Transport
for NSW

Landscape design guideline

Design guideline to improve the quality, safety and cost effectiveness of green infrastructure on roads and streets

NSW GOVERNMENT

Urban Design Roads and Waterways

Acknowledgements

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Image — Dean Street, Albury
Cover image — Remembrance Driveway

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Foreword

This document has been prepared to guide the provision of landscape and green infrastructure in our road and street corridors. It is published as part of the Beyond the Pavement urban design policy, procedure and design principles initiative and sets down the approach to the design and management of planting and revegetation.

Wherever they are situated, whether in town or country, communities, roads and their settings are enhanced by the presence of vegetation. It provides character, colour, texture and interest to our places. It helps filter air and water borne pollutants, provides shade and comfort to our customers from the sun and converts carbon dioxide to oxygen. It is a structural component of our road and street infrastructure, and provides long-term self-repairing stability to cuttings and embankments.

Vegetation is the perfect foil for the hard elements of roads and buildings. It helps provide structure and form to road alignments, helps integrate roads into built and natural settings, provides a distinctive frontage or entry to towns, and helps create a unique sense of place which assists way-finding. Vegetation is a relatively inexpensive element of our roads yet improves with age — at maturity providing great character as well as habitat for our native fauna.

Yet this asset can also be a problem if not designed properly. Vegetation can be expensive and hazardous to maintain and, more importantly, a safety issue for all road users.

This guideline, developed from the lessons learnt from many projects over the years, ensures that the right conditions are provided so that in time landscape is established that safely and cost effectively contributes to successful places.

1 Introduction

1.1 Purpose of the guideline

The purpose of this guideline is to set down a best practice approach to projects undertaken on roads and streets so that the landscape is:

- Responds to needs of the community and customers
- Integrated into the project and built and natural fabric of the area
- Ecologically sound
- Fit for purpose
- Functional and provides value for money
- Safe for road users
- Safe to build and maintain
- Low maintenance.

This document is intended for landscape designers, landscape contractors, and road designers as well as project managers. It focuses primarily on the design, establishment and maintenance of planting and seeding, and as such is not a comprehensive policy on landscape design and all its facets. It should be read in conjunction with *Beyond the Pavement 2020*, and other design policies.

It forms part of a series of urban design guidelines, including *Bridge Aesthetics*, *Noise Wall Design Guideline*, *Shotcrete Design Guidelines* and *Water Sensitive Design Urban Guideline*, which also contain advice on landscape in relation to their subject matter.

1.1.1 The value of good landscape

When it is designed well the landscape becomes an important component of the transport network.

It is one of the major elements that contribute to the character of an area — the combination of landscape and built form helps provide a unique sense of place of value to the community.

- It helps integrate or fit the road and street into its setting
- It provides structure and a three dimensional scale
- It helps unify the transport environment, providing interest and a milestone to users as well as helping create a simple, strong and intuitive driving experience
- It can be a valuable ecological asset in an area, especially when adjacent land is over-developed or when existing habitats and ecological corridors need to be augmented and connected

The landscape of the road corridor contributes to the quality of journey and the quality of the area.

Landscape areas must be designed with particular consideration to road safety, as poorly planned landscape can be dangerous and impair the safe operation of the road and ongoing community acceptance of roadside trees and landscape areas.

The setback of trees should vary for different speed roads. Higher speed rural roads need a greater setback for trees than lower speed urban roads.

- It provides shade for pedestrians and buildings and a setting to take a break from driving in rest areas along the road network
- It is valuable in terms of impact mitigation. It screens undesirable views of roads and traffic, helps filter air and water pollutants, suppresses weed growth, helps reconnect habitat and can help recover threatened species. It also minimises the carbon 'footprint' of road works — for at least the lifetime of the landscape
- It can contribute to a safer road, for example, by screening headlight glare, slowing errant vehicles and helping create an intuitive, self explaining driving experience
- It helps stabilise slopes and minimise erosion
- The landscape improves resilience of the transport asset to long term climate change and urban temperature extremes
- Well-designed landscape is flexible and adaptable to future growth and change in our cities and land uses.

1.1.2 Potential issues

When it is designed and managed poorly, landscape can be a problem:

- Overly complicated designs can look inappropriate and be expensive to maintain
- Permits for traffic lane closures for landscape maintenance are expensive, time consuming and difficult to obtain
- Poor plant selection can result in unsuccessful, ailing planting designs, increased bushfire risk or can cause ecological damage by introducing inappropriate or weed species
- Too much planting can block views and passive surveillance, and make the journey monotonous for road users
- Incorrect plant sizes and densities can lead to unsuccessful, high cost maintenance and a higher risk of weed infestation
- Poor location of planting can result in damage to the transport infrastructure, interference with utilities and obstruction of signage
- Vegetation can result in injuries and fatalities. Large trees in the wrong place can be a hazard for vehicles and other plants can obscure pedestrians from drivers.

The landscape design is an integral structured part of the whole urban design outcome and provides great character to the street, road and motorway.

A minimalist approach to planting provides open views and helps emphasise the landform and the sweeping road alignment.

1.2 Terminology

Refer to *Roads and Maritime Guideline for Batter Surface Stabilisation Using Vegetation* for terms related to revegetation methods and materials.

Clear zone

A clear area around roadsides that reduces the risk of collision when vehicles leave the road corridor.

Climbers

Prostrate spreading or climbing plants.

Cover crop

Fast growing but short-lived non-woody plants used to stabilise exposed ground and to help control erosion and improve soil quality.

Deflection zone

The distance the safety barrier deflects on impact by a vehicle.

Frangible planting

Planting which breaks under the impact of a motor vehicle (and hence helps to stop a vehicle).

Green Infrastructure

Green infrastructure is defined as natural vegetation and vegetative technologies — like urban forests, greenways, restored and constructed wetlands, green roofs, green walls, bio-swales and more; that provide society with benefits like enhanced liveability, improved energy efficiency, improved air and water quality, reduced flooding and increased recreational opportunities.

Ground cover

A low growing woody or herbaceous plant.

Cover crop is used to stabilise exposed batters and encourage native plant regeneration.

Dynamic deflection zones must be maintained behind the safety barrier.

The clear zone varies for different speed roads. Slower speed urban roads (upper) have narrower clear zones than high speed rural roads (lower).

Landscape

There are 3 accepted meanings:

1. A tract of land. Also taken to mean a prospect or piece of scenery or land, which includes buildings, villages, towns and cities and infrastructure as well as the environmental, vegetative and ecological elements contained within.
2. In construction works, “Landscape” is the portion of works and materials that creates and supports the provision and growth of vegetation from seeding or planting.
3. In maintenance terms, landscape is the area that is not used by traffic.

Median

The central reservation which separates carriageways from traffic travelling in the opposite direction.

Mulch

Organic woodchip derived from waste vegetation placed around the plant to suppress weed growth and retain soil moisture.

Planting

To establish a vegetation cover by planting of trees, shrubs and groundcovers. (Refer to TfNSW specification R179).

Planting sizes

Plants are available in different sizes from various sources. Rigid walled containers range from tubestock to 300 millimetres. Larger plants are generally supplied in bags or specialist container if ex-groundstock. Trees supplied in containers larger than 300 millimetres/25 litre must comply with the Australian Standard *AS2303 Tree stock for landscape use*. Containers smaller than tubestock may only be used for specialist plantings such as wetlands or threatened species with expert advice. The size and style of container should be appropriate to the species growth, habit and production requirements.

Provenance — indigenous, endemic, native, exotic

The location from which a seed or plant is sourced. Refer to Appendix B for more information.

Local native seed collection is an important operation in revegetation.

Plants come in different size containers to suit species growth and habit, regional variation and production requirements.

Revegetation

To provide vegetation cover by application of seeds. (Refer to TfNSW specification R178). Revegetation areas may also be a combination of planting and seeding.

Road reserve

A legally described area of land within which facilities such as roads, footpaths and associated features may be constructed for public travel.

Roadside

The area from the edge of the carriageway to the boundary of the road reserve.

Safe intersection sight distance

Safe intersection sight distance is the minimum sight distance which should be available from vehicles on legs of an intersection.

Grass

A wide variety of non-woody plants including sedges, rushes, pasture and crops. May be native like Mat-Rush (Lomandra) or exotic like Buffalo.

Seeding

The application of seeds and other materials by manual, mechanical, pneumatic or hydraulic methods to revegetate exposed ground.

Shrub

A woody perennial plant (smaller than a tree), that usually has several stems arising at or near the ground and giving the plant a bushy appearance.

Tree

Any woody perennial plant, any plant resembling a tree in form and size, generally with a single thick trunk and more than four metres tall at maturity. Trees have a variety of descriptions in different regulations and jurisdictions.

Turf

Grass maintained at a short relatively even length, used as a ground cover or lawn can be established as rolls or seeded.

Urban and rural context

For the purposes of this document, urban refers to built up, urbanised areas. Rural refers to non built up areas that can occur in cities and metropolitan areas. Areas between the two may be described as semi-urban or semi-rural.

Verge

The verge is the area of land between the carriageway and the edge of the road reserve.

Tractor seeding on a batter shallower than a 3:1 slope.

2 Design approach

2.1 Landscape design objectives

The following design objectives and related principles should be addressed in the design and management of the landscape.

2.1.1 Landscape should be safe

Landscape must be safe to construct and maintain and be safe for the community and customers. It should be designed to help improve road and pedestrian safety and where possible encourage safer driver behaviour.

As a minimum:

- Safe sight distances must be applied according to the design speed
- High speed vehicles must be protected from hitting trees either through separation or barriers
- Landscape must not create hidden public spaces with poor surveillance
- Landscape must not obscure signage
- Landscape must not be designed so that it is hazardous to build and maintain and should be as self reliant as possible for the context.

The landscape itself can also contribute to providing a safer road and street:

- Planting and seeding in the median can be used to screen headlight glare
- Prostrate ground cover plants can help smother weeds within sight distances
- Low planting between the footpath or cycleway and the road can help keep pedestrians and cyclists away from faster vehicular traffic
- Occasional feature planting can help provide milestones and relieve the monotony for people travelling on long journeys
- Planting can help create a self explaining road by providing visual cues to drivers as to the road alignment and the appropriate speed limits
- Frangible vegetation can help slow or stop errant vehicles, before they hit non-frangible objects
- Anecdotal evidence has shown that an interesting — not distracting — visual experience can help improve driver behaviour and alertness.

Example of safe planting in the median clear of non-frangible hazards and with open sightlines at bends and intersections.

The use of distinctive trees can provide subtle warnings of urban areas ahead as well as differentiate between settlement and rural areas. They help warn motorists of a change in character to an urban area and that slower speeds may be appropriate and required.

The design of this road helps restore the landscape and blends the road corridor into the adjacent context by continuing vegetation patterns and local species across the road reserve and median.

Ecological design replicates natural patterns and systems, which are cyclical and become self-reliant over time. Roadside landscapes that reuse site-won materials must apply these patterns and systems to properly establish.

2.1.2 Landscape should be integrated into the project and the built and natural fabric

Due to their linear nature, roads and streets have a wide influence on the built and natural fabric through which they pass. When designed well they can achieve a good fit.

Where they cut across the grain of that fabric, they can be disruptive.

The landscape design should help minimise that disruption by continuing the grain of the local character across the road corridor as well as knitting the new lines of the road corridor back into the existing built and natural fabric.

2.1.3 Landscape should be ecologically sound

With such a large state transport network there is a role to play in protecting and recovering local biodiversity. The landscape should be designed so that it: recovers and consolidates local habitat; reinstates wildlife corridors and connections; filters and cleanses stormwater runoff by shaping of the ground surface; consists of suitable species; and minimises waste and pollution in its construction and maintenance.

2.1.4 Landscape should add character and value to the built environment

People spend a significant amount of time travelling. A person's perception of a place is heavily influenced by the journey to that place as well as the quality of the roads and streets. Consequently, it is important that the landscape should contribute to the quality of the environment and travelling experience.

2.1.5 Landscape should be planned to evolve over time

Unlike other elements constructed as part of a project, the landscape will continue to change after completion. The roadside landscape should persist as long as the other infrastructure with which it is provided — if left undisturbed in an appropriate space, many trees will outlive the lifespan of the road and structures.

Designers should understand how planting and vegetation will grow over time. Well thought through consideration of factors such as views, services, clear zones and future widening will result in a design which performs as intended. The effect of unforeseeable events such as climate extremes, fire or flood and changes in adjacent land use will be mitigated if the underlying design is sufficiently resilient.

Species mix, spacing and container size should be selected for longevity, balancing the need for early effect where that expectation exists.

An important factor in the design is the choice of an approach which will mature in place but not fundamentally change, versus an alternate approach which is designed to evolve through succession, from pioneer and coloniser species to complex vegetation communities, especially in highly disturbed sites. The former is more likely to be appropriate for urban sites using planting only whilst the latter is more suited to rural areas using revegetation techniques.

2.1.6 Landscape should be cost effective

With an asset as vast as the state transport network it is important, for both cost and sustainability reasons, to minimise the maintenance requirements placed on the organisation and other agencies.

