss of urban and peri-urban nature such as trees and habitat to urban development.

The development and adoption of new standards for urban design and civil engineering are supporting the transition to greener and more liveable cities and towns. To '*provide guidance for the commissioning, design, planning, approval, construction, maintenance and operation of urban green infrastructure elements, systems and networks*' Standards Australia has recently released a planning and decision framework (Standards Australia 2023). This planning and decision framework builds upon previously released Australian Standards developed since the 1996 publication of AS4373, since revised, which specifically guide the protection of existing trees during development, nursery production of new trees, and tree pruning, with which all works in Australia should aim to comply with as a minimum:

- AS4373 - 2007 Pruning of amenity trees
- AS4970 - 2009 Protection of trees on development sites
- AS2303 - 2018 Tree stock for landscape use

As with any Australian Standard, compliance with arboriculture and urban forestry-related standards requires understanding of theory and practical matters relating to the materials, tools and processes involved in the project at hand. As in any profession, this understanding comes through appropriate training and experience. Success, therefore, relies on the involvement of all relevant professions in the different stages of urban development and civil works projects. If these projects involve trees - either the retention, protection and ongoing management of mature trees or procurement, installation, establishment and ongoing management of new trees – then a project arborist must be appointed at the concept scoping stage and involved for the duration of the project and beyond. This approach has been fundamental to the success of the case studies presented in this paper.

Concurrent with the development of arboriculture-related standards, engineering practices to support trees have also progressed including the use of structural soils (Grabosky & Bassuk 2016; Day & Dickinson, 2008), structural cells (Ow & Ghosh, 2017). Structural soils are designed to overcome the growth-limiting effects of soil compaction (Zisa, Halverson & Stout, 1980; Smith, May & Moore, 2001), by providing uncompacted soil to support root growth in the voids in a consolidated stone matrix which bears surface pavement loads. Structural cells bear surface loads via their structural members through uncompacted root-zone soil to a foundation beneath the root zone. In situations where site soil is highly compacted or otherwise unsuitable for sustaining the chosen tree species to maturity under the local conditions (Haege & Leake, 2014), structural soil or cells can make contribute to achieving the necessary soil volume.

These approaches are now well developed and understood but their application is increasing only slowly. While their use is not yet mainstream, community concern with environmental issues is encouraging some leading local government authorities to establish trials. Local government trials have many benefits but two that are of direct benefit and highly valuable to the council involved are (1) the ability to examine the effectiveness (including life cycle cost effectiveness) of alternative treatments under local conditions and (2) staff exposure to novel methods for professional development and education purposes. The learnings that come from trials will inform future planning and project decisions and likely accelerate local mainstreaming of innovative approaches. Progress always comes back to making informed decisions based on the latest, most complete knowledge, rather than business as usual approaches based on outdated knowledge.

This paper presents case studies where these and other innovative practices have been used in urban settings to establish new trees and to retain, protect and nurture mature trees on development sites. This paper's purpose is not to interpret or reiterate the horticultural or engineering science underlying these practices, but to demonstrate that they are realistic design and construction options that are available, are in current use, and should be considered for further use in appropriate locations. It seems inevitable that such options will be utilised more in the future as they become more cost-effective, familiarity with them increases, relevant standards are developed and increasing community awareness of environmental issues drives demand.

Case Studies

Case study 1: Tree retention in a master-planned greenfield development

The Springlake multi-stage residential housing development in the Mount Barker District Council presented both the need and an ideal opportunity to apply best practice in protecting existing trees. This greenfield development site on the land of the Peramangk people had been used for grazing and cropping since European colonisation. Many mature individual trees and stands remained from the site's pre-European River red gum/South Australian blue gum (*Eucalyptus camaldulensis*/*Eucalyptus leucooxylon* ssp. *leucoxylon*) woodland vegetaton, including roadside vegetation at the periphery. Trees with high retention value were identified early in the development planning process and designs were developed that considered tree protection needs.

Many high value trees were retained by designing community green space around them. Trees were protected in a major linear park aligned along the natural drainage line, others were retained in allotment-scale pocket parks, and others were protected by aligning streets to include them so they remained under council's care (Figure 1). Pocket parks for tree protection were designed to include the tree to the canopy dripline or beyond, to reduce the likelihood of impacts arising from lopping of limbs overhnging adjoining properties; parks of this size also ensured adequate root zone protection. Trees retanied in streets were protected by increasing the set-back of nearby properties, by informing and guiding site development in tree protection zones on private property through development assessment and approval processes, and through tree-sensitive engineering practices in the streetscape itself. Some of these methods are described in more detail in the following case studies.

Figure 1. The Springlake development protected remnant trees and stands a linear park, pocket parks and through appropriate road alignment and engineering.

Case study 1A: Red Gum Crescent: engineered root zone protection

Three mature River red gum trees with less than 20 m between their canopy driplines would have required large allotments to support reasonable development if tree retention had been required on private property. Instead, novel road design and engineering were used to provide safe access around the trees at the intersection of Springview and Red Gum Terraces (Figure 2). Designing the trees into the public realm kept them in community ownership, reduced the impact on the number of residential allotments, and allowed for ongoing tree protection and management by the council. Road construction at this site was completed in 2016.

To protect the largest tree a roundabout was designed to accommodate its root zone and canopy. Construction of the circular roundabout was completed with no impacts within a tree protection zone of 15 m radius, the maximum radius specified in Australian Standard 4790-2009 *Protection of trees on development sites.* This tree protection zone eliminated any need for tree pruning, with foliage retained to near ground level (Figure 3).

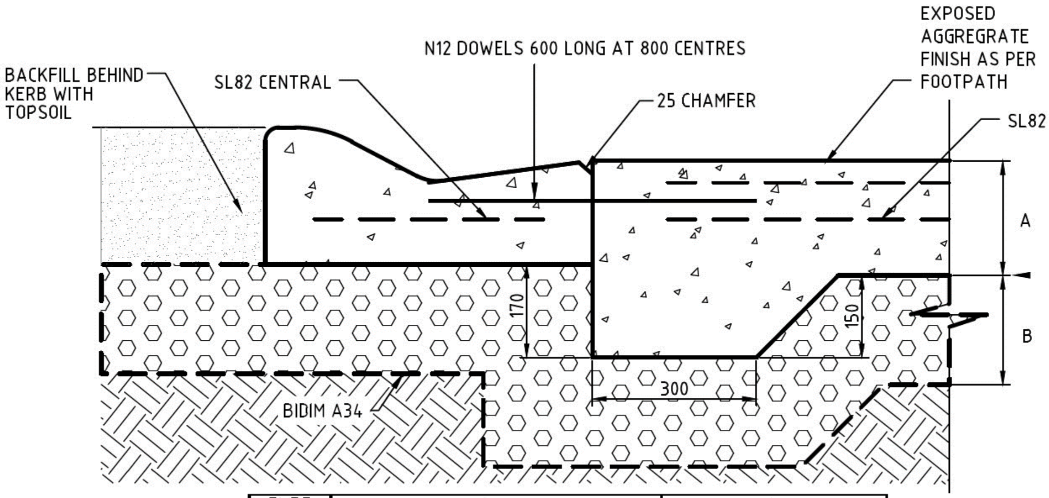
The critical root zones of the two River red gum trees on the verges near the intersection extend beneath the road. To maintain soil conditions beneath the road suitable for root growth a novel road design was used. The pre-existing ground levels were left unaltered, soil was not compacted during construction but invariably along the road alignments had received a degree of unintended compaction through heavy vehicle access. The surface of these sites was de-compacted by raking with the tynes of an excavator bucket to 100 mm deep prior to laying geotextile and a 200 mm deep layer of 40 mm ballast. The rock ballast was rolled and rattled to ensure interlock, which would have resulted in some subgrade compaction but to a lesser extent than conventional roadbuilding techniques. The reinforced concrete road surface was poured above the ballast (Figure 4) across the root zones of trees that were retained (Figure 5). The ballast base layer design provides structural integrity on low-strength (uncompacted) subgrade while supporting soil ventilation, with the added benefit of deterring shallow root growth (Coder 1998; Gilman 2006; Johnson et al. 2019), which could potentially damage the road surface.

Figure 2. Mature trees were retained through novel design and engineering (image: Google Maps).

Figure 3. Protection of tree root zone and canopy space are critical to long-term tree retention (images: T Johnson).

Installation of utilities and services in tree protection zones was minimized and utilities were laid outside of critical root zones where practical. Within critical root zones trenching was supervised to ensure minimal impact on trees. No roots greater than 25 mm in diameter were removed without prior approval of the project arborist. Roots greater than 50 mm diameter were treated as a live utility service.

The mulched areas beneath the trees are low maintenance, will improve soil organic content over time, and are available for future companion planting to maintain tree health and conserve biodiversity. Increasing soil carbon in the road reserve through mulching and companion planting has been shown to improve soil microbial diversity over time (Mills 2022), which has direct benefits for community and environmental health. Narrowing of the carriageway and designing its alignment to increase separation from the tree also increased separation of pedestrians from the carriageway (Figure 5), thereby improving community safety.



TYPE	A	B
4	210mm CONCRETE 32MPa	200mm 40mmø BALLAST

Figure 4. Road base design used in tree root zones (image: Greenhill).