As natural systems survive without human intervention, the closer the design approach is to a natural landscape — within the constraints of the design objectives — the less the level of ongoing maintenance (after the establishment period) and generally the more ecologically valuable the landscape. In many rural situations the best landscape approach is the simple, minimal solution of continuing the adjacent vegetation cover into the roadside.

The landscape should be robust enough to withstand various natural and human impacts such as drought, weeds and vehicular damage. This leads to cost savings in asset management.

It should also be simple and appropriate to the local area and the needs of the transport corridor. The value of broadscale and mass landscape planting must not be underestimated.

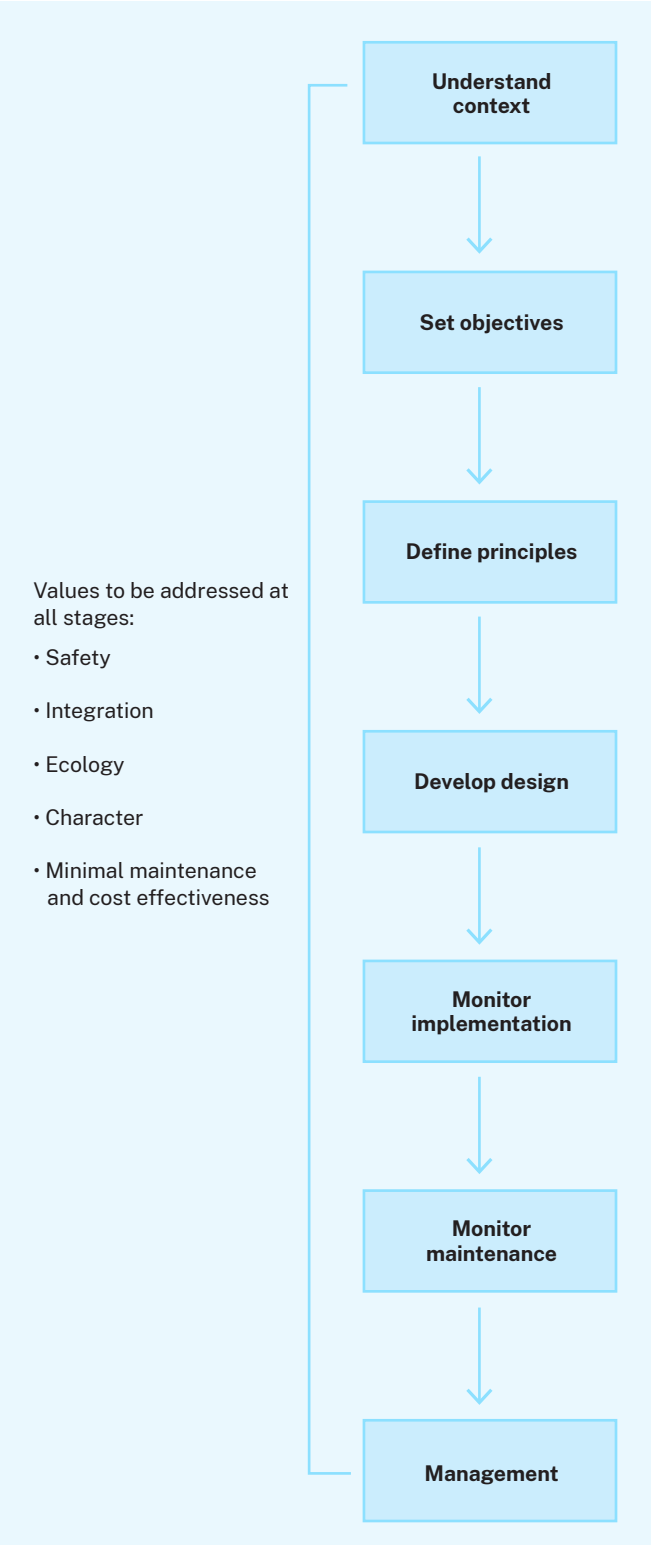
Natural regeneration of Pultenaea on the Pacific Highway creates a memorable impact, is ecologically beneficial and was free.

A simple continuation of the adjacent grass cover alone is appropriate and highly cost effective.

Bottlebrush, Mat Rush and other local native shrubs in the Blue Mountains create a simple, self-reliant and attractive design outcome.

2.2 Landscape design process

The following broad design process consistent with *Beyond the Pavement* should be followed in designing landscape:



2.2.1 Understand context

Designers must understand the context of the area, appreciate what is important about the local character and what role the landscape should play.

2.2.2 Set objectives

In parallel with the contextual analysis the design objectives should emerge. They should be simple, succinct and in accordance with this document.

2.2.3 Define principles

Once the objectives are set, the design principles which will realise those objectives, should be defined.

2.2.4 Develop design

The concept and detail design should then be developed translating the objectives and principles into physical form. The design must be developed in collaboration with the whole project team.

Each landscape design should be covered by a Safety in Design report. This report must capture the health and safety hazards and identify measures that will eliminate or reduce the impact of each hazard on constructors and maintainers (refer to Appendix D).

2.2.5 Monitor implementation

The implementation of the design must be monitored by the designers. Changes during construction are inevitable and need to be managed so that they are consistent with the design objectives and principles.

2.2.6 Monitor maintenance

Landscape is not instant and improves with age, however it can fail if neglected in the vital early establishment period. Therefore the landscape needs to be monitored in its early stages so that it can be self-reliant and thrive when established.

2.2.7 Management

Landscape should be managed in the long term in accordance with the landscape objectives. A landscape management plan for the established road landscape should be developed which incorporates the landscape design and management objectives (refer to Appendix E).

3 Design guidelines

3.1 General landscape design guidelines

The following general planting and revegetation guidelines should be addressed:

3.1.1 Ensure adequate space for landscape

A successful landscape requires space. Overly steep batters and cuttings and narrow strips of land for the verge and median will generally result in a poor landscape outcome. There are ways of vegetating steep slopes or using appropriate species to fit in narrow spaces but these are far from ideal. When corridors are planned, where possible, adequate room should be allocated to cater for the transport infrastructure, the landscape and its development over time.

3.1.2 Use trees where practical

The design principle is to use the largest plant element or unit where possible as they are the longest lived, most resilient and provide best value. Trees are the most memorable aspect of a planting design. They have an appropriate scale for a transport corridor, are clearly noticed when travelling and are the best means for ameliorating the hard built elements in the landscape in which they occur. Subject to their safe use, they should be the primary element of a landscape design.

Trees should however, be used judiciously in a corridor. For example they should not obscure expansive views and they should be located carefully and safely, clear of operational zones and not in conflict with utilities (see Sections 3.3.1 and 3.3.2). The designers must consider the growth habits and morphology of all proposed plants to ensure their potential impact on structures and services and traffic is avoided.

3.1.3 Use low shrubs, long grasses, groundcovers and sedges as an understorey

Groundcovers, sedges and long grasses are generally preferable to short cut mown turf grasses in rural areas for ecological and aesthetic reasons as well as the cost of maintenance. Turf species, which require regular mowing, are useful for edges, areas adjacent to pedestrian circulation like busstops, recreation and rest areas and drainage channels.

Adequate space is needed to create a good, well proportioned landscape outcome.

This median is not wide enough for this type of landscape treatment and the result is visually poor and hard to maintain. A simple turf strip or paved surface would be preferable.

Trees offer an appropriate scale for a road or street. When used in avenues they have a strong visual effect. Where used near to buildings, deciduous trees work well and provide winter solar access.

Revegetation of locally indigenous species to match the adjacent landscape is generally the most cost effective and fitting approach in rural areas.

3.1.4 Use turf rolls to establish low grass in urban areas

In general, grass in rural areas should be achieved by seeding and in low grass urban areas by turf rolls. Revegetation and grass seeding is generally not appropriate in urban areas because of the higher pedestrian traffic, the presence of more fertile and weed contaminated soils and the difficulties of maintenance under traffic.

3.1.5 Select appropriate species

The landscape design should be as simple and straightforward as the context allows. For example in urban areas designs should use one or two dominant species, but contain enough diversity for resilience, gradual adaptation and to survive extreme climate events. The simple repetition of the same species can have a powerful, memorable effect. Such a landscape is also easier to maintain. Rural areas may benefit from a diverse mix comprised of many species which reflects the surrounding native vegetation.

3.1.6 Provide good visibility in urban areas

Trees in turf, groundcovers or low shrub planting are generally preferable to trees used in combination with taller shrubs in urban areas. Trees with a low understorey allow views, sunlight in winter and passive surveillance of footpaths and public spaces. Turf should be used for large areas and where pedestrians are likely. Planting should be used for small areas or where the requirement is for a purely visual effect.

3.1.7 Use indigenous species where possible

To reduce water consumption, preserve local biodiversity and landscape distinctiveness, and increase design life, the use of indigenous species of certified provenance are preferred in rural areas and, where practical, in urban areas. This can be achieved either through seed collection and revegetation, purchase of plants from local nurseries or through propagating collected seed for the project.

The distinction between indigenous species and Australian native species must be considered. Australian native species may not always be appropriate for the local area. They may require a different climate and water regime and may even be classified a weed eg Acacia saligna in NSW (Refer to Appendix B).

3.1.8 Consider the value of exotic plants

Particularly in urban areas, exotic trees and shrubs can be useful in providing a distictive marker on the road or street, can be used to help fit roads into cultural landscapes, can be particularly hardy in a roadside environment and, in the case of trees, offer shade in summer and light in winter.

3.1.9 Consider the cost for landscape in terms of its context

Costs should relate to the design requirement, project purpose and the context. Often urban landscapes require more intensive and maturer outcomes at completion and therefore more expensive than rural landscapes.

Landscape is rarely expensive in relation to the total project cost, ensuring an adequate budget for landscape and its care is highly valued by the community and our customers.

3.1.10 Design for a project life of 40 years

Consider the design life of the project. Some landscapes such as wide medians have a limited lifespan until a road widening may occur. Other landscapes will have long, multi-generational lifespans. Design the landscape accordingly. Use faster growing species for shorter lifespan landscapes. Avoid fragile short-lived plants and where the future is assured use large long-lived trees and self-regenerating understorey.

3.1.11 Use the landscape to provide a connecting to country

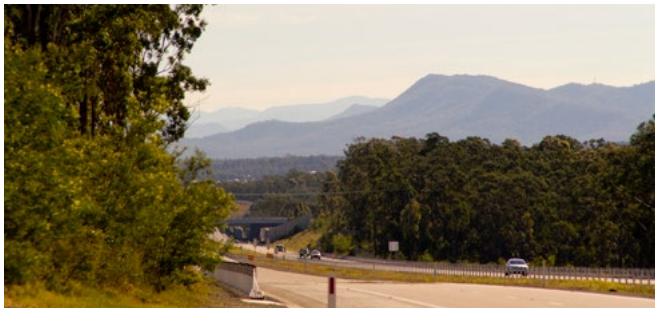
Plant associations, trees and their design have strong cultural significance. Work with Aboriginal knowledge holders to understand different species, their meanings, past uses and their value to the whole community. This is part of TfNSW Reconciliation Action Plan.

3.1.12 Consider green infrastructure services

Landscape can provide ecological and social services (water and air quality, climate change mitigation, shade, vandalism deterrence, fauna habitat, urban greening and health) beyond its important aesthetic value. These can be provided by approaches such as:

- Layering of different plant canopy heights and structures to provide dense ground coverage for shade, organic deposition, prevent raindrop impact and overland flow erosion

- Using water sensitive design (WSUD)
- Using large volume canopy trees to provide heavy shade
- Use dense shrubs to prevent graffiti, vandalism and unauthorised access
- Where appropriate, designing structures to accommodate landscape such as land bridges, green walls and roofs
- Where the road landscape can be safeguarded indefinitely against future development and managed in accordance with a biodiversity stewardship agreement, using it to provide biodiversity offsets.



Rural road landscape responding to local vegetation patterns and species. Using locally collected seed to revegetate earthworks, planting where necessary and respecting views and the journey experience. A safe, sustainable and self reliant landscape.

A full forested outcome can create monotony and open views are important where the landscape character supports this. In this situation a row of deciduous trees have been planted to replace the aging poplars that are part of the Remembrance Driveway.

Simple, ecologically benign, low maintenance road reserve design with a two metre wide mown verge adjacent to the carriageway. Note that natural regeneration has resulted in vegetation within the clear zone which if non-frangible would need to be removed.

3.2 Detailed landscape design guidelines by context

All landscape should be designed in accordance with the objectives and guidelines set down in this document, however there are some specific guidelines that should be addressed for different transport contexts. These are set down as follows:

3.2.1 Rural road landscape

Design approach

Due to the size of the areas involved, the majority of the vegetated landscape on rural road reserves should be provided by revegetation (native seeding or pasture if contextually appropriate) .

Planting should be used as an additional measure to provide assurance that particular design objectives are achieved. These may include a desire to reflect cultural plantings, to screen views, to frame structures or to connect habitat.

Detailed guidelines

All areas should be revegetated with a native seed mix at a minimum application rate of 10 kilograms per hectare of native seed (see Table 4, section 3.4).