Figure 5. Road alignment to increase space for retained mature trees and prevention of soil compaction in critical root zones are essential requirements when preserving trees on development sites (image: T Johnson)

Case study 1B: Wind Row Avenue: divided residential street

Road engineering allows some flexibility that can help to preserve existing trees as demonstrated in the previous case study, but greater creativity in design provides further opportunities as demonstrated in Wind Row Avenue. Not all existing trees warrant protection, including declared pest species, specimens that are structurally flawed, and trees that are diseased and untreatable, for example. An arborist's survey determined that near the intersection Wind Row Avenue and Honeysuckle Way the trees with the highest retention value were numbers 78, 79 and 83 in Figure 6, and so plans were developed to protect these. Removal of trees 75, 76, 77, 80, 81 and

82, being mainly smaller trees that were more readily replaced, supported better protection of the larger, more highly valued specimens. Using a 40 mm ballast road base on uncompacted subgrade in a divided road supported retention of tree 78 in a widened median island. Reducing Honeysuckle Way to a driveway link at the intersection allowed tree 79 to be retained. Tree 83 was protected using the method shown in the previous case study.

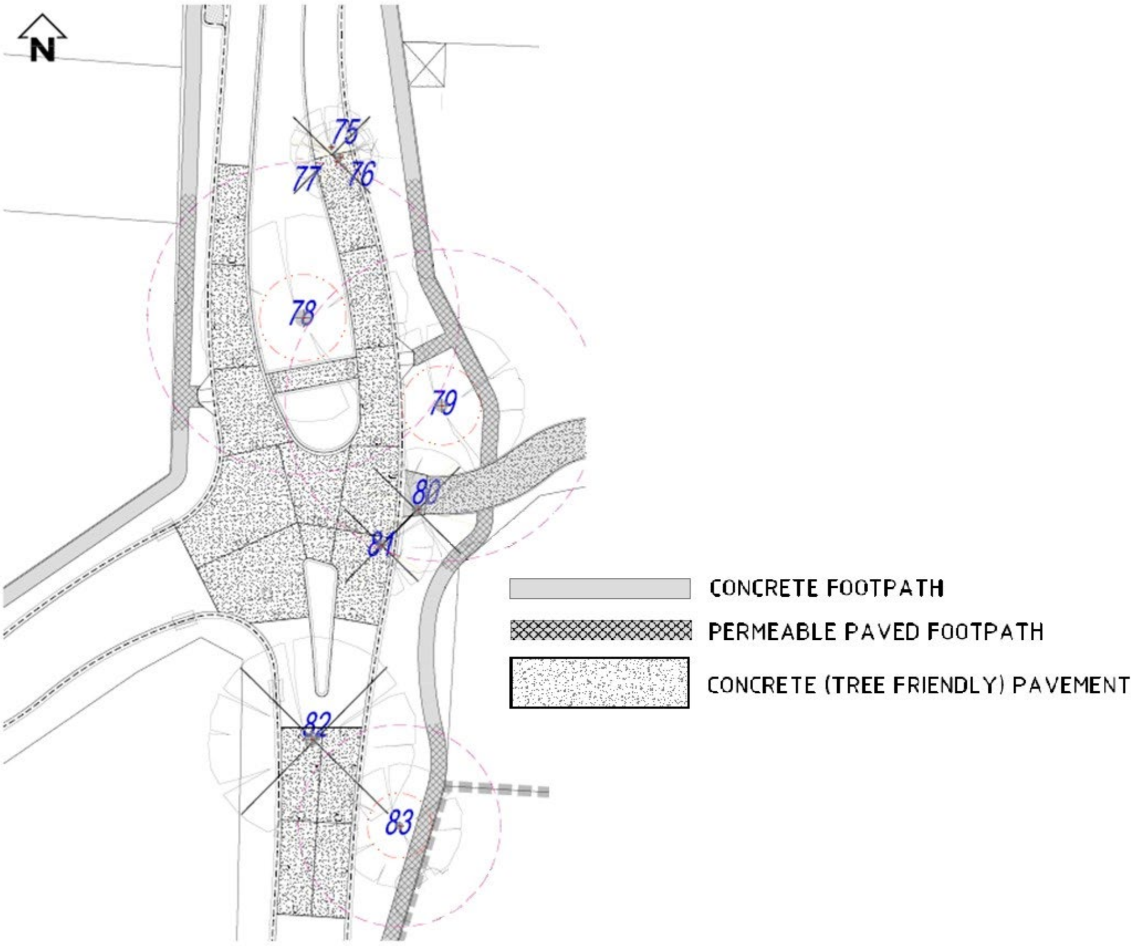


Figure 6. Protection of tree root zone and canopy space are critical to long-term tree retention (image: Greenhill).