For planting areas (limited to key locations such as rest areas and intersections) the aim should be a proportion of planted trees to shrubs of 80 per cent to 20 per cent, in a mulched bed. Container sizes should be in the ratio of 70 per cent Forestry tubes to 30 per cent advanced 5 litre containers. Average spacing of shrubs should be one plant per two square metres and for trees one plant per four square metres.

Generally a two metre wide mowing strip along either side of the landscape area adjacent to the carriageway should be allowed for in the design and maintained.

A revegetated reserve helps integrate the road with the landscape and provides a green, attractive corridor.

Rural road medians should match adjacent vegetation characteristics.

3.2.2 Rural road medians

Design approach

The median differs from the reserve in that it is segregated from the broader landscape by the carriageways. As such it presents a means to visually break up the expanse of hard paving and help continue the characteristics of the landscape across the road corridor.

The median landscape must be frangible within clear zones so that it is safe and helps slow vehicles that have left the road. It should also provide a screen to headlight glare where required.

Detailed guidelines

- All median landscape areas should be revegetated with a native seed mix using frangible species at a minimum of 10 kilograms per hectare (see Table 4, section 3.4)
- Again planting should only be used as an additional measure to ensure that a well vegetated corridor is provided and the design objectives are achieved
- Where planting is needed for medians an average planting density of one plant per two square metres should be adopted
- Where planting is needed for narrow medians native grasses in Forestry-tubes should be used. Average planting densities are contained in Table 2, section 3.4. A mowing strip is not necessary in such situations
- Native grasses in a Forestry-tube size should be considered for use in the median at interchanges. Average planting densities are contained in Table 2, section 3.4
- Where the median is wider than six metres, a two metre mowing strip at the edge of the median should be provided
- Generally, in medians the ratio of shrubs to groundcovers should be in the order of 50 per cent shrubs to 50 per cent groundcovers, depending on local context
- Ensure that all sight distance requirements are satisfied and maintained at the approaches to intersections
- Refer to Table 1, Section 3.3 for median vegetation widths and vegetation types.

Frederickton to Eungai median — Median revegetated with grasses, groundcovers and frangible shrubs through both seeding and planting to suit the longitudinal alignment.

Simple native shrub and tree tubestock plantings in seeded pasture grasses provided in wide, grade-separated median and cuttings, six years after planting.

Deciduous trees planted at the edge of the clear zone mark the approach to a town and provide a distinctive milestone. The same approach could also be used at intersections providing access to local towns along freeways and highways.

3.2.3 Rural road intersections

Design approach

Major rural intersections serve the added function of providing a milestone along the journey and an indication of the character and presence of towns or communities. If contextually appropriate, culturally and locally important trees should be used to highlight the intersection and thus way-mark the journey.

There is a temptation to provide more detail and variation to the planting at intersections. This should be avoided. Intersections should be as simple, robust and clear as possible for safety reasons. They should not be confused by complex landscape designs. Therefore the landscape should comprise of simple planting layouts, large trees of one or two species, and low groundcovers and grasses in large simple beds. Avoid the 'gardensesque' ie small beds of exotic plants and features.

Detailed guidelines

- All intersection landscape areas should be revegetated with a native seed mix using frangible species at a minimum of 10 kilograms per hectare of native seed (see Table 4, section 3.4)
- Planting in mulch beds should be used to define the intersection using minimum five litre containers
- The proportion of trees to shrubs to groundcovers should be in the order of 20 per cent trees to 40 per cent shrubs to 40 per cent groundcovers
- Ensure the landscape design is carried out in accordance with minimum sight distance requirements. Within the intersection, sight clearance should be maintained by a mowed grass area.

Tree avenues at the edge of towns often have a commemorative association, adding interest and a milestone along the route

Rest areas require a complex interaction between people and their vehicles — cars, buses and trucks. They must be carefully designed to be safe, functional, robust and restful.

3.2.4 Rural road rest areas

Design approach

To function properly rest areas must encourage road users to stop and rest. A simple, attractive and shade-providing landscape is one of the best ways to achieve this.

In simple terms rest areas must be designed as urban parks with trees in grass and open, safe views.

Detailed guidelines

- In the main rest areas, include a signature tall spreading tree species planted at 45 litre size, to shade truck and car bays
- Wherever possible use a mown turf treatment between the rest area and road to create a distinctive effect and allow views. Screening shrubs should be avoided
- Allow for an appreciation of the rest area by retaining good views where possible
- Provide open areas for passive recreation and areas of concentrated tree planting for shade in summer
- Consider security and allow good surveillance into and from within the rest area
- Provide a simple, distinctive design that is easy to maintain and recognisable to the motorist
- Consider the impact of noise on heavy vehicle rest areas and sleeping drivers. Noise mounding may be appropriate, but should still allow for good passive surveillance.

Hunter Expressway. Light vehicle rest areas need to be pleasant, shady places with good views to be most effective. Heavy vehicle rest areas often require more seclusion and should be unobtrusive but also shady and pleasant to be in.

Casuarina trees between bays provide good privacy but insufficient shade.

The design should allow for good passive surveillance into and from within the rest area.

3.2.5 Urban road landscapes

Design approach

Like rural roads, the urban road landscape must complement and contribute to the adjacent fabric. However in urban situations the surroundings are often more formal in character, space is tighter and there are fewer opportunities to develop native plant communities.

With higher pedestrian and traffic levels there is the potential for greater risk to safety. The road landscape should ensure that safe sight distances are maintained and open secure environments are provided. The need for shade should be considered along footpaths and cycleways.

In some circumstances the opportunity exists to create a new landscape approach that can help lift the character of the area. Such a landscape must be simple and structural, perhaps establishing a particular character that can extend on to adjacent streets.

The need for screening of the road also becomes more significant with the rise in the number of potentially affected properties.

Technical requirements

- Where adequate space is available between roads and paths a setback should be provided. A minimum of 750 millimetre bed width is appropriate if a successful and attractive planted or turf strip is to be achieved subject to the considerations in Table 1, Section 3.3.4. If this is not available then careful consideration of the species selection, soil volume and watering requirement is needed otherwise it is generally preferable to continue the hard surfacing to the road. Decomposed granite/ crushed stone should not be used as it creates a safety and maintenance problem
- The landscape should be established using either planting in a fully mulched bed or turfing. There should be no direct native seeding in urban areas except where safe access to the existing ground is not possible for installation or establishment, or where there is a future stage of works adjacent to the landscape area that will likely be disturbed
- All tree planting should be a minimum five litre container size in a mulched bed. All street and avenue trees should be super advanced size at a minimum
- Low maintenance turf should be used for grass areas adjacent to the road.

Well-vegetated road corridors can significantly contribute to the quality of the urban area and avoid a feeling of bleakness often apparent when planting is sparse.

The opportunity exists to provide something special to enliven the journey. This should not be overdone and the design must address future maintenance issues. Areas of gravel should be carefully considered as the constant removal of weeds is required, generally by chemical means.

Once established, ground cover planting is very effective as a weed suppressant and provides an attractive, neat edge to the road.

Urban roads are intricately connected with the surrounding built fabric. At Windsor the bridge replacement project included work on the river banks and the historic town square which was an integral, inseparable part of the project.

3.2.6 Urban road medians

Design approach

The urban median is a part of the local urban fabric and should be designed to benefit an area. At the very least it should be densely planted, and simple and attractive in appearance. Planting should be neat and structured with lower groundcovers next to the road followed by taller species.

Planting within clear zones must be frangible unless behind a barrier installed as part of the engineering design.

Pedestrian activity is higher in an urban area and median planting must not impede road user sight lines on the approach to intersections or crossing facilities.

Technical requirements

- Landscape treatments for urban medians should consist of hardy and durable groundcovers, or shrubs planted into a mulched bed at a minimum advanced five litre size at a density greater than one plant per square metre. If native grasses are used, the densities in Table 2 should be adopted. Planting should be set back 500 millimetres from the road edge to avoid overhang of the carriageway
- All areas to be grassed should be turfed using low maintenance turf
- Infrangible plants should not be located in the median unless outside clear zones or documented justification is provided for their need behind safety barriers or deflective kerbs (see 3.3.1)
- There should be a 300 millimetre minimum wide concrete margin along the edge of the median to provide a neat, easy to maintain edge
- Refer to Table 1, Section 3.3 for median vegetation widths and vegetation types.

Simple planting of groundcovers creates an attractive and safe median that does not obscure safe sight distances.

On narrow medians, generally less than seven metre, a higher density of ground cover planting is required to minimise maintenance and provide an attractive weed free appearance.

A grass sward is an appropriate finish to a narrow median. It is sufficient to provide relief to the expanse of bitumen in the road user view, however in this case is too narrow and poses maintenance problems.

3.2.7 Roads and streets in towns

Design approach

A particular road context which needs to be carefully considered is where a major road passes through a city, town or village centre. This occurs on many arterial roads where population centres have built up along the arterial road or at busy nodes or junctions.

In these situations the posted speed of the road is generally lower than in rural areas as there is a high pedestrian usage of the area with crossing points and footpaths alongside the road. Advertising, signage and shopfronts of businesses are located along the road all seeking maximum visual exposure.

Planting in these locations needs to be carefully designed to avoid impacts on visibility, access and movement and road user and pedestrian safety. With the higher pedestrian usage and car parking, planting also needs to be robust and well protected from damage by vehicles and pedestrians.

Tree species should be selected wisely. They should not pose a safety problem in terms of limb drop, or a maintenance problem in terms of fruit, seed or sap damage to vehicles.

Detailed guidelines

The following guidelines should be considered:

- Groundcovers and shrubs should be avoided or only used in carefully selected areas. Space for pedestrians and vehicles should be maximised
- Trees should be used to ameliorate the impacts of traffic and the expanse of the road and provide an attractive structure to the town or village
- It is preferable that trees are located to the edge of the road behind the kerb and outside the clear zone. Trees may be provided in the median but if this is their only location they would not offer any shade benefit for pedestrians
- Subject to context and local community requirements it is desirable that deciduous trees are utilised to allow sunlight to penetrate to street level in winter
- Tree species should be medium to large in size at maturity, have a good history of survival in urban areas and be able to be maintained with a high crown. They should be planted at a large size, a minimum of 45 litre where early effect is required.

Deciduous trees are distinctive in their response to the seasons, allow winter light and views of the architecture of the town or city.

London plane lines the road and creates a strong avenue effect with good shade.

Fastigiate deciduous trees and low groundcovers provide an appropriate landscape outcome in a small town in the Blue Mountains.

The visual effect of a strong avenue of native gum trees cannot be underestimated and creates a memorable experience. However, clear zones must be observed and in this case a 3m gap is appropriate for a road with a 60km/h limit and helps create a slower speed environment. In this case the speed zone is 50kmh, the road is straight with fully used parking lane after hours, and there is no crash history involving trees.

3.2.8 Low speed local roads and streets

Design approach

Landscape design of local roads should contribute to the public domain and character of the locality.

They have a strong role to play in creating a self explaining road environment that encourages safe driver behaviour and signals changes in speeds and street activity.

The landscape approach to local roads should be at the direction of the local authority but responsive to the road safety requirements of Transport.

The following guidelines should be considered:

- In locating trees, sufficient room for pedestrian passage should be provided as well as consideration of car doors and cyclists.
- In general, but dependent on context and tree species, tree spacings should be in the order of seven metres to 10 metres apart.
- Trees should be planted in grass or within a defined tree pit, grate or planting bed. There should be sufficient soil volumes to ensure a healthy tree and a stable root system.
- In general, to ensure success, street trees should be greater than 100 litre size at planting. In general the greater the time the tree is allowed to grow in the nursery to reach a strong durable size, the less time it has to grow in the less protected street environment.

Trees in low speed environment in Maitland with sufficient soils and appropriate scale for the street.

Local roads generally being of slower posted speed limits, have narrower clear zones and parking lanes. Trees planted at the edges of the clear zone can have a strong visual effect and reinforce an understanding of the lower speed limit.

Distinctive street tree planting is important in creating a memorable and attractive place. In this example the cherry trees reinforce the three dimensional qualities of the street and contribute to the sense of the place.

3.2.9 Roundabouts

Design approach

Like the median the roundabout is separated from the surrounding area by road with no pedestrian access. Because of this they are primarily visual elements and offer little in terms of pedestrian connectivity and built form.

It is therefore important to tailor the landscape approach to the context and produce a minimal maintenance solution. For example it might be of value to create a distinctive effect, but distraction and too much complexity must be avoided. Alternatively a simple paved or grass surface might be more appropriate on smaller roundabouts.

Detailed guidelines

- In general robust ground covers and grasses should be used in roundabouts. A wide concrete kerb should be provided to protect planting
- If used, trees must not be planted in a configuration that will impede road user sight lines or be in a location that might obstruct errant vehicles unable to stop at the roundabout. If used, trees should be frangible with a high crown. These should be planted at least an advanced size
- Mass planting of shrubs should be dense low groundcovers and native grasses, planted into weedmat overlaid with mulch. Species choice should consider whether the profile of the roundabout is domed, flat, or depressed
- Adequate drainage must be provided in such self contained, small areas.

Roundabout showing layout which maintains good sight lines, well considered drainage and a surface treatment which is self-recovering catering for large vehicles.

Roundabout in Windsor helping signal the town ahead and integrated with the project landscape design.

Caption: Street trees in Port Macquarie providing shade and character and helping reinforce a slower road environment.

3.2.10 Landscape associated with walls and barriers

Design approach

Whilst some walls are designed as interesting, elegant objects in their own right (and not requiring planting), the majority of noise walls are enhanced by planting on both resident and road user side. This usually assists in graffiti deterrence.

Detailed guidelines

- To achieve a good screen or softening of the noise wall, adequate space for planting and seeding must be provided. Two metres is just sufficient, however the wider the better. Planting can be partially successful as low as one metre in width, although it will not be as self reliant
- Where space is limited, planting can be achieved using climbers such as virginia creeper, but seek advice from the structural designers and asset management teams. Climbers on frames should be avoided where possible to minimise maintenance and vandalism
- Planting should consist of dense durable shrubs at minimum five litre size (advanced), to provide an effective screen to the wall. Planting should be in mulched beds. On the roadside it should have a sufficient setback from the roadway to avoid overhanging vegetation obstructing sight lines and clear of the safety barrier dynamic deflection zone
- The planting design should allow for access to the wall for maintenance purposes. This will vary depending on the terrain, wall type, and surrounding context
- Do not place vegetation beneath or in front of guardrails, wire rope barriers and other types of hazard protection — these must be able to be visually inspected to ensure safe operation. Plantings may be used in front of concrete barriers where there is a wide shoulder or other verge setback, overflow drainage to ensure no flooding, and protection to the pavement
- Species used should have adequate space for development of their roots, branch structure, canopy spread and dynamic sway without requiring any intervention maintenance or shaping when mature
- Set back verge plantings to prevent droop into gutters and carriageway. The amount of setback depends on the growth rate and habit of the species
- Tree species may need formative pruning at the nursery and during the establishment period to ensure that sight lines, travel clearance envelopes and adventitious roots and branches do not impact road operations or safety or damage the structure.

(For further guidance, reference should be made to the TfNSW *Noise Wall Design Guidelines*.)

Planting does not need to be continuous and the occasional well placed tree or shrub can be sufficient to complement a well designed wall.

Smaller frangible shrubs such as bottlebrush help filter views of the wall and provide a greener corridor than would otherwise be achieved.

Noise walls that are built into scenic or pastoral areas should be screened with species that are appropriately adapted to both the local area and the hostile conditions adjacent to the wall.

3.2.11 Water related landscapes

Design approach

An integrated ecological and landscape approach can combine the cleansing effects and biodiversity benefits of native wetland and riparian species, while creating an attractive natural drainage system. A natural, fitting appearance should generally be adopted, maximising the effective wetland and riparian area, and sculpted to fit into the existing landform (Refer to *Water Sensitive Urban Design Guideline*.)

Detailed guidelines

- Facilities should be designed to be as self reliant as possible. The area around the swale or pond should be revegetated with native seed at an application rate of 10 kilograms per hectare (see Table 4, Section 3.4)
- Planting in mulched beds should be used on the margins of the pond (eg one to three metres) to stabilise the embankments. Tubestock should be used at one per square metre in the wetter areas
- Ensure plants sit at correct level to suit the inundation/ operation of the wetland.

Established self reliant wetland demonstrates the value of good environmental design on the outset.

Stormwater treatment at Mowbray Road helps filter and cleanse run off and provides a fitting natural appearance in time. The road landscape should be utilised for water cleansing where practicable.

Revegetation on this cutting at Woomargama Bypass includes the cutting face, edges along the drains, rollover the bench hinges, and dense tree copses at the base of the leading and trailing slope transitions.

3.2.12 Steep slopes

Design approach

To achieve a successful vegetation cover on a cutting, adequate space must be allocated in the early stages of the project to lay back the batters no steeper than a 2H:1V gradient (and less where possible).

On embankments aim for a desirable grade of 4H:1V or 3H:1V to achieve a planted outcome.

Detailed guidelines

- Cuttings should be revegetated with a native seed mix (see Table 4, Section 3.4)
- Revegetate beyond the top of the cutting to help integrate the project into the surrounding landscape. Avoid planting in this area unless necessary as planting is out of sight and is unlikely to be maintained
- In the case of steep benched cuttings, with the exception of native grasses, there should be no planting or revegetation on the benches
- At the base of such cuttings it is preferable to allow for a vegetated verge to collect debris fall and soften the appearance of the cutting. An area of irrigated soil must be provided to achieve this outcome.
- On embankments revegetate with a seeding and planting mix.

(For further guidance, reference should be made to the TfNSW Shotcrete Design Guidelines and Roads and Maritime Guideline for Batter Surface Stabilization Using Vegetation)

Space for vegetation at the base of the cutting improves the appearance of the cutting and helps stop debris from the cut reaching the carriageway.

Heavy vehicle rest area on the Hunter Expressway shortly after completion and 8 years later. The batters (cuttings and embankments) vary in grade from 4H:1V to 2H:1V. There has been a good plant growth and the area is appropriately secluded.

3.2.13 Landscape on structures and walls

Design approach

While a landscape within the ground connected to the local water table and soils, is the minimal maintenance most sustainable outcome, there is a call for landscape on structures such as roofs or bridges as well as vertical gardens such as green walls.

These landscapes need good maintenance to survive, irrigation systems, good drainage and a plant replacement regime.

These hard structures can be hot environments for the plants to survive, but if well designed and built, they can cool the environment, improve air quality, 'soften' the urban character and make some structures less visually intrusive.

Like all elements, these distinct gardens need to be considered at the outset of a project and the conditions established for success. Sufficient funds must be allowed for their ongoing maintenance, and they must be safely and easily accessible for landscape workers.

Detailed guidelines

Ensure the structures are strong enough to support wet soils and mature landscape, as well as any traffic and pedestrian masses. These are high weight items particularly after heavy rainfall. Deeper girders, additional piers and appropriately sized bearings may be required. Consider the location of large trees over piers and abutments if girders can't be made deep enough due to maximum clearances.

Ensure structures are built to contain deep soils and drainage layers. A minimum of 800mm of soil in two profiles is sufficient for trees and shrubs and 300mm for grasses. Less and the soils are more likely to dry out and become hydrophobic and larger plants will have stability issues.

Minimise the number of seperate areas of landscape if possible. Large continuous soil volumes have a lesser surface area than the equivalent volume of smaller pockets and are therefore more resilient.

On land bridges or roof tops, dome the landscape areas if possible to allow natural drainage. If possible on bridges design to connect one or both sides to the adjacent landscape and soils.

Make the green infrastructure on structures count. This is some of the most expensive land for open space and it should contribute significantly, for example recovering parkland, making green spaces contiguous, shading and sheltering paths and making major transport corridors pleasant, attractive and therefore desirable to cross.

Ensure ease of maintenance for green walls and removable panels for swapping out failed sections of plants. Native species are preferred but plant viability and hardiness is more important.

Use the green walls as a part of the architecture and creativity of a structure, combining with panels, features and adjacent landscape. The materials should work together cohesively and create something special.

For further information refer to TfNSW's 'Restitching the built and natural environment — Land bridge Discussion Paper'.

Landscape on walls, buildings and bridge structures at Rozelle (unfinished project as at May 2023). Green panels have been used as part of the design of the ventilation outlets to visually break down the structure and integrate it into the parklands. Trees and shrubs have been planted into deep soils on the bridges and buidlings to extrude the parkland landscape and character across the wide and busy road, linking suburbs.

A 4H:1V embankment at Banora Point allows for safe mowing, trees, grasses and a successful outcome.

The 80m long land bridge at Banora Point over the Pacific Highway helped retain the Park, allowed space for a play area and provided an easy crossing of the motorway with lawn and trees. It also helped obscure the cut and minimise its visual impact on residents.

3.3 Safety considerations — tree setbacks, public utilities, sight distances and vegetation types

The following information is provided as a handy guide for information relating to the particular context of each design.

Austroads Guide and supplements should be consulted for more information and to determine the required dimensions for tree setbacks and sight distances.

3.3.1 Tree setbacks from roads and streets

In terms of Austroads (2022 version), Transport's current practices and this Guideline there are two aspects to be aware of when considering the setback of trees on roads.

Context Sensitive Design

Austroads emphasises the 'incorporation of context-sensitive principles into the design of road and roadside facilities'.

It states that 'Projects that consider Context Sensitive Design (CSD) are more able to meet transportation needs, recognise the need for cost-effective and at times innovative solutions, while enhancing the benefits to the community. This is achieved through preservation efforts, sensitivity to local values and recognising the needs of all road users (including people, goods distributors and those who provide essential services)

It goes on to say that 'Road design is often a compromise between what is considered an ideal solution and what is a reasonable outcome with regard to safety, driver expectation, economic imperatives, environmental impacts and community values.'

In this light tree setbacks are therefore a response to context that includes both the environment and the transport itself. They are also an element of design that needs thought and consideration rather than just exact rules and formulae.

Safety and risk

Clear zones are now no longer referred to in Austroads as a set of dimensions applied to road design. This is because they are no guarantee that a vehicle will not hit an object outside the clear zone and are considered a mitigating safety element only. Importantly they cannot deliver a safe systems approach in their own right.

Transport for NSW — and all other State transport authorities — are developing their own supplementary local guidance around this new approach, as each state has its own context and particular issues. Transport for NSW is continuing to use the old Austroads Clear Zone dimensions while it is doing this, but recognises that these are only a guide and contextual issues must be taken into account.

However in time the approach likely to be adopted, in line with zero harm on our roads, is a risk based approach with different roads and speeds having risk ratings and safety measures being based upon these.

What does this mean for trees on road sides?

Each situation will have its own outcome, but as a general guide the following will be useful:

On **high speed** roads (posted more than 70km/h), where vehicle energies are significant, the consequences of collisions with substantial trees will always require setbacks, barriers, a differentiation between background and isolated hazards and an awareness of situations where errant vehicles are more likely. Tree setbacks will be based on the higher speed clear zone dimensions, but these will not be seen as the only safety measure.

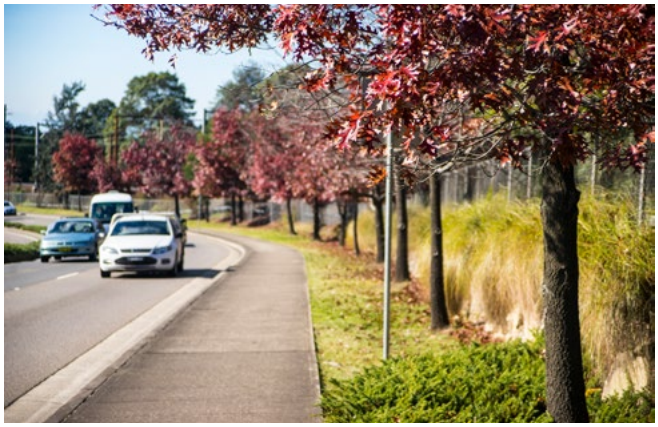
Trees set over 10m from the edge of the travel lane of the carriageway on the Hume Highway.

On **moderate speed** roads in urban or semi urban areas (posted 60km/h) — where the road environment has many elements and objects, roads are busy and there are many intersections — TfNSW crash research has found that tree crashes are exceedingly rare. However where land space is constrained, existing clear zone dimensions have the capacity to significantly minimise the provision of much needed trees. In this context, tree setbacks less than the standard dimensions (around 2 — 3m) may be justified as a part of the design, combined with consistent and modern road geometries as well as kerbs and barriers

depending on the situation. These setbacks help would provide a buffer for pedestrians and cyclists and support the provision of substantial tree canopy and a healthier cooler environment.

On **low speed** roads and streets in urban areas with many pedestrians and cyclists (posted less than 60km/h), where vehicle energies are low and drivers have time to take action, trees are a minor hazard, particularly where they are a normal part of the context and there are kerbs and many other objects in the built environment that cannot be removed. Trees help reinforce a self-explaining, slower road and setbacks are more related to avoiding vehicle and bus clashes, allowing free pedestrian movement and ensuring space for root and limb growth. Trees will also help separate pedestrians from misguided vehicles and provide many benefits to the town and city context.

All this information is provided as a guide only and designers should refer to the latest version of Austroads and any local supplements.



Trees set back 3m from the travel lane on the 60km/h posted Great Western Highway in Faulconbridge.

Trees alongside the road in a low speed environment with other objects such as poles, signs parked cars.

3.3.2 Public utility clearances

The design teams must consider all the clearances required for utilities at an early stage of the design so that they are jointly accommodated within the verge and do not affect the quality of the design outcome.

As part of an integrated engineering and urban design approach, additional space can be provided in a corridor if utilities are vertically stacked, bundled or share allocated spaces such as trenches.

Often in redevelopment areas the trees precede the replacement service. It is possible to retain them by exploring alternate design solutions for the service such as aerial bundled cable.