Interaction with roots during utilities installation is inevitable in cases such as Wind Row Avenue where critical root zones cover much of the road reserve. As in case study 1A trenching was supervised to ensure minimal impact on trees, non-destructive excavation techniques were used for root investigations, to the depth of the deepest services to be installed in tree protection zones, and no roots more than 25 mm in diameter were removed without approval of the project arborist. The typical location of the root investigation trench was beyond the structural root zone and near the proposed edge of the road infrastructure (Figure 7). These iconic trees now dominate the skyline and provide ongoing amenity and ecosystem services (Figure 8).

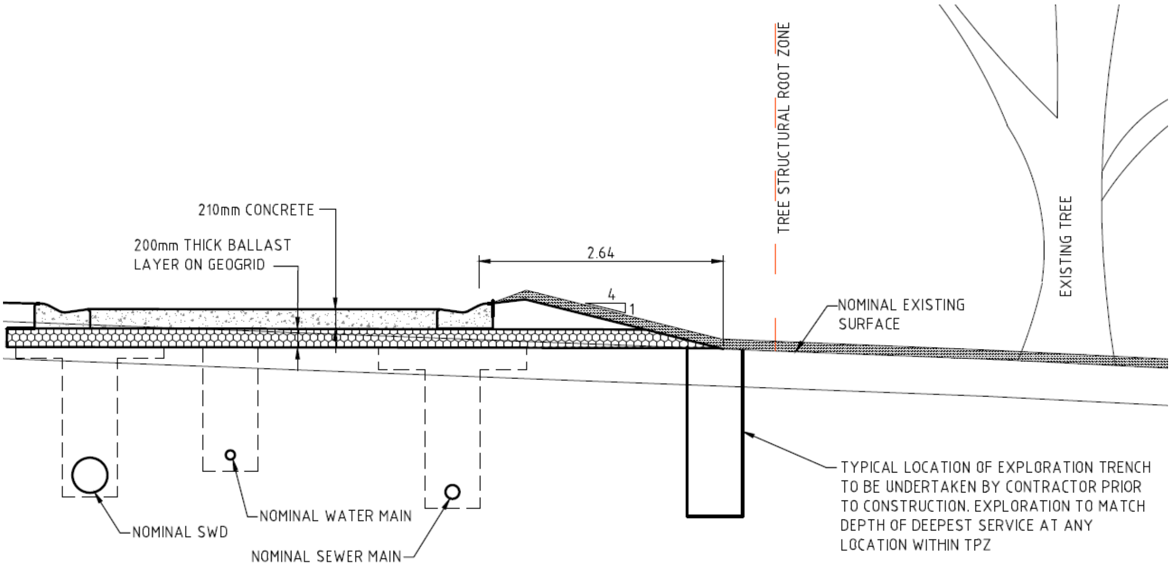


Figure 7. Root exploration trenches were excavated to the depth of the deepest service (image: Greenhill).

Figure 8. Wind Row Avenue divided road tree protection solution (photograph: C Lawry).

Case study 1C: Bremer Street driveway Links

One large River red gum and one SA bleu gum in what is now Bremer Street were identified as having very high retention value due to their size, long life expectancy and habitat values including abundant hollows of various sizes. Retaining these trees required a multi-faceted approach including revision of adjacent allotment sizes, boundary alignment, and road design and construction. Broader allotments near the trees allowed for increased set-back of dwellings to reduce issues resulting from perception of risk related to canopy overhang. Boundaries between adjacent properties were aligned so that driveways and utilities could be located on the opposite sides of the allotment to the trees.

Carriageway width was reduced to driveway links near the trees and these were located as far from the trees as possible, toward the opposite side of the road reserve to maximise undisturbed root zone and tree-protection clearance (Figure 9). Driveway links were constructed of concrete above a layer of 40 mm ballast on uncompacted subgrade (Figure 10). Specifications required inspection of the ballast layer prior to pouring of concrete and exclusion of plant and equipment from the root zone prior to and during construction. The driveway links with mature trees and landscaped understory plantings are attractive features in the street and they function as traffic calming devices (Figure 11).

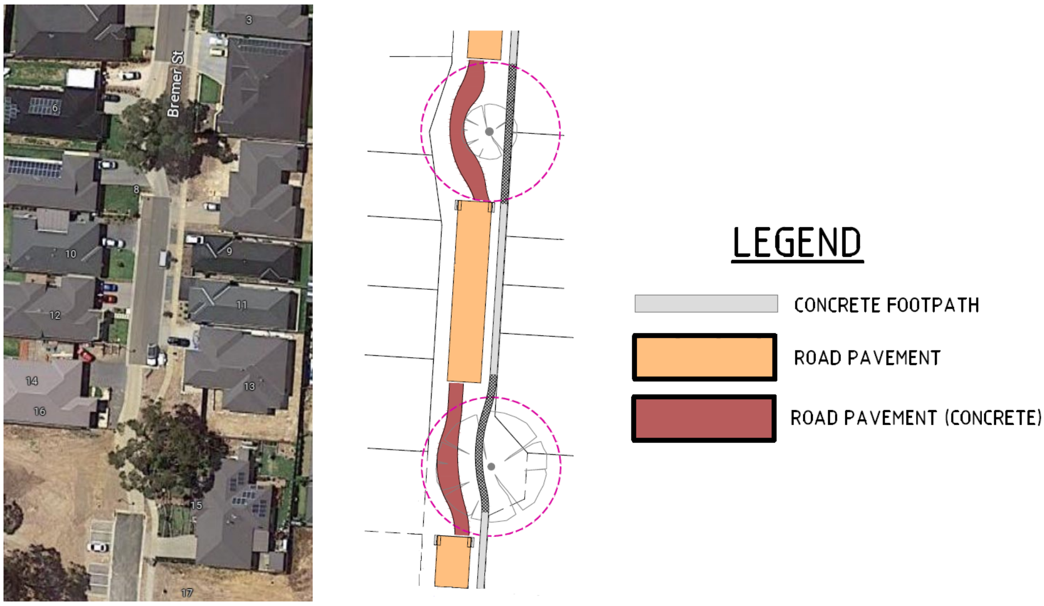


Figure 9. Tree retention and root zone protection achieved through modification of allotment size, replacement of road carriageway with driveway links, and novel road design (image: Google Maps)

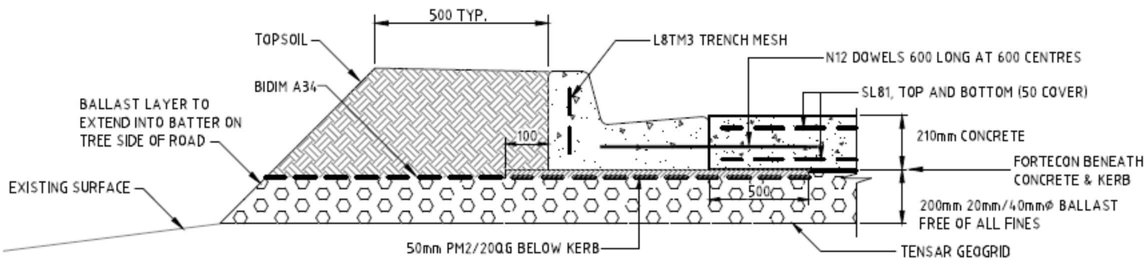


Figure 10. Bremer Street driveway link design cross section (image: Greenhill)

Figure 11. Novel alignment of driveway links and use of concrete road and ballast base over uncompacted subgrade protected the root zone to preserve a Blue gum (E. leucoxylon)(top) and River red gum (E. camaldulensis) in Bremer Street (photographs: C Lawry).

Case study 1D: Karra Circuit park

Where adequate space to preserve a tree's canopy and root system is available and it is possible to prevent compaction, contamination and any change to surface hydrology, the best way to protect remnant trees is to leave them totally undisturbed. Designing pocket parks into greenfield developments is one way to achieve this, as in Karra Circuit (Figure 12). The pocket park fully contains the canopy of two remnant trees and, whilst the roots may extend beneath what has been developed as footpath, road and adjoining residential allotments, any impact is minimal and trees are dynamic and will soon adapt to make use of alternative accessible soil volume. The Karra Circuit pocket park is a valuable addition to local open space as it adjoins the linear park to the south and extends habitat and canopy cover toward other remnant trees to the northwest and Martin Road. The location of these remnant iconic habitat trees should guide planning for greenway and habitat creation using optimal street tree cover and companion planting with understory species. Capture and biofiltration of stormwater could also be considered as part of a wholistic future design to further enhance biodiversity conservation and human and environmental health and wellbeing.

Figure 12. Preservation of high value remnant trees can be best achieved through land acquisition; such action is readily justified when connectivity, biodiversity and human, community and environmental health and wellbeing are considered (image: Google Maps)

Case study 2: Roadside tree trench, Old Princes Highway, Nairne, SA.

The Old Princes Highway through Nairne with its wide carriageway, narrow verges, deteriorating pavements and steep grade toward the northeast presented challenges to infrastructure managers responsible for asset renewal. Road and footpath renewal were essential, so council's engineers took the opportunity to address difficulties with drainage and levels which impeded access between the road and commercial premises to the north-east. The crossfall and proximity of the adjacent premises dictated the solution also had to incorporate a structural retaining wall component. With only 3.8 metres between the edge of the carriageway and the premises to accommodate the footpath, some might have been tempted to reduce or omit tree planting to accommodate underground utilities, verandas, and the retaining structure needed to deal with the crossfall. Council integrated trees into the design solution to improve amenity, improve pedestrian access (Figure 13, left) and to add value to the commercial space through increased alfresco dining (Figure 13, right). To achieve this a design solution was developed that incorporated a structural soil (Figure 14).