3.3.3 Sight distance requirements

There are three main sight distance requirements which should be addressed in the landscape design. These are Stopping Sight Distance, Approach Sight Distance and Safe Intersection Sight Distance. The dimensions of these will be determined by road geometry and design speed and should generally be clear of objects which restrict road user's vision.

Issues to consider are:

- Trunk height, caliper and amount of clear trunk
- Canopy spread and droop
- Amount of dynamic sway due to wind
- Density of foliage and other seasonal changes such as flowering or leaf drop.

The Eucalypt has been retained by bundling the overhead services so that the clearance envelope is reduced. Note that the side of the trunk which faces the service has been trimmed of branches which may otherwise cause conflict.

The trees on the right of the picture are located close to the carriageway, but behind parking and in line with other infrangible objects. The trees to left of the picture are set back and provide shade to a wider area of public space. This is a typical low speed built up environment where trees are a normal and expected part of the built fabric. They help provide visual cues that vehicles should be moving slowly and drivers aware of hazards and pedestrians.

3.3.4 Vegetation types and safety implications

Landscape design decisions have significant implications in terms of road safety and WHS issues. The following table provides a checklist for designers of some typical issues of the uses, safety and maintenance implications of different vegetation types — whether turf, groundcovers, trees or shrubs. The desirable minimum width of any type of landscape area is 750 millimetres, with appropriate access for the terrain, context, required maintenance activities and equipment. In a verge, this is normally available along a path, but in medians and adjacent to other structures, designed solutions to provide safe access may require dimensions well above the minimums described below. Further issues such as proximity of thorns to path users; fruit or flower drop on inclined surfaces causing a slip hazard; or seasonal drop of large botanical element like fronds, cones or flower spikes, should be informed by the Safety in Design review process.

Table 1. Vegetation type checklist

Vegetation type	Useful for	Road safety implications	Maintenance implications
Turf	Semi-urban situations Urban situations adjacent to open landscape such as parks Rest areas to allow good visibility and passive recreation space Visually separating footpaths and road, where space is limited Narrow medians in lower speed zones to visually break up expanse or road pavement	Safety barrier is not required Allows clear sight lines Does not discourage pedestrians Does not provide crash cushion effect	Minimum practical landscape area width: – Verge and median: 0.75m Requires mowing and possible lane closures
Ground Cover and low shrubs	Bushland areas to help restore landscape and habitat using endemic species Semi-urban and bushland areas Intersections and roundabouts Minimum maintenance planting in narrow medians and verges Roundabouts and intersections in semi-urban or urban areas	Safety barrier is not required Can maintain safe sight distances Does not provide significant crash cushion effect Discourages pedestrian access	Minimum practical landscape area width: – Verge: 0.75m – Median (urban): 1.8m – Median (rural): 2.5m May require trimming/ pruning and possible lane closures
Frangible medium and large shrubs	Bushland areas to help restore landscape and habitat using endemic species Encouraging native fauna corridors where width is adequate In front of noise walls in clear zones or immediately behind traffic barriers	Safety barrier is not required Obscures passive surveillance Can screen headlight glare Blocks pedestrian access Provides a crash cushion effect Can obstruct safe sight distances	Minimum practical landscape area width: – Verge: 0.75m – Median (urban): 1.8m – Median (rural): 3m

Vegetation type	Useful for	Road safety implications	Maintenance implications
Non-frangible vegetation	Bushland to help restore landscape and habitat using endemic species Providing structure and character to road corridor Shade in rest areas or along footpaths Providing landmarks and milestones along route Roads in towns and cities to help fit road into built fabric	Non-frangible vegetation is hazardous and must only be established so that it maintains a safe roadside environment When overshadowing the road large trees can extend the presence of frost into the day in colder areas	Pruning and lopping may be required long term

Do not use vegetation with spikes or thorns along paths, cycleways, near bus stops, along maintenance access ways or other locations where they could cause injury, such as this Bursaria spinosa along a shared use path.

3.4 Planting and revegetation guidelines

The following information has been provided as a guide for planting and seeding, implementation and maintenance for road landscape. It has been developed from experience and monitoring of the successes and failures of Roads and Maritime projects.

3.4.1 Principles of planting implementation

In general there are five main conditions which govern the successful implementation of a planting design. Achieving these conditions will greatly improve the success of the landscape, minimise weed infestation and ensure the landscape is less susceptible to drought.

1. The plants must be healthy, of an appropriate size and suitable for their context. In general using native species will ensure that plants are matched to local conditions and best able to cope with drought
2. The ground must be ripped, or planting holes well broken up, to ensure good drainage and root penetration
3. The optimal planting density to achieve rapid ground coverage must be used
4. The planting bed or individual hole must be fully mulched and weeding must be regularly carried out around the planting
5. The plants should be watered regularly after planting in the absence of rain. Planting during the dormant period (autumn/winter) will reduce the reliance on irrigation.

The following guidelines provide information on plant sizes, species and densities for different areas and uses in the road corridor.

Tubestock planting of native grasses around mature trees retained in the median.

3.4.2 Detailed guidelines

Plant material specification

All plants should be grown by a nursery situated in an area of similar climate to where they are to be planted. They should be grown from seed collected from the project area wherever possible.

All plant material should be true to species and sizes. That is to say they should be well grown, of good form, not soft or forced, and with large healthy root systems. They should not be root bound and should be free from disease, weeds and insect pests. Trees should have a single leading shoot. Nursery stock should be hardened for planting prior to movement to the planting location.

Container size and plant height

All plants should be supplied in containers and be grown to the approved heights as specified in Table 2.

Virocells or similar containers smaller than those indicated below are not to be used in Roads and Maritime projects due to initial high maintenance requirements and past failures.

Table 2. Guide to container size and plant height

Plant size	Container size	Approved plant height	Density (built up areas)	Density rural areas
Tubestock/Forestry-tube	45–50mm dia x 90–120mm deep	200mm–300mm	6–8 per m^2	1–4 per m^2
Semi advanced	150mm dia x 120mm deep	300mm–400mm	1–4 per m^2	1 per 4 m^2
Advanced	200mm dia x 200mm deep	300mm–500mm	As needed	As needed
Super advanced	20L container	1200mm–1500mm	As needed	As needed

Container size and plant spacing for urban areas

It is important to achieve a dense planting coverage in urban areas to ensure a successful, well vegetated project and avoid weed infestation more prevalent in urban than rural areas. Table 2 provides information on plant spacings for urban areas.

Planting size for urban and rural locations

Table 3 provides guidance on the sizes which should be used for trees shrubs, groundcovers and native grass in urban and rural areas. Information on mulching and direct seeding is also provided.

Roadside trees should be planted at a range of sizes to maximise resilience, early effect and longevity. This is standard horticultural practice. Using smaller container sizes provides energetic, adaptable young stock to quickly grow and form the long term canopy for the area. Larger size trees provide an early impact but are more expensive, will require additional maintenance input (watering, plant replacement and pruning) and are less adaptable to the road side environment. After a few years they are often overtaken by smaller stock.

Table 3. Planting size and direct seeding requirements for urban and rural locations

Location	Tree	Shrubs, ground covers and native grass	Mulching (Hardwood chip mulch)	Direct native seeding
Urban areas	Minimum 5L containers	5L, 140mm and tubestock	Fully mulched	No
Semi-urban and rural areas	70% Forestry-tubes and 30% Advanced	140mm and tubestock	Fully mulched	Yes
Intersections, interchanges and roundabouts	Minimum 5L containers	5L, 140mm and tubestock	Fully mulched	No
Noise walls and retaining walls	Minimum 5L containers	5L, 140mm and tubestock	Fully mulched	No

Cover crop and native seed application requirements

In general a coverage rate of 10 kilograms per hectare should be used for native seed works on Roads and Maritime projects. This is supplemented with the cover crop species listed in Table 4. Roads and Maritime specification R178 ‘Vegetation’ should also be used.

Native seed should be appropriate to surrounding ecology, foreseeable climate impacts, the proposed method of application (pneumatic vs hydraulic vs direct sowing) and commercial availability. This will vary the amount of seed for different applications.

Factors affecting performance and the quantity of seed will be the season of application, weather conditions directly after seeding, and quality of soil bed preparation and its subsequent maintenance including weed suppression and control of cover crop.

Refer to the Roads and Maritime Guideline for Batter Surface Stabilisation Using Vegetation for further guidance on seeding implementation.

Table 4. Cover crop and native seed application rates (recommended sowing seasons shown in brackets)

North Coast, Central Coast and South Coast	
Japanese Millet (Sep–Mar) or Rye Corn (Apr–Aug)	@ 35kgs/ha @ 35kgs/ha
Annual or short term rye	@ 25kgs/ha
Couch	@ 7kgs/ha
Red Clover	@ 5kgs/ha
Native Seeds	@ 10kgs/ha
Organic Fertiliser	@ 250kgs/ha

Central Slopes	
Japanese Millet (Sep–Mar) or Rye Corn (Apr–Aug)	@ 25kgs/ha @ 20kgs/ha
Annual or short term rye	@ 25kgs/ha
Couch	@ 7kgs/ha
Red Clover	@ 5kgs/ha
Native Seeds	@ 10kgs/ha
Organic Fertiliser	@ 250kgs/ha

Tablelands	
Japanese Millet (Sep–Mar) or Rye Corn (Apr–Aug)	@ 35kgs/ha @ 20kgs/ha
Annual or short term rye	@ 25kgs/ha
Couch	@ 7kgs/ha
Red Clover	@ 5kgs/ha
Native Seeds	@ 10kgs/ha
Organic Fertiliser	@ 250kgs/ha

Western Plains	
Japanese Millet (Sep–Mar) or Coolibah Oats (Apr–Aug)	@ 20kgs/ha @ 10kgs/ha
Annual or short term rye	@ 25kgs/ha
Couch	@ 7kgs/ha
Red Clover	@ 5kgs/ha
Native Seeds	@ 10kgs/ha
Organic Fertiliser	@ 250kgs/ha

Note:

1. Triticale species must not be used in revegetation mix in Tablelands, Central Slopes and Western Plains in order to avoid the spread of wheat rust in wheat growing areas.
2. White, strawberry and subterranean clovers should not be used in revegetation mix as these aggressive spreading clovers would prevent germination of native seeds.

Site preparation, establishment and weed control

Roads and Maritime has developed consistent and practical methods for site preparation establishment and weed control. The guidelines in Table 5 should be adopted for all Roads and Maritime projects.

Table 5. Site preparation, establishment and weed control for tubes and semi advanced sizes

Procedure	Container size Tubestock 50mm sq x 90mm deep	Container size Forestry-tube 45mm sq x 120mm deep	Container size Semi advanced 150mm sq x 150mm deep	Container size Advanced 200mm sq x 200mm deep	Container size 25L 300mm sq x 300mm deep
Ripping depth (300mm centres)	200mm	200mm	200mm	400mm	400mm
Cultivation depth	200mm	200mm	200mm	200mm	Nil
Mulch depth	50mm	75mm	75mm	75mm	75mm
Planting hole size	50mm dia x 100mm deep	200mm sq x 200mm deep	300mm sq x 300mm deep	400mm sq x 400mm deep	600mm sq x 600mm deep
Watering after establishment	16 weeks	16 weeks	16 weeks	16 weeks	16 weeks
Weed control (every four weeks)	Hand weeding Spot weeding with Glyphosate	Hand weeding Spot weeding with Glyphosate	Hand weeding Spot weeding with Glyphosate	Spot weeding with Glyphosate	Spot weeding with Glyphosate

Soils, mulch and compost

Landscape materials such as soils, timber and organic material should be stored and reused in the project where practical in preference to be being disposed of as waste. All the materials must comply to quality standards.

Site maintenance and management

The guidelines in Table 6 should be adopted for site maintenance and management. This information should be used in preparation of the landscape management plan for Roads and Maritime projects.