Figure 13. Structural soil supported improved pedestrian accessibility and increased soil volume for roots (images: T Johnson 2023)

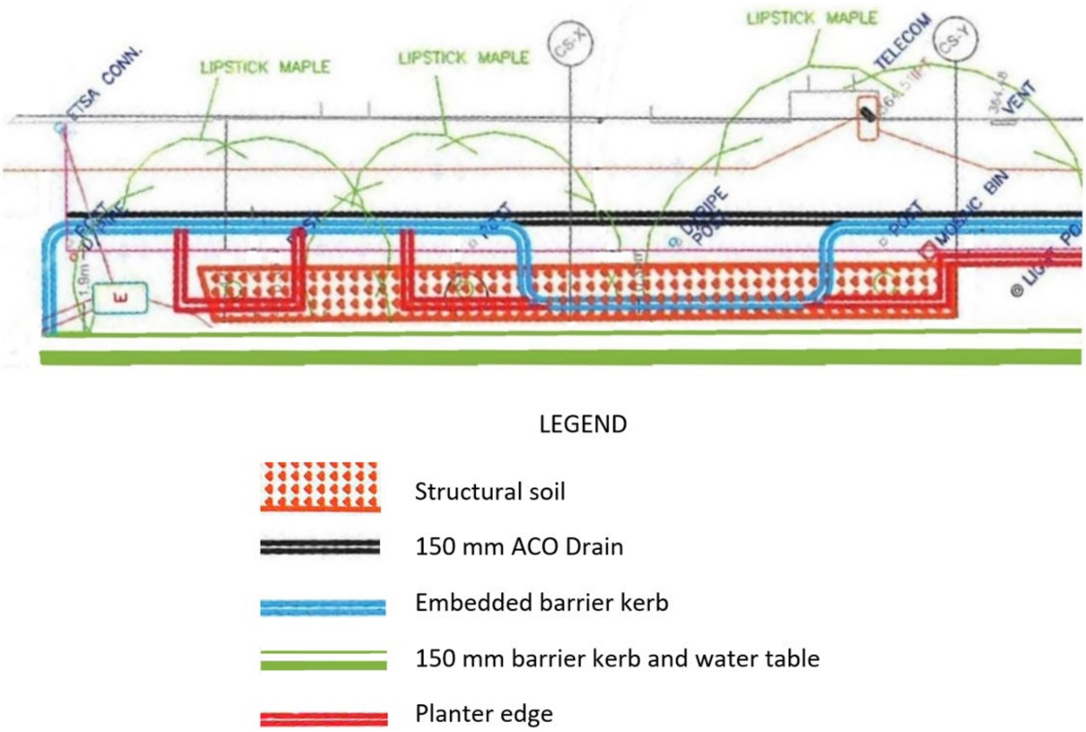


Figure 14. Tree trenches with structural soil increased root volume beneath tree pits and footpaths. The trench shown above is indicative; 16.6 m in length it contained 12.7 cubic metres of structural soil.

The structural soil was comprised of 80 – 160 mm crushed rock. Minimal soil was used in the voids between the stones to retain much of the void volume for air and water. This 'dirty rocks' approach was taken to provide tree roots with access to soil surrounding the trenches rather than to create an engineered root container, to maximise stormwater infiltration, and to maintain diffusion of gases between the atmosphere and the soil surrounding the trenches while supporting infrastructure loads. Seven soil trenches were used in the project, with a total volume of approximately 60 cubic metres (~130 tonnes) of crushed rock which was sourced from a local pit.

The rock had a neutral pH; other sources tested were rejected due to higher pH. The pavement base layer comprised 25-35 mm gap-graded gravel above the rock. Geofabric was used to separate the rock below from the pavement base rubble above. Geofabric was also used to line the sides of the trenches but not the base. 60 metres of 500 mm deep root barrier was used against the road edge compaction bench as required by the

Government of SA's Department for Infrastructure and Transport's engineers. Construction work was completed in autumn of 2018.

In total 9 Autumn Blaze hybrid maple (*Acer* x *freemanii* 'Jeffersred'), 1 London plane (*Platanus acerfolia*) and 1 Dutch elm (*Ulmus* x *hollandica*) were installed in load-bearing tree trenches and 2 additional Autumn Blaze hybrid maples were planted in generous, de-compacted 'block-outs' to enable comparison of trees planted under usual practices with those in the tree trenches. Autumn Blaze hybrid maple was selected for most of the planting based on its community desirability, proven local performance and its deciduous characteristics providing summer shade and solar access during winter. The total cost of the project was approximately $40,000, the rock-filled trenches cost ~$34,000 (i.e. ~$570 per cubic meter installed) and tree supply and planting cost $6,000, with 11 of the trees planted into load-bearing tree trenches.

Autumn Blaze was planted in the engineered spaces on the northeast side of the road and trees of the same stock were planted at the same time into verge soil on the southwest side. The trees were watered until established using council's water truck. After five years of growth the trees in the engineered spaces on the northeastern side of the road were visibly more advanced than trees on the southwest side (Figure 15).

: Figure 15. The tree in the foreground on the left side is the same species and stock and was planted at the same time as those in structural soil tree trenches on the right hand side. Distant trees on the left side (Gleditsia triacanthos 'Sunburst) were mature prior to and were retained through the streetscape upgrade (image: C Lawry).

Case study 3: Roadside tree trench, Dutton Road, Mt Barker, SA

Under normal circumstances a proposal to build a 3.5m wide shared-use pathway on a road verge would leave little space for tree planting. This was the case at Dutton Road in the centre of the Mt Barker township, where a path was needed to improve pedestrian and bicycle access and safety. Prior to its upgrade the verge of this collector road was available for informal parking including by heavy vehicles (Figure 16). Vehicle access and parking can compact soil to the extent that soil density becomes limiting to growth. Heavy equipment used during the road and footpath upgrading and undergrounding of powerlines would likely have further increased verge soil compaction. Additionally, soil on many road verges is often contaminated with (or replaced with) road materials which compact readily and can effectively prevent root penetration.

Figure 16. Verge compaction by vehicles can make soil impenetrable to roots (image: Google Streetview 2008)

In 2009 Dutton Road was upgraded and the shared-use path was added. The 4.5 m wide verge allowed for less than 1 m for tree planting between the back of the kerb and edge of the path. To provide suitable soil for tree root growth a series of continuous trenches were excavated between the kerb and concrete path. The length of the trenches was limited by footings for light poles that were spaced nominally 25 m apart. The trench was excavated 0.6 m wide to 1.4 m deep, then backfilled with natural site soil after it had been loosened and blended with a highly refined compost material (Figure 17).

Figure 17. The tree soil trench provided a pathway for roots to access natural site soil beneath a layer of compacted road base material (image: C Lawry).

Chinese pistachio (*Pistacia chinensis*) trees were planted in winter 2010 and growth has been reliable and consistent since. The trees are now well established; they have canopies approximately 6 m tall and 5 – 6 m diameter. The trees have begun to shade the road in the mornings and the shared-use path in the afternoons (Figure 18). After 13 years of growth there were no signs of root impacts on the kerb or path assets which are now within ~250 mm of the trunks; the trunks were ~250 mm diameter at their stumps Figures 18 & 19).

Figure 18. Chinese pistachio established consistently in tree trenches excavated to 1.4m deep between the kerb and shared-use path (image: T Johnson 2023).

Figure 19. Chinese pistachios well-established in 0.6 m wide tree trenches showed no impact after 13 years on nearby kerb, road or path assets (image: T Johnson 2023).

Case study 4: Planting roadside trees to calm traffic

A high incidence of speed-related accidents focussed the attention of traffic engineers on a 'black spot' roundabout at the intersection of Bald Hills and Springs Roads. Speed of vehicles approaching the intersection from the southwest was implicated in some accidents. The speed limit on this section of road is 80 km/h. Traffic visibility on approach to the roundabout is affected by its location near the crest of a hill.

Local government traffic engineers are occasionally called upon to have trees removed on the basis of encroachment within motorists' sight lines near intersections, yet some research counterintuitively shows more vegetation is safer. A study conducted in Melbourne showed that vehicle accidents involving pedestrians decreased as tree density and canopy cover increased (Zhu, Sze & Newnam, 2022). This may be due to trees increasing the visual complexity of roadsides, which increases driver alertness and attention and helps to reduce speed (Harvey et al. 2015). Trees also give a narrowing effect which is known to slow traffic (Kennedy et al. 2005), and peripheral vision of roadside objects such as trees contributes to speed perception (Lidestam, Eriksson & Eriksson 2019).

Based on this knowledge, to reinforce the perception of speed on approach to the Springs Road roundabout, trees were strategically planted on both sides of the road in 2015. A large species was selected, the Queensland kauri pine (*Agathis robusta*), which at maturity will visually restrict the space at the roadside and form a canopy above the road. To further benefit from the perception of speed, the distance between the trees was halved on approach to the roundabout to give the impression of increasing speed (Figure 20).