Table 6. Site maintenance and management for native grasses

Month in which plant should be cut back	April
How far to cut back above ground	300mm
Frequency of cutting back	Every 4 years
Fertilise once per year	August
Nitrogen:Phosphorus: Potassium (N:P:K) ratio and type of fertiliser	18:3:10 — Slow release
Rate (spread evenly into hole)	10 grams per plant

4 Drawing standards

4.1 Requirements for drawings

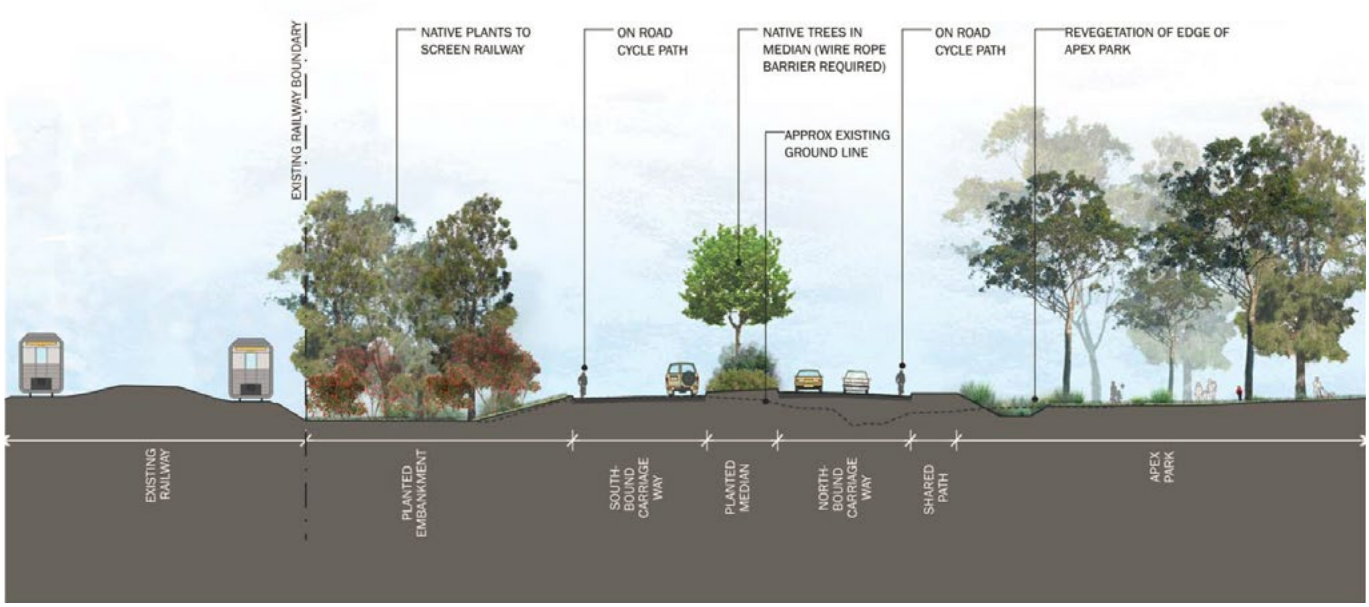
Landscape drawings are reviewed by a number of people including sponsors, verifiers, designers, stakeholders, the community and contractors. They must be easy to read, enable the design to be easily visualised and most importantly be easily understood for implementation purposes.

The following principles should be adopted:

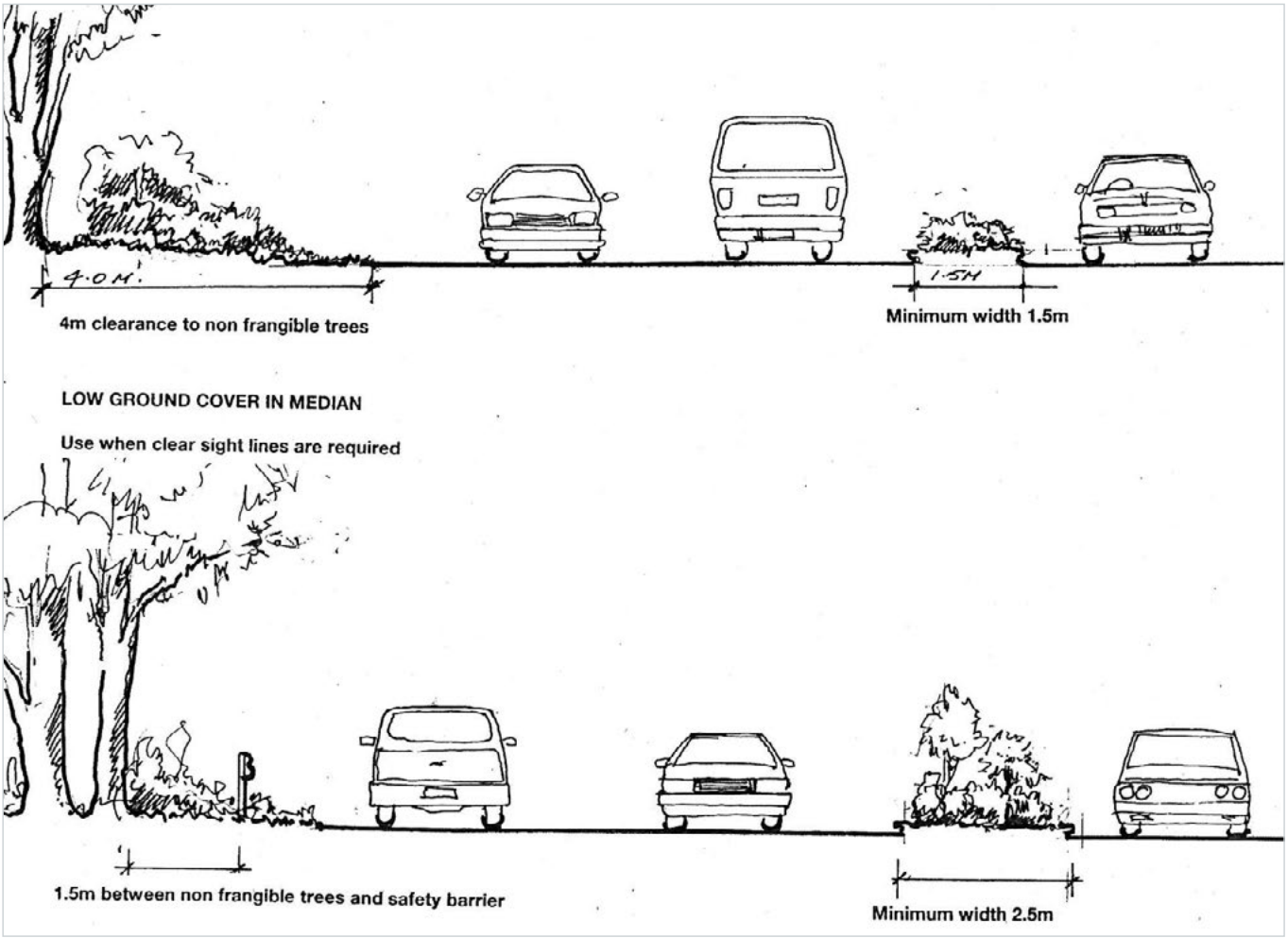
1. Consider the purpose and viewer of the drawings and tailor their content and presentation accordingly. For example:

- For public exhibition and planning approval, photomontages and colour graphics are attractive and easily understood. Photomontages should be carefully selected to show different key parts of the project. For honesty the image should be realistic and show the likely signage and other road furniture elements
- If public exhibition is not required, then it is likely that such high quality and costly presentation material is not needed. Simple, clear sketches and drawings are generally sufficient for internal review. Photographs of precedents are highly convincing and descriptive
- If the purpose of the drawing is to inform and guide the engineering team, then a complex drawing is unnecessary and probably too late to do its job — a quick mark up might be the best and most cost effective solution
- If a construction drawing is required, then simplicity is important and each drawing should stand alone. Plant locations and arrangements should be legible and unequivocal. Hatching and shading variation should be highly distinctive and full names of species, their sizes and planting details should be included. The drawings should work in black and white and abbreviations and cross referencing should be avoided.

2. The adjacent land uses, property boundaries, vegetation, underground and overhead utilities, context of the project should be shown in some form on the drawings. This can vary from simple sketched line drawings to photographic bases depending on the purpose of the drawing.



Proposed road cross section E at Ch. 1860 (Scale 1:400 @ A3)



Drawings serve many purposes. Artists impressions and photomontages are useful for public consultation, sketches are fine for general project team use.

3. Plant abbreviations should not be used. They can be misinterpreted and make it hard to visualise the outcome. All botanical plant names should be written in full.
4. The number of plants of each species should be stated for each planting bed and written down adjacent to the bed on the drawing. Individual trees must be shown.
5. Plant schedules should be provided stating numbers of each species, total number of plants, sizes, and staking/special requirements.
6. Application rates for seeding should be defined for each seeded mix area.
7. All plan type drawings, whatever their purpose must include a bar scale, north point and labelled key places/landmarks.
8. Sections, sketches and photomontages should be realistic in their illustration of vegetation growth. Five to 10 years growth is sufficient. Drawings showing the intended effect after 20–30 years can look unrealistic.

Appendix A — Right plant, right place

Woody plants are structures engineered by nature, context and evolution. They are small and harmless looking when young, but tenacious in their expansion to full maturity. If used in an environment that suits them they will grow into the form that they have been genetically programmed to achieve, and sometimes grow larger than in their natural location and plant community. A lack of water, nutrients root space or competition from other plants will restrict their size and health. But once they have a foothold they can absorb tonnes of carbon and water, and expand with enough force in their roots and branches to lift and crack many tonnes of rock, pavement, drains and other structures.

Generally, like all living things, woody plants prefer to grow in environments with the least resistance, which is why a root will penetrate a small crack in a rock cliff but will be deflected by simple integral plastic barrier. All plants differ in their ultimate form and vigour depending on the species, but all have a way of making the most of their situation and respond to even the most subtle of differences in their built surroundings — their microclimate.

This large eucalypt is growing in an inadequate space in Beattie St, Balmain.

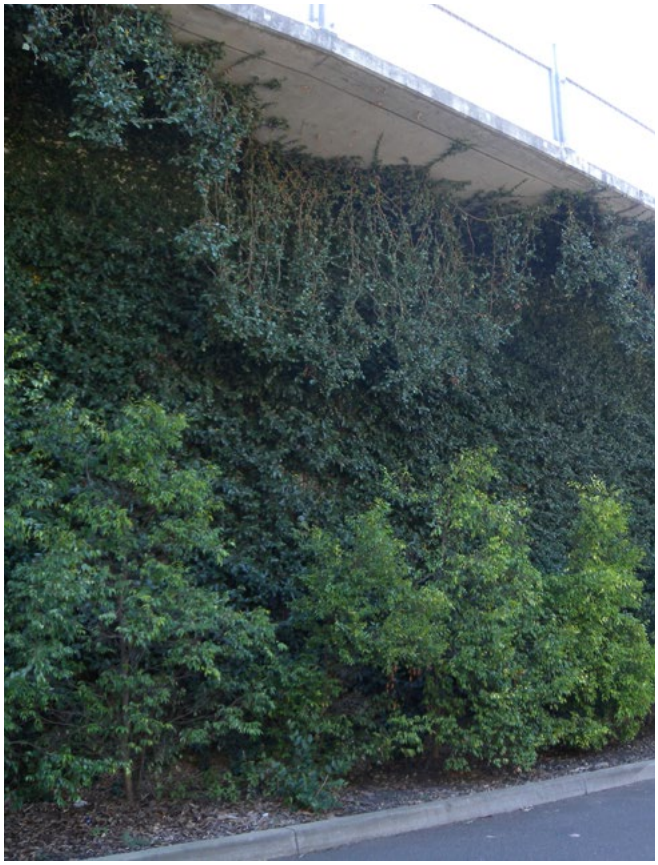
Trees are inexpensive when small, their value is in the investment of time in waiting for their mature benefits. If a tree species turns out to threaten the function or safety of the built environment (and needs to be removed or consistently maintained), then at best it is a waste of this time input and also a large opportunity cost compared to planting the right tree for the place at the outset. At worst it can be a dangerous hazard.

Most trees have lifespans that exceed that of normal residential structures, and are commensurate with the lifespan of bridges and civic structures. For instance, the oldest known street trees in Australia are the Swamp Mahoganies along the north side of the Macquarie Wall, planted in 1816 along the old Mrs Macquaries road alignment. Nearby are Red Cedars (1822) and Paperbarks (c1828). In 2009, Dr Tim Entwistle, then the NSW Chief Botanist, wrote: "Lasting 180 to 200 years is pretty good for a city tree having to tolerate air pollution, disruption to its roots as paths and roads are constructed, and growing outside their natural climatic range or their protective forest habitat."

Some woody plants have desirable characteristics when young or closely managed, but can be destructive or dangerous if neglected. For instance, Creeping Fig has delicate, attractive, flat young foliage, it doesn't need a frame and grows fast quickly covering up structures. But, if given enough time, will completely cover a structure, gradually increasing in mass until it falls off or disintegrates it. They are not good plants in a low maintenance road or street environment. They can be managed and pruned, keeping their juvenile beauty, but for less effort an alternative plant could be selected.

All woody plants are simultaneously both structures and organisms, so their selection and provision must be done with care and for the right purpose. Tree locations and species should be considered so that roots don't lead to damage of critical structural elements and that designed planting deters (out competes) the unrestricted growth and self seeding of potentially invasive species in these areas. For instance, iconic gum trees can provide shade and beauty to a large area, but unless they are given the room they need, they can become a liability, will need to be removed and will waste the time it took them to grow. Wide verges and reservations are roadsides and well suited to these trees, but they should be avoided at such locations as bridge abutments.

Large fig trees make excellent city avenue plants but must be given enough space to expand into the enormous building-scale structures they will eventually become. However these trees develop only shallow root plates which are likely to buckle and heave any pavements and drainage over them. Fig trees are best planted in locations with only organic surrounds, or have a specially designed soil vault.



Plants should be chosen for their holistic performance, not just an an individual characteristic. Ficus pumila or creeping fig is a fast growing effective climber but if regular maintenance is not provided it can become a hazard. In this situation the road is a low speed, low volume access road but even so the collapsing fig draped across the road and posed a hazard. Elsewhere this plant has been known to damage lightweight concrete structures because its trunk expands over time into joints, eventually prising them apart.