Figure 20. Spacing between the street trees is reduced towards the roundabout to give approaching motorists a perception of increasing speed (image: Google Maps)

The first Queensland kauri pine on the right hand side is passed 190 m before the roundabout and the separation between the trees is 27 m; on approaching the roundabout the separation between trees reduces as follows: 27, 25, 23, 21, 19, 17, 15, 12 and 10 metres. On the left side a dense planting of eucalypts fills the verge at the start of the approach, but the spacing between the trees then mirrors those on the right side. At 80 km/h a car travels 22 m in one second and at 40 km/h this is reduced to 11 m/s, so unless a car has reduced speed to below 40 km/h on the approach the roundabout (Figure 21) the rate at which the trees are passed will give the driver the impression that speed is increasing. For a driver travelling in the opposite direction and accelerating slowly away from the roundabout the increased spacing between the trees might give the impression that speed is decreasing. It will be interesting to monitor the incidents at this roundabout and investigate their frequency as the trees mature.

Figure 21. Spacing between street trees is reduced towards the roundabout to give approaching motorists a perception of increasing speed (image: T Johnson 2023).

Case study 5: Urban forest species diversity and richness – species trials

The Mount Barker District Council is committed to increasing tree canopy cover in urban areas and to ensuring urban forest resilience in the changing climate. Achieving these goals requires an increased palette of suitable tree species. To achieve this, Council plants small numbers of locally unfamiliar species to test their performance in Mount Barker's soils and climate. Locations for planting trial species can include any public area such as a roadside, traffic island, median or roundabout. Just as the previous case studies have shown that it is possible (indeed desirable) to integrate the design of infrastructure to protect valuable remnant trees, the design and construction of engineering assets can and should create space for significant trees of the future.

It has been shown that a 15m radius roundabout can accommodate a large River red gum (Case Study 1A), so this raises the question of what size roundabout might accommodate a tree as large and climate-resilient as a Moreton Bay fig? The answer depends more on the soil and available moisture than on the tree species; on alluvial soil near a creek or river the root zone may be much smaller, for example. With Mt Barker Creek only 40 m to the southwest, the 22 m diameter roundabout at the intersection of Dutton Road and MacFarlane Terrace might therefore easily accommodate a larger tree than the River red gum's 30 m diameter roundabout on Red Gum Drive (Figure 22).

A smaller roundabout at the intersection of Flaxley and Alexandrina Roads provides insufficient soil volume for a large tree species but its high profile with many thousands of vehicles per day passing provides an opportunity to greatly enhance the aesthetics of the site by planting an unusual and attractive tree species selection. A locally unfamiliar tree species was selected but one which was considered highly likely to thrive: a Horse chestnut (*Aesculus hippocastanum*) (Figure 23).

Figure 22. This Moreton Bay fig that is establishing well on a traffic roundabout will be a stunning green asset when it matures (image: T Johnson 2023)

Figure 23. Being subject to minimal pedestrian access a roundabout provides an ideal location to plant species which are highly aesthetic but relatively unknown in terms of litter or pavement impacts, such as this Horse chestnut (image: T Johnson 2023)

Discussion & conclusions

The projects summarised in this paper demonstrate that trees large and small can be protected on greenfield sites prior to, during and following development. By applying the same methods and standards new planting spaces can be created for saplings, to provide the root and canopy volumes and soil resources that will sustain them as they grow into large, iconic landmarks and beyond into their old age. These case studies demonstrate that tree protection and planting are readily achievable, but delivering the resulting urban forest requires the commitment of community leaders and decision makers.

Australian Standards now guide decision making and planning in relation to green infrastructure, with protection of existing green assets given highest priority amongst measures to increase canopy cover to reduce urban heat. Adequate soil volume, avoidance of soil compaction and contamination, and soil access to atmosphere for rain infiltration and gas exchange are essential. Protection of tree root zone integrity is paramount. Compliance with Australian Standards should be considered a minimum requirement. As urban heat is already responsible for more deaths than any other natural hazard and this is increasing, non-compliant, sub-standard urban tree protection and provision may soon be considered negligent.

Providing urban forest canopy equitably across communities needs multidisciplinary expertise. Collaboration across the disciplines of urban design, civil engineering, landscape architecture and arboriculture, from project scoping, planning, design and construction to commissioning and maintenance, is essential. Involvement of all disciplines at planning review stages is vital.

Trees are multi-functional, high-value community assets. They are essential urban infrastructure; they deliver essential and increasingly valuable services. They can be cost-effectively protected in greenfield developments, designed into street infrastructure renewal projects and upgrades, and retrofitted into existing streetscapes. Tree protection isn't difficult, Australian Standards guide its achievement, it simply requires leadership and commitment. The designs and approaches presented in this paper are realistic, are in current use, and should be considered for further use in appropriate locations.

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