Choosing the right species for a purpose and a place requires skills and knowledge of the biological, ecological and cultural requirements of the plant.

Some factors to consider when selecting woody plants:

Value:

- Choose species that provide the most value for cost. Transport advocates that large, long-lived woody species represent the best value by influencing the largest possible surrounding area for the longest time
- Use species that require the least amount cost and effort to establish and maintain. Self-reliant species are preferred. However, no cultivated plant is completely free from some establishment and maintenance costs, especially in a completely constructed environment
- Use species that fulfil the broader city plans and objectives.

Resilience:

- Tolerance of both acute and chronic events such as drought, flood, extreme heat or cold, wind, fire and pathogens
- Tolerance of urban patterns of movement and management, such as pedestrian traffic over the roots and exhaust from vehicles
- Tolerance of possible disturbance or intrusive impact in the future from pruning of branches for sightlines to new signals, a new path or drain or change of levels nearby
- Roads and Maritime advocates maximising diversity in species where possible to increase the resilience of landscape areas — this is especially important in areas revegetated by seed.

Flexibility:

- Use of the species as a lone specimen or in groups, mixed with other species or in a monoculture
- Use species that are timeless and are not bred for design fads
- Transport prefers species that have multiple uses, such as provision of shade, soil binding, privacy screens, cultural markers and fauna habitat. Species with multiple uses are particularly suited to linear corridors or areas with spatial constraints.

Adaptability:

- Use species that are capable of establishing in areas that may be either small or large, or may change configuration due to future development in soils of variable depth and type (especially modified or manufactured soils)
- Use species that can establish through changes in their surrounding land use and management
- Use species that are suited to changing ecologies, including transition from rural to urban.

The characteristics and growth habits of all woody plants should be carefully considered and researched — relative to the place they will be used — to avoid liabilities and make the most of their natural qualities and longevity.

Appendix B — Native or exotic?

Propagules are seeds, spores, rhizomes or other material that grow into vegetation.
Endemic species are organisms that are native and can be found ONLY in that location.
Indigenous species are organisms that are native and can be found in that AND other locations.
Native species originate within Australia.
Exotic species originate outside a particular location, whether that is within Australia or overseas.

Order of preference	Condition
1. Use propagules or plants grown from propagules that are endemic to the project site.	• Endemic material (endemic propagules or plants grown from endemicpropagules) must be used where there are ecosystems or vegetation at the site that must be conserved and protected. • There must be sufficient sources of endemic materials that can be certified to complete the works. • There must be enough time to collect endemic materials without compromising the source or the project outcome. • The soil and site conditions must be suitable to establish and support endemic vegetation. Imported growing media, constructed landforms or weed-infested site materials may inhibit the use of endemic vegetation. • Endemic materials may be appropriate to use in rural or urban locations subject to agreed design objectives.
2. Exhaust options for procuring endemic propagules or plants grown from endemic propagules from the project site. **Supplement** the balance of required species **with indigenous** propagules and plants grown from indigenous propagules.	• Where some endemic materials are available, use that material in works that have the highest ecological value and lowest risk of failure. • Identify matching ecosystems and environmental conditions radially from the project site to source supplementary indigenous materials. Use geographically closest options. • Endemic material may no longer be available at sites that are developed or modified by human activities. • Endemic and indigenous materials may be used concurrently subject to ecological review and to agreed design objectives.
3. Use propagules or plants grown from propagules that are indigenous to the project location.	• Indigenous materials may be used where there are ecosystems or vegetation at the site that will not be detrimentally impacted by nonendemic species, or where endemic materials are unavailable. • Indigenous materials must provide a vegetation result that fulfils the design and operational requirements at the site. • Indigenous materials may be collected from the site or procured elsewhere subject to agreed design objectives.
4. Exhaust options for procuring endemic or indigenous propagules or plants grown from endemic or indigenous propagules from the project bioregion. **Supplement** the balance of required species **with non-indigenous** materials.	• Where endemic or indigenous materials are available, use that material in works that have the highest ecological value and lowest risk of failure. • Identify matching ecosystems and environmental conditions (known as “bioregions”) radially from the project site to source indigenous materials. Use environmentally and geographically closest options. • Non-indigenous materials including exotic species may be used concurrently, subject to ecological review and agreed design objectives.
5. Use propagules or plants grown from propagules that are non-invasive exotics (ie not endemic nor indigenous) to the project location.	• Only use non-invasive exotic materials where high-value ecosystems or vegetation will not be detrimentally impacted. • Justification for the use of non-invasive exotic propagules or plants grown from exotic propagules must be provided (eg cultural heritage). • Non-invasive exotic species may also be used in areas for temporary vegetation, as landscape buffers to high-value ecosystems or where provision of endemic or indigenous species is not sustainable or self-reliant subject to agreed design objectives.

Appendix C — Climate resilience and Urban Heat Island (UHI)

In metropolitan and other development and growth areas, urban heat islands are generated which exacerbate the impacts of extreme hot weather and other acute climate events on the landscape. Gradual chronic increases to the UHI diminish and degrade the quality and benefits of ecosystem services provided by green infrastructure, and acute extreme events can disrupt or destroy them completely.

Urban roadside landscapes are very exposed and vulnerable to small changes in microclimates as they are comprised of a subset of vegetation communities, rather than a complete system.

To ensure that green infrastructure and other roadside landscape continue functioning into the future, species used must be adaptable to rapid weather changes and resilient to temperature extremes. Industry research and plant breeding trials are underway to produce plants that will adapt to future changes, especially trees and other plants that are food and shelter sources for pollinators and urban wildlife.

Typically, plants along the edge of the road are grasses or ground covers, with plant height and canopy size increasing with setback. Spatial and operational constraints along roadside usually result in vegetation habits and forms that are unlike their natural condition.

Plants that are smaller and lower to the ground are more susceptible to ground heat especially if planted in beds surrounded by hard surfaces, or if they are species which normally have other plant canopy over them.

Designers should consult decision-assistant tools and databases for understanding long-term species resilience and climate analogues such as:

Climate analogues:
climatechangeinaustralia.gov.au/en/climate-projections/climate-analogues/about-analogues/

Climate projections for NSW:
climatechange.environment.nsw.gov.au/Climate-projections-for-NSW

Climate change natural resource management tools and resources:
adaptnrm.csiro.au

RBGSYD tool for ecological restoration planning:
restore-and-renew.org.au

Other tools are in development, such as plant selector “Which Plant Where” (whichplantwhere.com.au)

Table 7 lists some commonly-specified tree species to avoid and some that are suggested for use in urban development areas (especially Western Sydney) and other locations where heat extremes might be a factor. Designers should evaluate their use based on detailed site knowledge and proposed maintenance regimes, such as amount of irrigation, microclimate including overshadowing from high density developments, aspect and reflected heat from surrounding surfaces. The inclusion of specific cultivars is not an endorsement of these particular plants, but is a cue for designers and specifiers to undertake appropriate research and have knowledge of the traits and requirements for non-generic species. The availability and use of specially bred trees is expected to become increasingly common as climate events continue to impact urban areas.

Trees in cities assist with cooling. Shaded areas are preferred by all road users. Reducing heat in public spaces is a public health priority.

Table 7. Suggested list for street trees in Western Sydney

Consider avoiding	Issue	Suggested alternative
Platanus hybrida	leaf burn in heat waves)	
Prunus spp *Liriodendron* spp *Ulmus* spp (broad leaved var's e.g. 'Lutescens') *Acer* hybrids / *palmatum* *Malus* spp *Magnolia soulangeana* *Betula pendula / utilis* *Flindersia* spp * *Cupaniopsis* spp * *Quercus robur* * *Backhousia citriodora* *Elaeocarpus* spp	Intolerance of heat extremes and/or drought (and heavy soils if marked *), leading to susceptibility to disease and partial structural failure	*Quercus palustris* / EDF *Lagerstroemia* varieties *Ulmus parvifolia* 'Todd' *Acer negundo* 'Sensation' *Lagerstroemia* 'Sioux' *Betula nigra* *Acacia binervia* *Photinia robusta*
Melaleuca quinquinervia *Agonis* spp *Populus* spp except *P. simonii*	Myrtle Rust and other disease — prone conditions exacerbated by climate change issues	*Callistemon salignus* *Brachychiton populneus*
Eucalyptus scoparia *Eucalyptus nicholii* *Hymenosporum*	Poor long term performance in heavy soils and humidity	Other local Eucalypts and *Angophora* spp *Geijera parvifolia*
Fraxinus raywoodii *Corymbia ficifolia* grafted hybrids	Structural issues in mature trees	*Fraxinus pennsylvanica* 'Urbanite'

Heat stressed leaves of species failing to adapt to extreme heat events.

Appendix D — Safety in Design

The landscape design can have a significant effect on the health and safety of persons constructing or maintaining the end product. Careful consideration by designers regarding the impact on health and safety is necessary.

Some issues include:

- Planting and future need for maintenance on overly steep slopes
- High maintenance planting that requires work under traffic at regular intervals requiring lane closures at night
- Landscape that requires regular weed control and use of pesticides
- Planting around wire rope fences that makes maintenance difficult
- Landscape that can lead to bush fire risk
- Appropriate plant selection for space and context
- Emerging technology which may assist maintenance work to be undertaken in a safer manner.

Transport is required to implement the Safety in Design legislation (SiD Act S10), sound health and safety design principles to risk manage the SiD hazards associated with construction, maintenance and demolition of the end product. The requirements for SiD design applies to projects whether the design is developed "in house" or using external SiD registered consultants.

Each landscape design for Transport projects must be accompanied by a landscape design SiD report. It is the responsibility of the landscape designer to develop the SiD report ensuring input from stakeholders is captured. It must capture the health and safety hazards and identify measures that will eliminate or reduce the impact of each hazard on constructors, maintainers and persons involved in demolishing the end product.

Emerging technology such as this remote control mower may inherently improve safety of maintenance activity on our corridors.

The intention of the landscape design SiD report and SiD development plan process is to:

- Demonstrate and record the orderly identification and management of health and safety throughout the life of the project, including the maintenance period and thus provide evidence that designers and the Roads and Maritime project staff have met their legal SiD responsibilities
- Provide a process where key project stakeholders consult on project hazards at development stage
- Identify hazards at an early stage of the project and establish systems to eliminate/control these hazards
- Provide a resource document for those who will carry out maintenance work on the project in the operation phase.

The SiD development plan is reviewed and modified through each of the project stages and hold points to ensure appropriate parties involvement and input. A generic hazard list is also available to project teams from their Roads and Maritime project manager to assist in identification of project specific hazards.

Hazards that have not been eliminated at the completion of the design phase are included in the SiD contract specification for the attention of the constructor in their project SiD management plan. Contractors' procedures/ processes for managing these identified hazards are then assessed for completeness during the tender process.

This part of the corridor had trees planted in a steep batter above a vertical cutting face with a long drop onto the carriageway. Particularly during establishment this was a maintenance problem and safe access to maintain the landscape works required ropes for safety. More space at the base to allow access by a platform, a lower height cutting or a railing would have improved the inherent safety of workers needing to access this site.

Appendix E — Landscape Management Plan

Purpose

The purpose for introducing a landscape management plan after delivery of the project is to support asset maintenance in maintaining the landscape, and ensure that all the landscape elements designed into the project are established and successful.

Often on projects landscape works are amongst the final activities with recently completed work having little time to establish and with defects carried into the maintenance establishment period. It is envisaged that with the implementation of a landscape management plan defects can be rectified and plants become established for a progressive reduction in longer term maintenance activities. Vegetation is a living component of the landscape continually developing and it is necessary to have the knowledge and capacity to be able to harness this movement and direct it to the desired outcome. Introducing inappropriate work activities can often do more harm to the establishing vegetation and require costly repair or replanting. Alternatively by following contemporary horticultural maintenance practices with procedures in place and carried out by experienced tradespersons will increase the likelihood of success and extend the life of the landscape.

With all landscape works, the critical period for its overall success will come within the first three to five years depending on the landscape treatment and road context. This should be classed as the establishment period and will require frequent maintenance activities within the first 36 months followed with a scaling down of work over the following 12 to 24 months before handover.

Plan

The management plan sets out a list of procedures that need to be implemented within a set time frame after construction. Frequency of these procedures will be dependent on the particular requirements of each project and specific landscape environment.

Year 1

1. Verify that all landscape works have been completed from construction and any defects rectified according to the relevant drawings and specification.
2. Maintain moisture levels to prevent plants from drying out and to provide optimum conditions for plant establishment and growth.
3. Manage weed infestation in mulched planting areas and around individually mulched plants. Weed control preferably by hand removal or by registered application of herbicide.
4. Replace dead and missing plants with identical species. If a particular plant species has a high mortality rate consideration may be given to a substitution of a more suitable plant species.
5. Replace damaged or missing tree stakes and tree guards and ensure that trees and guards are secure to their stakes.
6. Provide slow release fertilising (3–6 month) of plant material suffering discoloration by placing fertiliser around plant stem or use spiking method to reduce surface weed growth.
7. Lightly prune shrubs to encourage lateral branching. Standard horticultural practice for all pruning must be followed.
8. Monitor all plants for damage, disease and other harmful conditions not part of the landscape work. Where damage is detected, identification from a qualified horticulturalist should be sought and recommended treatment implemented.

9. Safely remove all litter and extraneous material from the site at regular intervals. Location of the landscape area will determine the frequency of the litter removal.
10. Maintain turf areas at a height from 50 millimetres to 150 millimetres based on the time of year and availability of irrigation. Newly laid turf will require regular watering to encourage quick establishment. Broad-leaf weed spraying with selective herbicide will be required if weed is identified. Fertilise with an organic fertiliser in Spring and Autumn to encourage a more dense turf that will be more resistance to weed infestation.
11. Regularly slash pasture grass and weed in native seeded areas where unsightly.

Year 2 to 3

1. Manage weed infestations in mulched planting areas and around individually mulched plants. Weed control by hand removal should be encouraged rather than registered herbicide application to reduce the opportunity of weed colonisation as plants develop.
2. Ensure trees are secured to stakes and that the stakes are not causing any damage to the trees by wind movement. Replace damaged or missing and stakes where necessary. Any trees that fail to be self-supportive should be replaced.
3. Remove tree guards from around plants that have outgrown their guard.
4. Undertake crown lifting of trees to allow more light and establishment of groundcover. Standard horticultural practices for pruning are to be followed.
5. Monitor all plants for insect damage, disease and other harmful conditions not part of the landscape work. Where damage is detected, identification from a qualified horticulturalist should be sought and recommended treatments implemented.
6. Safely remove all litter and extraneous material from the site at regular intervals.
7. Maintain turf areas at a height from 50 millimetres to 150 millimetres depending on the time of year and availability of irrigation.
8. Fertilise plants with a slow release (3–6 month) organic type fertiliser in Spring and Autumn may be of benefit to plants in some situations where soil quality requires amelioration.
9. Replenish mulch depth as specified to suppress weed and retain moisture.

Year 3 to 5

1. Manage any weed infestations, insect damage and disease can be greatly reduced by early detection and intervention at the earliest stage by a qualified horticulturalist.
2. Remove any self-seeding trees species on a yearly basis from clear zones to reduce disturbance from removal of larger trees.
3. Remove any tree guards and stakes where trees are not relying on their support.
4. Prune trees and shrubs to maintain view corridor to signs and barriers. Remove dead, diseased and damaged branches from all trees. Where work is required on mature trees a qualified arborist should be engaged to carry out the work.
5. Safely remove all litter and extraneous material from the site at regular intervals.
6. Maintain turf areas at a height from 50 millimetres — 150 millimetres depending on the time of year and availability of irrigation.
7. Replace woodchip mulch in areas where necessary.

Appendix F — Landscape change over time

The following case studies show a variety of the Roads and Maritime landscape design principles for roads in practice. Understanding the performance of different species in context over time is a critical aspect of the design process, as this affects:

- the value and outcomes from green infrastructure services
- the cost and frequency of intervention and maintenance activities
- the longevity and quality of landscape results
- the value and appreciation of the landscape and land uses.

The timeline below and discussion on the following pages shows how the planting and revegetation has changed for a variety of corridors and sites over a number of years.

2010 — 2011 — 2012 — 2013

1. Cowpasture Road near Greenway Road, Carnes Hill
2. Camden Valley Way near Georges Road, Leppington
3. Camden Valley Way near Raby Road, Leppington
4. Warringah Expressway near Cammeray Golf Club, Cammeray
5. Hume Highway near Little Billabong, North of Holbrook


2014
2015
2016
2017
2018

Case Study 1 — Cowpasture Road near Greenway Road

February 2010 — a few weeks after installation

1. Tall remnant trees provide shade and glare relief to shared user path (SUP), and help to frame the road corridor. Trees also humanise the scale of the widened road and increased development to the other spaces occupied by people. Canopy trees also retain a number of other ecosystems services that are usually under threat in urbanised environments.
2. Median edged with two metre width turf for easy intervention control and infilled with dense upright groundcovers and shrubs. All other landscape elements are appropriately set back to allow easy inspection and not to impede slashing or other maintenance activity.
3. Supplementation of existing vegetation with species from the same vegetation community, but ensuring appropriate diversity of species and canopy layers to adapt to further macro and microchange in development areas. This is particularly important along narrow lengths of planting bed where minor changes in ground surface levels or hydrological system strongly affect the viability of the vegetation establishment and longevity.
4. Verge plantings set back from kerb and path edges to ensure drainage, clear sightlines and prevent spillage of foliage into gutters. Travel along road or SUP pavements is not impeded. The mulch is installed set down from the path level to prevent mulch spillover into the drain. The landscape areas are established by passive irrigation and manual top-up watering instead of inground irrigation system.

February 2018 — 8 years of growth

1. Most plants have reached mature size, with some additional height and spread yet to come for the trees. The landscape character has been realised and complements earlier existing landscape. Further changes due to plant maturity and gradual self-replacement should be expected as the area continues to develop.
2. Median and verge is kept clear of infrangible vegetation, has clear sightlines along and across the road space, and has adequate area to provide a buffer of plants that separate the road from the path, which increases the feeling of comfort and safety for the users.
3. Plants along the road boundary have adequate space for development of their roots, branch structure, canopy spread and sway without requiring any intervention maintenance or shaping when mature.
4. The landscape levels in the verge have settled due to incidental compaction (from adjacent development and some vehicles using the path), and trapped surface water. The Blady Grass has yellowed after hot summer season and bound soils well. It has also begun to thin in patches where the trees are increasing their dominance over the ground surface, and soil and water resources. The groundcover is gradually replaced with organic mulch from leaf litter.

Case Study 2 — Camden Valley Way near Georges Road

March 2016

1. Existing trees retained and protected to keep original landscape character, with new landscape works to rehabilitate the disturbed areas nearby. The species palette for this area was selected for:
   - road safety and minimal maintenance
   - predictable growth and seasonal habits
   - resilience to new urban impacts and further disturbance, including vandalism and pollution
   - complementing both indigenous species and highly managed gardens of surrounding development.
2. Monoculture of rhizomatous grass has established in the verge and in the median.
3. Initial cover crop species have given way to perennial grasses and groundcovers, with some coloniser shrubs indigenous to the area. Embankment cutting has been stabilised but surface protection still requires imported landscape materials because the “O” horizion not yet reinstated.

February 2018

1. Tall canopy trees underpin the landscape character and provide the main ecosystem services. Screening shrubs and replacement trees beginning to take effect.
2. Taller shrubs and small trees have established and now developing canopy height and spread. The position of these plants complies with the clear one, sight distances to the intersection for stopping and turning, and do not intrude to the shared user path.
3. Toe of the embankment and the strip between kerb and path are planted with rhiztomatous grasses which bind the soil and prevent erosion. The grasses are persistent, self-reliant and do not impede any road function. However, the constructed landscape areas are still establishing and more time is needed before final landscape result is realised.
4. Some groundcovers have begun to thin out where close to larger shrubs, due to competition for water and soil nutrient. Bare areas created by maintenance to feature estate sign wall (corner seen in bottom left of image) and public access shortcut from intersection crossing to residential estate through the landscape. There had been a prolonged dry spell at the time of the photo.

Case Study 3 — Camden Valley Way near Raby Road

January 2015

1. Matrix of native grasses including cultivars planted in the verge at six per square metre. The planted area extends from back of kerb to top of vegetated drain across a range of slopes and around utilities and drainage structure. The broad expanse of low plantings will develop into complete surface coverage, but remain frangible and retain sightlines to the traffic signals and sightlines for intersection and safe stopping distance from the turning lane.
2. The flat area may optionally become a footpath or cycleway in future development. If this occurs, the matrix of grasses remains an appropriate landscape treatment.
3. The planting bed uses ameliorated site soils with imported woodchip mulch.

February 2018

1. The matrix of grasses provide consistent landscape character along the road corridor. The variety of foliage texture, colour, seasonal differences in the species is evident at closer scale and provides interest to pedestrians, cyclists and road users stopped in adjacent lane, and the broadscale patterns contribute to self-explaining road environment for motorists.
2. The maturing native grasses provide almost full surface cover, with some informal tracks through the planting area created by maintenance access to drain, fenceline and utilities. Some weeds have begun to appear through the plantings, typically at the margins where occasional slashing and regular herbicide weakens the plantings. The diversity of species in the matrix has provided resilience through expanding the range of climate and weather impact tolerance, encouraging greater soil health and food sources for pollinators, and increasing the overlapping time of green infrastructure services (such as leaf drop becoming mulch layer, rhizomes binding the soil and shooting new plants, tussocks expanding and reducing space for weeds).
3. At the property boundary (out of picture, right), some taller shrubs and trees are colonising the planted area from remnant vegetation stands. It is likely that seed and other propagules have been carried into the area by animals, wind, surface water and maintenance equipment/clothing. Species succession is a characteristic of disturbed roadside landscapes and is to be expected after several years growth. Selective removal of tall woody plants from this planting bed may be required in a decade, but further development may occur prior to that requirement.

Case Study 4 — Warringah Expressway near Cammeray Golf Club

Views west to Cammeray on-ramp

February 2011 — 2 weeks before planting

600 litre broad-leaved paperbarks (Melaleuca quinquenervia) have already been planted behind this prepared batter to extend line of existing paperbarks around pond. The works required removal of mature Hill's Figs (Ficus hillii) along one of the busiest roads in Australia, which exposed distant residential areas across a long gully to day and night road movement, and reduced visual landscape amenity for road users and residents.

March 2011 — 1 week after planting

There are three layers of planting — grasses and groundcovers for surface stabilisation, small shrubs for rapid protection and interim site conditioning, and large woody plants including trees for long-lived landscape effect. All plants cost the same, but have different functional roles and longevity. It is intended that the plantings will grow and die at different rates, and simulate succession as would occur in their natural condition.

May 2013 — 2 years + 2 months after planting

The 600 litre paperbarks are approximately the same height as when planted, but have increased their canopy volume. They are mostly masked by the rapid growth of native shrubs. In several decades, it is expected that the shrubs will have thinned and the trees will still be the key landscape element.

April 2017 — 6 years after planting

The 600 litre paperbarks have started to regrow, but are not currently visible from the road or path behind the mature native shrub screen. They are expected to become visible in the next decade.

Views east to Cammeray golf course compound

February 2011 — 2 weeks before planting

Topsoil prepared to 150 millimetre depth for native plantings. The site soil is clayey over sandstone base, and required only basic conditioning suitable for native species. The planting area topography ranges from flat at the eastern end, to 2H:1V batter at the western end, with a minimal catchment being sheet flow from the new cycle path and itself.

March 2011 — 1 week after planting

The native species have been planted as tubestock at a density of one per square metre, then the area mulched with coarse woodchip. The 2H:1V batter face is short enough to safely plant out the whole area. The mulch is shaped like shards, rather than nuggets, which prevents it from slipping. If the slope run was longer, then an organic fibre mesh, mat or other stabilisation product might have been added.

May 2013 — 2 years + 2 months after planting

The large woody shrubs have established and are semi-mature; their average height is two and a half metres. Trees planted as tubestock have established to equal size of the shrubs.

Smaller groundcovers and nursery shrubs are mature and have kept the site area and slope surface stable. The rapid establishment of a dense shrub screen also eliminated the need for additional fencing. The planted area was established and maintained by the golf course staff due to proximity to fairways, contributing their expertise to the result.

April 2017 — 6 years after planting

The large woody shrubs have fully established and progressed to self-reliant maturity; their average height is four and a half metres. Trees planted as tubestock have established and some formative pruning to remove low spreading limbs has occurred.

Original smaller groundcovers and nursery shrubs are senescing, but have also self-seeded and replacement plants are growing as understorey patches as they would in their natural condition.

Case Study 5 — Hume Highway near Little Billabong

February 2011

1. The species palette has been selected from local communities. In rural highway settings, groundcover planting should be used only around culverts, bridge piers and abutments, fauna crossings, rest areas and intersections where plant size needs to be controlled. For all other areas, using large plants to exert influence over a larger space has better long-term result.
2. Native trees planted as tubestock in wide median seeded with pasture grasses to stabilise slopes and control overland flow. Trees are planted well set back from clear zone and away from drainage alignments and other structures.
3. Edge of pavement sealed to inhibit vegetation that may mask the roadside barrier, sign face and other objects.

February 2017

1. Native trees are semi-mature and match the character of the existing landscape. These trees will not grow to a size where they intrude to the operational road space due to the soils, climate, aspect and available moisture. It is expected they will be mostly resilient to some change in climate.
2. Maturing vegetation adaptable to other changes and disturbance in the roadside such as replacement of the sign, wheel damage and other intervention activities such as edge spraying, slashing and inundation.

Appendix G — Multi purpose landscape

Image showing a well designed and implemented landscape design, which considers context, site constraints and asset maintenance


Design allows for clearance to services
Mix of species and heights appropriate to context
Roadside services and shared path clear of obstructions
Dense establishment of groundcover vegetation
Median vegetation breaks apparent expanse of pavement

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